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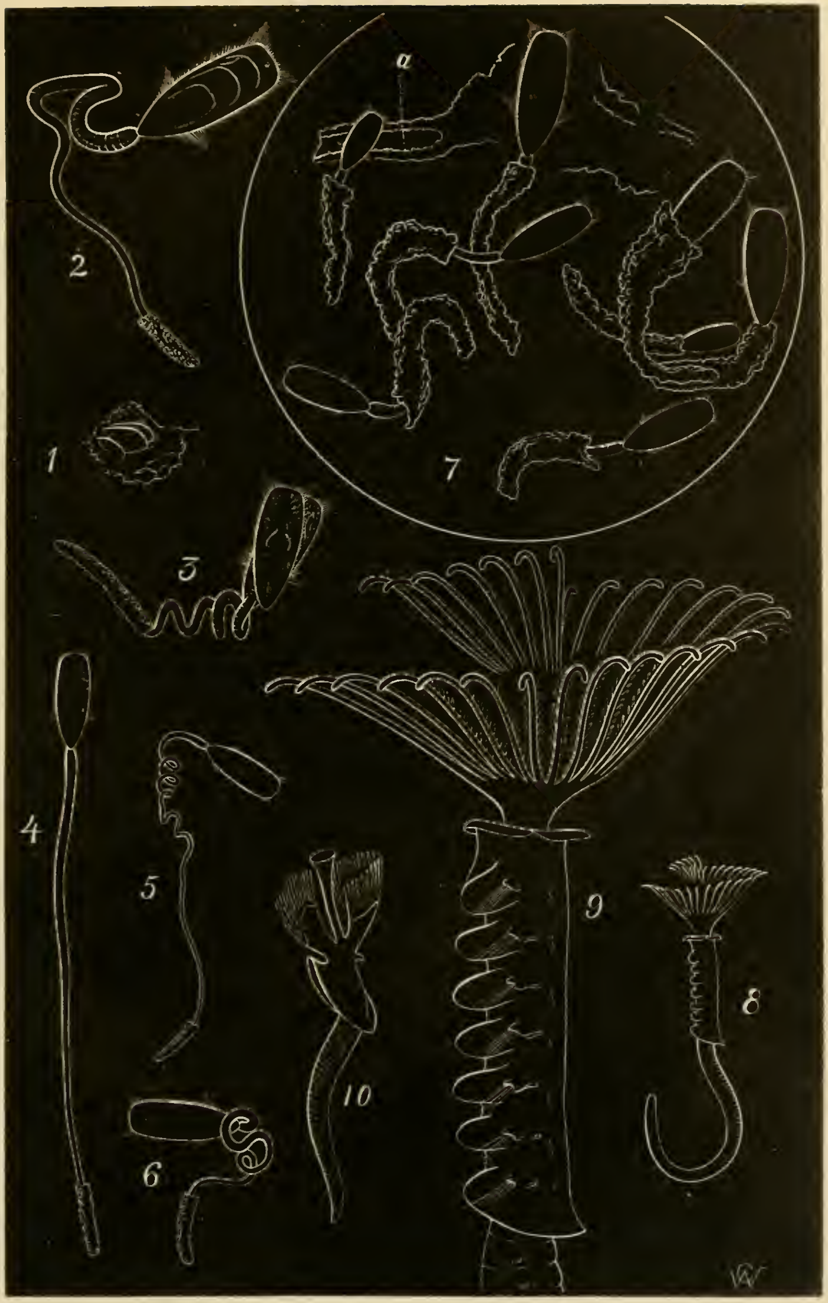


MORSE, SYSTEMATIC POSITION OF BRACHIOPODA.

PROCEEDINGS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY.

TAKEN FROM THE SOCIETY'S RECORDS.

January 3, 1872.

The President in the chair. Twenty-five persons present.

Dr. Anton Dohrn of Jena, Dr. Armand Thielens of Tirlemont, Prof. E. Van Beneden of Liege, and M. Henri de Saussure of Geneva, were elected Corresponding Members.

Messrs. James F. Pickering, Gurdon Saltonstall, Frank W. Stearns, George W. W. Dove, Paul S. Yendell, David L. Nichols, Samuel Wells, James Boll, R. Stuart Chase, Edward P. Austin, Charles E. Hosmer, Alfred Bowditch, William F. Freeman, Theodore W. Gore, were elected Resident Members.

Prof. T. Sterry Hunt made some remarks on the so-called Devonian and Silurian fauna, and presented from the author a work on the "Flora of the Eriean Division," by Prof. Dawson.

Prof. W. H. Niles stated, that while studying the effects of pressure upon rocks, he had observed certain facts connected with the metamorphism of some pebbles contained in the conglomerate rocks at Chestnut Hill Reservoir.

In a collection of these pebbles which he exhibited, each specimen had clusters of small acicular crystals at two directly opposite points upon the surfaces. The position of these crystals bore no relations to the size, form or character of the pebbles, but was always directly related to the position of the pebbles in the rock. An imaginary line passing from one centre of crystalization directly to the other, while the pebble was in position in the rock, would represent correctly the direction of the dip of the stratum. Among the hundreds of specimens examined, this relation between the position of the crystals upon the pebbles and the inclination of the strata, was found to be invariable. He believed that this indicated the cause of the metamorphism, and that the physical force which elevated the strata was likewise concerned in determining this constant position of the crystals. It was clearly evident that some of the pebbles had been subjected to a pressure, as they were often curved, broken and elongated, as Hitchcock and others had observed at other localities. Moreover, the whole rock was somewhat metamorphosed. It seemed to him in this instance, at least, pressure must have been the chief cause of the first crystalline metamorphism of the pebbles, as it was also the cause of the well known metamorphism of form. But he was not prepared to explain the chemical change which had taken place. He had observed that there were often cavities between these pebbles and the surrounding rock, at just these two points where crystallization appeared, and yet the crystals had so firmly united them with the matrix as to often make it difficult to separate them, though at other points upon the surface the separation was comparatively easy.

He exhibited some pebbles which had been broken, the parts slightly displaced and then united by crystalization. He hoped some of the members present might explain why the usual chemical changes had been apparently limited to these two centres of crystallization.

Prof. Shaler said he had observed a similar feature in the rocks in Switzerland, and had found there cases of the penetration of softer rocks by those of harder substance. He thought that the elongation of some pebbles might be due to lateral pressure; this would tend to produce cavities at the extremities of the longer axes of the pebble. He had had opportunities of studying this subject in the Newport conglomerate in the neighborhood of Black Point.

Dr. Chas. T. Jackson said that he could not admit these pebbles were ever plastic, and attributed their form to the action of water.

Mr. A. H. Tuttle described a shelter cave once used by the Indians at Illyria, Ohio.

It is at the junction of the Black and Monongahela Rivers, and has been disclosed by changes in the form of one of these rivers. Within the soil to a depth of nearly three feet, is composed of ashes, bones, shells, etc., with fragments of pottery, axes and arrow-heads. Some human skeletons were said to have been found, in a position indicating that they had been crushed by the fall of fragments of the overhanging rocks.

The following communication from Dr. T. M. Brewer was read: —

The announcement was recently made that the committee on birds had obtained, by exchange, with Mr. H. W. Henshaw specimens of the *Oporornis agilis*, or Connecticut Warbler, in the immature and in the mature plumage, both male and female. As this has been regarded as a very rare species, and was almost unknown to the older ornithologists, the fact that these birds have twice made their appearance in Massachusetts for brief periods, in comparatively large numbers, is one of marked interest, and worthy of mention.

These birds were first observed in the autumn of 1870. In the early part of September, among the marshes of Fresh Pond, Cambridge, they were quite numerous, and a number of specimens were procured, both by Mr. Henshaw and by Mr. Wm. Brewster, upwards of fifty in all. During September and October, 1871, these birds were again observed in the same localities, and apparently in even greater numbers. They were first noticed as early as Sept. 7th. From that time to the 27th, they were very common throughout the swamps of Fresh Pond; nine were seen after October 5th.

Wilson and Audubon speak of these birds as very lively, and hence their specific name of *agilis*. This appears to be a misnomer. Mr. Henshaw states that they appeared to be terrestial in habit, seeking their food on the ground. When startled they fly to the nearest bush upon which they sit perfectly motionless, in the manner of a thrush. If not farther disturbed they soon return to their search for food among the leaves. If greatly startled they take a long flight among the bushes and cannot be again found. Their only note was a single sharp chirp, uttered when surprised. They were all remarkably fat and were nearly all in immature plumage.

A letter from Dr. Brewer announcing the following donations to the museum from Mr. Harvey B. Bradley, was also read: —

Nest and eggs of *Dendroica castanea*, *D. coronata*, and *Ampelis carolinensis*. The nest of the first species is new to our collection, and is an acquisition of great value, having been found only once or twice before. The nest of *D. coronata* is also quite rare, and is interesting as coming from so southern a locality as Upton, Maine.

January 17, 1872.

The President in the chair. Seventeen persons present.

The following papers were read: —

The Non-Reversionary Series of the Liparoceratidæ, and Remarks upon the Series of the Allied Family Dactyloidæ. By A. Hyatt.

In my last communication to this Society I endeavored to trace the reversionary series of the Liparoceratidæ, and necessarily left out of consideration all those species which did not belong to one or the other of the truly reversionary series.

Of these last there is a very curious group, all the species of which, at a young stage, resemble more or less closely the young of the original type, *Microdoceras Birchii*, but betray by their development, adult characteristics and geological succession, a closer affinity to *Deroceras Dudressieri*.

This species in the communication referred to was shown to be the probable ancestor of a series of forms which include *Deroceras confusum* and *Deroceras densinodum*. All of my observations, as well as those of Quenstedt, indicate that the true position of *Deroceras densinodum*, is between *Deroceras Dudressieri* and *Deroceras armatum*, and its geological relation is similar. It is found in the Raricostatusbed, just between the Obtusnsbed containing *Deroceras Dudressieri* and *Deroceras planicosta*, and the Armatusbed of the Middle Lias. My material, however, does not permit me to compare the young of *Deroceras armatum* and *Deroceras densinodum* in order to ascertain whether the former is really more closely allied to the latter than to *Deroceras Dudressieri*, but Quenstedt supplies this deficiency in the proof. According to his figure, this species is really an *armatus*, in which the young is pilated or ribbed at a very early period as in *Dudressieri* instead of being smooth as in *armatus* proper.

The general tendency of the series, as shown by the adults and by the growth of individuals, is to produce the spines at wider intervals, depress or obliterate the pilæ, and by decreasing the breadth of the abdomen render the whorl more cylindrical. *Deroceras Davœi* carries this tendency still farther. The young being smoother, the spines more sparsely distributed, the fold-like pilæ almost absent in some specimens, and wholly superseded by the projecting lines of the transient mouths. These having previously been merely subordinate pilæ, have become primary and replaced the folds. It is not at all improbable that *Deroceras alternum*, from Plateau de Lazac, which appears to be very closely allied to *Deroceras Davœi*, may prove to be a local variety of the latter. However this may be, the young are more like those of *armatus* than are those of *Davœi*. *Deroceras minatum* is labelled by Dr. Krantz as a new species from the Upper Lias of the Plateau de Larzac. It differs in the form of the adult whorl and in the septa, though not in the young, from *Deroceras alternum* of the Middle Lias. The sides and abdomen are flattened instead of gibbous, as in the latter, and the shell is much flatter and thinner. The lobes are more deeply divided, and larger every way in *Deroceras alternum*, and the cells narrower at the neck, and spreading more at the base than in *Deroceras minatum*. In neither of these species are the specimens probably fully matured, but yet in one specimen of *Deroceras alternum*, only a half inch in diameter, the changes are fully as extensive, and the septa as completely developed as in the adult of *Davœi*.

The quadragonal form of the whorl and the tuberculated pilæ occasion in the young *Deroceras minatum*, during the later stages of growth, a resemblance to *Holandrei*, which subsequently changes to a nearer resemblance to *annulatum*.

Another series begins with *Deroceras muticum* of the Lower Lias, which appears in the Raricostatusbed, just above its nearest ally, *Deroceras Dudressieri*. This species is very much smaller than the last named, and differs in other respects; but it resembles it more closely than *Deroceras armatum*; whether it compares in the same manner with *Deroceras densinodum* or not, I am unable to decide. Its adult characteristics, however, and development, while they approximate to *Deroceras armatum*, do not permit of its association in the same series. The absence of intermediate pilæ, the constancy and closeness of the tuberculated pilæ and the septa are very distinct in this species, and the huge *Deroceras nodogigas* of the Middle Lias, which appears to form the second term in the same genetic series. Both of these series exhibit, so far as I can trace, no reversionary characteristics. Whether the modifications may be considered progressive or not, remains to be determined. There is the same tendency as exists in the other series of the family previously described to suppress the fold-like pilæ and prominent tubercles. It is noticeable that in the *armatus* series this takes the same direction as in the genetic series of the Dactyloidæ, which begins with *Dactylioceras commune* and ends with *Dactylioceras Braunianum*. The tendency in both of these groups is .to obliterate the large tuberculated fold-like pilæ, with the minor ridges or pilæ gathered and joining in fascicles at the tubercles, and to substitute for this and the flattened abdomen a rounded whorl, single, sharply defined, entire pilæ. It must be remembered, also, that in neither of these series is there any increase of the involution in successive species. The umbilici are entirely open. The septa of *Deroceras Davœi* are rather more ornate and complicated than those of *Deroceras armatum*, and the lobes and cells of the latter than those of *Deroceras Dudressieri*. A certain amount of progress may perhaps be claimed for this series, but the other series, that of *Deroceras muticum*, is too incomplete. *Deroceras muticum* is certainly much smaller than its immediate ancestor, *Deroceras Dudressieri*, but on the other hand, *Deroceras nodogigas* is just as large. The septa, also, of the first named, which can hardly be said to be more complicated, cannot be claimed as simpler than those of *Deroceras Dudressieri*. The varieties of *Deroceras muticum* indicate that there is a tendency existing in the organization to flatten the sides, and render them convergent instead of divergent. Whether this is a governing one or not in the series cannot be determined, and perhaps may never be, for it would not be at all surprising if these two species represented all that ever existed.

It is well to remember, however, that this is the same tendency which finds a fuller expression in the series made by *Dactylioceras commune*, *Holandrei*, *annulatum*, and *Braunianum*. It is here, however, only slightly shown, and the sides do not, in the most extreme variety, approximate, or become so convergent as to make the abdomen acute, as in *Dactylioceras Braunianum*.

The difference between the varieties of *Deroceras muticum* are however, comparable, so far as the divergency or convergency of the sides are concerned, to the difference between the divergent sides o *Cœloceras Desplacei*, and the convergent sides of *Dactylioceras Holandrei* or *annulatum*; species undoubtedly distinct and easily definable, on account of numerous other characteristics.

Deroceras armatum.

Amm. armatus Sow., Min. Conch., vol. I, p. 215, pl. 85.

Deroceras armatum Hyatt, Bull. Mus. Comp. Zoology, no. 5, p. 95.

This species has, from the earliest period, a very marked character. It is smooth much longer than the young of *Deroceras Dudressieri*, or than any of the Liparoceratidæ, except *Microderoceras Birchii*. This species it resembles closely in form also, and in the acquisition of the spines. Thus the young *Birchii* have no pilæ, or only slight swellings or ridges, and in this species this condition is maintained throughout life. The whorl is crossed by numerous ridges between the spines, and three or more of these are often gathered into knots by the spines themselves, but no true pilæ, such as appear in the adult of *Microderoceras Birchii* appear. The sparseness of the spines and of pseudo-pilæ or ridges is also remarkable, especially as it is found in all of this species.

The septa closely resemble those of *Microderoceras Birchii*, — the large abdominal or siphonal cell in the centre of the abdominal lobe, with the adjoining superior lateral cells apparently stuck on to the side of the latter, — the height and extremely widespreading minor lobes, as well as the size of the superior lateral lobes, and the depth, narrowness and mode of division of the superior lateral cells by the very prominent minor lobes, — these decisive similarities, and the singularly close likeness of the very ornate outlines of all the lobes and cells show that there can be no doubt of the affinity of this species for *Microderoceras Birchii*; but the single row of prominent spines indicates that, like *Deroceras Dudressieri*, it is a generic derivative from *Microderoceras Birchii.* And an examination of the young septa shows that at one stage they have the large cell in the centre of the superior lateral lobes so common in *Deroceras Dudressieri.* Thus the species is properly and more directly a descendant of *Deroceras Dudressieri* with reversions to *Microderoceras Birchii.* The absence of a planicostan abdomen at all stages places it in advance of *Deroceras Dudressieri.* The geological position of the latter in the Lower Lias Obtususbett, and of this species on the borders of the Middle Lias, confirm this view.

Deroceras alternum.

Peronoceras alternum Hyatt, Bull., *Op. cit.*, p. 85.

The young of this species is smooth, like the young of *Deroceras armatum*, the tubercles and pilæ are developed slowly, as in that species, and the characteristics of the adults are similar, with fold-like, spined pilæ, and numerous crenulations between. The abdominal cell is exceedingly large. The abdominal lobe is very broad, and much deeper than the superior lateral lobes. The superior lateral cells are extremely narrow, and much cut into by the minor lobes. The superior lateral lobes have three wide spreading branches and the intermediate cells therefore are very large, and the inferior lateral cells very much attenuated at the top. These characteristics approximate also to those of *Deroceras muticum*, though not so closely as to those of *Deroceras Davœi*, while the shell is more like *Deroceras armatum.* It possesses just the same intermediate character as *Deroceras Davœi*, but is a very much smaller species, with the young more like *Deroceras armatum.*

Deroceras Davœi.

Amm. Davœi Sow., Min. Conch., vol. IV, p. 71, pl. 350.

Deroceras Davœi Hyatt, Bull. Mus. Comp. Zoology, no. V, p. 84.

This species carries to excess the sparse distribution of the spines, the mere folds instead of pilæ, and the multitudinous crenulations observed in *Deroceras armatum.* The spines unite these when they occur in knots, but this is subject to the greatest variations, and the number of the spines varies considerably. They are not present in the young until a late period, and then occur pretty regularly, though much wider apart in some specimens than in others, and finally disappear suddenly as old age approaches. The advance of age is indicated not only in this way, but by the irregularity of the crenulations. These, at intervals, are almost obliterated, and then grow gradually more prominent, again dropping suddenly to mere lines. Undoubtedly this indicates a failure of the vital powers, and a much slower growth of the shell. Longer and longer arrests of growth explain the increasing prominence of the crenulations, and a renewal of energy by means of these long rests may possibly explain the sudden smoothness; the animal affected by senility not being able to build and retain the crenulations, when the old rate of growth is suddenly resumed. The septa resemble closely those of *Deroceras muticum*. The superior lateral cells are, however, wider, the superior lateral lobes deeply divided, the inferior lateral cells very narrow. The abdominal lobe is deeper than the superior laterals.

Thus while more like *Deroceras muticum* than *Deroceras armatum* in its septa and in the external characteristics of the shell, still the folds, instead of pilæ at each spinous node, the spines and the crenulations between them, are characteristics uniting it with *Deroceras armatum*. The affinities therefore are doubtful, though in my opinion it is nearer to the latter than to the former, and is probably a species in the same series as *Deroceras armatum*.

Deroceras muticum.

Peronoceras muticum Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 85.
Amm. muticus D'Orb., Terr. Jurass., Ceph., pl. 80.

This species has two well marked varieties, one closely resembling *Deroceras Dudressieri* in the breadth of the abdomen and the divergency of the sides; the other peculiar, with flat, or slightly convergent sides. The pilæ and lower portion or base of the spines are not, as in *Deroceras Dudressieri*, filled with shell, and they are very distinct on the casts; nor do the young or adults even, so far as I have seen, exhibit the planicostan abdomen. The young, in other respects, are very similar to the young of that species, but the pilæ and the spines appear at an earlier age.

D'Orbigny's figure of the septa is excellent, and by comparison with those of *Deroceras Dudressieri* many constant differences can be observed, though the general characteristics are similar; the narrow, prominent, abdominal cell, the deep divisions, or minor three lobes at the bases of the superior lateral cells, the huge lateral cells on either side of the tops of the superior lateral lobes, and the extreme narrowness of the aperture at the top of the inferior lateral cells.

According to Oppel[1] this species is identical with part of *Amm. armatus densinodus* of Quenstedt, and is found in the Raricostatus-bed of the Lower Lias. This agrees admirably with its affinity for *Deroceras Dudressieri*, which occurs in the next bed but one below the Obtususbed. Quenstedt (Der Jura, p. 105) also places this species with *raricostatus* in the Lower Lias. There are, however, a large number of specimens labelled "Venary près de Semur, Middle Lias," by Boucault, and these are associated with others which he has named "*subarmatus*," but which are merely the broad *Deroceras Dudressieri*-like variety described above.

Deroceras nodogigas.

Peronoceras nodogigas Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 85.

Amm. nodogigas Quenstedt, der Jura, p. 125, pl. 15.

The Museum possesses one large, but indifferently preserved specimen of this species, which does not enable me to throw much light upon its affinities. Quenstedt asserts that it is distinct from Oppel's *Amm. armatus*, which appears to be plainly enough indicated by this specimen. The pilæ and spines have none of the irregular swollen and divided aspect of those of the typical *armatus*, but are closely similar to those of *Deroceras muticum*. They are also more numerous than in *Deroceras armatum*.

SERIES CYCLOCERATINÆ.

This series[2] exhibits some remarkably curious and interesting features. Like the Dactyloidæ it does not increase the involution of the whorls, but merely the flatness of the sides, the narrowness and prominence of the abdomen. The approximation of the earliest existing species, *Platypleuroceras brevispina* to *Microderoceras Birchii*, is very marked, and very curiously the adult is almost identical with the adult of *Microceras latæcosta*. From this species to the next but one, *Cycloceras Valdani*, is a considerable step. Not only has the character of the abdomen entirely changed from a rounded planicostan form to a keeled outline, but the young display this characteristic at an early age. The remaining species simply

[1] Die Jura formation. Jahrshefte fur Naturk. in Würt., 1856, p. 209.

[2] This series was formerly described as a separate family in Bull. Mus. of Comp. Zoology, on account of the differences of the adults.

exaggerate these peculiarities. The geological succession does not strictly accord with the manner in which the organization of the species arranges them in the series.

Platypleuroceras brevispina occurs in the lowest bed of the Middle Lias, Jamesonibed, and *Cycloceras bipunctatus* and *Actæon* in the next, or Ibexbed; but *Cycloceras Masseanum*, instead of following these species, as would be naturally expected, is associated with *Platypleuroceras brevispina*. This discrepancy will probably be ultimately explained, but at present it must be quoted as an exception to the usual law of agreement between zoological rank as determined by development and geological succession in time. It is only fair, however, to state that the affinities of *Cycloceras Masseanum* were considered very doubtful before its geological position was ascertained.

PLATYPLEUROCERAS.

Platypleuroceras brevispina.

Amm. brevispina Sow., Min. Conch., vol. VI, p. 106, pl. 556.

Amm. natrix (rotundus et oblongus) Quenstedt, Die Ceph., p. 85, pl. 4, figs. 16, 17.

Platypleuroceras latæcosta Hyatt, Bull. Mus. Comp. Zoology, no. V, p. 92.

Cycloceras molare Hyatt, Bull. Mus. Comp. Zoology, no. V, p. 92.

In this species we find a more singular combination of the characteristics of *Microderoceras* and *Microceras*. The young are for a lengthened period, until, in fact, they are over two inches in diameter, very similar to *Microderoceras Birchii*. Then the pilæ begin to stretch across the abdomen, forming a whorl closely identical externally with that of the adult of *Microceras latæcosta*. The double line of tubercles is retained, however, much more persistently, and is usually more prominent than in the latter. The septa are very distinct at the same age in this species, the sutures being much more complicated, with more prominent cells and deeper lobes, and also as in *Microderoceras*, very deeply divided by three minor lobes. In the adult this contrast is not so great; the lobes and cells appear to spread considerably, and become more like those of the adult of *Microceras latæcosta*.

CYCLOCERAS.

Cycloceras natrix.

Amm. natrix Schlot. Petrefact.

Amm. natrix Ziet. Verst. Wurt., p. 5, pl. 4, fig. 5.

Cycloceras natrix Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 92.

The adult alone was observed, and only fragments of the whorl, but these showed two lines of tubercles, single pilæ not stretching across the abdomen, the latter region elevated and keeled. *Amm. natrix* Ziet., according to Oppel, is the same as *Amm. brevispina* Sow., but the figure of the former has a distinct keel, whereas the latter has none.

Cycloceras bipunctatus.

Amm. bipunctatus Roem., Ool. p. 193.

Amm. Valdani D'Orb., Terr. Jurass., Ceph., p. 255, pl. 71

Amm. compressus Quenstedt, Die Ceph., p. 90, pl. 5, fig. 3.

Amm. Valdani Quenstedt, der Jura., p. 131, pl. 16, figs. 2, 3.

Cycloceras Valdani Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 95.

Amm. bipunctatus Oppel, der Jura., p. 280.

The young of this species shows at an early age the keel and flattened whorl of the adult, thus showing no material difference either in development or adult characteristics from *Tropidoceras,* which genus is therefore suppressed.

Cycloceras Actæon.

Amm. Actæon D'Orb., Terr. Jurass., Ceph., p. 232, pl. 61, figs. 1–3.

Tropidoceras Actæon Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 93.

This species is very closely allied to *Cycloceras bipunctatum,* and I much doubt the propriety of separating the two. The material at my command, however, does not permit me to examine the younger stages of *Cycloceras Valdani,* with the requisite fullness and accuracy.

Cycloceras Ægæon.

Amm. Ægæon D'Orb., Terr. Jurass., Ceph., p. 234, pl. 61, figs. 4–6.

Tropidoceras Ægæon Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 93.

The progressive flattening of the sides and elevation of the abdomen reach a very advanced stage in this species.

Cycloceras Masseanum.

Amm. Masseanus D'Orb., Terr. Jurass., Ceph., p. 225, pl. 58.

Amm. Masseanus Quenstedt, Die Ceph., p. 90, pl. 5, fig. 2.

Tropidoceras Masseanum Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 93.

SERIES PERONOCERINÆ.

This series has a development which connects it genetically with the Liparoceratidæ, but the adults possess the characteristic pilæ and general aspect of the family of Dactyloidæ. They combine the characteristics of both the Dactyloidæ and Liparoceratidæ without, however, being in any sense, so far as I can judge, transition types. The adults have the Dactyloidan characteristics, but these appear to be only mimetic. All the species of this last family, which are the real ancestors of the Perisphinctes group through *Cœloceras Pettos*, never repeat any of the characteristic features of *Peronoceras* in the course of their development, nor, on the other hand, do the young of *Peronoceras* show any genetic connection with either the young or the adults of the Dactyloidæ.

This series consists of *Peronoceras acanthopsis* and *subarmatum*, all of the Upper Lias, and found in the Posedonomyenbed. The horizon of *acanthopsis* is doubtful, but as this species is generally considered identical, and may really be a variety of *subarmatum*, it is probable that it is associated with the latter in the Posedonomyenbed. The adult of *acanthopsis* is similar, as shown in the specific description, to the young of *subarmatum*, which resembles it in the flatness and breadth of the abdomen, divergency of the sides, etc.

The young of *Peronoceras subarmatum* has, before the period at which it resembles *acanthopsis*, smooth, cylindrical whorls, then a period in which the highly divergent, tuberculated, but partly smooth sides remind one of *Deroceras muticum*. The slow increase of the whorls during the smooth period reminds the observer at once of the young *Deroceras armatum*, and the subsequent resemblance to the adult of *Deroceras muticum*, together with the near affinity of the septal outlines, appears to settle the question of derivation.

PERONOCERAS.

Peronoceras acanthopsis.

Amm. acanthopsis D'Orb., Prod. d. Pal. Stratigraphique, p. 247.

Deroceras acanthopsis Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 94.

One specimen of this species agreeing precisely with D'Orbigny's description, was found in Bronn's collection, labelled "*subarmatus*." It differs from this species, however, exactly as D'Orbigny described. The abdomen is much broader, and the pilæ are much more numerous and closely crowded. They are gathered into knots at the spines from both the abdomen and the sides. At irregular intervals in the young a single pila will cross the abdomen between the spines, aud this seems to become constant in the full grown shell. Whether it is to be considered a lower form of the series than *Peronoceras subarmatum* cannot be definitely decided. The adult is similar to the young of that species, but the young in our single specimen is wanting, and it cannot be decided therefore whether it is an arrested development of *Peronoceras subarmatum*, or simply an undeveloped lower form. The precise geological horizon is uncertain, Oppel not mentioning the name at all.

Peronoceras subarmatum.

Amm. subarmatus Young & Bird, Geol. Yorkshire, p. 250, pl. 13, fig. 3.

Amm. subarmatus Sow, Min. Conch., vol. IV, p. 146, pl. 407.

Amm. fibulatus Sow., Min. Conch., vol. IV, p. 147, pl. 407, figs. 3, 4.

Peronoceras subarmatum Hyatt, Bull. Mus. Comp. Zoology, no. V, p. 85.

The separation of the two forms *fibulatus* and *subarmatus*, seems to me unnatural, though Oppel evidently considered them entirely distinct. His material was assuredly better than mine, but nevertheless I venture to think that in this case he erred. In the Museum collection there are nine specimens only, but nearly every specimen is distinct from every other, and if "*fibulatus*," or the flattened variety, is a distinct species, so are the others. The range also is here much less, both in form and characteristics, than between the variations of *Cœloceras Desplacei*. The young are either like *Peronoceras acanthopsis*, or they have exceedingly broad abdomens, divergent sides, pilæ similar, numerous whorls on account of the slow increase of the animal in thickness, or dorso-abdominally. The pilæ, however, are single in the young, and the tubercles do not gather them into knots though present at an early period. D'Orbigny quotes this species from the Middle Lias, but as shown, it occurs only in the Upper Lias.

DACTYLOIDÆ.

Cœloceras pettos appears to be the central form of this family; certainly its principal characteristics, the smooth, rotund abdomen, divergent and smooth sides, and single line of prominent lateral tubercles along the edge of the abdomen, are repeated in the young, or during life in all the species which I have examined. There appear to be several series, but owing to the manner in which they have been found, to a great degree mixed or confused in the same formation, it is not possible to pick out the series so clearly. The evidence afforded by the geological succession of the species is wanting, and the observation made upon the zoological affinities cannot therefore be verified and corrected.

The first series may be considered somewhat doubtful.

Cœloceras pettos occurs in the Jamesonibed of the Middle Lias, and in the next bed, or Ibexbed, is found the only representative of the first series, *Cœloceras centaurus.* This species is referred with much doubt to the same genus, on account of certain resemblances of the young. If this position is the natural one for the species, it exhibits a degraded condition of *Cœloceras pettos.* The second series consists of *Cœloceras Desplacei*, and the specimens described under the head of *Cœloceras a* and *Cœloceras b*, from the Middle and Upper Lias. This series is closely connected in some of its characteristics with *Peronoceras*, such as the flat abdomen, and divided and tuberculated lateral pilæ of the young. On the other hand the untuberculated rotundity and single continuous pilæ of some varieties of *Cœloceras Desplacei* and *Cœloceras a* and *b* in the adults, render it somewhat similar to *Dactylioceras.* The next series, beginning with *Cœloceras pettos*, and having in it *Cœloceras mucronatum* and *crassum*, has septa with a narrow abdominal lobe; the cells and lobes are remarkably simple, generally bifid, and rather small. *Cœloceras crassum* has the young like *Cœloceras pettos,* but the sides become gibbous, and in some varieties finally flattened and parallel. In the next species, *Cœloceras mucronatum*, these stages are repeated in the young, and as the shell nears the adult period the sides become not only flattened and parallel, but convergent.

The next series consist of *Dactylioceras commune, Holandrei, annulatum* and *Braunianum*, all of the Upper Lias, Posidonomyenbed. In the young of *Dactylioceras commune* we find a smooth, slowly increasing whorl, which resembles the young of *Peronoceras subarmatum* at the same period. A distinct resemblance to *Cœloceras pettos* may be shown in the young, and was traceable in well preserved specimens, but in others the tubercles were not apparent. The principal features are closely representative of the adult of *Cœloceras mucronatum*, especially of the narrow abdomen and tuberculated, but widely gaping pilæ of the abdomen. This is the pervading characteristic of the growth of the individual throughout the series, and is as strongly marked in the young of *Dactylioceras Braunianum* as in any of the other species. The adult whorls of *Dactylioceras commune* are rounded, those of *Holandrei* flattened on the sides; in *annulatum* with sides flattened and tendency of the abdomen to rise, or become somewhat subangular; in *Braunianum* all these changes are consummated in a very flat form of the whorls, and a subangular abdomen. The pilæ also cease to be divided on the abdomen in *Dactylioceras annulatum*; and in *Dactylioceras Braunianum* the abdominal area is smooth.

CŒLOCERAS.

Cœloceras pettos.

Amm. pettos Quenstedt, Flotz., p, 178.

Amm. pettos Quenstedt, der Jura, p. 135, pl. 16, fig. 14.

Amm. crenatus Zieten. Verst. Wurt., pl. 1, fig. 4.

Amm. Grenouillouxii D'Orb., Terr. Jurass., Ceph., pl. 96.

Cœloceras pettos Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 87.

Cœloceras Grenouillouxii Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 94.

In this species we find a remarkable form, flattened abdomino-dorsally; the sides very divergent, even in the adult, the abdomen rising with a gibbous curvature, and the involution reaching to the line of tubercles which ornament the outer edges of either side.

These may be either mere folds vanishing at a short distance from the tubercles, or well defined pilæ, passing almost entirely across the sides. There is as slight change made in the septa by growth as in the shell. At the earliest period examined, about the third whorl, the sutures had the full adult proportions. The abdominal and superior lateral lobes were of about the same height, the inferior laterals very small, but the top is on a level with that of the superior laterals. The superior lateral cells are much longer than the inferior lateral; the latter, however, are remarkably broad and low. Whether the extreme young had lobes and cells, and an external form like *Cœloceras centaurus*, I am not able to say, though they are similar to the adult of one variety of that species. The agreement of the name on several labels led me to quote *Grenouillouxii* independently, whereas it is evidently identical with *Cœloceras pettos.*

The specimens referred to, however, under this name, as quoted above in the synonymy, were not identical even with *Grenouillouxii*. They are from the upper Lias, and though very similar in many respects to *Cœloceras pettos*, really belong to *Cœloceras Desplacei*.

Cœloceras centaurus.

Amm. centaurus D'Orb., Terr. Jurass., Ceph., p. 266, pl. 76.

Cœloceras centaurus Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 87.

The rounded and exceedingly gibbous sides, fold-like, but very prominent pilæ, and dorso-abdominally compressed whorl are peculiar, and markedly characteristic. The sides are not so flattened and divergent as in *Cœloceras pettos*, but rounded between the pilæ, and in certain specimens this rounding is excessive, and even the pilæ themselves are rounded off in conformity with the sides, and hardly elevated above them. In other specimens we have a form which in the young is precisely similar to this species, and then the sides begin to assume a great similarity to *Cœloceras pettos*. Instead of the depressions being very deep between the pilæ and those less wide apart and prominent, as in the typical *Cœloceras centaurus*, the former are shallow, and the latter close together and depressed. The pilæ are also tuberculated, as in *Cœloceras pettos*, and the whole of the side begins to assume the flattened convergent aspect of that species. The whorl, however, is not so depressed abdomino-dorsally as in that species, and the young are rounded as in *Cœloceras centaurus*, whereas the young of *Cœloceras pettos*, except at much younger stages, retain the typical adult characteristics of their own species. The septa of the young, on about the third whorl, alone were examined. This species had a broader and deeper first auxiliary cell, the superior and inferior laterals were equally divided in *Cœloceras pettos*, and trifid, or unequally divided, in this species. The inferior lateral lobes are not so deep apparently as in *Cœloceras pettos*, and the minor lobes and the whole outline more immature also, than at the same age in *Cœloceras pettos*. Its geological position above this species in the Ibexbed, first attracted my attention to the fact that it could not be considered an ancestor of *Cœloceras pettos*. The long duration of the smooth period in the young, the aspect of the pilæ and general form of the young whorl are very like the young of *Coroniceras Bucklandi* of the Lower Lias. A comparison, however, shows that its septa are more like those of *pettos* and the abdomen never possesses a keel. All the evidence in our possession thus favors the opinion that *centaurus* is a more or less degraded descendant of *Cœloceras pettos* or of some common ancestor.

Cœloceras Desplacei.

Amm. Desplacei D'Orb., Terr. Jurass., Ceph., p. 334, pl. 107.

Cœloceras Desplacei Hyatt, Bull. Mus. Comp. Zoology, no. 5, p. 94.

The adults vary excessively, and the young also. They vary at all stages of growth, except the first few whorls which have sides invariably divergent. The sides may remain divergent with large spines, pilæ in knots, or may become flat or rounded, either with or without spines, or even flattened and convergent. Often without spines, the lateral pilæ single. The abdominal pilæ are always divided, but alternate with single pilæ, which cross the abdomen without interruption. Several specimens of this species, which were formerly referred in the Bulletin (No. v, p. 94) to *Cœloceras Grenouillouxii*, exhibit the characteristics of the young very fully. These are extremely broad, with very divergent sides. The spines are large tubercles, each uniting a couple of pilæ, or only perhaps thickening one. These occur sparsely, and between them are entire pilæ which may either split on the abdomen into two or three, which is the more common way, or run across unbroken. This is also characteristic of the adult. The youngest stages, however, with their almost smooth, highly divergent sides, and prominent tubercles on the edge of the abdomen gives very faithfully the prominent characteristics of the adult of *Cœloceras pettos*.

In other varieties of *Desplacei* not only are the adults devoid of tubercles on the cast, but this may extend to the extreme young. Generally speaking, however, at some time during the life of an individual, tubercles are present even on the casts. There may be some exceptions, but there are very few. When spines do not occur in the adults, as they do not, probably, on the shell itself sometimes, the sides are convergent, and they are conversely more prominent upon those shells which have divergent sides, like their own young, or the adult of *pettos*.

Cœloceras a.

This species is considerably smaller than *Cœloceras pettos*. The young are, however, very like the young of that species for a long period, then the sides become parallel and drop their tubercles, then convergent. The pilæ on the abdomen at this time cease to be divided, and sweep across the abdomen and sides as in the last variety of *Cœloceras Desplacei*. During this period, also, the whorl decreases in breadth, so as to become perceptibly narrower than the next inner volution. Two specimens were examined, one from Middle Lias, Milhaud Coll. De Konnick, the other from Plateau de Larzac, Upper Lias. The septa hardly differ from those of the adult of *Cœloceras pettos*. A specimen of *Cœloceras crassum*, having the same contracted outer whorl, seems to show that these may be merely dwarfed varieties of *Cœloceras Desplacei*; the septa also show that the diminished end is not a body chamber, but part of a true whorl.

Cœloceras b.

This species from Plateau de Larzac appears to be different from all other forms. The young for a variable, but rather long period, probably five or six whorls, have the prominent tubercles, slight, lateral and divided abdominal pilæ of *Cœloceras pettos*. The form, also, of the whorls during this time is like that of the adult of *pettos*. On about the sixth or seventh whorl the tubercles disappear, and the pilæ, instead of splitting invariably at the abdominal border, often dichotomize on the side, as in the advanced age of certain varieties of *Cœloceras Desplacei*. At the same time several may be observed intermingled with these, which pass entirely around the whorl without division. In the course of a quarter of a volution the transition is completed, and all the pilæ have this character.

Cœloceras crassum.

Amm. crassus Phil. Geol. York., p. 12, fig. 15.

Amm. raquinianus D'Orb., Terr. Jurass., p. 332, pl. 106.

This species increases the abdomino-dorsal diameter faster, and is therefore a larger and stouter shell than *Cœloceras pettos*. The pilæ also on the sides, though still single, and each one bearing a tubercle, are more distinctly marked. On the abdomen two or three unite at each tubercle, and the intermediate spaces are occupied by single pilæ, which, however, do not extend on to the sides. In the adult the sides become parallel. They are at first divergent, then gibbous, and finally flattened and parallel.

Cœloceras mucronatum.

Amm. mucronatus D'Orb., Terr. Jurass., Ceph., pl. 104.

Cœloceras mucronatum Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 95.

The young of this species is like the adult of *pettos*, then as it increases in size resembles with great exactitude the adult of *Cœloceras crassum*, and finally the sides become parallel and flat, and begin to exhibit their own specially characteristic convergence. Some individuals attain a diameter of one third of an inch before the sides become parallel.

DACTYLIOCERAS.

Dactylioceras commune.

Amm. communis Sow., Min. Conch., vol. v, p. 9, pl. 107, fig. 23.

Amm. annularis Zeit. Verst. Wurt., p. 14, pl. 10, fig. 10.

The adults of this species have a narrow abdomen and bifurcated pilæ similar to those of *Cœloceras mucronatum.* The pilæ are much closer set, and not tuberculated, and the sides and abdomen rounder. These same differences are very distinctly marked at a very early stage. The young are smooth, and resemble the adult of *pettos.* The lateral pilæ are single, and though tubercles are present in the young during the *pettos* stage, these disappear immediately. It is doubtful whether any of the adult pilæ are ever truly tuberculated. The young whorl is very broad in proportion to depth abdomino-dorsally, otherwise it closely resembles its own adult. The sides are not divergent but rounded, and the abdomen rising slightly. The increase is very slow to the adult, whose whorls are rounded and cylindrical.

Dactylioceras Holandrei.

Amm. Holandrei D'Orb., Terr. Jurass., Ceph., p. 330, pl. 105.

Dactylioceras Holandrei Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 95.

This species is so closely allied to *Dactylioceras commune* that I can see no grounds for their separation, except that both D'Orbigny and Oppel have considered them as distinct. The history of the development and all other characteristics are the same, except the flattening of the sides of the adult in *Dactylioceras Holandrei.*

Dactylioceras annulatum.

Amm. annulatus Sow., Min. Conch., vol. III, p. 41, pl. 223.

Amm. annulatus D'Orb., Terr. Jurass., Ceph., p. 265, pl. 76.

Dactylioceras annulatum Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 95.

In some specimens of this species the young appear to have been smooth and tuberculated, as in *Dactylioceras Holandrei*, but in others the reverse occurs. The young resemble more decidedly, in the single instance examined by me, the adult of *Cœloceras Desplacei* than anything else. The lateral pilæ were bifurcated and coarsely tuberculated, as in that species. It resembles *Desplacei* in the in crease of the single pilæ, which make their appearance between the bifurcated pilæ. The latter do in old age entirely give way to the bifurcated, and in some adults are very numerous. It should be mentioned that Oppel found spines on the umbilical whorl of Sowerby's original, and the Museum specimen described above has one or two fine spines on what is probably the eighth whorl.

Dactylioceras Braunianum.

Amm. Braunianus D'Orb., Terr. Jurass., Ceph., p. 327, pl. 104.

Dactylioceras Braunianum Hyatt, Bull. Mus. Comp. Zoology, no. v, p. 95.

The cast of this species is particularly interesting. At or just before the adult stage the cast does not receive any impression from the abdominal pilæ, and looks smooth, narrow and subangular. The pilæ are prominent laterally, and have very slight tubercles. That the pilæ are continued on the exterior of the abdomen until a much later period than this, is very probable. The young of this species has, after the smooth stage, a period with tuberculated pilæ, during which the shell closely resembles the adult of *Cœloceras crassum*, having the same form and crenulations. Subsequently we see a repetition of the rounded sides of *Dactylioceras commune*, and as these flatten and the abdomen narrows, the whorls resemble those of *Dactylioceras annulatum.*

Descriptions of New Species of Marine Mollusks from the Coast of Florida. By Robert E. C. Stearns.

Marginella (Glabella) opalina Stearns.

Shell ovate, solid; light to dark amber, some specimens showing obscure bands, more or less intense, of same color; subtransparent, smooth, polished; spire elevated, apex rounded; whorls four, suture distinct; aperture rather more than half the length of the shell; outer lip thickened, internally crenated, and strongly notched above; columella with four well developed plaits.

Largest specimen measured long. .21, lat. .1 inch;

Smallest do. do. long. .17, lat. .09 inch.

Habitat: Rocky Point, Tampa Bay, west coast of Florida, where several specimens were collected by Col. E. Jewett and myself; this beautiful little shell was found by us upon the under side of bunches of oyster shells, near low water mark. I know of no other species with which it might be confounded.

Marginella (Glabella) auroecincta Stearns.

Shell small, solid, ovate-conic; spire elevated, rounded at the apex; whorls, five, suture indistinct, being hidden by the enamel; aperture narrow, linear, about half the length of the shell; outer lip thickened, its internal edge moderately notched above and crenated below; surface smooth, polished, white, with two revolving amber-colored bands; columella with four prominent plications.

Measurement: long., .16, lat., .07 inch.

Habitat: Long Key, on the west coast of Florida, where I obtained the single (living) specimen described. An exceedingly beautiful shell, resembling in its general features, color excepted, my *G. opalina*, but less robust, with a more acute spire; the internal crenations of the outer lip less prominent; the columellar plaits less conspicuous, closer and more oblique. The color of the bands will quite likely be found to vary in different individuals; in my solitary specimen the bands are a light, clear amber, golden when seen through the intensified light of a magnifier, suggesting the gilded striping on French porcelain.

Drillia ostrearum Stearns.

Shell small, elongated, slender; spire elevated, sub-acute; whorls, seven or eight, concavely angulated above and moderately convex below; longitudinally sculptured with (16–20) rounded ribs, inconspicuous on the angle, most prominent upon the extreme convexity of the whorls, decreasing and becoming obsolete anteriorly; intersections of sculpture nodulous; suture marked with a thread-like, revolving rib; color, dingy yellow to purplish black; aperture ovate, narrow, about two-fifths the length of the shell; outer lip thin, with a rounded, shallow notch near the suture; columella nearly straight, canal short.

Measurement: long., .67, lat., .24 inch, largest specimen; long., .51, lat., .18 inch, smallest specimen; number of specimens, three.

Habitat: Pine Key, Tampa Bay, west coast of Florida, where I found them on bunches of oysters, in a shallow pool overflowed by the tides. The sculpture varies in prominence in different individuals.

Mangelia stellata Stearns.

Shell small, fusiform, turrited, yellowish tinged more or less with reddish brown; number of whorls seven, angulated above; suture distinct; sculptured with twelve to thirteen strong, smooth, longitudinal ribs, which extend to the extremity of the basal volution, which also shows near its termination a few revolving lines; intercostal spaces marked by fine incremental striæ; aperture narrow, rather oblique, less than half the length of the shell; labrum effuse, externally much thickened, and deeply notched near the suture; canal short; columella somewhat calloused and bent forward.

Measurement: length of largest specimen, .35 inch, lat., .14 inch.

Habitat: Tampa Bay, west coast of Florida, where I obtained specimens on the mainland at Rocky Point, and in a lagoon at Point Penallis, upon an oyster bar in lagoon at Pine Key, also on Long Key.

This well marked species varies in color from light buff to dark ferruginous brown; the mouth in most of the specimens is of the latter color. Viewed from above this simple shell has the form of a many short-pointed star.

Architectonica tricarinata Stearns.

Shell small, solid, trochiform, moderately elevated; whorls four, angulated, with three equidistant, prominent, revolving ribs on the periphery of the basal volution and two on the whorl above; suture distinct, sometimes marked with an inconspicuous, subnodose rib; aperture round, peritreme much thickened; umbilicus profound, strongly crenulated; color of shell white, more or less spotted and blotched with light red or dark umber; number of specimens, seven.

Measurement: The largest measures long., .12 inch, lat., .16 inch.

Habitat: Long Key and shores of mainland, Tampa Bay, west coast of Florida, where I found it (dead) on the beaches; it was also collected by Col. E. Jewett and Dr. Wm. Stimpson.

Specimens vary one from another in sculpture and color markings; in one specimen the sutural rib is of equal prominence with the other ribs, and in all the specimens the sutural rib is broken into slight nodules, which are, as well as the umbilical crenulations, regularly spotted with dark umber; other specimens show inconspicuous riblets on the external portion of the outer lip, which soon blend into the general surface of the shell.

Siphonaria naufragum Stearns.

Shell oval, depressed conic, with numerous fine radiating ribs of a whitish color, the interspaces of a reddish or chocolate brown; also marked by many fine and occasional, irregular, coarser, concentric striæ; edge of the shell internally finely crenulated; muscular impression distinct; siphonal groove shallow, inconspicuous; shell moderately convex in outline; apex recurved, subcentral, nearer the posterior margin; interior of shell enamelled, with same color marks as externally; number of specimens, twenty-five.

Measurements of largest and smallest as follows: long., .93 inch, lat., .71 inch, alt., .47 inch; long., .73 inch, lat., .54 inch, alt., .35 inch.

Habitat: Outer beach of Amelia Island, east coast of Florida, upon the timbers of an old wreck,[1] near low water mark; numerous specimens of this fine species were collected at the same time by my friends Col. E. Jewett and Dr. William Stimpson.

Carithidea turrita Stearns.

Shell small, elongately conic, rather delicate, purplish white to dark purple, with whitish revolving band on the middle of the whorls, inconspicuous except in the aperture; spire gradually tapering; whorls twelve, moderately convex, with sixteen to twenty prominent, smooth, equidistant, whitish longitudinal ribs, which terminate abruptly a little below the periphery of the last whorl, with a single narrow, revolving keel below; suture deeply grooved; anterior portion of body-whorl smooth or marked only by incremental lines; aperture rounded above, subquadrate below; outer lip effuse, externally thickened; labium anteriorly prolonged, angulated; in some specimens the peristome is continuous. Number of specimens (adult) about one hundred, varying in measurement from lon. .51, lat. .16 inch to lon. .33, lat. .11 inch.

Habitat: Point Penallis, Tampa Bay, west coast of Florida, where I found it abundant beneath a confervoid growth in a shallow lagoon, associated with *Cyrena Floridana*; also Mullet Key, Col. E. Jewett; Dr. Stimpson found specimens at other points on Tampa Bay.

C. turrita is much smaller than Say's species (*C. scalariformis*), which has a greater number of longitudinal and several revolving ribs; it is a more delicate and handsomer shell than *C. ambiguum* C. B. Ad., from Jamaica, which it somewhat resembles; it is smaller than *C. costata*, of Da Costa, from New Providence in the Bahamas, which latter is more finely and closely ribbed. All of the above species possess characteristics in common, which place them naturally in the same group, analagous to the West American group, of which *C. Montagnei* and *C. pulchrum* are representatives.

[1]See "Rambles in Florida," in Am. Naturalist, vol. III, p. 287.

The following donations were announced, two woodpecker's nests from Mr. Chas. Ruggles of Hardwick, Mass., to whom thanks of the Society were voted, and a finely mounted Snow Bunting from West Dedham, by Mr. C. E. Copeland.

The President appointed Messrs. John Cummings and R. C. Greenleaf, Drs. T. M. Brewer, S. L. Abbot, and B. Joy Jeffries, a committee to nominate a person to fill the offices of Secretary and Librarian.

Section of Entomology. January 24, 1872.

Mr. Fred. A. Clapp in the chair. Eleven persons present.

Dr. Hagen read a paper on the epidermic and hypodermic colors in insects.

Mr. F. G. Sanborn exhibited living specimens of *Boreus nivoriundus* Fitch, recently taken by him on the surface of the snow in the "Bussey Woods," West Roxbury. This species differs from *B. brumalis* Fitch in the reddish color of the legs and aborted wings, as well as in being slightly larger. It leaps on the snow a distance of four inches, but on a sheet of paper in a warm room cleared about eight inches at a spring. The female is uppermost during connection.

Dr. Hagen spoke of the parallelism between these and the two European species, which differ in size and color just as the American species do.

The following subjects were mentioned by the Secretary of the Section, as among the most desirable for investigation during the coming season: —

1. The insects living directly or indirectly on the "black-knot" (*Sphærium morbosum* Schwein) of the plum and wild cherry.

2. What species of Trochilium or its allies bore, in the larval state, the birch, willow and ash?

3. To rear from the egg or larva any of our common Lampyrides.

February 7, 1872.

The President in the chair. Thirty-two persons present.

The following paper was read:—

Description of the Whale (Balænoptera musculus) that came ashore in Boston Harbor, Nov. 25, 1871. By Thomas Dwight, Jr., M. D.

Although nothing specially new is to be learned from the gross appearances of this whale, yet they are worthy of note, for it is by the description of every specimen that can be examined that the obscurity may be removed which now confuses the classification of the Finners.

I first saw the carcass on November 27th, two days after it had drifted ashore dead, at Point Shirley, and I visited it on several subsequent occasions. Excepting in the tongue, which had the appearance of a green feather-bed, there was but little decomposition; the abdomen, however, was somewhat inflated, and in places the epidermis was beginning to peel off. It is never easy to measure a whale accurately, and as in this case I went alone and with only a short tape measure, many of the results are open to doubt. I was unable to take the girth at any point, and on account of the position of the animal some measurements were in part by estimate; they are, however, I think, pretty accurate. The length is the one concerning which I am most in doubt, but I believe that a straight line from the snout to the fork of the tail approached, but did not exceed, 65 feet. The expanse of the flukes was about 16 feet.

	ft.	*in.*
From the tip of the lower jaw to the front of the blow holes	10	10
To the insertion of the fore limb (partly by estimate)	18	
Breadth of skull between the eyes	6	6
From the notch in the tail to the dorsal fin	13	4
Base of dorsal fin	2	6
Height of dorsal fin	1	4

The individual was a female. The most striking feature was the proportionate length and slenderness of the tail and the great beauty of its lines.

The color was black on the upper side of the animal, and of the flukes and flippers; white below. The transition from one color to the other was rather gradual. The ventral folds extended from near the point of the lower jaw to within six feet five inches of the genital opening. The external surface of the folds was white and the clefts black between the outer and upper folds, but between the lowest of a pinkish hue, with occasional black blotches. Mr. Murie has called attention to the fact that one fluke of the tail is convex above and the other convex below, which Prof. Struthers (Journ. Anat. and Phys., Nov., 1871) believes to be due to the position in which the body may lie. I examined this specimen with regard to this point several times in the course of about three weeks, during which there had been great changes of temperature, though usually it was very cold, and I was unable ever to discover any difference in the form of the two flukes. The whalebone could not be well examined, but was white toward the end of the jaw, further back striped with black, and ultimately entirely black as far as could be seen.

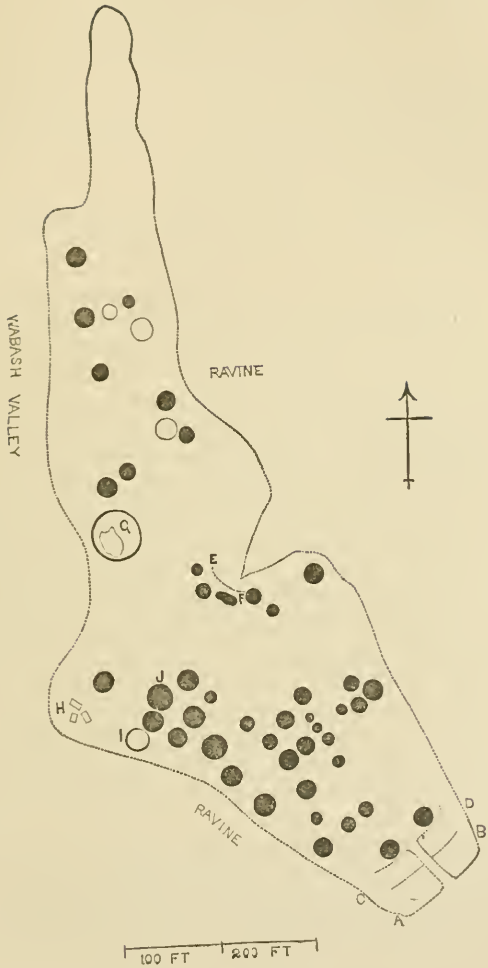
As compared with the specimen in the Museum of the Society, which for convenience I have, in my paper on it in the Memoirs, called the "Boston Whale," this one, though evidently of the same species, is much more slender; and this is not due alone to a less degree of distention, but to the fact that in proportion to the head the body was decidedly longer. The length of the Boston Whale in the flesh was 48 feet, and of the skull after dissection 12 feet—precisely one-quarter; but in this whale the skull after removal was less than 15 feet, as I am informed on good authority, which is less than one-fourth of 61 feet, which is the very least estimate (and I think is an under-estimate) that I ever made of the animal. These proportions are more in accordance with the measurements usually given than are those of the Boston Whale, and considering that the latter was in the adolescent stage, or at from two-thirds to three-quarters of its normal length, the question arises whether the increase of length after that age is not due chiefly to an elongation of the vertebral column?

The following paper was read: —

Mr. F. W. Putnam gave an account of a recent examination he had made of an ancient "fortification" on the Wabash River.

After the adjournment of the Indianapolis meeting of the American Association for the Advancement of Science in August last, it was his good fortune to be able to take advantage of the kind offer of Prof. Cox, State Geologist of Indiana, to make an examination of an ancient earth work at Merom, Sullivan Co., Ind., which had been christened "Fort Azatlan" by Mr. John Collett, Assistant of the Survey, and is so designated on the geological map of the County. Accompanied by Messrs. Cox, Collett, Cooke and Emerton, and provided with free passes over the Terre Haute and Indianapolis, and the Evansville and Crawfordsville Railroads, by the open-handed liberality of the officers of the roads, and cordially entertained and greatly assisted by T. Kearns, Esq., President Holmes, the Doctors Harper and other kind friends in Merom, he was able to make a partial examination of the earth work, of which the following engraving, prepared from a large plan made by Mr. J. H. Emerton, from plottings taken with the assistance of Messrs. Holmes and Collett, gives the outline and general character.

The "fort" is situated on a plateau of loess, about one hundred and seventy feet in height above low water, on the east bank of the river. On the river side, the bank, which principally consists of an outcrop of sandstone, is very steep, and forms the western line of the fortification, while deep ravines add to its strength on the other sides; the weak points being strengthened by earth works. The general course of the work is from the north, where it is very narrow (not over 50 feet) owing to the formation of the plateau, south along the river bank about 725 ft. to its widest portion (at *H*) which is here about 375 ft. east and west. From this point it follows a deep ravine southerly about 460 ft. to the entrance end of the fort. The bank traversed by the entrance road is here much wider than at other portions, and along its outer wall, running eastward, are the remains of what was evidently once a deep ditch. The outer wall (*A*, *B*) is about 30 ft. wide, and is now about 1 1-2 ft. high; a depressed portion of the bank, or walk way, then runs parallel with the outer wall, and the bank (*C*, *D*) is then continued for about 20 ft. further into the fort, but of slightly less height than the front. Through the centre of these banks there are the remains of a distinct roadway about 10 ft. in width.


WABASH VALLEY
RAVINE
G
E
F
J
H
I
RAVINE
D
B
C
A
100 FT
200 FT

From the northeastern corner of this wide wall the line continues northwesterly about 350 feet along the western ravine to a point where there is a spring, and the ravine makes an indenture of nearly 100 feet to the southwest. The mouth of the indenture is about 75 feet in width, and the work is here strengthened by a double embankment (*E*, *F*). The natural line of the work follows this indenture and then continues in about the same northerly course along the banks of the ravine, to the narrow portion of the plateau about 550 ft. to the starting point.

There is thus a continued line, in part natural and in part artificial, which, if measured in all its little ins and outs, would not be far from 2450 ft.

Besides the spring mentioned as in the indenture of the eastern ravine, there is another spring in the same ravine about 175 ft. to the north of the first, and a third in the southwestern ravine about 125 ft. to the west of the southwestern corner of the work.

Looking at all the natural advantages offered by this location it is the one spot of the region, for several miles along the river, that would be selected to-day for the erection of a fortification in the vicinity, with the addition of the possession of a small eminence to the north, which in these days of artillery would command this fort. Having this view in mind a careful examination was made of the eminence mentioned, to see if there had ever been an opposing or protective work there, but not the slightest indication of earth work fortification or of mounds of habitation was discovered, though some five or six miles up the river on the Illinois side, at Hutsonville, a large group of some fifty-nine mounds of habitation were investigated.

The interior of this fortification contains much of interest, and its history may yet be in part made out by a more extended examination than it was possible to make during the few days given to its exploration.

On crossing the outer wall a few low mounds are at once noticed, and all around are seen large circular depressions. At the southern portion of the fort these depressions, of which there are forty-five in all, are most numerous, thirty-seven of them being located south of a line drawn from *E*, on the northern side of the indenture of the eastern ravine, to the projecting extreme western point of the fort at *H*.

These depressions vary in width from ten to twenty-five or thirty feet and are irregularly arranged, as shown by the accompanying engraving, where they are represented by the black circles. One of the six depressions opposite the indenture of the eastern ravine is oval in shape, and is the only one that is not nearly circular, the others varying but a foot or two in their diameters.

Two of these depressions were dug into, and it was found that they were evidently once large pits that had gradually been filled by the hand of time with the accumulation of vegetable matter and soil which had been deposited by natural action alone. In some instances large trees are now growing in the pits, and their many roots make digging difficult. A trench was dug across one pit (J), throwing out the soil carefully until the former bottom of the pit was reached at a depth of about five feet. On this bottom ashes and burnt clay gave evidence of an ancient fire, and at a few feet on one side several pieces of pottery, a few bones of animals and one stone arrowhead were found. A spot had evidently been struck where food had been cooked and eaten, and though there was not time to open other pits there is no doubt but that they would tell a similar story, and the legitimate conclusion to be drawn from the facts is that these pits were the *houses* of the inhabitants or defenders of the fort, who were probably further protected from the elements and the arrows of assailants by a roof of logs and bark or boughs. The great number of the pits would show that they were for a definite and general purpose, and their irregular arrangement would indicate that they were not laid out with the sole idea of acting as places of defence, though those near the walls might answer as covers from which to fire on an opposing force beyond, and the six pits near the eastern indenture, in front of three of which there are traces of two small earth walls, and the two commanding the entrance of the fort, would strengthen this view of the use of those near the embankment.

In many of the ancient fortifications that have been described by Mr. Squier and others, pits have been noticed, but they have been only very few in number, and have been considered as places for the storage of food or water. The great number in this small earthwork, with the finding that one at least was used for the purpose of cooking and eating food, is evidence that they were for some other purpose here, though some of the smaller ones may have answered for storehouses.

The five small mounds were situated in various parts of the enclosure. The largest (G) was nearly fifty feet in diameter, and was probably originally not over ten feet in height. It had been very nearly dug away in places, but about one-fifth of the lower portion had not been disturbed. From this was exhumed one nearly perfect human skeleton, and parts of several others that had been left by former excavators. This mound also contained several bones of animals, principally of deer, bear, opossum and turtles; fragments of pottery, one arrowhead, a few flint chips, and a number of thick shells of unios, two of which had been bored near the hinge. From this mound a number of human bones have been taken by Dr. H. Frank Harper.

The second mound (*I*), which was partly opened, was some twenty-five feet in diameter and a few feet in height, though probably once much higher. In this a number of bones of deer and other animals were found, several pieces of pottery, a number of shells and a few human bones. The other three mounds, one of which is not over ten or twelve feet in diameter and situated the furthest to the north, were not examined internally.

The position of all the mounds within the enclosure, which are indicated by the white circles on the cut, is such as to suggest that they were used as observatories, and it may yet be questioned whether the human and other remains found in them were placed there by the occupants of the fort, or are to be considered under the head of *intrusive* burials by a later race. Perhaps a further study of the bones may settle the point. That two races have buried their dead within the enclosure is made probable by the finding of an entirely different class of burials at the extreme western point of the fortification, indicated on the engraving by the three quadrangular figures at *H*. At this point Dr. Harper, the year previous, had discovered three stone graves, in which he found portions of the skeletons of two adults and one child. These graves, the stones of one being still in place, were found to be made by placing thin slabs of stone on end, forming the sides and ends, the tops being covered by other slabs, making a rough stone coffin in which the bodies had been placed. There was no indication of any mound having been erected, and they were placed slightly on the slope of the bank. This kind of burial is so distinct from that of the burials in the mound, that it is possible that the acts may be referred to two distinct races who have occupied the territory successively, though they may prove to be of the same time, and simply indicate a special mode adopted for a distinctive purpose.

Mention has been made of a group of fifty-nine mounds a few


G
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100 FT
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miles up the river from Merom, on the Illinois side. The relative position and size of the mounds in this group is shown by the preceding cut from a plan made by Mr. Emerton, assisted by Mr. Collett. This group commences just beyond the river terrace, and widens out to the east and west, covering a distance of about one thousand feet from the mound, on the extreme east to that furthest west, and continues southward, back from the river, on the second, or prairie terrace, some fourteen or fifteen hundred feet. The greater number of the mounds forming the group are situated in the northern half of the territory covered, while only ten are to the south of this central line. The mounds are very irregularly dispersed over the territory included in the limits mentioned, and vary in size from fourteen to eighteen feet to forty-five or fifty in diameter, and are now from a foot and a half to five feet in height, though probably formerly much higher. Four of the mounds at the southern portion of the group were surrounded by a low ridge, now somewhat indistinct, but still in places about a foot in height. These ridges are composed of dirt, evidently scooped up from round the base of the mound, as between the ridge and the mound there is still a slight and even depression. The ridges about the two southernmost mounds (*O*, *P*) have openings nearly facing each other, while the one to the north of them (*M*) has the ridge broken on both the eastern and western sides, and the one still farther to the north (*L*) has the ridge entire.

In referring to this group of mounds I have called them mounds of habitation, and it seems as if that was most likely to have been their use. First, from the character of the surrounding country, which is level, and only some twenty-five or thirty feet above the present river, with every indication of a clear, damp soil in former times, though now the part not under cultivation is covered with a heavy growth of trees, several large trees even growing immediately on some of the mounds. What would be more natural to persons wishing to avail themselves of this terrace prairie, and proximity to the river, than to make a *mound* on which to erect their dwelling?

Secondly, their great variation in size and irregularity in position, would indicate that a number of persons had got together for some common purpose, and each family, working with a common view to provide for certain ends, had erected a mound, varying in size according to the number at work upon it, or the degree of industry with which its makers worked during the time at their disposal.

Thirdly, four of the mounds, marked *K*, *M*, *N* and *O* on the cut, were most carefully examined, to ascertain if they were places of burial, one of them (*K*) being opened by digging a trench through it some three or four feet in width, and to a depth of about one to two feet below the level of the surface on which the mound was built. The other three were opened from the top, by digging down in the centre until the original underlined surface was reached. None of these excavations brought a single bone, or an implement of any kind to light, but, on the contrary, showed that the mounds had been made of various materials at hand, and in one case ashes was found which had probably been scraped up with other material and thrown upon the heap.

Fourthly, the ridges surrounding four of the mounds may be the dirt thrown up to help support a palisade, or stake fence enclosing these particular mounds for some special purpose. The absence of human remains and all refuse in the shape of "kitchen heaps," as well as implements, would seem to indicate that the place was not inhabited for any great length of time, and that it may have been simply a place of resort at special seasons, or for some particular purpose. That the mounds are of quite ancient date there can be no question; but beyond the fact that at least a second growth of trees has taken place on some of them, we have no data for indicating their age.

Dr. Chas. Pickering remarked, in confirmation of Mr. Putnam's theory, that the Indians along the Sacramento live in similar pits, and also in huts erected on slight elevations, and use obsidian arrow-heads at the present day.

Mr. R. C. Greenleaf, in behalf of the Nominating Committee, appointed at the last meeting, reported as their nominee for the offices of Recording Secretary and Librarian, Mr. Edward Burgess.

February 21, 1872.

Prof. A. Hyatt in the chair. Thirty-three persons present.

The following paper was read: —

On the Glaciers of the Yosemite Valley. By Dr. Samuel Kneeland.

There have lately come into my possession some interesting, and I think, conclusive observations as to the former great extent of the glacier system of the Sierra Nevada Mountains, in the neighborhood of the Yosemite Valley. They seem to throw light upon the causes which formed the valley, or rather, by way of exclusion, upon the forces which did not form it. Before calling your attention to these observations, which have recently been made by Mr. John Muir, a gentleman who has made the region of Yosemite his study for years, and who records thus his personal examinations, it may be well to say a few words on the physical configuration of the region, that the force of his remarks may be better appreciated. The maps of the Geological Survey of the State will furnish all the explanation required.

In all this immense region, with a radius of fifteen miles at least, there are now no proper glaciers, though there are large accumulations of snow upon the higher crests and in their valleys, whose melting in the summer gives rise to the magnificent cataracts of the Yosemite Valley. The rocks, as every traveller there knows, are smoothed and polished to the very edge of the valley, showing the former existence of an immense sheet of ice. What ordinary travellers saw on a limited scale, Mr. Muir has examined on a very large scale, having traversed the upper Sierra in all directions, and ascertained the existence of a glacier system, frequently alluded to in the "Geology of California" published by the State, whose size and direction had previously been rather guessed at than determined. That there are no glaciers there, as in the Alps, and comparatively little snow remaining till summer, is accounted for by the rapid evaporation in the very dry air of these high ranges. Not only are grooved polishings found, but well marked moraines in the higher part of the range; but they do not exist to any great extent in the valley proper, though they are traced far down the three great cañons at the eastern end, the Tenaya, Merced or Nevada, and Illilouette or South cañons. There is a well marked median moraine from the union of the Nevada and Tenaya glaciers, on the north side of the Merced river, near the hotels — well rounded, and now overgrown with large trees. The markings indicate a former glacier extending from Mt. Dana and Mt. Lyell, 13,000 feet high, fifteen miles in length and more than a mile thick to the edge of the valley;

these marks are plain on the Sentinel Dome, 4,150 feet above the valley, and the Society have seen, and will soon be in possession of, a slab from Tenaya cañon polished by the ice, brought home by Mr. Waterston, which I have here. This glacier filled the upper or little Yosemite valley, a counterpart of the larger one, but 2,000 feet higher, communicating with it above the Nevada fall, the main stream of the Merced river flowing through both. Also, a glacier passed down the Illilouette cañon from the Obelisk group to the edge of the great valley. It has been generally assumed that the land at the head of the Merced river was not high enough for the formation of a glacier into the valley.

Now comes the question, which Mr. Muir proposes to discuss: Was the valley once occupied by a glacier?

The following are Mr. Muir's observations, almost in his own words, in a recent letter to Prof. Runkle:

"I have been over my glacial territory, and am surprised to find that it is so small and fragmentary. The work of ancient ice, which we proposed to christen 'glacial system of the Merced,' is only a few tiny topmost branches of one tree in a vast glacial forest. The Merced ice basin was bounded by the summits of the main range, and by the spurs which once reached to the summits, viz., the Hoffman and Obelisk ranges. In this basin not one island existed, for all of its highest peaks were overflowed by the ice, Mt. Starr King, South Dome, and all. Vast ice currents broke over into the Merced basin from the Tuolumne, and most of this Tuolumne ice had to cross the Tuolumne cañon.

"It is only the vastness of the glacial pathways of this region, that prevents their being seen and comprehended at once. A scholar might be puzzled with the English alphabet, if it were written large enough, and if each letter were made up of smaller ones.

"The beds of these vast ice-rivers are veiled with forests, and a network of small water channels. The sketch shows that Yosemite was completely overwhelmed with glaciers, and they did not come down gropingly to the main valley of the Merced by the narrow, angular, tortuous cañons of Tenaya, Nevada and Illilouette, but they flowed grandly and directly above all of its highest domes, like a steady stream, while their lower currents went mazing down in the crooked and dome-blocked channels of cañons.

"Glaciers have made every mountain form of this whole region; even the summit mountains are only fragments of their pre-glacial selves. The summits enclosing the basins of the glaciers are steeper on the north than on the south side, on account of the greater depth and duration of the ice sheltered from the sun; and this difference in steepness between the north and south sides of summits is greater in the lower, as those of the Obelisk group. Such mountains as Starr King, Cloud's Rest, Cathedral Peak, etc., do not come under this general law, as their contours were determined by the ice which flowed about and above them; but even among these inter-basin mountains we frequently find a marked difference in steepness between their north and south sides, because many of the higher of these, and crests extending east and west, continued to shelter and to nourish fragmentary small glaciers long after the disappearance of the main stream to which they belonged.

"In ascending any of the principal streams of this region, lakes in all stages of decay are found in great abundance, gradually becoming smaller and more recent until we reach the almost countless ones of the summits. Upon the main Merced and its branches there are not less than a hundred of these lakes, from a mile to a hundred yards in diameter, with many more of much smaller size. Both Yosemite and Hetch-Hetchy valleys are lake basins filled with sand, and the matter of moraines abundantly and rapidly supplied by their swift descending rivers from upper moraines.

"The mountains above Yosemite have scarcely been touched by any other denudation than that of ice; perhaps all of the post-glacial denudation of every kind would not average an inch in thickness for the whole region. I am surprised to find that water has had so little to do with mountain structure in this region. None of the upper Merced streams give record of floods greater than those of to-day. A cross section of the glacial and water basin of the Nevada branch of the Merced, a few miles above the little Yosemite, shows glacial striæ, clear and unwashed, with undisturbed glacial drift nearly to the water channel of the river, whose perpendicular walls are about two feet deep; this stream even in flood was never more than five feet in depth, showing a water area, as compared with the ice stream, utterly insignificant."

With the light of Mr. Muir's observations, it seems to me that the formation of this valley could not have been due to the action of water or of ice.

The characteristic feature of this valley is the concentric structure of the granite, as seen in the "Domes" and "Arches." According to

Prof. Whitney, who has given this region more study than any other geologist, this structure is not the result of the original stratification of the rock, and there are no evidences of anticlinal or synclinal axes; the curves, arranged strictly with reference to the surface of the masses of rock, show, in his opinion, that they were produced by the contraction of the material while cooling or solidifying, giving the impression that one sees the original shape of the surface. That the peculiar appearance of these dome-like structures, very general in this portion of the Sierra, is not the result of ice or water action, is shown by the overlapping of these concentric granite plates, overhanging the valley, and causing the enormous cavities or " Arches,' left by the fall of the masses from the action of the frost and the elements, at the present time high above the reach of ice or water.

According to Mr. Muir, as taken from his published and unpublished letters to newspapers and friends, there were in the Merced basin,— bounded by the ridge extending from Mt. Lyell northwesterly to the Cathedral Peak and to Mt. Hoffman; by a shorter parallel ridge eight or ten miles to the westward, running also northwesterly to Mt. Clark of the Obelisk group; and a connecting ridge running a little east of north to Mt. Lyell, this last being the divide between the tributaries of the Merced river on the north and the San Joaquin on the south, an area ten miles square on each side of the middle or Nevada cañon of the Yosemite valley — there were three great central glaciers, named respectively from the south northward: 1. The Nevada, coming down the cañon of that name, through the little or upper Yosemite valley, in which now flows the main stream of the Merced with the Nevada and the Vernal falls, flowing in a generally west direction from the Lyell group, and about twelve miles long. 2. The Tenaya, in the cañon of that name, coming down by Cloud's Rest and, leaving as its most beautiful traces the Tenaya and Mirror Lakes — flowing in a southwesterly direction from the Cathedral Peak and the neighboring summits; of about the same size at the Nevada glacier. 3. The Hoffman glacier, from the easterly slope of the mountain of that name, coming into the valley by Indian cañon, the North Dome, and the Glacier cañon. The marks left by these glaciers, miles in length and width, and thousands of feet in thickness, are now the polished surfaces, the smoothed domes, the extensive moraines, the beautiful lakes, and the green meadows — the striæ and grooves are mostly obliterated by the frosts and the rains and the streams of centuries, except in a few protected, small, and hardly accessible places.

The fourth great ice stream which flowed to the Yosemite valley, was the glacier which filled the basin of the Yosemite creek on the north side of the valley, from which now descends on the edge the beautiful Yosemite Fall, 2,600 feet high. This basin has been thoroughly examined by Mr. Muir, who estimates its glacier as having been fifteen miles long, five wide in the middle, and in many places 1000 feet deep — uniting with the central glacier in the valley by a mouth extending from the east side of El Capitan to Yosemite point, east of the Falls, a distance about four miles; on the north flowed by the great Tuolumne glacier from Mt. Dana and its range, the mightiest of these ice-rivers. It came from the western and southwestern slopes of Mt. Hoffman, and the main stream flowed nearly south; it had several branch basins among the higher spurs of this range, flowing to the east, now abounding in small clear lakes, set in the solid granite, without the usual terminal moraine dam. The north sides of these, and most of the spurs and ranges in this portion of the Sierra, as long since noticed by Prof. Whitney, are very steep compared with the southern, and as the spurs here mainly run east and west, their glaciers were deeper, more sheltered from the sun, and therefore longer lived than the main stream; the result is small glacier action, little detritus, and a quiet melting into clear lakes, with comparatively small borders of the meadows so characteristic of the disappearance of the lower glaciers. Though the declivity and rate of progress of some of the tributaries were great, the main stream, according to Mr. Muir, was rather level and in one part of its course compelled to make a considerable ascent; to this fact of levelness, width at mouth, and overwhelming power of the concentrated central glaciers, he attributes in great measure the present height of the Yosemite Falls. The main stream of the Merced river, flowing through a narrow and deep cañon, has in its course the thundering Nevada and Vernal falls; while the wide and gently sloping Yosemite basin conducts its stream almost noiselessly and with comparative smoothness till it makes its final and only feathery plunge of half a mile vertical descent into the valley.

Looking into the Yosemite glacier basin from any of its surrounding domes, you see many small patches of dark forests, apparently in close contact with bare rock, which mark the places of the fragmentary moraines of the basin, as later eroding agents have not had time to form a soil thick enough for the general growth seen in the valley itself. Wherever, says Mr. Muir, a deep tributary was laid against a narrow ridge, sheltered from the sun by surrounding rocks, there are invariably found one or more small terminal moraines; melted off from the main trunk, with an independent and longer duration, their moraines are left entire, because the water basins above them do not furnish streams large enough to wash them away, as is the case in the moraines of the cañons and deeper water courses. In the basins of exposed tributaries there are no terminal moraines, as their glaciers disappeared with the main stream. He says "Medial and lateral moraines are common upon all the outside slopes, some of them nearly perfect in form; but down in the main basin there is not left one unaltered moraine of any kind, immense floods having washed down and levelled them into border meadows for the present stream, and into sandy flower beds and fields for forests."

Between the three upper tributaries of the Yosemite basin glacier, he found well defined medial moraines, these having been preserved from levelling floods by their position on the higher slopes, with only small water collections behind them. Down at their junction, where they were swept round by the main stream, is a large level field of moraine matter, which, like all the drift fields of this basin, is covered with a dense forest, principally the *Pinus contorta* and *Picea amabilis*, the summit forests being composed almost entirely of this thickly-growing and pitch-covered pine. The domes of this upper basin present the same concentric structure and perpendicular cleavage already alluded to in the North and the Half-Dome of the Valley. Next west of the Yosemite basin, on the north side of the valley, is the Ribbon stream basin, in which now runs the stream flowing into the valley west of El Capitan by the Virgin's Tears fall, dried up so early in the summer that it is rarely seen by travellers. This basin Mr. Muir found was occupied by a glacier, flowing nearly south, about four miles long, and three wide, joining the central glacier, west of El Capitan. He spent two days in this basin, whose glacier was one of the smallest which entered the valley, the most of whose ice was derived from a south-west spur of the Hoffman group. The slope of its bed is steep and regular, and its ice must have moved with considerable velocity; exposed to the southern sun, it must have disappeared among the first, leaving a comparatively long period for the obliteration of the striated surfaces by the storms and the various disintegrating agencies of the weather ; as in the Yosemite basin, the unprotected rock is disintegrated four inches deep, and no ice marks could we expect to find except upon hard quartz, or under a protecting boulder. Though he has not yet found the glacial striæ, the fact of its existence is fully proved by the moraines, and meadows, and valley grooves, characteristic of glacial action here; its smooth and lake-like basin has fine forests of firs, (*Picea amabilis* and *P. grandis*) growing upon moraines leveled by overflowing waters.

Next west of this, on the north side, he explored the Cascade basin, and in it he soon found a large patch of the old glacier bed, polished and striated, with the direction of the flow clearly indicated as South 40° West. At the head of the Cascade meadows he discovered a well defined terminal moraine, and the ends of both ridges which formed the banks of the ice are broken and precipitous, indicating great pressure. Following up one of the tributaries some miles, he found throughout the entire length many polished surfaces, moraines, and striæ, giving as clear and unmistakable evidence of glacial action as can be found anywhere in the Alps.

Still farther to the west is the Tamarack basin, which had its glacier opening into the cañon of the Merced below the Yosemite valley, and still others for more than twenty miles west of the valley proper, which he intends to explore hereafter.

On the south side of the valley was also a glacier of immense extent and thickness, coming down from the Obelisk or Mt. Clark group, overtopping Mt. Starr King, the main stream flowing in a westerly and northerly direction—entering the valley of the Illilouette or South cañon, one of its great sheets scoring and polishing the Sentinel Dome and Glacier Point. Farther to the west, on the south side, was also the Pohono glacier, in the basin where now flows the stream of that name, pouring into the valley under the name of the "Bridal Veil" fall, nine hundred feet in height.

While the Sentinel Rock and the Cathedral Rocks on the south side were fashioned by glaciers, so the Washington Column, North Dome, and the Three Brothers mark the action of the ice stream on the north side; the depressions between these peaks being so many glacier grooves or valleys, modifications, doubtless, of previously existing cañons or gorges.

Judging from what has already been discovered, it is altogether probable that future investigation will demonstrate the former existence of an immense glacier in this portion of the Sierra Nevada, larger even than Mr. Muir supposes, extending quite to the foot hills of the range,—causing by its gradual decay and tremendous force the present configuration of the country, with its streams, fertile meadows, and forests,—covering the Mariposa region, and carrying in its detritus the auriferous sand, so profitably worked in the beds of its rivers — extending over the present valleys of the Merced and Tuolumne rivers, even into the plains of the San Joaquin river and the Stockton valley.

Mr. Muir's researches, have, I think, shown that all of the higher basins were filled with ice, with a sheet so deep and universal, that only a few of the highest crests of the Sierra were large enough to separate it into individual glaciers — many of the highest, and the great domes having been flowed over and polished and rounded, like the boulders in a river. The enormous thickness and weight of this universal glacier will explain the marks of pressure above alluded to in the Cascade glacier; this, with the glaciers filling the valley, was but an insignificant fragment of the great whole. Glaciers poured into the valley by all its deeply covered cañons, and the great depression of the valley, we now behold with wonder and admiration, was hardly more than a deep rut in the grand pathway of this magnificent ice stream, so high did its thickness rise above the walls of the valley. All the rocks, and mountains, and domes, and meadows of the upper Merced we can now readily believe received their peculiar forms and distribution through the agency of ice, and not of water; and that the domes and cañons and walls of the great valley itself have been fashioned by the same ice-action — the ice stream finding the valley previously existing, modifying, but not producing it, through the grand combination of its forces acting in a long continued, uniform direction upon granite of the peculiar concentric structure above alluded to.

Among the most characteristic proofs of the existence of former glaciers here, are the innumerable lakes and meadows of the Sierra. The glacier receives boulders, and transports sand and dust from its polishing of the surrounding rocks, and on retreating builds up a terminal moraine, which forms a dam for the waters which are derived from the melting ice, at the same time by its irresistible grinding hollowing out a lake basin more or less deep. Gradually retiring, and finding a long period of rest under protecting rocks, it forms another moraine and dam like the first, but higher up, scooping out another basin and forming another lake. If the glacier then formed disappears two lakes are thus formed, one above the other, as are frequently found; if there are more numerous periods of rest, there will be a chain of lakes in proportion to this number.

At first pure and filled with floating ice, in course of time the streams from the higher crests and the melting snows carry their detritus to these rock-rimmed lakes; then the lake becomes fringed with a border of yellowish and brown carex, or sedges, deriving their lowly sustenance chiefly from their water-absorbing leaves; then, as the soil increases in thickness, come other rush-like plants and mosses in the swampy edges, exactly defining the limits of the water; then the grasses, and the flowers, and the shrubs, and the forests, as the meadow becomes more solid and extended. In the spring of the year, these high meadows are flooded with water from the ridges on each side, and are at all times to be traversed cautiously by the traveller, a wandering from the path being attended with the danger of sinking inextricably into the springy and treacherous peat-like bog.

With these facts before us, it seems to me evident that the formation of the Yosemite Valley is not due to water. The erosive action of water, the tremendous power of which the Niagara gorge amply proves, is well seen in the Sierras, but not remarkably in this portion of it; its action does not produce such vertical walls as those of this valley, nor such perpendicular surfaces in granite as the sides of El Capitan, more than three thousand feet high, meeting each other almost at a right angle, and with faces turned down the valley in a direction opposite to that in which water must have acted. There is no source for water of depth sufficient to have filled this valley; and the Half Dome rises two thousand feet above the top of the valley, and the same above the action of water had it filled the whole valley — this is five miles in length, one-half to a mile wide, with very irregular sides, and a narrow outlet at its western extremity.

It should be remembered that the material to be worn by water here is granite, comparatively indestructible by agents which might readily wear away and undermine the shales and limestone at Niagara. The granite behind the Vernal fall is hardly at all worn by water, and even most of this possible erosion may be more reasonably attributed to ice. The insignificance of the water area compared to the ice area in the cañons here has been shown by Mr. Muir in the Nevada glacier basin, and the fact that floods have never risen, and do not now rise high enough to change perceptibly the proportion of these areas. Floods now arise from rains and melting snows in all probability as great as ever occurred from the melting of the glaciers, and yet their action upon the walls of the cañons and the contour of the valley is not perceptible. Such a flood occurred in the latter part of December of last year, 1871, as witnessed by Mr. Muir, and described in a letter from him, in which he writes that more than one hundred cataracts were then pouring into the valley, and forty in sight at one time, each one with more water than flows over the Nevada or Vernal fall in midsummer. We can not believe, therefore, that any causes now in action there, have had much to do with the formation of the cañons and the valley.

Has ice, then, made this valley?

After Mr. Muir's observations, there can be no doubt that ice once filled this valley, and overwhelmed it at least one thousand feet deep, making a total thickness, supposing the valley to have antedated the glacial period, of more than three thousand feet of ice. From the sketch as given by him, it will be seen that, while the upper layers of the ice stream moved with irresistible force and considerable velocity, as shown by the polishings and the inclination of the surfaces, the comparatively insignificant portion of the glacier in the valley, from the narrowness of the cañon of exit on the west, could not have moved much, but must have slowly wasted away, remaining long after the main glacier had disappeared, leaving a lake of gradually decreasing depth, and at last a wide valley, with the narrow and shallow Merced river in it, fed by the snows of the upper ridges.

Was the valley formed by ice? The Hetch-Hetchy valley, an almost exact counterpart of the Yosemite, but smaller, and about sixteen miles farther north, through which flows the Tuolumne river, as the Merced flows through the Yosemite, throws light on this question. The Tuolumne glacier, the largest in this region, flowed across this valley and across a cañon three thousand feet deep, on its way to join the great glacier of the Merced basin below Yosemite; the course of the former across the latter is shown by the grooving of the rocks, and yet the Hetch-Hetchy valley and its cañon above show groovings in their own axis, about east to west, the great glacier moving more nearly south-west. The united Tuolumne and Merced glaciers, below Yosemite, moved very nearly west, across the numerous angles of the crooked cañon of the Merced. These two valleys and their cañons, though half a mile deep, and each with their local glaciers, were so small in comparison to the great ice sheet, that this flowed over them without being influenced by them; the form of the valleys and cañon was doubtless modified by the ice, which, had it produced them, would have greatly multiplied them, and have made these singular depressions the rule and not the exception ; and moreover the valleys would have borne in size a closer relation and proportion to the immense force that was at work over them.

There seems no hypóthesis left except the one given by Prof. Whitney, in the Geology of California, a hypothesis which his and all subsequent investigations seem to me to strengthen, viz.: that during or after the upheaval of the Sierra, there was a subsidence, the bottom of these valleys sinking down to an unknown depth, the debris going to fill the abyss. During the glacial period they were filled with ice, which, gradually melting formed great lakes, imprisoned by moraines at the lower part; these have gradually been washed away by the floods, and scattered over the plains of the Merced, Tuolumne and San Joaquin meadows ; now only a small stream flowing along the bottom, which is slowly filling up, the small and comparatively undisturbed last terminal moraine extending across the valley about opposite El Capitan, the force of the diminished flood being enough to cut a passage for the Merced river without disturbing the glacial deposits above its highest level.

Evidence of tremendous volcanic agency is not wanting in this region. Some of the high peaks are found capped with lava; Mt. Dana, perhaps the highest, has its granite nucleus flanked with metamorphic slates. This agency is even now active, as is shown by the hot springs and geysers which abound, and by the many severe shocks of earthquakes near the coast, of the extent and severity of the last of which, a few years ago, not the half of the truth has ever reached the public.

The general absence of debris on the sides — the splitting of the Half Dome, with its perpendicular face of nearly half a mile above the edge of the valley and facing it — such immense vertical masses as El Capitan, can hardly be explaned by any theory except that of subsidence. This is an exceptional theory perhaps, but the phenomena are also exceptional.

Whether this subsidence may have taken place during the Champlain epoch, which succeeded the Glacial period, future investigations must determine ; in either case, the valley must have been filled with ice, and the subsidence would seem especially liable to occur, whether from volcanic disturbance alone, or assisted by an immense weight of overlying ice, from the concentric structure of the granite, which has been remarked by all observers throughout this region.

If the valley was not formed by water or ice, its width (on an average, half a mile,) the absolute non-correspondence of the two walls every allowance being made for subsequent erosion, and its depth, would prevent us from regarding it as a geological fissure; we can form no idea of a force which could separate these immense Sierra ranges to the distance of half a mile. Being east and west in direction, great and little Yosemite and Hetch-Hetchy, and transverse to the line of upheaval, they cannot be considered as the result of folding.

Prof. Runkle said, in company with Mr. John Muir he had studied the Yosemite Valley cursorily during the past summer, and that he thought Dr. Kneeland correctly explained the origin of the peculiar domes and half-domes.

After some discussion on this subject, the Society proceeded to ballot for a Recording Secretary and Librarian, which resulted in the election of Mr. Edward Burgess to those offices.

The gift of a large boulder of jasper and iron from the Mass. Institute of Technology was announced, for which the thanks of the Society were voted.

Section of Entomology. February 28, 1872.

Mr. C. S. Minot in the chair. Ten members present.

Mr. Gurdon Saltonstall was elected a member of the Section.

Mr. James Boll exhibited a beautifully prepared collection of insects taken by himself during the winter, including eight species of Diptera, a beetle from the Juniper, *Desmiphora tomentosa?*, several Lepidoptera, *Gracilaria*, *Lithocolletis*, *Gelechia*, *Holocera glanduella*, raised from acorns, *Erastria nigritula*, and other interesting insects.

Mr. B. P. Mann exhibited drawings illustrating the external anatomy of the thorax of *Telea polyphemus*.

The following paper was presented in substance Dec. 7, 1870,[1] but publication has unavoidably been postponed until the present time.

Hints Towards the Post-Tertiary History of New England, from Personal Study of the Rocks, with Strictures on Dana's "Geology of the New Haven Region." By John B. Perry.

A paper by Prof. Dana, on the Geology of the New Haven Region, with special reference to the origin of its topographical features, has recently made its appearance in the transactions of the Connecticut Academy of Arts and Sciences. It has also appeared in a separate form. This account, as coming from one of generally recognized ability as a geologist, is eminently deserving of notice. It has a special claim to attention, since it is a more than ordinarily detailed exposition of a single neighborhood, which the author has had unusually favorable opportunities for studying, during a long series of years, with great minuteness and care. So, again, it has peculiar interest, as indicating the waning prevalence of the "iceberg hypothesis," and as being itself an evidence of the advance already made in the recognition and adoption of the "glacial theory," so ably propounded and defended by Prof. Agassiz as a generalization from his studies of the glaciers of the Alps. It is likewise deserving of particular regard, since it gives in miniature, due allowance being made for local differences, what may be presumed to be the author's view of the glacier of the Connecticut, and, in fact, of what occurred in New England generally during the Post-Tertiary era.

It may not therefore be amiss to take up the paper furnished by Prof. Dana, and the matter of it as presented by him in connection with other phases of the subject, in order that a more thorough understanding of its import may be reached; that all the good there is

[1] See "Proceedings of the Boston Society of Natural History," vol. xiv., p. 62.

in it may be confirmed; that, if any points chance to be inadequately handled, they may be supplemented; and that, if possible, new aspects of the truth may be brought to light. Perhaps it will be specially worth while to examine with critical care some of the views set forth, that we may learn on what foundation they rest; to question given positions closely, in order to discover just what weight should be accorded to them; also to sift particular statements, both that we may know how much confidence they deserve, and the way be prepared for a better elucidation of many points not yet fairly unfolded. In this manner we may hope to secure greater accuracy, and to make some substantial advances in knowledge.

With the desire of gaining a more intimate acquaintance with the matters suggested, I accordingly enter upon an examination of this paper. In doing this it is proper to bear testimony to the evidences of scholarship and careful inquiry which it exhibits, and to commend many points as excellent and well put. With the aim of securing most benefit and of working to the greatest advantage, I propose in this examination to follow, with requisite modifications, the order of the paper, while some well-ascertained facts relating to other parts of New England will be given as occasion requires. This course being taken, new light is likely to be supplied from various sources to elucidate, temper and modify what is advanced by Prof. Dana, and thus by combination, perhaps more depth, breadth and clearness will be gained than would be otherwise possible. Having such an end in view, I proceed to notice

I. THE GLACIAL REGION.

This, so far as the paper under consideration deals prominently with topography, is New Haven and its environs. It is also by implication the whole of New England. The author aims to show "by special facts, and by the course of events, that the region [about New Haven] in the glacial era, like that of New England to the north, was moulded at surface largely by the action of the Connecticut Valley glacier and its underflowing streams, and covered, through the subsequent melting of the ice, with stratified and unstratified drift formations simultaneously."[1] In various passages of the paper the writer distinctly indicates that, in his opinion, all the northern portions of the continent were thus overspread by an immense sheet

[1] See title page of the pamphlet.

of ice. He also speaks of the "universal glacier." This expression, however, is in various ways so limited by him that it is clearly evident that he refers to a body of ice mantling nearly, if not quite, all the boreal part of North America, and not to such a view of the universality of glacial agency as has been propounded by Prof. Agassiz.

Such is, substantially, our author's estimate of the region which he supposes was shrouded in ice during the so-called glacial period. Whether so much surface was then covered by an icy garment, or whether, indeed, there were any glaciers in this neighborhood at that time, is another question which must be answered according to the testimony. While, however, some are still indisposed to believe that vast fields of ice were spread over this portion of the continent; while the view of an almost universal glaciation of the earth during the period in question has not as yet been widely adopted; while there is no time in this place to discuss the facts appealed to in its support, it is very interesting to observe the progress that has been made in the reception of what has been called the "glacial theory." Thirty years ago it had only just begun to be thought of, and when first suggested it seemed to many incredible; in some quarters it was scouted as wild and visionary. It, however, gradually gained ground; from time to time it was expanded and enlarged in its scope; by degrees its bearings came to be better seen, while it was so ably presented and vindicated that it is now widely recognized, and is gaining acceptance wholly, or in part, with the great majority of geologists. Meanwhile the iceberg theory, which years ago was almost universally adopted, is now held by far fewer than formerly, and in a very restricted sense even by such as will endeavor to sustain it.

Which of the two suggested solutions of the problem is right? whether both may not be wrong? or whether each have not somewhat of truth and somewhat of error? and if so, which is the better able to explain all the facts concerned? are queries which can only receive an adequate answer as the evidence comes before us. Meanwhile Prof. Dana's view of the matter is very explicit. Referring to the results effected during the glacial period, he says even on the title page of his pamphlet "that icebergs had no part in the matter, and the supposed iceberg sea over New England no existence." This language is decided, and shows conclusively, that, in respect to all this region, the author stands firmly and squarely on the glacier hypothesis. As to the validity or invalidity of his position, we shall be better prepared to judge when we look at the facts involved, and endeavor to put them to the test of a rigid examination. But before proceeding to an orderly exhibition and discussion of these facts we ought to glance for a moment at a few points relating to the earlier history of the region; in other words, we need cursorily to notice

II. THE PRE-GLACIAL TIMES.

These, as preparing the way for what was effected during the last days, receive, as they properly should, a few passing remarks from the author. The lowest rocks in the valley of the Connecticut belong to the two grand divisions known as the *Massive* and the *Foliated*, the former consisting for the most part of igneous masses, the latter of gneiss and the associated beds of crystalline schists. Above these are a few sedimentary layers, which are perhaps Devonian. They occur in the northern limits of the Massachusetts portion of the valley. A short way south of these beds may be seen the celebrated deposit known as the Connecticut River Sandstone, which extends thence southward to Long Island Sound.

"One of the last events of the Palæozoic ages," according to Professor Dana, "was the formation of the Connecticut River Valley, by the bending of the earth's crust."[1] That there was a very marked action at about the time specified, there seems to be abundant proof. It is perhaps equally plain, though the evidence be of a kind with which the author does not evince the same familiarity, that many preliminary steps had been taken in this direction long before the close of the Permian period. That each such step tended to "the bending of the earth's crust," and that in places it was actually bent, is no doubt true; but there appears to be equally good evidence that there was not merely a bending, or a series of plications, but that there were also a great many breaks — far more than some seem disposed to recognize or admit. Not a few valleys and chasms, which were once cited as decisive proof of the effect of simple aqueous agency, are now known to have had their inception in fractures and faults; these, of course, prepared the way for the subsequent action of water and ice, which with other associated instrumentalities performed their legitimate work of erosion. So it is not perfectly apparent that this valley was formed merely by bendings of the earth's crust. A close inspection of the position of the existing rocks, especially in east and west sections, clearly shows that

[1] Geology of the New Haven region, p. 46.

denudation has been a very prominent agency concerned in its formation. If any one doubt this, let him scrutinize the evidence which he will everywhere encounter, as he advances from Long Island Sound to the Connecticut Lake. Then, too, at times so late as the Permian or the Triassic, probably the older rocks, now forming considerable portions of the bottom of this valley, were generally to a considerable extent solidified; they were perhaps to such a degree hardened as not to bend readily, like plastic material, but rather, after somewhat of yielding, to break like a pipe-stem, or any other form of baked clay. It is not, moreover, so clear as the language used seems to imply, that the Palæozoic age witnessed "the formation of the Connecticut River Valley." While a beginning was certainly made in Palæozoic times, the greater part of the work was no doubt accomplished at a far later day.[1] Again, it is not so evident as the author seems to suppose, that the formation of this valley actually "took place as a sequel to, or in connection with, the crystallization of the granite, gneiss, crystalline schists, and other similar rocks, which make the bottom of the valley."[2] That the rocks referred to received their crystalline structure at so late a day is a point which, so far as appears, is simply assumed; a point, in confirmation of which I have thus far failed to find any adequate evidence; a point, therefore, which seems to need a thorough reinvestigation, and in respect to which I hope at some future time to offer a series of facts accompanied by germane suggestions, pointing in an entirely different direction.

According to Professor Dana, "the first fact of the succeeding age [comprising the Triassic, the Jurassic and the Cretaceous], of which there is record, is the existence of a Connecticut valley estuary, twenty miles or more wide, stretching from New Haven to northern Massachusetts, . . . and the commencing deposition in this estuary of the Red Sandstone formation. The production of this formation is believed to have taken the whole of the Triassic period, . .

[1] Since the above was written, Professor Agassiz, while in conversation on this point, said to me. "I have come to the same conclusion. The Connecticut valley is very recent, Post-Tertiary." On his return from a sojourn in the valley of the Connecticut and among the White Mountains, where he passed the last summer, he in substance added: I have now found evidence that geologists have scarcely begun to appreciate the work of denudation effected during the Glacial period.

[2] Paper cited, p. 46.

and also part of the next or Jurassic period."[1] Among other points here suggested, the question may be fairly asked, whether this estuary had not an earlier origin than supposed; whether it does not date back, if not to the beginning, at least to a portion of the Permian period; and thus, whether the lower sandstone — that, for instance, on the western border in the neighborhood of Greenfield — be not of Permian (or Dyassic) age, and not Triassic. It may be also asked, whether the next higher portion be Permian and Triassic, or Triassic and Lyassic, or simply Triassic; and finally, whether the uppermost beds be merely Triassic, or Triassic and Jurassic. These points, respecting which Professor Dana seems to have no doubt, for he calls all the beds Triassic and Jurassic, are beset with difficulties of no ordinary magnitude. They are accordingly brought forward with diffidence, and still with hope that new light will be speedily thrown upon them, such light as will place the matter beyond the possibility of mistake. Regarding them as by no means settled on a satisfactory basis, I have raised these questions as preliminary to a more searching investigation and adequate determination, which I hope soon to make, of the relative age or ages of the great sandstone deposits of the Connecticut valley.

III. THE POST-TERTIARY TIMES

Are now to receive, after these introductory considerations, more special notice. It is perhaps best to present them first of all in outline. As Professor Dana suggests, they may be conveniently divided, according to the indication of the rocks met with in New England, into subordinate periods. Beginning with the older, he designates his divisions as, (1) the Glacial epoch, (2) the Champlain, and (3) the Terrace or Recent. The term "epoch" as thus used to indicate a lapse of time, is, no doubt, open to objection. It is properly applicable, not so much to a period or an extension, as to a point of time — to the moment that marks a culmination or a crisis. Thus "epoch" refers to a point, "period" to a duration — that is, the *way* from one epoch or point, *round* to another point — of time. If it be joined to a word usually expressive of duration, it should simply mark it as a point, or *halting*-place, according to the original meaning of the word among kindred durations; as an acme, and

[1] Paper cited, p. 46.

thus as being for some such reason distinguished from, and superior to, other similar periods of time.

As to the nomenclature adopted by Professor Dana for the designation of the divisions of the Post-Tertiary, a few words may not be out of place. The first term, "Glacial," [1] to such as admit that the agency of ice was predominant during the period under consideration must seem comparatively free from objection. It being convenient, as well as characteristic, we may adopt it with advantage. The second, or "Champlain," is preoccupied, it having been employed by the New York geologists as descriptive of a series of formations lying along the border of Lake Champlain, at the time of its adoption generally supposed, and now well known for the most part to answer to the original Cambrian, or Lower Silurian of England and Wales. To the third term, "Terrace," some are likely to take exception, since the terraces are the result of several different processes, and really belong to successive stages of action. On the whole, however, it is a good name, and may be adopted with advantage. Meanwhile a careful study of the monuments of the time thus designated, and so of the agencies operative during its continuance, in portions of New England which were not subject at least to the action of the sea, and which are favorable to the discrimination of differences, has suggested several minor divisions, and the employment of the word in a sense more restricted than that implied in Mr. Dana's "Terrace epoch." The recognition of these smaller sections of geologic time is of moment, insomuch as they are calculated to show more distinctly the steps of progress characteristic of the period. Their recognition is also of importance, since, if they be investigated in detail, they are able to throw light on preceding periods, which, as more remote, cannot be, in most instances, studied in all their minutiæ to so great advantage.

The relation of this classification to that of Sir Charles Lyell, should receive a moment's notice, especially as the latter is familiarly known, and has been widely adopted, in this country. Mr. Lyell's divisions are, (1) Plistocene (= Newer Pliocene), (2) Post-Pliocene, and (3) Recent. His Plistocene includes the Drift or Glacial deposit, and the superimposed stratified beds; it thus answers exactly, or very nearly, to the Glacial and Champlain of Prof. Dana. Accordingly the last-named writer has only one period,

[1] This term as applied to the time in question, was first used by Professor Agassiz in 1840. See his paper, "On the Ice Period."

which he terms Terrace or Recent, to stand in correspondence with the Post-Pliocene and *Recent* of the English geologist. In case he used the word Recent in the Lyellian sense — this he does not seem to do exactly — he would ignore for the most part, if not altogether, the times designated by the term Post-Pliocene. And the question may be well raised, whether he does not give it less prominence than it deserves, — less importance than intrinsically belongs to it, not so much from its great length, as from the phases which it exhibits, and from the opportunity it furnishes for minute discriminations on account of its proximity to the present. The term Post-Pliocene is, at the same time, open to objection, (1) because a special limitation is needful, in order that it may not be understood to include the Recent, or *all that follows* the Pliocene; (2) from the inappositeness consequent upon the introduction of "Plistocene" for "Newer-Pliocene"; and (3) in view of the additional change suggested by the results of more recent investigations, that the Plistocene formations are really Post-Tertiary, and accordingly need to be more emphatically discriminated from the older Pliocene, or Pliocene proper, which are strictly Tertiary. I have dwelt thus at length on this matter, since a great deal of vagueness is observable in many writers on the Post-tertiary times.

In the light of what has been advanced there may be suggested, and as furnishing an outline for the remainder of this paper there is presented, the following classification of the Post-Tertiary formations. This is thought to be in essential harmony with the facts, while it preserves the substance of the Lyellian nomenclature. This system is followed, not in approval of Sir Charles's principles of classification, for these, as originally proposed, have lost their significance, but because his mode of designating the Cainozoic formations is more widely prevalent than any other, both in England and in this country. Reading from below upward, we have: —

3.	Autocene (or Recent)	Newer; Historic Period: — Forming Alluvium.
		Older; Prehistoric " — Ancient "
2.	Holocene	Newer; Peat Period: — Peat-beds, Mammoth, etc.
		Older; Marl " :—Marl-beds, fresh water shells.
1.	Plistocene	Newer; Terrace Period: — Modified Drift, stratified clays and sands.
		Older; Ice Period: — Typical Drift, unstratified.

Of the three general terms in the left hand column, two require an explanation. "Holocene" is proposed in conformity with the "Plistocene," etc., of Sir Charles Lyell, as descriptive of the times which he calls Post-Pliocene, during which all the Molluscan species were recent in the sense that they belong to the Post-Tertiary, though not necessarily in the sense that they all are now actually living. Probably a few of the Plistocene species of Mollusks are extinct. It is possible, as many have asserted, while, as others affirm, it is as yet by no means certain that some of the species are properly Tertiary in their character, they having simply survived the age of which they are more chiefly characteristic. The other term requiring explanation, "Autocene" is introduced into the table, in the place of "Recent" or "Present," merely for the sake of uniformity. Were it desirable to extend the nomenclature of Sir Charles Lyell, this term might be conveniently substituted for "Recent," *Autocene* meaning, as the etymology of the word suggests, *the emphatically new*, and thus appropriately designating the latest times. On the subordinate divisions a word may be necessary. The Plistocene consists of two stages closely akin, but very distinctive in their characteristic marks, the Ice or Glacial period, and the Terrace period. Of these terms, the latter, though not altogether appropriate as it has been ordinarily used, is inserted in the table for want of a better. It is perhaps also best to look at the Holocene as comprising two closely related sections of time: viz., (1) the Marl period, in the course of which there was a marked prevalence of ponds, in which the remains of fresh water Mollusks were deposited; and (2) the Peat period, during the continuance of which the growth and deposition of swamp mosses were characteristic processes. Until something more definite is made out, the Recent may be conveniently looked at under two subdivisions, viz., the Prehistoric and the Historic, just what ground the Ages of Stone, of Brass, and of Iron will eventually cover being as yet uncertain.

As these several subdivisions are to be now taken up in their chronologic order, I proceed to notice,

IV. THE PLISTOCENE TIMES.

New England is covered with a superficial, unconsolidated mass of matter, which is very characteristic. The lower part, which usually rests directly on the underlying solid rocks, consists of heterogeneous material in a disorderly state of accumulation, and spreads like a thick uneven blanket over the region, from the sea-shore far up the sides of the highest mountains. Overlying limited parts of this vast expanse of jumbled elements, for it is of far less extent, is another portion, which is composed of clays and sands, and is more or less stratified. It constitutes in the main the surface of the low plains, while it occurs very generally in the valleys, in some cases in those which are even high up among the mountains. The former is known as drift, drift proper, or typical drift; the latter is often called modified drift, and appears in many localities, especially along the principal streams, in the form of terraces. These two masses of material are regarded as characteristic of the Plistocene times, the divisions of which, with their distinctive deposits, may be considered separately.

1. *The Ice Period.*

This portion of the past may be called, according to the Lyellian terminology, the Older Plistocene period, and the inferior mass of matter which was just referred to as revealing its character, the Lower Plistocene deposit. This material, however, is conveniently, and perhaps just as fitly, designated Drift, and the time of its accumulation the Drift, the Glacial, or the Ice period, for during its progress, as is admitted on almost every hand, ice in some form or other was predominant; and, on its thawing, the deposit, now known as Drift, almost everywhere made its appearance. Although the latter word be usually associated with matter supposed to come from the wasting of icebergs, which once drifted along the ocean, or were drifted over its bottom, it may no doubt equally well refer to masses of material which glaciers have dragged, or drawn forward in their course. But, whatever be the term chosen for the designation of the times, ice in some shape or condition is generally supposed to have been largely prevalent during their continuance, and to have been their most marked and distinctive feature. In order to determine whether such were the case, in order also to a right understanding of the period, and of the work wrought during its progress, it is needful to secure at the outset a thorough familiarity with the facts. Let us accordingly pass a few of the more prominent particulars pertaining to the Glacial times, in rapid review, noticing as we advance some of Professor Dana's statements.

§ 1. *The Indications of Ice-Agency,*

Or the facts suggestive of the extensive presence of moving ice in New England, require an accurate enumeration in order to their critical and careful study. While the glacial hypothesis is admitted and defended by Professor Dana, he does not profess, as it was not needful for him, to give in his paper a formal presentation of the evidence respecting the point suggested. As the question whether this region were once subjected to the agency of ice, be it in the shape of icebergs, of glaciers, or in any other form, is one of importance, it will be well, perhaps, to cite several of the more weighty considerations supposed to point in that direction. These may be conveniently classed under three heads, accordingly as they pertain almost universally to the underlying solid rocks, or very generally to the superimposed loose material, or finally, to certain results which are only occasional in their appearance.

A. *Indications from Underlying Rock-Masses.*

(1.) The *erosion* of the subjacent rocks. This is clearly manifest from exposed surfaces which may be seen, here and there, all over New England. In some way or other vast amounts of matter have been certainly worn off, and removed from nearly, if not from quite all the earlier surface of the country. A slight examination shows that the work wrought by denudation has been immense. And this was of a peculiar kind, not from ordinary atmospheric influences, and not from flowing water; there was apparently a stupendous agency, as it were a huge machine, acting like a gouge, or working in a rasp-like way on the entire surface of the rocks. In connection with this agency lake-beds were evidently deepened, perhaps in some instances formed outright, their rocky shores in places lately laid bare affording marks, as of an immense plane, passing downward into their basins at an angle varying from a slight inclination to seventy or eighty degrees. So river-channels, at a comparatively recent day, have been as clearly made wider and deeper; in given localities they have been manifestly scooped out and broadened by this wondrous instrumentality; while the remaining vestiges of the operation evince, beyond reasonable question, that the result was not effected by water in its usual mode of working. All this is evident from the various indications found here and there on the rocks that form their sides, and the flanks of the valleys which they traverse. Pot-holes, which are generally supposed to have been eroded by torrential streams, likewise occur in peculiar positions and at various heights; they are found far up the sides and near the tops of mountains, along which, so far as one can now judge, no ordinary river ever flowed.

(2.) The *planation* of the subjacent rocks. Long-continued examination of the surface of the solid frame-work of the country, as it has been gradually uncovered by natural processes, or from time to time laid bare artificially, both in the State of New York and in each of the New England States, to say nothing of other parts of the country, clearly shows that such surfaces have been not only eroded, but also smoothed in a striking manner. The great extent to which this smoothing prevails over all newly-bared rocks, also suggests that probably the superficial area of almost the whole region has undergone a peculiar kind of planing. Indeed, rocks nearly everywhere, when freshly uncovered, disclose a characteristic sort of polishing. And they have been thus smoothed, not by the usual action of aerial agencies, and not by water in its accustomed modes of working. All this is manifest on the close inspection of these surfaces, especially when they are compared with those which have been subjected to various other influences. Nearly every ledge, if examined when the soil is just removed, is seen to have been worn down, smoothed and polished, as if with emery — polished in a manner seldom to be mistaken, particularly if concomitants be brought into account by such as have become familiar with the distinctive features of this planation. The reason that the surface of so many solid rocks fails to exhibit the results of this process, is found in the fact that continued exposure to the elements has led to their effacement. But even on the face of rocks long weathered, the practiced eye will often detect abundant traces of this peculiar character. No one, it is confidently believed, can attentively observe the evidence on this point, and not be amazed at its extent.

(3.) The *striation* of the subjacent rocks. This is likewise very evident. Almost every recently exposed surface of underlying rock reveals furrows, grooves and scratches of a distinctive kind. They have characters which seldom need to be mistaken, and which usually render their recognition easy. Ordinarily they are in straight lines, and those of the same series are, in the main, parallel, while such as belong to different sets are often seen to cross each other at greatly varying angles. These markings are also of a nature to indicate that they could not have been produced by the ordinary action of the elements. So the course of the striæ seems to be, for the most part, independent alike of mountains, hills and valleys — it extending, in many cases, either directly or obliquely over the most formidable obstacles. While apparently not a little diverse in some instances, these striæ are yet, on the whole, very uniform in their trend, and may be exhibited as occurring with comparative regularity. Though there be innumerable minor variations there are three main directions in which they run. The first, and this is the dominant direction, is north-south, or in New England from a point a little west of north, toward one at a like distance east of south. The second is east-west. Striæ with this trend lie for the most part in east-west valleys, on the western slopes of north-south ridges. The third main direction of these furrows is west-east. Such as take this course are usually found in west-east valleys, on the eastern sides of meridional ranges of hills and mountains. Of furrows, which have either of the latter directions, it may be said that they generally run pretty nearly at right-angles with the strike of the principal ridges, though they largely follow valleys and the inclinations of the surface. In addition to these three main bearings, there are various deviations of an intermediate character, many of the lines running more or less in a south-easterly, and a few in a more or less south-westerly direction.

B. *Indications from Overlying Matter.*

(1.) The *composition* of the superimposed material. The vast sheet of unstratified elements, known as Drift, which spreads over most of the older consolidated rocks of New England, is very heterogeneous in its character. The materials of which it is composed vary greatly in different localities. They are such as are, for the most part, known to occur in ledges situated at a greater or less distance from the places in which they are now found. Facts in great number seem to indicate generally that this is substantially a true statement in regard to drift. That it did not originate in the simple decomposition of the surface of the consolidated rocks which it now overlies, through the action of atmospheric, or of other kindred agencies, is clear from the circumstance that it usually contains many rocks and given elements which are entirely different from the subjacent consolidated masses. What, then, is the composition of the drift? It consists, first, of fine comminuted matter in the form of a paste. This is composed of sand or clay, and serves as a bed or matrix to hold a second material which is made up for the most part of fragments of rock of varying size. These, which are in some instances angular, are, in the majority of cases, polished or grooved, at least on one side; while in other instances they have several smoothed faces; occasionally they are also striated in two or more different directions, and in most portions of the aggregate mass of matter they are, to a considerable extent, rounded.

(2.) The *derivation* of the superimposed material. This is peculiar, and needs particular consideration. It is not enough to say that it came from a distance; in every case, a knowledge of its exact origin is desirable, since it is calculated to throw light on many related points. But while the derivation of the drift is peculiar, the facts about to be stated are almost as universal as is the occurrence of the mass itself. In New England it is plainly the fact, though there should be minor modifications of the statement, that this travelled matter was usually brought from localities lying in a direction a little to the west of north of the place in which it is found. This remark applies to the great bulk of the drift formation; smaller portions, which constitute occasional exceptions, are no doubt ordinarily due to local peculiarities, or to the action of agencies under limited relations. This mass of material was also clearly derived from rocks which lie for the most part only a short distance from the position in which it now occurs. Close examination of a great number of localities convinces me that the larger proportion of this matter has not been carried more than fifteen or twenty miles; other portions have been borne forty or fifty, and a few perhaps have travelled even several hundred miles. Such is largely the fact in the Eastern States, and, as I am convinced, in most hilly regions. In many of the western portions of the Union, so far as my observations have extended, and probably in level countries generally, a considerably larger proportion of this glacial material is from a greater distance, and some of it is very far-travelled. That this heterogeneous matter — reference is now made to drift proper — was not laid down in water under any ordinary circumstances, is clearly evident from the fact that it is not stratified, or in any wise arranged in layers.

(3.) The *condition* of the superimposed material. In this point, also, as in the one just noticed, the drift has peculiar features; and still the peculiarity about to be considered is little less general than the very existence of the glacial formation, wherever it has remained undisturbed. While it is never stratified it is almost universally in a confused jumble. In looking at it in its typical state one might readily imagine that a world of diverse elements had come into contact helter-skelter. Fragments of rock of various sizes lie indiscriminately blended in the pasty matrix of finely comminuted stone. There is no order discernible in this mixture of heterogeneous materials. In a word, its appearance is that of a mass of matter, not assorted by water, or laid down in successive sheets, but thrown together pell-mell, and allowed to remain in that seemingly anomalous condition. Such being the case, it constitutes a peculiar kind of formation, if this term can be applied to that which has no regularity of form, and it is never likely to be confounded with other deposits. That its shape is not due to any ordinary form of atmospheric agency, or to aqueous deposition, should accordingly be evident beyond a question. It may be added that it is usually in a comparatively loose state; in some places, however, it is found very compact; indeed, in rare instances, it is consolidated into firm rock.

C. *Indications from Incidental Phenomena.*

(1.) The *accumulation* of travelled matter. In some instances drift is met with in huge piles. Reference is made to the masses of jumbled heterogeneous material, ordinarily known as moraines. These are composed of rough, angular pieces of rock, varying in size from minute fragments to huge boulders weighing many tons. Moraines, as made up of such ungainly blocks and unpolished fragments, are very characteristic. Those described as terminal are, in given localities, of frequent occurrence. With them are usually associated other masses of unstratified matter, which seem to answer to lateral moraines. In places they are found in a good state of preservation. These terms are used, not as prejudging their mode of origin, but because they are perhaps more generally applied than any others to the masses of matter now in question. Closely related to these morainic heaps of earth, indeed appearing to owe their origin to substantially the same cause, are trains of boulders which have been variously named. They consist of long lines of travelled rocks, which are, to a great extent, parallel with each other. Of such boulder trains, perhaps among the most remarkable are those which occur in Huntington, Vermont, and in Richmond, Mass. How they could have assumed their existing attitude, unless in connection with the agency of ice, under some form of its working, it is difficult to conceive.

(2.) The *location* of perched rocks. These masses being likewise travelled material, and for the most part angular, are generally known as boulders or erratics. Strictly speaking, boulders are such as are rounded, while "erratic" properly applies to an angular block which is usually far travelled, reference being had to the fact that it was once a rover or wanderer, it having strayed from its parent ledge. While boulders and erratics occur in places all over the northern part of the continent, these travelled rocks are specially met with on the summits of high hills and of mountain peaks, and in some cases in extraordinary abundance. Because of the peculiar position in which they are often found they have come to be called "perched," perhaps for the reason that they may occasionally almost remind one of so many birds gone to roost. In given cases they are situated in such a way as to appear to have been thus placed only by the exercise of consideration and intelligent care,—as it were with plan and forethought. Some of them weighing many tons are almost exactly poised on the underlying rock, or upon a small boulder, so evenly balanced, in many instances, that they may be tilted with ease. Why these erratics should thus occur — not so much why they are poised, as why they should be found — perched in many cases in unusual numbers on the crests of solitary hills, at first sight seems very strange. It is thought, however, that by invoking the agency of ice, we discover a ready solution of the whole matter.

(3.) The *position* of ancient beaches. The remains of what have been called old sea-beaches occur at various points, and at considerable heights along the flanks of our New England mountains. Rolled material is met with at these places which, so far as can be judged, is just like that of our existing shores. It is in the form of sand, of rounded pebbles, and of stones evidently smoothed in substantially the same way as similar materials now found on the banks of streams and lakes, and along the sea-coast. That some of these are remnants of ancient beaches, that they are the surviving portions of old shore lines, is no longer doubted by the many competent observers who have examined them with care. The striking peculiarity of these old beaches is the great height at which, in several instances, they occur. Some of them are at elevations between two thousand and twenty-five or twenty-eight hundred feet above the ocean. Such is the case with those met with in Ripton, Vermont, and in Peru, Massachusetts. In many other localities deposits occur somewhat similar in appearance, which have been usually described as old sea-beaches. As some of these certainly owe their existence to an entirely different set of conditions, which will be mentioned in the sequel, they need not be cited even by name in this place.

The three-fold statement now made furnishes a brief, but comprehensive enumeration of many of the more important points connected with the glacial times; of some of the more striking appearances, indicative of what took place in New England at a comparatively recent day; of a few of the more prominent points that are, or may be, appealed to as proof that ice has done a mighty work in this region. They are phenomena, most of which are regarded as indications of ice-agency; and they all are invoked, in the way of evidence or of explanation, and on the one side or the other of the glacial hypothesis, in the broad sense of the expression. They are facts which stare us in the face whichever way we turn; facts which every enquirer must admit, however he may seek to account for them. and which no one thinks of denying: facts, many of which are regarded as unmistakable proof of ice-agency. In exactly what form the ice acted is another question, and one respecting which all are by no means agreed. Granting for the moment, and until the facts have received that more explicit elucidation which is suited to waken conviction, that ice was mainly concerned in the production of the effects under consideration, I would next raise the query whether it was in the form of icebergs, as many have tried to maintain, or in that of glaciers, as not a few are now disposed to insist. Taking up the iceberg hypothesis as a mode of explanation which has been widely recognized, and which many have believed to be the true one, I proceed to inquire whether one can really discover, under this phase of the subject,

§ 2. *The Causation of the Phenomena.*

The view now to be considered in relation to New England, is substantially the one which has been so ably advocated by Sir Charles Lyell, not only in respect to the British Isles, but as generally applicable to drift wherever it appears. This theory was accepted, illustrated, and defended with great labor and skill by the late President Hitchcock.[1] Indeed, many have adopted the Lyellian explanation,

[1] See his various "Geological Reports," and especially his "Illustrations of Surface Geology."

and some of them have presented it with not a little ingenuity and acumen. Prof. Dana, however it may have been in the past, now rejects the view outright, at least so far as its application to New England is concerned. And yet, in the paper under consideration, he advances one, and only one direct item of evidence against it, viz., that the boulders so often met with in New England are, for the most part, derived from rocks not far distant from the localities in which they are now found.[1] A few will be disposed to take this bare statement as deciding the question at issue. As no one, however, should be satisfied with a decision resting on the mere authority of names, as there is also a great conflict of opinion in regard to the explanation of the phenomena, it becomes important to examine the matter critically, that we may see whether icebergs be sufficient to account for the work wrought, in whole or in part, and whether it was actually effected by them or not.

The iceberg hypothesis implies (and if this be the explanation adopted most of the facts to be explained compel us to presume) that this region was some four or five thousand feet beneath the ocean during the whole or a major part of the ice period; that there was an arctic continent abounding in separate glaciers, or shrouded in a broad sheet of ice, from the southern limits of which huge blocks constantly broke off and floated away, in the form of bergs; that these passed over what is now New England, and did the work to which reference has been made, eroding, smoothing, striating the surface, covering it with debris, and producing the various other effects already named. Some, again, have supposed that the work in southern New England was largely wrought by icebergs derived from glaciers in the White Mountains. This last is the phase of the subject which Prof. Dana has more particularly noticed, and which he has, for the most part very well disposed of.[2] To the statements he has made it may be well to add, that so great a depression would have allowed small space in New England for the formation of glaciers. The summits of the White Mountains at the very best could have been only a cluster of islands, and thus must have failed to furnish the requisite conditions for the accumulation of any extensive ice-masses. So had there been such a submergence, testimony would have been borne to the fact by stratified marine deposits. There are, however, no beds of this kind in any portion of the drift proper,

[1] Paper cited, pp. 48, 49. [2] Paper cited, p. 49.

at least at a distance from the seaboard. Then the direction of the striæ in the greater part of New England is such as plainly to show that the White Mountains were not the centre of the main force exerted. There are also similar phenomena in the region lying further to the north, belonging to the great sheet of typical drift which spreads over the country, — phenomena which were evidently produced by substantially the same agency, and equally demand an explanation. We may accordingly dismiss the supposition of White Mountain glaciers as unequal to the task imposed upon it. We may likewise waive, for the moment, the further consideration of these local details, and look, not merely at a few isolated cases, but at all the main facts heretofore suggested as indicative of ice-agency.

If we admit that there was such a depression as the one supposed, it is easy for us to imagine that bergs of ice derived from a northern continent passed over the submerged region, and that they must have worn the face of the southern rocks in very many places. But while I am willing to grant all this, if there be sufficient evidence in its favor, I can hardly conceive that so much as is actually met with could have been accomplished in this way. It is certainly difficult to believe that icebergs, even under such conditions, would have ground over almost the entire area of what is now New England, between points of elevation some five thousand feet above the existing height of the ocean, and others lying considerably beneath its level at low tide — ground them all over, so far as one can see, substantially alike, irrespective of the manifold inequalities of the supposed sea bottom. Owing to varying depths, moreover, they could not have passed, by any known action of currents, from the valleys of the St. Lawrence and of Lake Champlain, obliquely across the Green Mountain Range, forming uniform sets of groves, and a continuous planing of the rock surface. Or, if we may conceive of their doing this much, we must admit, in order to it, a set of conditions more wonderful and difficult of explanation than the facts in question. Again, it is not probable that icebergs would have made, in connection with the north-south planation which evidently extended hundreds of miles, the east-west striæ, just where we find them in the valleys on the western sides of the meridional ridges, and the west-east striæ in like situation on the eastern slopes of the same ranges. They must have been equally unable to do much in connection with the wearing and deepening of lake basins; for, notwithstanding their power to erode in given cases, they could not readily have gained access to these basins for the accomplishment of such work, unless they gradually increased in size and thus sank deeper in the sea as they gradually advanced southward — a supposition which contradicts all we know of such bodies of ice. Indeed, to cite a single instance, unless the supposed subsidence at St. Johns, in Canada, were vastly greater than it was a few miles further south, icebergs could not have entered the Champlain Basin from the north so as to do the work, which ice or some kindred instrumentality has wrought at so low a level as the surface of the lake, to say nothing of the erosion of subjacent rocks. So river channels, particularly those extending easterly or westerly, could not have been formed by floating ice from the Arctic region under the conditions named. And of course the supposed depression and presence of icebergs is in no wise able to account for the existence of pot-holes on the summits or flanks of isolated hills and mountain peaks.

And the iceberg hypothesis seems to be no more tenable, when we examine the overlying deposit of drift. Of course the melting of such masses of ice must have been accompanied by the laying down of a considerable amount of detrital matter. This is evident to all. So, too, it is clear that this material would have been very heterogeneous in its composition. Indeed, had it come from an Arctic continent, the question at once arises, whether it must not have been, in a far greater degree, different from the consolidated rocks of New England, than is the case with the existing drift. We also see that bergs of northern ice would not have been able, if the supposition be true, to deposit the largest proportion of this detrital matter within a few miles of its origin — matter which was clearly ground from ledges lying only at a short distance to the north, or the north-west, of its present position. And it is by no means evident that this material would have been laid down in a jumble, as was clearly the case with typical drift. It should be ever remembered that the wasting of the icebergs must have been gradual — not sudden, as it were at a stroke, as seems to be implied in many of the current explanations. Accordingly, as the bergs slowly thawed, the particles of matter, and especially the vast amount of finely comminuted material, whether the masses of ice were stranded or in motion, could not have been readily left in a confused heap, wholly unstratified and without regularity of form. They must have been laid down, so far as one can now judge, with considerable uniformity and order, as they successively fell, particle by paritcle, into the sea, and were scattered far and wide over a broad surface both by waves and the flux and the reflux of the daily recurring tides. Under such circumstances the deposit should certainly have been very unlike that known as typical drift.

Again we find the case not essentially different, when we come to examine some of the incidental phenomena of the glacial period. Looking at the matter in the light just suggested, we at once see that icebergs are not sufficient to account for many peculiarities of the masses known as morainic. Let a berg of ice as grounded gradually melt — suppose it to waste away by slow degrees, as it naturally would — the result surely could not be a moraine, an osar, or anything of the kind. Were a mass of ice, as it moved along, to plough up the stratified material which lay in its way, while effects of the disturbance would appear, there would seldom, and perhaps never, be an entire obliteration of the marks of bedding; still less should we find the mass an indiscriminate blending of diverse elements, as in existing moraines. And it would be a rare incident — a most extraordinary marvel—for icebergs to produce a series of what are known as boulder trains. While one can readily conceive of the occurrence of a single line of erratics, he might rather expect in places to see the whole surface covered with travelled rocks. Meanwhile we should not look for three, four or five, much less for six or seven, parallel sets formed like those in Berkshire County, Mass., each being for the most part distinct, and characterized by rocks peculiar to the portions of the ledges lying at their respective sources, with the parallelism and distinctness preserved for five, ten and even fifteen and twenty miles. And it would be stranger still if icebergs actually chose just those heights for their resting-places, on which perched rocks are now found in greatest numbers, and if boulders, cargo after cargo, were so deposited as not to be removed by later bergs, or by the action of waves and tides, when these peaks came to be on the surface-level of a retiring ocean. As seen in this light the usual explanation of those remnants of old lines of shore, which have been often, if not generally, called ancient marine beaches, derives little probability from the supposed existence of an iceberg sea. In fact, the whole matter seems to be an outright assumption, so far as marine agency is concerned.

To take a single instance illustrative of the matter in question: up to this time no one has discovered any direct or satisfactory evidence that the famous Ripton Beach was either shaped, or ever for a moment washed, by the ocean. In case this beach were a long time in forming, and it is clear that it was,—and were it, during all this time, bathed by the sea, as seems to be claimed,—there must have been other marine deposits laid down in the neighborhood, and, in fact, in all those portions of the country which were then beneath the deep. Meanwhile we find no traces of any such deposit. On this point, indeed, there is room for an emphatic statement. As the advocates of the iceberg theory assume and imply that, during the glacial times, there was such a depression of the land that the sea laved the highest of the ancient beaches; in fact that it covered, as some would maintain, the most elevated places containing polished or striated drift surfaces, it may be remarked that the supposed submergence is only a guess; for no unquestioned relic of the ocean, and not an iota of positive evidence have been yet adduced in any wise showing that the country at large was at all submerged during the ice period. As no marine remains cotemporaneous with its deposition have been thus far found in the drift at a distance from the existing sea coast, the whole matter is seen to rest on a basis which is purely hypothetical, and not merely on this, which might be well enough, if there were no counter evidence, but on one which has in its way a host of objections, of which there is not time even for a brief enumeration.

If such be a true statement of facts, so far as it goes, and it is substantially what present knowledge warrants us in affirming, it must be evident that there is comparatively little, so far as is yet known, to recommend or authorize the adoption of the iceberg hypothesis, as it has been usually advocated. In this view of the matter it is not at all surprising that, in his last paper, Prof. Dana seems entirely to reject it, and that he advocates another explanation, which many regard as in essential harmony with the facts and comparatively free from objection.

§ 3. *The Glaciation of the Region.*

As some of the more important facts are now before us in outline, —as it has become evident that we cannot readily, or at all reasonably, account for the manifold phenomena by the supposed presence of ice in the form of bergs,—we are to look at the subject from another point of view; in other words, at the agency of ice, in the shape of vast masses, perhaps of almost continental extent. Because one explanation fails we are not necessarily to drop the matter, or even ice-agency, but may inquire whether ice seen under a different aspect, and in the light suggested by modern glaciers, can furnish an adequate explanation of the facts in question.

By the glaciation of the region we are to understand that it has undergone an experience in which ice played the most prominent part; that the country was once liberally iced over, ice being the predominant agency and the characteristic feature of the times; that for a while the whole land was covered by an immense sheet, a widely-extending expanse of ice of great thickness; and that in connection with the accumulation, the continuance and the wasting of this vast body of frozen water, it underwent all the processes necessary to the production of the manifold effects everywhere met with, and some of which have been enumerated as indicative of ice-agency. This is substantially the view which not a few now take of the matter, the view which has been presented and discussed with great ability by Prof. Agassiz,[1] to say nothing of later adherents, as Prof. Guyot, Prof. Forbes, Prof. Tyndall, and many other distinguished observers. Whether it will pass the ordeal of a searching examination is now the important question. If not able to render the facts clearly intelligible, consistent with each other, and with all that is known of related facts in nature, we must regard it as so far unsatisfactory and undeserving of confidence. In case, however, close examination shows that the presence of a vast body of ice would afford the vantage ground requisite to a clear and coherent understanding of all the main phenomena, we may conclude that there is presumptive evidence of the truth of the view, so long as nothing adverse comes to light.

How is it, then, with the glacier hypothesis—the hypothesis of a continental ice-sheet, a portion of which is supposed to have spread over this region? Does it meet the facts, and bring in such a flood of light as to render them comparatively easy of explanation; easy in the sense that there is nothing forced and unnatural about it? Can it help us to see them as the legitimate outflow of its agencies? Or

[1]Prof. Agassiz was the first, I believe, to apply the glacial theory to the drift phenomena not only of the British Isles, but also of this country. Remarks on the drift of Lake Superior, made before the American Association for the Advancement of Science in 1848, contain, so far as I am aware, the first published application of the view to this country—remarks which were more fully expanded in his work on *Lake Superior*, published in 1850.

is it in any respect inconsistent; inconsistent in itself considered; inconsistent with well-recognized principles generally; inconsistent with the little we know of the record in its details, as it lies spread out for inspection in New England? Simply because the iceberg theory appears untenable it does not follow that the glacier hypothesis is true. The fact that able men have adopted the latter view may be, indeed it is, in so far a presumption in its favor. But men of real ability have sometimes advocated indefensible positions. The matter, therefore, needs to be examined; it should be critically discussed in all its aspects; ventilated that, if it be true, it may be kept fresh, and made more widely prevalent in its influence; shaken up that we may see it in its more prominent and important bearings, and receive it or reject it, according to the clear indications furnished by a discussion of the facts in question. Every one who would master the subject should look at the evidence, and judge of it for himself, in the best and broadest light at his command.

But such an examination of facts and discussion of evidence cannot be completed in a moment. It is needful to go over the whole ground cursorily, and look at some of the more salient aspects of the subject from various points of view. As this is the explanation which Prof. Dana advocates,—which, indeed, he seems to recognize more broadly in the paper before us than in any of his previous writings,—it will be well to notice particularly how far he is in consonance or at discord with the glacier hypothesis as properly looked at, and with the facts requiring an interpretation. With a view to the fairest exhibition of his positions we may go on the supposition that they are true, putting them meanwhile to the test of what is found in the field, and thus passing in review some of the more prominent relations of the subject. With this aim we propose to take up the consideration of a position which he advocates, in his explanation of the supposed glaciation of the country, viz.,—

§ 4. *The Elevation of the Land.*

In order to account for the intense cold which apparently prevailed during the drift period, Sir Charles Lyell has conjectured that there was a variation in the level of the land-masses of the earth; he also adds that a great uplift in the boreal part of the Arctic hemisphere would have induced a marked change in the climate. This conjecture has naturally led to the supposition that there were high mountains during the glacial period in the northern portion of this continent, and that they were covered with an ice-sheet or abounded in glaciers. If we grant that glaciers or an extensive field of ice actually thus existed, the question whether there were also such an uplift becomes legitimate, and should be answered according to the evidence. Now, in his "Manual of Geology," Prof. Dana suggests what has been just pointed out as in part the view of Sir Charles Lyell, "that an elevation of the continent over its northern regions of a few thousand feet is sufficient to account for the existence of a *glacial epoch* in the earth's later history; and an elevation of five thousand feet is as probable as a subsidence of five thousand feet."[1] This supposition having been made, he seems tacitly to take for granted that there was such an elevation in reality, he assumes the thing as a matter of fact. Indeed, in the paper under consideration he says that during the glacial period "the land stood at a *higher* level than now."[2]

In respect to this supposition, a few remarks may be in place. The conjectured elevation referred to took place, as is presumed, at the close of the Tertiary era, and was maintained through most of the Glacial period, giving rise to a great increase of cold, and to the formation of vast fields of ice. Now these suppositions are in no way shown to answer to facts; and while it is not easy to establish their validity, it is no light task to overthrow them. Indeed, whether there were any such preparation for the change of climate that probably occurred cannot be readily proved or disproved, any more than many other guesses that might be thrown out at hazard. These and other cognate conjectures seem to have been made, because glaciers were assumed to be impossible without the existence of mountain heights. But grant, for the moment, that there was such an elevation as the one supposed, it by no means follows, it in fact appears hardly possible, that this condition alone would have induced a degree of cold sufficient for the production of all the phenomena of the glacial times. Meanwhile I have been unable to find a jot of substantial evidence in favor of the implied elevation. Admitting that it seems to help us in our explanation of given points, it remains for us to see whether these very points may not be equally well explained, without reference to this hypothesis. It is no doubt true in one aspect of the subject, that an uplifting of the continent to

[1] Manual of Geology, p. 544. [2] Paper cited, p. 48.

the height of five thousand feet might as readily occur as a depression of equal amount; but this does not relieve the matter in the least. The glacier hypothesis surely cannot stand on the ground simply that it is not less probable than the suppositions made by the advocates of the iceberg theory. If it be not far more credible, in a much greater degree consonant with the facts, let us drop the theory, and simply cling to what is capable of defence. So much for the present in respect to a continental elevation.

In regard to the New Haven region during the Glacial period, Prof. Dana observes: it "stood probably one or two hundred feet *above* the level of the sea."[1] After examining what he has to say, and all that I can find respecting the question whether the neighborhood of New Haven were then at a greater height than now, I am constrained to add that there appears to be little known evidence that is decisive in either direction. It is not easy to disprove the supposition that such may have been the case; no more can one always, at once and readily, rebut many conjectures that are merely vagaries. At the same time, the several facts which the Professor adduces as proof may be all, so far as yet appears, as satisfactorily, if not far more adequately explained in other ways. This being so, and with no positive evidence up to this time of an elevation, it seems to be wiser, while it is certainly the more sober course, not to suppose that there was really an uplift until we find in the rocks, our great "book of testimony," some distinct intimation of its occurrence.

But if there were no elevation of the continent how are we to explain the formation of fiords; the existence of sub-marine river channels, like those extending from the mouths of the Hudson and the Connecticut; or the fact of sub-aerial deposits, as mud-flats, now found beneath the level of the ocean? As to the supposed evidence in favor of elevation, furnished by these phenomena, a few words are necessary. In his "Manual of Geology," Prof. Dana, while speaking of the deep bays known as fiords, says, they "must have been excavated, like most other valleys, by the action of running water or ice, and this could have been done only when the country along the sea-border was so raised that they were occupied by streams and glaciers from the land, instead of the waters of the ocean."[2] Without entering upon a discussion of the questions involved in the origin and

[1] Geology of the New Haven Region, p. 48. [2] Manual of Geology, p. 543.

formation of valleys, I would simply observe that, while admitting the agencies referred to, I should be unwilling to omit others which are perhaps fully as important as those mentioned. Granting that many valleys had just such an origin as the author suggests, still the conclusion which he states by no means necessarily follows. Indeed, I have looked in vain for any stable ground on which to rest his "must." Suppose that the existing river-channels began to be scooped out by descending glaciers; the ice masses themselves, as we readily infer, might advance for miles beyond the present shores. Let these limited glaciers be finally lost in one immense sheet of ice, this moving seaward must, in displacing the waters on the shallow margins of the ocean, do its legitimate work of erosion. Thus the process of excavation, already begun, would still go on; all the shoals along the coast might be covered, the icy mass finding its limit only as it reached or encroached upon the deep. This being the case, we are enabled to see that old depressions would be deepened, while new valleys and broad fiords might be readily formed, as well as sub-marine river channels, where the shallow sea prevails to-day, even though the continent remained at substantially its present height.[1]

Or again, if we suppose with Prof. Dana, that the sub-marine river channels and fiords were excavated by the action of running water, the conclusion is by no means more necessary than on the other hypothesis. Whence came the immense ice-sheet that mantled the whole region? It seems to be forgotten that, in order to its formation, a vast amount of evaporation must take place; that this would be, not from the land alone, but largely, nay mainly, from the ocean; that it would necessarily make a large draft upon its resources; that, in consequence, its waters must have undergone a great depression, perhaps one of several hundred feet; that thus it may have been far lower than at the present day, possibly lower than at any preceding epoch since its introduction upon the face of the globe; that, accordingly, the continents were perhaps broadened out; and, finally, that the ice-sheet no doubt extended to a considerable distance over and beyond the shoals now occupied by

[1] Prof. Agassiz once remarked to me, "I have seen the polished and grooved surfaces of rocks in many fiords of Scotland as far below the present level of the ocean as the transparency of the water would allow; also along the shores of Lake Superior." I may add that I have observed similar instances on the coast of Maine, as well as on the rocky shores of Lake Champlain and Lake George, and at one point on Lake Huron.

the Atlantic.[1] Not positively asserting that such were the facts, I simply suggest them as points for consideration; points which readily occur when it is supposed that this region was once covered by an immense blanket of ice; points which indicate that what is regarded as necessary proof of elevation may be explained without resort to an extravagant assumption, of which there is not a shadow of direct evidence. It is scarcely needful to add that the submarine valleys of the Connecticut and of the Hudson — valleys which extend out under the sea from the existing mouths of these rivers — receive an easy explanation in the light of the views propounded. Also that mud-flats, during the depression of the ocean, would be very naturally laid down as sub-aerial deposits, at various points which are to-day beneath the level of the sea; and that thus the subject is readily relieved of the main difficulties with which Prof. Dana seems to find it invested.

There is, accordingly, little, if any, satisfactory proof of an elevation of the land during the glacial period. Meanwhile no one should infer, on this account, that there was no special preparation for a change of temperature, and that there was not an adequate cause for the more or less intense cold supposed to have prevailed during the Glacial times. On this point, indeed, we are very ignorant. There are, however, certain facts which have a bearing upon it. Having reference to these, though without being able, or intending to assign an exact value to their influence, I proceed to notice

§ 5. *The Preconditions of the Ice-sheet.*

Respecting the climate of the later Tertiary times, many conjectures have been made, while some important facts have been brought forward. Such quantities of snow as must have fallen in order to the formation and maintenance of a continental ice-sheet, imply the existence of not a little moisture in the atmosphere, a moisture which could not be readily produced in a vaporous form without a considerable degree of heat, accompanied by an immense amount of evaporation. Are there then any facts, or series of facts, suggestive of an adequate explanation of what is thus brought before us?

[1] It is certainly probable that the glacial mass reached as far as the most distant islands along our sea-board, since they bear the peculiar striæ ascribed to glaciers, as well as typical drift. Says Prof. Agassiz, "I have missed these marks nowhere upon the coast islands of New England."

We should, first of all, remember that in one view of the matter, what may be perhaps properly called an Æonian summer, — a great summer of the ages — was just drawing to its close. A previous warm season of the ages had long before passed its meridian, and, as its decline advanced, its mild evening was perhaps only the precursor of the long period of cold which was to follow. So the fact suggested by Prof. Agassiz,[1] that volcanic agency was very active during the last part of the Tertiary era — a fact which I can not stop to account for and explain in this paper — supplies an important consideration in this direction. Be the cause of this outbreak what it may, the effect upon the climate must have been considerable. Again, there is the supposition which astronomers have from time to made, that the sun is a variable body, liable to be much warmer at given periods than at others, from the falling into it of planetary masses: that at about the epoch in question there was a large addition of this kind to its fuel; and that there thus resulted a great increase in the degree of heat which it sent forth. While this supposition is not perhaps improbable, while it is indeed rather plausible, it is still only a conjecture, at best a guess, though possibly one of prime importance, which we as yet have no recognized means of either proving or disproving to our satisfaction. Admitting that such may have been the fact, I am indisposed to press it; meanwhile there is the point already mentioned to which the rocks themselves bear witness; volcanic agency was peculiarly intense in the times just preceding the glacial.

But this agency, and most of the facts thus far presented, are mainly indicative of warmth. The glaciation is not in this way accounted for. In order to the production of the immense masses of ice supposed to have existed, there must have been a far greater than ordinary degree of cold. The high temperature which had prevailed would naturally fall to some extent, with the diminution of the Plutonic agency which caused it. This, however, would be only the restoration, or a tendency toward the restoration of the equilibrium of the prevailing temperature of the earth. Far more cold than this was probably requisite to produce such results as followed; far more than any mere medium, or average of temperature, estimated according to the usually recognized data. And for so marked a change is there any adequate cause? A hint at this has

[1] In a Lowell Institute lecture.

been already given in the reference made to an Æonian summer. This requires an explanation no less than does the great winter which duly followed.

Now there are certain astronomical facts which seem to point in just this direction. These may be simple stated as facts, indicating the probability of great summers and winters of the ages, and thus leading us to look upon Glacial periods as a part of the regular course of nature. These facts, briefly stated, and they can be stated here only in the most general terms, are the following: —

1. Variation in the obliquity of the earth's axis to the plane of of the ecliptic. Such variations, there being a passage from one extreme to the other, and back again, are known to occur in given periods, though, so far as I am aware, their exact duration has not been determined.

2. Variation in the precession of the equinoxes, in connection with the advances of the perihelion. One of these has its revolution in about one hundred and eleven thousand years, while the other completes its circuit in some twenty-five thousand eight hundred years. Their rapidity being unequal, they so revolve, each in its legitimate course, as to coincide in periods of about twenty-one thousand years' length.

3. Variation in the eccentricity of the earth's orbit. It is now well ascertained that the orbit of the earth undergoes changes, that it passes from the figure of a considerably flattened ellipse to a form almost circular — in cycles, each of which consists in round numbers of two hundred and thirty-four thousand years, thus causing the earth to vary greatly, at different times, in its distance from the sun.

Let it be now remarked that each of the points just mentioned involves elements which occasion marked differences in the relation of the sun to the earth, and thus in the condition of the earth itself. Each one of them has been also referred to as sufficient to account for the cold of the Glacial period. No writer, however, so far as I am aware, has brought them altogether in a way to show just how and when, in the course of a large number of revolutions, the conditions in each favorable to extreme heat have *all* coincided, so those in each tending to the intensest cold have *all* coincided, in a manner to produce a great Æonian summer, followed after a long interval by its alternate Æonian winter. Such a combination, both of points already stated, and of others perhaps equally important, involves elements from which, when fully wrought out, conclusions may be drawn of no small moment, it is thought, to a right understanding of much pertaining to the Glacial period.

I am, of course, well aware that Mr. Croll, a distinguished English physicist, has enthusiastically adopted one and another of these and of kindred explanations in succession, and that, after holding his ground in favor of them for a while, he has with equal warmth rejected each of the suggested causes as insufficient to account for the facts requiring an explanation. And his rejection of any or of every one of them in succession as inadequate, when looked at in an isolated way, was no doubt in a certain sense justifiable; indeed, he was perhaps right in each particular instance; for probably no one of them by itself is able to produce the effects in question. But, while none of them is singly sufficient, the conclusion may be, and clearly must be, very different in respect to them all combined, and regarded somewhat in the way suggested. Would we arrive at the truth it should be our aim not to drop from the calculus any cause, however insufficient by itself, that can have the least bearing upon it, but to bring in all the elements so far as possible, and combine them in such a way as to approximate toward just the co-operative combinations which appear in nature.

It should be remembered that, owing to the many different elements which enter into the calculus, these periods to which reference has been made cannot usually consist of a definite number of centuries or millennia, but must vary from age to age. So, to the astronomic facts which have been briefly noticed, the exact relative importance of which is not yet fully and clearly made out, there should be added, in order to the better understanding of the Æonian winter, two conjectures. These are of an astronomic kind, have been heretofore hinted at, and tend to show that the great climatic periods of the ages are liable to various mutations. First may be mentioned the supposition that the sun is a variable heavenly body, and that thus after a time of new fuelling, and consequently of more than ordinarily intense ignition, there would naturally come a period during which less heat would be given off. Should such a state of the sun concur with the other conditions favorable to the greatest degree of cold, on the coincidence of the three astronomic elements already mentioned, the winter, as must be evident, would be unusually severe, and perhaps very long-continued—probably far more protracted than under ordinary circumstances. The second supposition implies that some portions of the celestial spaces have far less heat than others, and that the earth in traversing such tracts of space must be sensibly cooled. Should there be a concurrence of this condition with that of the three astronomic points heretofore noticed, as there surely would if the supposition be correct, or should one of them directly succeed the other, there would be another likelihood of an extremely severe and very long-continued Æonian winter. These several conditions of heat and cold, as may be additionally remarked, would often be such as in a large measure to neutralize one another. In such instances they might bring about a comparative uniformity, sometimes for a longer, sometimes for a shorter period. Without, therefore, resorting to a supposed elevation of the northern part of the continent, in order to prove the existence of the ice period, and of the phenomena peculiar to it, we may invoke certain astronomical *facts*, which in their combination were no doubt abundantly sufficient to produce this great winter of the ages.

The foregoing considerations, though very inadequately presented, have still been given at greater length than wonld have been thought necessary were there not in some quarters a disposition simply to bring in conjectures, to the entire exclusion of facts. It is not my wish to discard hypotheses; I would only have them in their true position; while facts should not be supplanted by mere fictions of the understanding. The several points mentioned have been dwelt upon at so much length, not because their exact importance has been fully established, but because they involve suggestions which, as followed out with sober discretion, promise to lead to more accurate and trustworthy results than have been thus far reached. Enough has been said to indicate that there are facts deserving careful consideration; that the way is open for their investigation, and for our gradually securing a broader and more intelligible view of the Glacial period; that we are not to single out any one element or series of elements, as affording an adequate solution of the manifold difficulties, but that we should learn to take all the factors in their proper connection; and that they all, or most of them, may have come at great intervals so to operate in a given direction, as not to counteract, but to favor, each the agency of the several others, and thus to produce a long, cold winter of the ages. Such, if I mistake not, are some of the antecedents of glaciation.

§ 6. *The Inception of the Ice-Sheet.*

There being some such kinds of preparation as those just mentioned—there being an abundant supply of moisture, followed by a steadily increasing cold—snows would fall in winter, and gradually waste less and less each succeeding summer. This process continuing as the warm season became shorter and more fitful, the cold would finally be largely in the ascendant. In connection with these several circumstances, there being alternate thawings and freezings, the snows on the elevations might become adhesive, and not waste away; we should expect them slowly to change to *névé*, and this in due time to glacial ice. Masses of congealed moisture could thus begin to form in regions lying far to the north, and by slow degrees in those situated more to the south. These would at first remain all summer long only on the higher grounds. They might occur on most of the elevations properly situated for such results. At the outset they would doubtless be local. Probably they might be found in all the more elevated basin-shaped valleys with narrow outlets, usually separated from each other, one or more proceeding from very favorable height. And these inceptive glaciers would be characterized, and have their behavior determined according to the nature of the surface, the local conditions of heat and cold, and the various modifications in the working of the agencies operative in their production. Accordingly the fact of intense igneous activity near the close of the Tertiary period — suggesting the occurrence of immense evaporation, and thus the source of abundant aqueous supply, results which were no doubt of long continuance — and the fact that a time of greater cold finally followed, probably occasioned by cosmical influences, afford sufficient occasion for the beginnings of an ice-sheet even in New England. Thus there may have been formed many ice-rivers, both far to the north, and more or less speedily in this neighborhood. These, at first, might be somewhat isolated in their character, and flow in various directions. Those from the White Mountains perhaps moved toward every point of the compass; such as originated in the north-south mountain ranges, would extend, some westward, others toward the east, down the existing valleys and lines of depressions. Of course in connection with these growing glaciers there must have been the various phenomena appropriate to the conditions. Associated with most of them would be those processes and results usually occurring in the masses of like dimensions, and existing under kindred relations. We should naturally look for the denudation of the surface of the underlying solid rocks, with their polishing and striation, all taking place at once, and in directions determined by the course of each glacier, in fact by that of its several different portions. Loose rocks might be taken up, debris gathered from the sides of the valleys, forming lateral lines of angular stones and half-comminuted matter, while some of these would unite in medial ridges on the occasional junction of two or more ice-streams. Resting on inclined surfaces, pressed onward by forces suited to secure motion, accelerated and retarded by the alternation of favorable and of adverse conditions, the mass under the action of cold would encroach all winter long upon the plains below, and during each recurring summer, as heat prevailed, it might, and no doubt usually did, retreat somewhat for a while, leaving where the ice melted terminal moraines, with lateral and medial, as witnesses of the advance of the preceding season. In case of a great increase in the intensity of the cold, the mass of ice must be augmented, the old markings planed off, new polishing effected, fresh inscriptions written, while the previous morainic masses would be wiped away by the advancing stream of ice, and thus few, if any, traces left of their former existence.

Such is a brief, and of course a very inadequate account of what was, perhaps, the beginning of the vast ice-sheet which eventually spread over all this region. While it is, indeed, only a rough outline, it possibly serves to call to mind substantially what we may suppose was the opening chapter in the history of the Glacial period. The inception of the work was the formation of a great number of limited glaciers of distinct ice-streams on the flanks of the mountain heights, in the northern half of the continent, and still later in all New England. This beginning was not, of course, exactly synchronous in its several different parts; the work travelled from the north southward; and when it was only fairly initiated in what is now our neighborhood, there was probably a far more advanced stage of progress in the northern portions of America. It is scarcely necessary to add, after what has been presented, that in the very nature of the case the records are extremely scanty. The whole account must be constructed largely on theoretical grounds; theoretical, not as entirely apart from a stable foundation, but in the sense that, having few immediate facts before us, we are compelled to rear the structure, not without facts, but in the light of such as stand, if I may so express it, in a secondary relation to the original occurrences, and so to the restored edifice, which is supposed to answer to them. While this involves disadvantages, while it renders the work of reconstruction more difficult, it is really no objection, in case the later materials on which we rely for evidence prove actually to be what the glacier-hypothesis implies they are. Thus this beginning of ice-streams perhaps properly constitutes the first stage of the Glacial period.

§ 7. *The Formation of the Ice-Sheet.*

Many local glaciers having come into existence in the manner supposed, it may be inferred that the way was at last prepared for the production of an immense field of ice. It is possible, if not probable, that there was little intermission in the formation of the ice-sheet. Snows falling in winter all over the northern regions, and gradually coming to melt less and less during the summers, there would be the first steps toward a broad blanket of ice, which would be thickest, of course, in the more elevated regions and mountain valleys. The cold continuing to grow more intense, the work already begun must constantly advance. Snows still forming to some extent, whether so rapidly as before or not, since the waste would steadily diminish, there would be in the aggregate a gradual increase in the quantity. The mass of *névé* receiving constant additions, we may presume that there was a perpetual augmentation of material, and that thus the several ice-sheets, or the thicker portions of a broad ice-sheet, experienced a proportionately rapid expansion and thickening. The many distinct glaciers (and there must have been what was substantially their their equivalent) having their respective sources far up in the mountain fastnesses), would accordingly extend further and further down the valleys, and by degrees inosculate with each other.

This process going on with little or no interruption, and there being less and less wasting of the ice masses, we may surmise that they were finally much prolonged. Thus they must have been thrust down into the plains in various directions to a great distance; from the White Mountains eastward, westward, southward, and perhaps northward; from the Green Mountains mainly toward the east and the west; and likewise from the Adirondacks, according to the nature of the region, and the various conditions which were there prevalent. Consequently the long valley now occupied by Lake Champlain and the Hudson River (for what are to-day regarded as two valleys were then virtually one, as well as the Valley of the Connecticut River, to say nothing of other north-south depressions, must have begun at last to receive the incoming ice-streams. These would enter somewhat from the glacial mass lying on the north, also from the east and from the west, as they slowly left the mountain heights. In this way, not to speak of all even by name, two greater glaciers were likely to be formed from these minor ice-streams, each advancing according to the main inclination of the surface, as favored by various attendant circumstances.

But this is not all. The time doubtless came, and it may have come much more speedily than has been implied, when these several great rivers of ice each ceased to have a separate existence. The processes already referred to still advancing, the ice-flow steadily making headway, the countless local east and west glaciers could remain no longer distinct. They doubtless lost themselves in, or came to be simply members and feeders of the various great ice streams that extended from the north southward, through the principal meridional valleys; and we may presume that they finally ceased to exhibit individual distinctness. The snows continuing to fall, the time must have arrived when all the before isolated streams of ice at last became connected. Thus they may have more and more lost their separate identity as the snows accumulated in the highlands, and the mass thickened over the plains until the whole region was covered, not by several isolated glaciers, as some seem to suppose, but by one immense sheet of ice, only interrupted here and there by a few outstanding mountain ridges. The agencies already mentioned continuing to operate in their legitimate way, the great winter of the ages having set in with all earnestness, finally every valley in the region, including the beds of the existing lakes, must have been filled, all the plains covered, and each height, save some of the topmost peaks of the White Mountains, shrouded in a continuous blanket of ice. Such being the case, there could no longer be a separate Connecticut River glacier, or a distinct one of the Hudson River, as Professor Dana appears to suppose; instead of these, and of the many more which possibly existed at an earlier day, there was doubtless a single immense ice-sheet spreading over the country. And the formation and continuance of this vast expanse of ice in such force, properly constitute, as it is thought, the second and grand stage of the Glacial period.

§ 8. *The Declination of the Ice-Sheet.*

In due time the height of cold must have been reached, and, after a long interval of equilibrium, succeeded by a slowly returning season of warmth. After a protracted succession of feeble oscillations, the heat element no doubt gradually came into the ascendant. The immense mass of ice began at last slowly, and by almost imperceptible degrees, to diminish; this state of things continuing, must finally have lost more by thawing than it gained by accretions. The melting, of course, was likely to be at first largely on the southern limits, and only gradually to advance northward, thus causing the sheet of ice slowly to retreat, until it finally disappeared entirely from New England. This retreat was no doubt by very slow degrees, for ice does not melt in a moment, even when the weather is hot, much less when it is comparatively cold; while there must have been additions each winter, tending in a measure to balance the perpetually recurring losses. The recession of the icy mass was also probably very far from uniform. No doubt the southern border was irregular or jagged, like the existing coast of the ocean. It likewise, perhaps, receded by occasional hitches, or slowly recurring strides, there being a succession of pauses, the measures of which were in all probability largely determined by the inequalities in the surface of the country.

Professor Dana seems to look at the matter somewhat differently. He says there was "an extended change of climate. . . . . The melting would therefore have gone forward over vast surfaces at once, wide in latitude as well as longitude, and not merely along a southern edge with slow creeping progress northward." That the melting must have occurred over a broad area, in fact, to some extent over the greater portion of the glacial field, is no doubt true. This statement, however, by no means annuls, or in any wise impairs, the probability that the wasting took place largely along a southern margin which was constantly varying, and from time to time perceptibly receding from the south. While there was almost uninterrupted melting, there were also constant repairs. Thus the ice-sheet, which was no doubt considerably thicker in its northern than in its southern portions, would, though it lost somewhat by thawing, continue to present an equal thickness for a long time, as it

[1] Paper cited, p. 67.

slowly advanced southward. And, as thus advancing, it would tend constantly to repair the wasting edge, bringing in a high and almost precipitous wall of ice to take the place of the melting parts, there would, therefore, doubtless be considerable abruptness on the southern limits of the ice-field, maintained in connection with the incessant strife between the wasting and the replacement of the mass along its slowly receding border.

The exact conditions under which this wasting occurred are not yet known with certainty. That there was a change of climate is generally admitted; but how it was brought about is a question which, though it has been often discussed, is still waiting for a satisfactory answer. According to Professor Dana, "there was a sinking of the land below its present level, resulting in a mild climate and the melting of the great glacier."[1] Patient and long-continued examination of the drift phenomena has failed to bring to light any evidence of such a subsidence, while it has wakened great doubt as to its occurrence. It is true that the mass of ice overspreading the country would tend to depress it, but such tendencies by no means result invariably in actual subsidence, or at least in subsidences great in amount. But aside from this one point, viz., the antecedent probability that the weight of ice would depress the region in whole or in part, I know of no evidence that there was any considerable submergence of New England during the closing, or indeed any part of the Glacial period.

That small portions of the country were *perhaps* slightly depressed during subsequent times is freely admitted; for there is evidence that parts of the region were at one time lower, relatively to the sea-level, than they are to-day. But they may have been a trifle lower at the beginning of the Post-Tertiary times, and thus there has been little if any subsequent depression; or the apparent change of level may have been, as it probably was, due to another cause, to be mentioned in the sequel. Meanwhile there seems to be no satisfactory proof that this subsidence, if there really was one, equalled 500 feet in any part of New England. But, granting that there was such a subsidence, and that it actually occurred, as Prof. Dana seems to think, during the glacial period, we are to remember that so far as can be yet shown, it did not extend far to the west, and so far as the evidence goes that it was very slight—in the New Haven region, accord-

[1] Paper cited, p. 48.

ing to our author,[1] only somewhere from 40 to 65 or 70 feet below its present level. Under these circumstances it is evident that the depression in question could have had, at the best, only a very limited effect on the climate. Such a submergence, or one even of 500 feet, must have left the ice mountain-high all over this region. Indeed, the ice would have continued to stand far above the sea, in case it were at its present level, and especially if the surface of the ocean had been considerably lowered by the immense loss of water caused by experienced in the formation of the ice sheet. But, even admitting that the land was slightly depressed, we do not get rid of all difficulty. It seems to be forgotten that a submergence, in order to be effective, either in changing the climate or in the wasting of ice, must be great. Submerged ice scarcely melts at all, unless it be in water having some ten or twelve times its own volume, and unless the surrounding temperature be comparatively high. Now these conditions must have been wanting, according to Prof. Dana's suppositions interpreted in the light of facts, so far as I can make them out. Indeed the ice-mass, in spite of the conjectured depression, must have continued broadly to spread over the continent, as it probably stood high above the ocean during the closing stage of the glacial times. Unless, therefore, there had been a change of climate from some other cause or causes, the ice, so far as we can now see, could not have wasted, but must have remained as it was—unthawed for ages.

Meanwhile, however, there is peculiar evidence of an astronomic kind which ought not to be overlooked. As the earth appears to have been, at what was perhaps the beginning of the glacial period, in a position relative to the sun and the planets favorable to a greater degree of cold, so, toward its close, it was in an attitude probably suited to induce a return of warmth, and with it to cause the long winter in due time to come to a close. Whatever theory is held in respect to this matter the facts none the less exist, if we may trust the calculations of astronomers; and to all appearances they are certainly very significant. But this point must be left with the simple query whether it does not deserve a far closer investigation than it has yet received from either the astronomer or the geologist. Such a change of climate accordingly occurring, whatever may have been the cause, a time of waste was sure to follow. The main sheet of ice

[1] Paper cited, pp. 48, 66.

must slowly melt, until at last there would be left only local ice-streams, and these for the most part in the more elevated portions of the country. This process gradually going on, the long winter slowly retiring to more boreal regions, and its accompaniments disappearing at about the same rate, though with protracted pauses followed by sudden starts, finally even the minor valleys of New England lying high up on the flanks of the mountains would come to be free from ice. And it is this wasting of the ice which, as it occupied the closing part, constitutes the third stage of the glacial period.

§ 9. *The Extension of the Ice-Sheet,*

Both superficial and vertical, is a matter as yet by no means fully settled. While not a little has been said and written upon this point—much perhaps that has been to no good purpose,—a great deal remains to be done in the way of careful observation of facts, of accurate estimates and critical deductions. There is meanwhile constantly accumulating evidence that the ice was probably of much greater extent than most observers even conjectured, only a few years ago. That some such agency as the glacial has wrought on the surface of all New England, a few isolated summits of the White Mountains alone excepted, now seems to be clear beyond a doubt to those who advocate the glacier hypothesis. Prof. Dana indicates that the entire continent north of about the 40° of latitude must have been affected by it during some portion of the drift period. As to whether it extended further southward, New England, so far as we yet know, furnishes no evidence except that implied in the estimated thickness of the ice-sheet. Had it been in great force in the southern portion of the Eastern States, or say in the vicinity of New York city, the probability is that it must not only have stretched along the Alleghanies, but also spread widely over the country on both sides of the range, and far to the south, even in the Mississippi Valley.

As to its actual thickness in New England there is, up to this time, considerable uncertainty. Granting that the work done in this region was effected by glacial agency, we cannot doubt that the mass of ice covered almost the entire surface; but very different estimates have been made as to its vertical extent. Supposed traces of glacial action may be now seen on the White Mountains, at points some 5,500 feet above the existing level of the ocean. Indeed, up to that height it is evident that nearly the whole surface has been smoothed and more or less striated. Rising superior to this line of elevation there was no doubt a considerable mass of solid ice, and above this perhaps, as many infer, somewhat of *névé* and of unconsolidated snow. Some are of the opinion, and for this view there appear to be plausible reasons, that the surface of the great ice-sheet was much higher than the present summits of the White Mountains. The upper portion of the ice, even the last 2000 or 3000 feet, would be far less effective in wearing off and smoothing down an underlying rock surface than parts overlaid by a greater superincumbent mass. Be this, however, as it may, the least supposed thickness is comparatively great. If now we assume the ice-sheet to have been, as Mr. Dana does, comparatively level on its upper surface, we are compelled to admit that it not only covered all the rest of New England, but that it also actually lay above what are now the highest summits of the Green Mountains which have glacial furrows, in a mass more than a thousand feet in thickness. It is not improbable, however, that the surface of the ice-sheet was somewhat lower to the south and to the south-east of the White Mountains than it was all along their flanks, and along the most elevated line of the Green Mountain range.

On the other hand, it seems probable that the height of the ice-sheet was very much greater still further to the north and to the north-west. So far as I am aware, every known fact points in this direction. It would not perhaps surprise one to learn we may hereafter discover decisive proof that there were many inequalities in the surface of the ice, and that between such elevations as the White Hills of New Hampshire and those of the Adirondacks there may have been slight, if not considerable, depressions. While these points are by no means certain, there seems to be good reason for supposing that the thickness of the ice-mass was immense. The agency that was at work certainly has left traces in New England little less than 6000 feet above the present level of the sea; and, in places lying further to the north, it may have reached, as some have inferred that it actually reached, even if it did not exceed, the height of eight or ten thousand feet.

§ 10. *The Motion of the Ice-Sheet.*

If such a mass of ice as has been supposed actually existed it, of course, moved; not necessarily under the exact conditions, and with just the rapidity, of a glacier of to-day; still it moved. And while its presumed motion suggests many difficult points—some which cannot be readily explained—it involves others which are clear beyond a doubt. It should be distinctly remembered that the prevalent conditions of the glacial period were on a far grander scale than those connected with modern ice-streams, and in some respects very different from them. For such differences due allowances ought always to be made.

Now glaciers have been compared with rivers: and, though there are important differences, there are also many points of similarity between an ice-stream and flowing water, so many that the comparison is to a limited extent just. A large amount of moisture condensing and falling on the table lands of a continent at once seeks the lower levels. The fact is essentially the same, whether it be in a liquid or in a congealed state. In the latter case, of course, the operation is slower, but the *tendency* is in no wise different as respects the point in question. This being so, we see that if an immense body of ice were lying to the north of New England it would naturally seek, though the slope were slight, all the lowlands and depressions. Were it lying on a horizontal plain there must be from simple weight a tendency to motion, from its centre outward, in all directions over the level surface. In case the plain were gently inclined toward a given point or points of the compass, we should expect the predominence of the tendency to be determined, other things being equal, by the inclination. If heat were brought to bear on the edge of the side most inclined, or occupying the lowest position, so as readily to waste this part of the mass, the tendency to motion in this direction would be increased. Should this exposed portion of the ice be largely removed by thawing the tendency must be greatly augmented; for room would be made for, and movement imparted to, the remainder of the mass lying in the rear. Were there also alternate freezings and thawings, alternate instances of contraction and expansion, there must likewise be successive instances of retardation and acceleration. Meanwhile there should be in addition, first, the motion secured by contraction of the ice-wave on an inclined plane, and next, the motion generated by the expansion from freezing, especially if moisture derived from the melting of the snows on the surface percolated all the crevices of the ice-sheet. The simple application of the principles suggested by these statements, and of others of a cognate character which it is not necessary to mention in this place, since a careful study of the matter is sure to bring them to mind, may serve to show that the motion of the icy mass is almost a matter of necessity. One may also surmise from these hasty statements the nature of some of the many conditions and agencies concerned in glacial motion, which cannot be given in detail, though a knowledge of them be requisite to a full understanding of the subject.

Professor Dana, however, appears to look at the matter differently, if not in an entirely diverse light. He says, and this seems to be his main statement in reference to the point, "the glacier owes its power of movement to the facility with which it breaks and mends itself."[1] That ice breaks under certain circumstances, and in breaking, or as broken, may more readily pass over, or move around given obstacles, is of course perfectly evident; but what causal relation exists between its mending and its motion, or what motive power inheres in the process, is not so plain. Applying the same phraseology to water, of course with due allowance for admitted differences, we fail to find in the second term any meaning whatever, so far as tendency to motion is concerned. But, waiving the further examination of this point, one may reasonably ask, whether there be not far too much efficiency ascribed to this supposed agency.[2] Breaking and mending, while they should not be overlooked, are, after all that may be said, little more than concomitants in glacier-motion. All the breaking and mending in the world, by themselves alone and if there be nothing besides, would not necessarily carry the mass of ice forward in the least.

Meanwhile there are various conditions and agencies, in connection with which, as we have seen, movement would actually occur. Great cold prevailing on the northern limits of the ice-sheet, and serving as a barrier to its motion in that direction, there being at the same time a partial melting of its southern face, the waters from the wasting snows on its surface percolating the icy mass, there also being contractions and expansions consequent upon alterations in the temperature; all these being connected with the gravitating force

[1] Paper cited, p. 50.

[2] A remark of Professor Agassiz, who is perfectly familiar with the phenomena of existing glaciers, suggests the little prominence which should be given to the agency in question. "Breaking and mending," he lately said to me in conversation, "only take place where glaciers form cascades, or rapids as it were, over greatly uneven ground."

of a mass from five thousand to ten thousand feet in thickness, motion toward the south would inevitably result, even on a horizontal plane, and much more, if there were a southward inclination of the country. A southerly motion being thus almost a matter of necessity, its probable rate becomes a question of interest, and deserves a passing glance. In looking at this point, one ought not to forget the marked difference in the conditions under which the great ice-sheet apparently existed, and those connected with the short, isolated glaciers of modern times. We should remember that we have no positive evidence that the face of the country was any more broken or mountainous, during the glacial period, than it is to-day; that the mass of ice probably rested on a surface not so far removed from a plain as some suppose; that in addition to the comparative absence of slope in the region, it had occasional mountain ridges, many hills, and other kindred obstructions to surmount; and that, consequently, its motion must have been very slow, as compared with that of any of the existing glaciers of the Alps. We are also to bear in mind that there must have been considerable variation in this movement, in different localities, determined by the existing exigencies, as the equality or inequality of the surface, the degrees of its inclination, the thickness of the ice-mass, and the like.

Now, while accurate measurements have been made[1] of the motion of glaciers of different dimensions, slope, thickness, age, and the like, in the steep, narrow valleys of the Alps, we can hardly apply these, without modification, to the broad and comparatively level ice-sheet, as it probably existed in this country. Indeed, an attentive examination of a great number of facts has forced me to believe that the movement in New England was extremely slow. Professor Dana suggests that the glacial sheet had a motion "not exceeding a mile in a century, which is equivalent to about a foot a week."[2] This estimate, as should be remembered, was made on the supposition that the northern part of the continent was elevated during the ice period, and that thus the slope was then much greater than it is now. Various considerations indicate, that the rate of movement, in most localities, was by no means so great as the estimate implies; while in some, it may have been greater. The conviction wakened, as the result of considerable observations, is that the average rate

[1] See "Système Glaciaire," by Prof. Agassiz.

[2] Paper cited, p. 50.

of motion was very far less than even that stated by Mr. Dana,—say from ten to fifteen feet a year. But in making an estimate of this kind, a great many elements need to be taken into account—too many for present consideration. It may be simply remarked, therefore, that the motion of the ice-sheet, like that of an existing glacier, was undoubtedly very unequal in different parts. Indeed, on this point I have already found conclusive evidence.[1] In some portions of the mass, there were plainly accelerations; while in others, the ice necessarily met with obstructions, and was thus in a greater or less degree retarded.

§ 11. *The Direction of the Ice-Sheet*

Is indicated by a great number of facts, which need not be enumerated. It is easily made out in an uneven region by the characteristic aspects of what are called the stoss and lee sides of the rocks. Like horizontal and vertical isotherms, the phenomenon was to a considerable extent climatical. Accordingly, it must have been largely determined by the climatic conditions of moisture, temperature, and the like; meanwhile it was partially, and in some places greatly, modified by the general contour and the everywhere varying features of the country. In the earlier stages of the work, before the masses of ice were very thick, and while they mostly lay in distinct and separate depressions, the direction of each sloping valley would be that of its ice-stream; so that, moving along in their chosen channels, the several glaciers must have denuded, polished and striated the surfaces of the rocks over which they passed, thus leaving vestiges of their existence, of their work, and of the course they took down the valleys which they traversed. Such traces, had there been no subsequent abrasion, would have remained to tell us, no doubt explicitly, the direction of the local glaciers during the earlier part of the ice period.

On the increase of these local glaciers, and the final union of all in one immense sheet, a marked change appeared not only in the

[1] I may refer to a single item of evidence pointing in this direction. The observations which I have made clearly indicate that travelled matter has been transported to a much greater distance in the comparatively level basin of the Mississippi than in the rough hilly country striking the eastern border of the continent. It is not improbable that a like comparison would hold true between the drift of this great basin and that of the mountainous region lying along its northern border. Similar testimony is found, only it is on a smaller scale, in the basin of the Connecticut, and in that of the Housatonic, to mention no other instances.

icy mass itself, but in all its concomitants. There being, on the whole, a slope of the country toward the south, — a vast pile of ice accumulating, slowly but steadily, in the northern regions; the wasting of the mass being, at the same time, for the most part on its southern border; there being thus a constant removal of obstructions to progress in that direction,—the tendency to motion would be mainly southward. Hence ice, in unknown amount, must force itself slowly through the valley of Lake Champlain, and down that of the Connecticut River, from the great winter store-house in the north. These main ice-flows would be fed for a while, and finally impinged against, by the minor streams from the east and from the west. The large valleys just mentioned being at last gorged with ice, of course the small east and west glaciers could not any longer find their way into these reservoirs, for the immense pressure from the north must have kept them full even to overflowing. Hence the local glaciers might be, for a while, almost at a standstill; but in due time they would necessarily overflow, and begin slowly to move southward. The vast mass of ice in the north, because of its great thickness, under the simple action of gravity, with the several accompanying conditions and agencies favorable to like results, must thus gradually extend over the region lying toward the south. So doing, it would tend to push southward whatever lay before it, and in the end it must force along, perhaps by lingering, and yet by certain steps, not merely what some might call the upper parts of the mass, but all the underlying and lateral masses, which probably existed as local glaciers in the opening of the ice period. Only one course, therefore, was left for what were once minor east and west ice-streams—they would become merged in the great glacial sheet; accordingly, their movement must be slowly southward, not merely in connection with, but as an integral part of, the vast mass of ice that followed the natural outlets of the region in that direction.

Perhaps a remark should be added, in respect to the change experienced by many local ice-streams, when they came to be part and parcel of the great glacial mass. This is the more needful, since the point seems to have been very widely misapprehended. The change may be illustrated by reference to the action of water, though it should be ever borne in mind that, while the illustration is good as it is used, all the conditions of ordinary streams are by no means to be applied to glaciers, for they do not hold. Such a change, then, as the one referred to, in the direction of what were probably once isolated masses of ice, moving toward the east or west, is just what occurs, only more rapidly, in the case of water. Small streams, having a given course, lose themselves in the mighty deluge which sweeps over the country at right angles to their trend. Their individual identity is no longer maintained; they are swallowed up in the vast stream, and themselves flow on an indistinguishable part of its madly rushing current. Substantially this, according to the evidence, only at a slowly-lingering pace, perhaps took place in the transition from the Earlier to the Middle Glacial times. The general erosion, smoothing, and furrowing of the rocks show that the force passed the east-west valleys and hills nearly at right angles to their trend. Connected with this change in the direction of the force exerted, the markings of the opening glacial period must have been, for the most part, erased. Indeed, such a change and its long continuance would result in the obliteration of all the earlier vestiges of ice-action, and to the inscription of new characters, peculiar to the middle Ice period. And these later markings must have been written on the surface of the solid frame-work of the whole country, just as we find them, north-south in their direction, and suited to tell their characteristic story. Thus what were probably local east-west glaciers being turned from the course which they originally followed, the whole mass would move southward, often modified somewhat in its direction, but never entirely deflected, by local barriers.

Brief reference should be here made to an evident misconception on the part of Professor Dana. So far as I can see, his discrimination between the main ice-sheet and local glaciers recognizes, not difference in time, but simply upper and lower portions of a vast ice-blanket,—such inferior parts of the great ice-mass as occupied valleys, and the like, being in his view local glaciers. He seems to suppose that the superior portion of the main mass was largely distinct from the lower; that there was this general glacial sheet which spread widely over the country, and had its peculiar motion and direction; that there were beneath it, and to a great extent separate from it, many local glaciers, each having its characteristic features, and moving for the most part independent of the overlying ice-stream; and that thus there were, above and below, at one and the same time, not merely a difference in position, but also in motion, and that the lower part of the mass had a distinct and an essentially different direction. Such is substantially the impression I have received from Mr. Dana's paper. It is easy to see, from this point of view, how he has come to misconceive what he calls the glacier of the Connecticut, the glacier of the Hudson, the glacier of the Mohawk. and to speak of them as if they were under, and still distinct from, the great ice-sheet that moved from north southward over the country. The fact is, New England, during what was its main ice period, had no local glaciers. One huge mountain—as it were a table-land—of ice covered the whole region, filled all the valleys, planed the rocks, and did the manifold work that was done, of which the north-south striæ still surviving are a part of the witness. In the opening of the glacial times, there were possibly, to me it seems there were probably, local glaciers which were finally swallowed up as the great winter of the ages advanced. The small local glaciers, of which we have positive knowledge, belonged to what was in New England the closing part of the Ice period, and were what remained of the great ice-sheet when it left the low lands, and the conditions for the maintenance of glaciers existed only in the higher regions. Thus Professor Dana's presentation seems to be almost wholly untrue in the sense he gives to it, and in the manner in which he appears to view the subject, when endeavoring to account for what he regards as abnormal furrows, and other kindred anomalies.

The final wasting of the main ice-sheet must have introduced marked changes. While the low lands were laid bare, remnants of ice must have been left in the high lands, filling most of the elevated valleys. Thus local glaciers would make their appearance on the reduction of the main mass of ice in New England. East and west local ice-streams, and others of a limited character, no doubt, for the greater part and gradually, assumed courses determined mainly by the existing depressions. They would in a large measure, and in most places, especially in the more central portions of the valleys, wear off the legends of the Middle Glacial times, and write in their stead a new record, the lines of which might run in a more or less east-west direction, according to the trend of the valleys. And such is substantially what is now found to be true. Reference may be made, particularly, to the east-west valleys of the Green Mountain range; valleys, in which the existing striæ are for the most part characteristic of the later Ice period. On the western side of these mountains, the high lands in the counties of Chittenden, Lamoille and Franklin are almost everywhere traversed by north-south drift-marks of the main ice-mass, while the valleys of the Winooski, of the Lamoille and of the Missisquoi which cut through the Green

Mountains and these high lands, on their way to Lake Champlain, have westerly (and not, as has been affirmed, easterly), striæ in great abundance.

In the light of what has been advanced, I am constrained to question another statement of Professor Dana. "In the case of *large* continental valleys," (the italics are his,) "the glacier followed the course of the valley even where this course was east and west, as is shown by the author to have been true of the Mohawk valley."[1] This language is evidently used in regard to the phenomena of the Ice period generally, and without any intention of restricting it to any portion. That what is asserted may have been, to some extent, the fact in the lower part of the River St. Lawrence, and thus near the Atlantic side of the great ice-sheet, is not denied; it was perhaps actually the case. Indeed, I have found some evidence that, along the eastern margin of the ice-region, as in Essex County, Mass., (though this instance was perhaps due to another cause), there was, as might be naturally expected along the lateral limits of the continent, a strong tendency eastward.[2] This, however, is one thing, while the case of the Mohawk valley is quite another. So far as the evidence in regard to the latter locality has come to my knowledge, the course of the ice-stream, during the Middle Glacial times, was southward, and directly across the valley in question. That the ice followed the depression now traversed by the Mohawk River, perhaps during the opening, and very evidently during the closing portion of the Glacial period, is of course most cheerfully admitted. Another statement may be noticed, not because of its intrinsic im-

[1] Paper cited p. 50.

[2] Many, no doubt, in their study of the evidences of the former activity of ice-agency in New England, have been surprised that the prevailing direction of the striæ is so strongly toward the south-east. Since the predominant trend of these striæ is regarded by some as conclusive evidence of an elevation of the region lying to the north-west of New England, from which it is supposed the ice-mass descended, a few additional words on this point may be in place. Granting the existence, in the northern part of the continent, of a vast ice-sheet, with a southerly motion, we see at once that other things being equal, the main trend, especially in the centre of the continent, would be north-southward. If we grant again, that the ice was of great thickness, and that there was an Atlantic basin on the east, it is equally evident that the prevailing trend of the mass along the eastern margin of the continent would be somewhat toward the southeast. Such would be the case, the whole continent remaining at substantially its present height. Thus the eastings in New England have a legitimate origin in the conditions that no doubt prevailed during the Ice period; they therefore neither prove the theory of upheaval, nor require it in order to their natural explanation.

portance, but because it relates to an instance of variation which seems to be regarded as remarkable, and deserving of special explanation. Reference is made to drift-striæ, which occur near Allingtown, in the vicinity of New Haven. These "scratches having the course south 33° west"[1] may have been due to the special conditions stated in the pamphlet, or to some other local circumstances. Such variations, however, are by no means unusual in given localities. In many cases, as long-continued observations have convinced me, markings of this kind, so widely divergent from the meridional line, were not made during the Middle Glacial times; they are the still unobliterated vestiges, not of the main ice-stream, but of local glaciers connected with its waning power.

§ 12. *The Duration of the Ice-Period.*

How long the great winter lasted, is a question still open for discussion; indeed it is one, respecting which it is not easy to give a definite answer, so little is yet known of the endless details of the subject. The investigations of each succeeding year are bringing into view new bearings of the case at issue, and are thus preparing the way for a more exact decision. So collateral evidence, indicating what was done during the period, and seen under relations which up to the present moment have been only partially discussed, may by-and-by throw a flood of light on this problem of time. Astronomy, as discreetly interrogated and candidly interpreted, will perhaps hereafter yield elements calculated to help us in our endeavors toward its solution.

Professor Dana seems to think that the duration of the glacial work was comparatively short. He surmises that most of the effects. (candor constrains me to suggest that, in thus speaking he may have reference more especially to what occurred during the later, rather than the earlier part of the Glacial times,) required no very long period for their accomplishment. While not able as yet to disprove this supposition,—while not wishing to regard the glacial agency of great duration, unless it really were so,—I am, as I study the facts, more and more deeply impressed with the conviction that the Glacial times must have been immensely extended, especially as estimated according to human chronology. Fresh data are constantly coming to light, and revealing new points of view, tending to

[1] Paper cited, p. 59.

show that the work done, during the winter of the ages, was prodigious. While familiar with the facility shown by some in explaining away facts, or making them bend to a preconceived theory; while also well aware that, in given cases, large depositions are rapidly made, and great changes effected in a short time; I am still reminded, that such depositions and changes are the exception; that the whole of New England is covered with loose and more or less finely comminuted material; that this could not have been ground from the solid rock, and reduced in large amount to the condition of a powder, in a moment; and that, consequently, this material, in passing through so many changes, and assuming its present position, *may* have required a long period, even in the geologic sense of the term. I do not say that this is the fact; I simply state the problem, that it may lie open for solution.

With this aim in mind, it may be well that some of the facts already mentioned be again referred to, and now briefly set forth, in the light furnished by the glacier hypothesis. This is important, both that they may be seen as distinctly exhibited, under this aspect of the question, and because they are perhaps suited to give a faint indication of the relative duration of the Glacial times, in their several divisions; the later probably being far shorter than the middle, and possibly even than the opening portion of the Ice-period. With this purpose in view, I proceed to notice

§ 13. *The Action of the Ice-Sheet.*

(1.) *As attested by the underlying rocks.* The consideration of this action, as calculated to throw a glimmer of light upon the point in question, may at the same time enable us to determine whether the facts be explicable on the ground of the glacier-hypothesis. The wearing agency of ice is very powerful in itself considered; and it must have been peculiarly energetic, as brought to bear in the operations specially under consideration, if one may judge from the many effects which remain as intelligible traces of its presence, and as trustworthy witnesses of what was once going on in this region; and these effects may be looked upon with propriety, as direct consequences of glacial agency.

First of all, *erosion* has occurred, and to an immense extent. As an evidence of this, reference need be only made to the vast amount of denudation which has taken place on the surface. In many instances, this may be estimated in connection with what are known as axes of elevation, portions of the beds having been removed in such a way that, in some localities, the exact amount can be determined. In case the rocks in given places were peculiarly hard and unyielding, the glacial plough seems occasionally to have passed over them, scooping out the softer material, both in front and in the rear of these tougher parts. Thus to some extent, hills and valleys were formed in connection with the denuding agency, and remain to tell us of its extent. So lake-beds have been apparently deepened--in not a few instances they were, no doubt, largely eroded and fashioned—by the action of moving ice. The same is true of river-channels; they have been hollowed out and widened, the rocks having been deeply furrowed, seemingly by ice-streams. Pot-holes also occur at various levels and of considerable depth, which, so far as we can now see, could only have originated in connection with an immense ice-sheet.

Reference may be made to a single locality, in which such pot-holes occur at a considerable height, in the basin of the Connecticut River. They are in Newfane, Windham County, Vt., near the crest of a hill, some 2600 feet above the ocean. While these pot-holes have been generally, if not universally adduced as the work of a torrent, it is difficult to conceive that a river, in the usual sense of the term, ever flowed in the place. In other words, the hill is isolated; whereas the descent of a stream upon it implies the existence of higher lands in the neighborhood, probably lying to the north; that such was the case, during the Ice-period, the face of the country affords no indications. Again, there is a valley, just below the pot-holes on the west, some 300 feet deep. This, if the explanation suggested be true, must have been eroded since their formation, and since there could have been opportunity for the flowing of an ordinary stream, to say nothing of a torrent, along the surface which they occupy. And surely to suppose that such erosion took place, and yet spared the pot-holes which were apparently as much exposed as the part of the rock removed, (and this is not a solitary case, for there are many like instances in different portions of the country, *e. g.*, in Oxford County, Maine,) is to make a heavy draft on our confidence, if it do not overtax the strongest credulity.

Instead of resting in this unsatisfactory explanation, let us suppose that there was a great ice-sheet; that its motion was southward; that it was of a thickness to cover, and that it accordingly passed over, this elevation. Of course with such an obstruction[1] in the way of the ice-mass, there could readily, and, one may presume, there probably did occur a break in the ice, what is known in a modern Alpine glacier as a *moulin*, or well, just above the summit of the hill. Now a glacial stream—a thing of constant occurrence in the present, as it undoubtedly was in the past—flowing on the surface of the wide spread field of ice from the north or the north-west, in consequence of the thawing of the superficial snows under the heat of the noon-day sun, and falling into the *moulin*, must have had precisely the effect of a cascade or mountain torrent.[2] Indeed, it would be a torrent, or a cascade, according to varying circumstances, —a glacial torrent or cascade,—and thus naturally produce the results in question. The pot-holes connected with modern glaciers differ greatly in form. Those of the Ice period, as one might expect, have a like diversity. Frequently they are round, or nearly so; sometimes they are more or less oval; while in many instances, they are oblong, perhaps having somewhat the appearance of one in the vicinity of New Haven, described by Professor Dana as "like a bread trough in shape."[3]

This explanation of the phenomena in the locality referred to, which was suggested years ago by what Professor Agassiz says of results, probably kindred in their character, produced by Alpine glaciers, may render the whole matter easy of comprehension and help to account, in an intelligible manner, for many similar occurrences in different parts of the country. It should be remarked that such pot-holes were probably formed at various heights. in connection with the surface streams of the overlying glacier. Of course, the most elevated could have been produced only during the Middle Glacial times, when the ice was probably of great thickness; those

[1] It is well known that, when existing glaciers meet with obstructions, there occur in them breaks which are called *moulins* by the Swiss mountaineers; that, from the melting of the snows on the surface of the glaciers, many streams are formed; and that these, flowing into the breaks, become cascades and torrents, which wear pot-holes in the underlying rock, in every respect similar to those requiring an explanation.—See Professor Agassiz's *Système Glaciaire*.

[2] Professor Agassiz informs me that there is no end of the cascades upon the large glaciers of Switzerland. He says that all these cascades, from the superficial rivulets upon the glaciers, falling into the *moulins*, remain stationary—just as eddies in a river—while the glaciers moves on. His explanation is: the ice breaks constantly, as it moves forward, and closes up again after passing the obstacle which causes the break.

[3] Paper cited, p. 62.

at lower elevations may have originated in the closing Glacial period, and thus would for the most part occur only in valleys, or depressions occupied by local ice-streams. Remembering that all the elevated pot-holes of this kind, which are in some cases of considerable depth, must have been eroded when the ice was immensely thick, we may get some, though it be a very inadequate impression of the the probable duration of the Middle Glacial times.[1]

The view of the matter just presented, if it be substantially correct, reveals the *non-sequitur* of much that Professor Dana advances on this phase of the subject. Referring to pot-holes at a low level, he observes[2] "These pot-holes must have been made by torrents from the land. For the existence of such torrents the land [from which the torrents flowed] should have been above its present elevation. . . The era of this higher level . . . may have been that of the great glacier, and the torrents sub-glacier streams." Respecting these statements it may be said, in the light of what has been advanced, first, that there is no such necessity, as the author supposes, for land-torrents in the usual sense of the expression; none for the asserted elevation of the region in order to the production of a torrential stream; that the work, since it is at a low level, was doubtless wrought during the later Glacial times; that in some instances, in which there was a rapid descent of land, pot-holes were possibly worn by sub-glacial torrents; that in most cases, and probably those cited in the paper under review, this was effected, not by *sub*-glacier, but by *super*-glacier streams falling into breaks in the ice-mass. This aspect of the matter should clearly remove all the necessities implied in Professor Dana's suppositions. So, according to the phase of the subject now presented, there appears to be no occasion for the

[1] As illustrative of the great duration of the Middle Glacial period, I may cite a single item of evidence. In Orange, N. H., on the summit ridge between the Connecticut River and the valley of the Merrimac, more than 1200 feet above the ocean, there are the remains of a pot-hole, which, according to Professor Jackson (*Report on the Geology of N. H.*, *p.* 113), was eleven feet in depth. This pot-hole was clearly worn during the continuance of the main ice-mass. Post-glacial pot-holes may be seen in a similar granitic rock at Bellows Falls, Vt. Of these the deepest are only five feet in depth. Professor Jackson accordingly infers, "that if the pot-holes on the mountain top (in Orange) were excavated by a waterfall of the same power as that of Bellows' Falls." (and if it were by a glacial stream, it was probably of far less power,) there must have been required for its formation "more than twice the length of time that the present Connecticut has been running." *See Proceedings of Am. Ass. Ad. of Science; 4th meeting*, *p.* 139.

[2] Paper cited, p. 62.

hypothesis of elevation. Indeed, it seems to be rather an incumbrance than a help. This being so, it may be asked whether the glacial explanation does not greatly impair the force, if it do not entirely dispose, of the main point urged by Professor Dana, as evidence of a higher level of land, during the earlier and middle Glacial times.

But there are not merely traces of erosion; there has been very extensive *planation* of the rocks. This has taken place over a broad area, and in a marvellous manner. The surface of the country has been rubbed, scoured, and polished to an extent which might be deemed incredible, by one who has not studied the subject long and carefully in the field. The portion of New England which has not been thus planed and smoothed is almost as nothing compared with the whole. It comprises, for the most part, only the south-east mural faces of hills and peaks, and a few of the highest summits of the White Mountains. The parts of the surface thus spared distinctly indicate the direction in which the abrading and smoothing force acted. The fact that the work of denudation and polishing, even on the south-eastern slopes of hills and mountains, was in all cases renewed, after an interval, evinces with equal clearness that icebergs were by no means the instruments in operation. It also suggests that the sheet of ice, in passing over an elevation, was in many instances so arched as to leave a portion of the leeward surface unaffected, only in due time to resume its suspended work of abrasion with renewed force. Indications of such action as this are to be found in abundance in various portions of the country. No one can need a better exhibition of it than is furnished by the Adirondacks of New York, whether looked at in outline at a distance, or examined in minutest detail.

There has also been almost equally extensive *striation*. Nearly everywhere the eroded and polished surface has been scored, scratched and furrowed. These furrows and scratches and scorings vary greatly in size. In rocks recently laid bare they are in some cases so fine as scarcely to be discerned by the naked eye; while in other instances, they are many inches and even feet in diameter. Occasionally the objection has been urged that this striation was not produced by the action of sand, gravel, and boulders in the foot of the glacier, but is the work of man. In reply it may be said, that such markings do not occur merely on surfaces which have been for some time bare; on the removal of soil, which evidently had never been disturbed since its deposition, solid rocks have been reached, all written over with these strange hieroglyphics. In one instance a boulder, which had thus served as a plough-share, was found in the very furrow which it had formed.[1]

Again it may be objected by some, that the surface of many rocks shows no signs of such work. If it be remembered that, in many cases, the best polished or striated surfaces, after an exposure of fifteen, twenty or thirty years, will have largely lost their striation,—that in rocks better able to withstand the action of the elements, a century must do a marked work of obliteration,—and that nearly all rocks, when first uncovered, have vestiges of such marking, — we shall, as we observe exposed surfaces without striæ, find our objection fast fading into thin air. We may be led to believe that almost every weathered rock once bore marks of glacial action. Indeed, the experienced observer can often detect such traces in the outline of the rock and in many other forms, when the unpractised eye will only see a blank, unlettered surface.[2] It is thus doubtless true, that the vestiges of the ice-plane have been both largely effaced, and are in process of effacement, from most exposed surfaces; while almost every freshly bared ledge gives unmistakable evidence of former polishing and striation. So there are, at many low points, (take as an instance the Isle la Motte in Lake Champlain) several sets of striæ crossing each other at varying angles. These are indicative of different directions, and thus of successive stages of the glacier; they accordingly evince that the glacial times really consisted of several distinct, though closely related stages, instead of one uniform process of short duration, as some seem to have supposed.

Now these facts—these evidences of action on the underlying rocks, in the way of denudation, polishing, and furrowing—which we encounter all over New England, and which never could have been caused, some of them at all, and most of them even on a very limited scale, by icebergs, seem to be the legitimate work of ice slowly moving southward, in a vast sheet. The various points cited

[1] Emmons' *Geology of the Second District of New York.*

[2] It may be proper for me to quote the following statement by Professor Agassiz, which has recently fallen under my eye:—" These erased and obliterated surfaces (rocks moutonnés) without scratch or furrow, are often intersected by large dykes, the surfaces of which show all the markings that have vanished from the adjoining rocks. The inequality in the level of the rocky hill and of the dyke shows the amount of decomposition since the glacial period." For other kindred statements see his paper *On the parallel Roads of Glen Roy.*

and many more which might be readily adduced, indeed the manifold other facts of a cognate character, all seem to be just what we should presume they would have been, in case the whole region had been once traversed by a vast body of ice, impelled, slowly but steadily, toward the south, as the winter flow of an ice-continent. And this view enables us to understand how the ice, which must have been thicker in the deep valleys of the Hudson, of the Connecticut, and of other north-south streams, than on the intermediate hills, would in connection with the main mass move onward beyond their present outlets, especially during the Middle Glacial times, and form the submarine glaciated channels, as it made its way over the shallow plateau to the deep sea. And the same is true in respect to various other points, some of which are very hard to interpret on any other recognized hypothesis, than that of an extensive mass of ice covering the whole region to a great depth.

§ 14. *The Action of the Ice-Sheet,*

(2.) *As attested by the overlying material.* The traces of this action reveal additional evidence of the time required for the accomplishment of so much work, and of the way in which it was effected. Only a few facts need to be mentioned as illustrative and confirmatory of this phase of the subject, and these the most obvious. If there were such a denudation of the surface of the country as has been already referred to, it must have led to certain results—it could not, indeed, fail to reveal itself in given effects—which may be properly regarded as accompaniments of glacial agency.

There would be, in the first place, the erosion of a vast amount of material. Something of the kind would necessarily follow, if a mountain of ice shod with tough erratics moved slowly but steadily along, constantly furrowing the surface of the subjacent solid rocks and scraping up and carrying off the loosened material.[1] Under these circumstances, we should expect an important work to be done during the earlier part of the ice-period. The local glaciers, filling the mountain valleys, would, as they advanced, plough up the surface, and push along, at once before them and beneath, a large

[1] Professor Agassiz says, "On creeping under a glacier, I actually saw the lower surface of the ice studded with pebbles and boulders, immovably set in the glacier, like mounted stones; and once I saw, still in its place, the powder that had been ground by the rubbing of these pebbles against the wall rock of the valley, in which the glacier was moving." Similar remarks are of frequent occurence in his various works on glaciers.

amount of disengaged matter. They were also likely to take not a little from the sides of the mountains that chanced to skirt the valleys which they traversed.

During the Middle Glacial times, the work must have gone on with even greater vigor. The vast accumulations of ice, spreading far and wide, of great thickness, would abrade the surface at large, and in some respects tend to plough deeper furrows than in the earlier portion of the cold period. Nearly every height being covered by the broad mantle of ice, the material must have been mainly furnished from the surface of the underlying solid rocks. This matter, as disengaged from the subjacent rocky floor, might be borne along, and to a considerable extent broken and ground to powder, by the immense rock-crusher that slowly and with irresistible force moved over the country. There would thus be a large amount of detrital material especially beneath, and to some extent in front of the great ice-sheet.[1]

On the final wasting of the stupendous mountain of ice, one might expect all this matter to be left in a confused jumble, overlying the surface of almost the entire region. Such a mass of material now covers nearly all New England. It must have been likewise spread, very largely, over what is to-day the submarine border of this portion of the continent, the level of the sea perhaps being at that time still somewhat depressed. Accordingly, the submarine valleys, extending from the mouths of the Hudson and of the Connecticut, would be, as they are now found, overspread by typical drift.

But this leads me to notice what seems to be a misconception, on the part of Professor Dana, as to actual facts in the production and distribution of drift. He evidently has the impression, that the boulders and comminuted material which were abraded from the underlying rocks, were taken up into the body of the ice, and only dispersed over the surface of the country, in connection with its final melting. Referring to the abrasion of the subjacent surface, he says

[1] The statements in the above paragraph suggest the prevailing marks of the vast blanket of matter underlying the glacial mass in a comparatively level country like ours, and wherein it is likely to differ from the drift of a region traversed by lofty mountains. In confirmation of this, I take pleasure in quoting from one of the lectures of Professor Agassiz:—"The characteristic difference of the drift in North America, as compared to that of Europe, is that here, owing to the absence of high mountain chains, the drift is almost entirely sub-glacial, *i. e.*, rounded, polished, and scratched, and the supra-glacial angular boulders are comparatively few, and mainly found in the vicinity of our higher hills (the White Mountains, for instance)."

that one result of the movement of the ice-sheet was "the taking up of the sand or gravel, stones and rocks, thus separated or dislodged into its own mass, which it was enabled to do because of the attendant breaking of the ice . . . and the readiness with which ice becomes solid again by regelation. . . . Thus the glacier moved slowly on, engorging itself with whatever loose material it made, as well as with what it found in its path."[1] He accordingly appears to think that the matter disengaged from the inferior rocks by the action of the ice-sheet, was lifted up into its body, more or less diffused through it, and of course not distributed until its final thawing. Now this view, so far as I am aware, has no countenance from facts; none from the best observers of existing glaciers;[2] none from theoretical considerations. While the glaciers of the present rest upon the drift proper, and are themselves masses of pure ice, with the exception of the sands blown over their surfaces, and the material of lateral and medial moraines, such must have been still more the case, during the middle and main portion of the Glacial times, when there were only a few solitary peaks, from which superficial material could have come.

I may accordingly resume the statement, that there was necessarily not a little detritus beneath, and somewhat of it in front of the great glacial mass; and that this would be left, to a very large extent, in its confused condition, on the final wasting of the ice. Now this great accumulation of matter, known as typical drift, remains as an existing witness of the work done, and of the time consumed in the process. While it is true that considerable portions of this heterogeneous jumble have been removed, all that part of it which is now found above the valleys, as should be clear, belongs to the Middle Glacial times. Remembering that there is no evidence that any appreciable amount of detrital material was taken up into the body of the ice from beneath, or in any wise enfolded in it, one can see how difficult it must have been for the glacier to plough the underlying rocks with rapidity, or to any great extent in a short time, especially during the later portions of its existence. Thus the abrasion, after its first inception, must have been very slow; meanwhile the quantity of matter which was disengaged from the underlying

[1] Paper cited, p. 51.

[2] Professor Agassiz informs me, that the mass of a glacier consists of pure ice, wholly free from detrital matter, and the same is the testimony of other and later observers of glacier-phenomena.

rocks, is large; hence the period during which so vast a work was in progress,—a work requiring, according to all ordinary calculations, a vast length of time for its accomplishment — must have been very protracted.

The material thus accumulated, as should be borne in mind, likewise had a *derivation*, which is full of instruction. It having come, for the most part, from localities lying a little west of north of its present position,—it having generally travelled only a short distance, and having in all its main portions shown great constancy, in passing somewhat obliquely across meridional valleys and hills,—it is difficult to see how it could have been in any wise so transported by water, as uniformly to exhibit these characteristics. Meanwhile, as to origin and distance of removal, as to direction and mode of transportation, it has observed all the conditions, and shows every mark, which we may conceive it would have observed and be likely to show, had it been the result of glacier-action.

While such seems to be the character of the largest portion of the typical drift among the hills of New England, there are occasional exceptions in the form of erratics. These are far travelled, and composed of tough material; they are hard-heads indeed, in the literal sense of the expression; thus they were likely to be preserved, in spite of all the wear and tear to which they must have been exposed in their removal, in their protracted journey, and during the long subsequent lapse of time. That other rock-masses which set out with them, were ground to powder, and thus unable to tell precisely the same story, is no doubt true. The fact that the rounded blocks which remain travelled so far, and only just survived the vicissitudes to which they were exposed, involves a significant piece of evidence. Bearing in mind that the continental ice-sheet probably had only an infinitesimal motion, in comparison with that of the local glaciers that now descend mountain valleys,—that the portion which bore the far-travelled boulders, was doubtless equally slow; and that these rocks were, perhaps, transported the greater part of the way during the Middle Glacial times,— we find ourselves possessed of a new element, indicating that the winter of the ages must have been of long duration.

The *position* of the materials of the drift-sheet is also characteristic. Matter having been derived as supposed, it having been forced along beneath the mass of ice, and to a limited extent in front of it, in some such ways as have been indicated, we readily see that, on the melting of the ice during the newer Glacial period, it would be left in a jumble,—perhaps very nearly in the state in which we now find it. We should expect it to cover the whole surface, overlying the hills, spreading across the valleys, and filling the old gorges and river-beds substantially as is known to be the case. Consisting of a strange medley of heterogeneous, unarranged material, it would appear, as it now lies in its undisturbed portions, in some places in greater, in others in less thickness. So we might expect to discover in it, sometimes far-travelled matter, sometimes not, accordingly as the portion of the ice-mass which transported it was favorably situated for movement or the reverse. Parts of the same heap must likewise have come from afar, and portions from the neighborhood in which they are found. And while we cannot readily conceive the production of such a result, all over the country, in high places and low, by the action of icebergs, we see that the drift material is in just the plight it would have been likely to assume, it case it took its position in connection with the agency of a vast sheet of ice.

These several points as connected with the overlying matter known as typical drift, that have been just passed in review, are facts which the iceberg theory cannot explain as a whole, or in anywise render consistently intelligible in their details. They are seen, however, so far as I can discover, to be perfectly natural, on the supposition that an immense ice-sheet once covered the land for a long period. In the light thus brought to bear, the various facts appear to be perfectly explicable, and they all seem to point in the single direction indicated. While, thus, the hypothesis that a vast sheet of ice spread over New England, during the drift period, is becoming more and more probable, there are many attendant circumstances which appear to indicate that the work was only effected during a long lapse of time.

§ 15. *The Action of the Ice-sheet,*

(3). *As attested by incidental phenomena.* The facts now referred to, no less than those of the two classes just noticed, may bear testimony as to the length of the Glacial period, and the mode in which its work was accomplished. The phenomena in question, though they be not equally prevalent in all parts of the country, are sufficiently abundant in localities which were manifestly favorable to their production. They may be regarded as occasional concomitants, for they are not unfailing results, of glacier-agency. Properly looked at, they are accidents rather than uniform accompaniments, of a continental ice-sheet.

Primarily deserving of notice is the *accumulation* of travelled matter. A prominent form, in which this detrital material occurs, is strictly an accumulation; since it is found in heaps, or piled up in peculiar masses. Angular boulders are also occasionally met with in long lines, as if they had been accumulated with design. Both these aspects, under which travelled material may be seen in different parts of the country, are calculated at once to arrest the attention of the geologist, and to attract the eye of the ordinary observer. Reference is now made to moraines and trains of boulders. As the mass of ice slowly melted, the matter which had been pushed on by it, and to some extent before it, must have been left, in more or less nearly east and west ridges, along its southern border. These, however, have been greatly modified by the constant action of agencies at work in the closing Glacial period, and during subsequent times. But in addition to these deposits, there are still to be met with in vast force and in unmodified condition, the detrital materials which lay beneath the ice-sheet, and were left in place on its retreat. These in one view may be regarded as morainic, though they be moraines in a disguised form.[1] Accordingly the deposits thus left as the remnants of the Middle Glacial period, are only now and then recognized as terminal moraines.

The morainic accumulations which found place, as the local glaciers slowly wasted, near the close of the Drift period, are in much greater degree characteristic, since they have a more marked outline, and because they are frequently seen lying at right angles with the direction of the ice-movement during what were in New England the Middle Glacial times. While the earlier deposits, for the most part, cover the whole region, and especially are seen to occur on the more elevated grounds, or in the broad level depressions, from which the great ice-sheet would first disappear, the later are usually found in valleys which were probably occupied at a more recent day by local ice-streams. But not merely terminal moraines occur; those known as lateral are also met with. They were doubtless formed during these later times, indeed they must have found place, though

[1] I have here, and in another paper, unwittingly called "disguised moraines," what I now suppose Professor Agassiz has described as "ground moraines." Of this I was not aware, until I read his recent paper, "*On the evidence of the Existence of Glaciers in the White Mountains.*"

they be now somewhat obscured, in not a few of the valleys of New England. As an instance of what I suppose to be such morainic masses I might cite, though seventeen years have elapsed since I last saw them, the ridges along the valley of the Shawshine River, in Andover, Mass.

At this point a statement made by Professor Dana requires notice. He says, "there were no lateral moraines in the ordinary sense of this expression." (p. 52). This, in the light in which he views the matter was no doubt true, during the earlier Glacial period, as the ice was for the most part extending, and thus allowed little opportunity for the formation of permanent moraines. Or, perhaps it should be said, if there were occasional wastings and retreats of the ice, and thus the accumulation of the deposits answering to them, they must have been speedily obliterated by the advancing ice-sheet. During the Middle Glacial times, or as I might more correctly say, on the melting of the ice aggregated during those times, boulder-trains and other accumulations somewhat like lateral moraines, and partaking in part of a morainic character, must have been formed, though they were not probably very numerous.

While such trains of erratics are occasionally met with in different parts of the country, they are perhaps nowhere better exhibited than in Richmond, Berkshire Co., Mass. Those in this locality are especially deserving of notice, both as illustrative of the point in hand, and because they have been in many respects greatly misapprehended. These boulders rest upon typical Drift, and are of two kinds, (1) such as have been rounded, smoothed and striated, and (2) angular. The rounded occur almost entirely in six or seven nearly parallel lines, two of which are particularly well defined; meanwhile the angular are scattered over the ground more promiscuously. These trains lie largely to the south-east of several peaks near the State-line. They originate partly in a nearly meridional range of hills, consisting of chloritic slate, in Canaan, Columbia County, New York; but more especially in two other parallel ranges of peaks with a like trend, situated to a considerable extent in Richmond. The latter ranges are also mainly composed of a greenish slate which contains extensive beds of interstratified limestone. For the most part, the character of the boulders is such, that they can be readily traced back to their exact source,—those of the two most prominent lines, to isolated peaks of the Canaan hills; those of the other trains, to similar heights in the Richmond ranges. Some of these lines of erratics may be followed south-easterly for four or five miles; others, passing over the next eastern tier of hills known as the Lenox range, can be followed for ten or fifteen, and one of the larger, for some twenty miles. Their direction, in the first portion of their course, is southward about 55° east. Somewhat further on they change their trend, it being in the main some 35° east of south. Such are the main facts in regard to the Richmond boulder-trains. Having been familiar with the erratics in question from childhood, —having such an acquaintance with them as a lad in the neighborhood might have, even years before they were pointed out to President Hitchcock by my friend, Dr. Reid, of Pittsfield,—and having carefully examined them a great number of times since, I am prepared to vouch for most of their general features as given above, and for many of their essential characteristics, even for some which have been impaired since they have been rudely assailed by man.

Dr. Hitchcock, presuming that there was a submergence of the country during the Ice period, speaks of these boulder-trains as *osars.* Sir Charles Lyell, also supposing a depression, thinks these materials were transported by coast-ice; while Professor Rodgers, in order to account for all such phenomena, has assumed the occurrence of vast waves of translation. There being no proof of these suppositions,—especially in view of the straight course taken by the several parallel series of rocks, obliquely over high hills, and through the deep valley of Richmond,—the question arises, How is one reasonably to account for these trains of boulders?

As to those which are rounded and in regular lines, and as to a portion of the angular which lie with them and are near their place of origin, it seems evident that they were torn from the hills by the ice-mass; that they were forced along, and most of them smoothed, beneath it; and that the variation observed in their trend was caused by the change in the direction of the ice-mass adapting itself to the face of the country; on its wasting, they were laid bare in uniform lines as they now appear. As to the angular erratics, particularly those which have travelled furthest and are spread over the surface more at large, another explanation is needful. As the vast ice-sheet which once covered the region gradually wasted, the elevations from which these angular rocks were derived would be at last laid bare. The ice could no longer pass directly over the top of the hills; indeed, there is evidence that the mass was parted, moving around the north-eastern and southwestern flanks of the several peaks. Of course, under these circumstances, the hill-sides would be closely pressed and rubbed, blocks of slate and limestone detached from their places, and borne along at first as lateral moraines, and on uniting as medial moraines, on the summit of the ice-sheet. The ice gradually wasting, there would be changes in the direction of the moving mass, determined among other conditions by the character of the underlying surface of solid rock, thus causing many variations, while on the final dissolution of the ice, the angular erratics would be left, as they now occur, more or less dispersed over the surface of the typical Drift.

Substantially the same explanation is applicable to similar phenomena in other portions of New England, and perhaps in part to a track of boulders in Huntington, Vt. It is about two miles in length, some forty or fifty rods wide, with a nearly north-south trend, and entirely made up of uncouth angular blocks, strikingly different from any known rock in the neighborhood. Hence it is probable that these are true erratics, and were borne a long way on the back of the ice-sheet. And these travellers, like the Richmond boulder-trains, belonged to the main glacial mass; this is clear from their direction, seen in connection with the fact that they extend from one valley to another, passing obliquely across a steep intervening hill.

Such in brief, is the explanation I would give of these lines of boulders,—an explanation suggested by the study of these strange remains in the light derived from the researches of Professor Agassiz on the existing glaciers of Switzerland; an explanation, which takes from these instances the exceptional character which has been ascribed to them, since it regards them as legitimate concomitants of the great winter of the ages; an explanation which, while it is in entire consonance with all the known facts connected with the glaciation of the country, has the great advantage of requiring no resort to an arbitrary and unsupported hypothesis of continental depression.

During what was the Later Glacial period in New England, morainic masses were formed in comparative abundance, and, while some of them were no doubt obliterated long ago, not a few remain to tell their quaint and characteristic story. In Vermont, they occur in nearly all the principal valleys, and particularly lateral moraines along their sides, especially in the more elevated portions. I have also observed them in Maine, and, if I do not entirely mistake the evidence, occasionally in Massachusetts. Under these circumstances

I am amazed at Professor Dana's denial of their presence, and am unable to account for it, unless on the ground that his knowledge comes from Geological Reports in which lateral moraines have been usually described under other names. Indeed, so abundant are the morainic heaps and ridges characteristic of the Local Glacier times, that I confidently look for a much more extensive recognition of their fragmentary remains, in different portions of New England,—under one or another of the forms mentioned,—as traces of glacier-action come to be better understood, and more careful examinations are made. As nicer discrimination is brought into play, much will be discovered, and found to be attested by actual facts, which was once ignored, and is perhaps now scarcely deemed possible[1].

As to the light which this phase of the subject is calculated to throw on the relative duration of the Glacial period, a few sentences should be added. Taking the Richmond angular erratics as furnishing an item of evidence,—presuming that they extend as far as the longest boulder-trains, as I have been credibly informed is the case; remembering that the time of their removal from their native ledges and deposition could have been only from the moment the peaks, from which they were mainly derived, were laid bare, until the remainder of the ice-sheet in the neighborhood was wasted: that they extend at least twenty miles ; that the rate of motion of the ice-mass, according to Professor Dana, could not have exceeded a mile in a century; and that the movement of the ice was no doubt much more rapid than that of the underlying boulders,—I find that at least 2000 years were required for the thawing of ice from five to seven hundred feet thick, in a given locality. Grant that the thickness of the ice in that place, at that time, was 600 feet, and that of the ice-sheet in its prime about 6000 feet, the entire mass must have been ten times as thick ; thus, other things being equal, there would be required for its melting, in that one neighborhood, some 20,000 years. Again, the wasting, on the whole, probably advanced slowly from south to north; on this ground another element of time enters into the calculation; it thus necessitates a longer duration for this part of the closing Glacial times

[1] Since the above was written, Professor Agassiz informs me that he has recently discovered, in great number, terminal, lateral and medial moraines in the White Mountain region; that within a space of about two miles he found sixteen terminal moraines; and that many of them are as distinct as any he ever saw in Switzerland.—See also his paper On the *former Existence of Local Glaciers in the White Mountains*. (*Proceedings, Am. Ass. Ad. Science,* Vol. XIX, pp. 161—167, or *American Naturalist*, for Oct., 1870.)

simply of New England, to say nothing of the addition required, on account of the extension of the great ice-sheet far to the north, and perhaps much further southward. I would not intimate that this view affords any exact measure of the single portion of the Ice period now in question, it simply suggests one of the many elements which are to help us in our study of their relative duration. If now it be granted, as I think it should, that the presumed rate at which the ice-sheet moved is perhaps far too great, that its actual movement was possibly no more than one fifth as rapid ; that, as many suppose, the great ice-mass must have been at least 10,000 instead of 6,000 feet thick; that thus the closing Glacial period was 35 or 40, or even only 30 thousand years in length: that the opening portion was as long as the closing, and that the middle equalled, or exceeded both the others,—it is evident, after making every necessary deduction, that the Later Glacial times, in New England, must have been of very considerable duration; and that the facts, as adequately explained, are likely to require a far greater lapse of time than has been ordinarily admitted or supposed.

The *location* of perched rocks may be next considered. This point is deserving of attention, both as requiring an explanation, and as furnishing another element in the computation of time. We have already seen that huge boulders are often found perched on the summits of isolated hills ; and that, in many such instances, they are in far greater number than in other localities of equal area. How came they to be in this position, and why do they occur in such profusion? Not being able to explain these seeming anomalies by reference to any known agency of icebergs, we are to look for another cause. Without dismissing the action of ice altogether, I would ask (since it seems to have played an important part during this period) whether there be any other form, under which it could have led to such an accumulation and deposition of erratics?

Most have doubtless noticed, as they have traversed boggy grounds in the spring of the year, that the ice thaws soonest in the spots which have underlying hummocks. The rays of the sun are attracted to these points; indeed, they seem to concentrate their main force in such places: the heat-rays, as transmitted by the transparent medium, are absorbed by the dark subjacent mould, and thus a speedy melting of the overlying ice ensues. There is accordingly an earlier melting in some spots than in others. Let us now suppose the whole country covered by a glacial sheet: the hill-tops and mountain peaks would be like uprising hummocks beneath the surface of the wintry garment.

Now "ice," to quote Professor Agassiz, "is transparent to heat."[1] Accordingly heat would be transmitted to the underlying rocks. These becoming warm, the directly overlying ice must waste. Such boulders, therefore, as were beneath the melting portion, could not fail to be laid bare, while those upon the back of the ice-mass, and immediately above the summits were likely, as the thawing took place, to be laid down upon them. But more important deposits were to follow. As rear portions of the ice-sheet moved forward, they might occasionally force along into the open space an underlying rounded boulder. Thus advancing, successive parts of the ice-mass would be constantly forced upon the edge of the bared summits; each of these parts must in due time melt, and drop such far-travelled angular erratics as chanced to rest upon them. And this operation was likely to continue, until the gradual wasting of the sheet of ice reduced the level of its surface, beneath that of each mountain peak. When the ice contained an erratic, as the upper portion of the continental mass must have occasionally enclosed a straggler derived from more northern heights, and when it was so situated as to be carried directly upon a given height, we see that it might be readily perched in the isolated place in which it is now found. By this process, if it were long enough protracted, many boulders must at last find themselves collected together, and placed in the strange attitude to which reference has been made. Thus erratic after erratic would be left permanently fixed, the ice not being able again to pass over the summit, and sweep away the accumulated deposits of the many preceding years.[2]

Travelled rocks of this kind are occasionally met with in various parts of the country, sometimes isolated, sometimes thrown together in great profusion. One of extraordinary size and of vast weight may be seen in Whitingham, Vt., on the summit of a hill lying on the east of the valley of the Deerfield, and 500 feet above the river. This huge boulder was evidently transported across the deep valley, and left in its present elevated position by the slowly wasting field of ice. There is another of like character on Hoosac Mountain, 1300 feet above the depression on the west, which it clearly crossed, probably borne along on the surface of the great ice-mass or enclosed in

[1] See *Système Glaciaire.*

[2] "These perched boulders," as Professor Agassiz informs me, "may be seen in the Alps in such proximity to the present glaciers as to leave no doubt of their mode of deposition."

its upper portion.[1] These and many kindred instances, so difficult to be explained in any other way consistently with known facts, thus seem to be perfectly natural, when looked at in the light shed upon them by their supposed connection with a continental ice-sheet, while they also bear witness to the probable lapse of time. Bearing in mind that such boulders are found huddled together, on some mountain heights in great numbers,—that they are, for the most part, angular ; also that there was probably a comparative rarity of these travellers on the surface of the main ice-sheet (for usually there would have been only here and there a straggler, detached from occasional elevations lying to the north) and that only one, out of many, could be borne upon the summits of isolated heights,—we are led to infer, that the wasting of the glacial mass must have been very slow, in order to allow such accumulations of perched erratics to be deposited on lofty peaks.

It is in point next to notice the *formation* of elevated beaches. The old shore-lines, occasionally met with high up the sides of mountains, are perhaps most of all deserving of examination, since inferences have been drawn from them, which appear to be by no means warranted by facts. These curious remains occurring at considerable heights in different parts of the country, and being clearly beaches, it has been supposed that they are ancient *sea*-beaches, and that the ocean once laved these points,—the land having been submerged to a great depth. The time of this supposed depression was the latter part of the Glacial period or during the times immediately subsequent to it, since the beach-shingle invariably overlies the drift.

Now it should be observed that no remains, of undoubted marine origin, have ever been discovered in connection with these water-worn materials, or at corresponding heights in other parts of New England ; we thus have no satisfactory evidence that these beaches were formed by the action of the sea. And yet, where an old shore-line was discovered at Ripton years ago, it was at once announced, and I believe it has been very generally cited since that time, as an evidence of oceanic agency. Indeed, so far as I am aware, it has been almost universally referred to a marine origin.[2] Attracted by

[1] Such as have not time to visit the localities are referred to President Hitchcock's *Geology of Vt.*, Vol. I, pp. 57, 58.

[2] This is the view taken by President Hitchcock, and as I suppose by the several other members of the late Geological Survey of Vt.; (see Final Report) by Professor Hungerford, one of Professor Dana's pupils (see Proceedings of the Am. Ass., for the Advancement of Sci. for 1868, p. 112;) and many other competent observers.

the discovery, I immediately engaged in its investigation. Guided in the study of the facts by the light which they afford, and by the suggestion of Professor Agassiz as very inadequately given by Sir Charles Lyell,[1] I was soon satisfied that this beach should not be thus referred, but must be accounted for, if at all adequately, on other grounds.

This so-called marine shore lies on the western slope of the Green Mountains, nearly 2200 feet above the existing level of the sea. Some miles to the west, there is another height called Hog Back, which is several hundred feet lower than Ripton Mountain. Let us now suppose the whole region covered by a sheet of ice; that it had passed its acmé; that it was already decidedly in its decline. As the ice slowly wasted, the summit of Ripton Mountain must finally come into view. This process going on, we should expect the underlying drift, no less on the western slope than elsewhere, to be to some extent laid bare. The detrital material, which in this place contains a considerable percentage of clay, was suited to retain water. Thus, as the thawing advanced, no break happening to occur in the glacial mass, a basin might be formed in the ice. This could have the mountain slope as its eastern side, and extending westward be there supported by the portion of the ice-mass which rested on Hog Back.[2] A stream, or possibly several glacial rivulets, flowing on the surface of the ice from the north, water would be supplied; while a beach might appear on the mountain side, the drift being washed, its angular fragments rounded, and all its superficial matter sifted and sorted by the glacial lake, as is the case with many an inland shore to-day. Thus we should have a beach, not necessarily oceanic, having sand, rolled pebbles, and other water-worn materials as its characteristics—all these without any marine remains. The ice-sheet wasting very slowly, the icy banks of this glacial lake, after a considerable lapse of time, must disappear. Meanwhile the portion of the shore which rested on the slope of underlying drift might naturally remain to tell to coming ages its weird and strangely-fascinating story of a lake which was once perched high up on the mountain flank, extending out from its side perhaps for miles, hovering in space that is now mid-

[1] *Principles of Geology* (Am. Ed., 1855,) p. 37.

[1] Professor Agassiz tells me that there are many such lakes in the Alps, lying between the glaciers and the rocky walls of the valleys. See also his *Système Glaciaire.* For an account of such lakes during the Ice-period, the curious reader is referred to the paper by Professor Agassiz *On the Parallel Roads of Glen Roy.*

air, suspended as it were between heaven and earth, above the region in which clouds are sometimes wont to float to-day.[1]

A word is required in respect to the cause assigned by those who regard the old elevated beaches as oceanic in their origin, for the entire absence of marine remains. It is said that, while the region was under the ocean, and be it remembered long enough for the formation of distinctive and well-marked shore-lines, the climate was too cold for the existence, or at least for more than a sparse display of organic forms. This reason, which may have seemed valid years ago, surely would not be assigned to-day by a well-informed zoölogist or botanist; for it is now clearly established that even the Arctic seas abound in phases of life—not in the same kinds, but still in given varieties of life—scarcely less than those within the Tropics. And this remark, as should be born in mind, has a broader reference than to the old beaches; it touches an essential defect in the whole iceberg hypothesis. But on this point it is not necessary to dwell, and the same must be said in regard to the lapse of time. Indeed, so much has been advanced in respect to the elements indicative of duration that a single sentence must suffice for this phase of the subject. The condition of the old beaches at Ripton, already considered in sufficient detail, the amount of sand and pebbles of which it is in part composed, and the degree in which they have been worn by water, all suggest that the supposed glacial lake probably existed for a considerable length of time. Their comparatively low elevation shows that the ice was on the wane and thus indicates how slow must have been the wasting of the ice-sheet. Other instances of old shore-lines might be given ; but the single one cited must answer. It may serve to make plain the mode in which some of the other elevated beaches in New England were probably formed, and thus relieve us from the necessity of supposing a submergence of the region to a depth of several thousand feet when it is contradicted by facts, and unauthorized by any substantial evidence.

[1] I ought perhaps to add that the so-called old sea-beaches were formed at different times; that a few of them, like those at Ripton, belong to the Ice-period proper; that some had their origin in what was the early part of the Terrace period in New England, while others took their rise near its close; and that most of them are to be regarded as terraces and not as beaches. Professor Agassiz having spent several weeks in the White Mountains since the text was written, informs me that the "beaches" of the Franconia Notch, and of the White Mountain notch are the most recent with which he is acquainted, *more recent* than the terraces of the Deerfield valley.

We accordingly find in a continental ice-sheet an instrument fully able to plane, smooth and striate the rocky floor of the country as it now appears, and thus to account for the debris in its manifold forms, as almost everywhere encountered in greater or less abundance. The various different phases of the subject, which have been just brought into view—the manifold facts connected with the underlying rocks, with the overlying material, and the incidental phenomena referred to, point by point—while they receive little confirmation from the iceberg hypothesis, while some of them utterly fail of an intelligible explanation in all the light we have been able to get from it, seem perfectly natural on the supposition that they were brought about in connection with glacier-agency. In fact they all, so far as appears, are in every essential respect just what one may presume they would have been, in case the region were at the time covered by an immense mass of ice. And the same is substantially true in regard to the relative duration of the Glacial period. Evidence is already found, and it is constantly accumulating, of a kind and in a way, to show that the time was very protracted ; that it was much longer than has been usually supposed ; indeed, that it was far more extended than even geologists have been generally inclined to believe.

§ 16. *The Dissolution of the Ice-Sheet.*

The time finally came, as we have seen, when the vast mass of ice began to melt, especially on its southern limits, and thus steadily to recede, so as to occupy only the more northern portions of the country. On the whole, however, this recession must have been very gradual, and therefore the field of ice a long time in taking its departure even from New England, to say nothing of the whole northern portion of the continent. The face of the region suggests that there was a comparatively rapid retreat from Long Island to Middletown, Connecticut ; that there a high wall of ice was for a long while nearly stationary; that the next retreat was to Mount Holyoke; that thence, after a protracted halt in that neighborhood, the front of the glacial mass receded to Turner's Falls; that thus by recessions, succeeded by delays, it retreated to Brattleboro, to Bellows Falls, to Charleston, to Windsor, and so on until it reached the neighborhood of the White Mountains, which occasioned a long-protracted rest. Thus there were probably stages of progress, and places of repose; in given instances retreats may have been made by gigantic strides, followed by delays of great duration ; for in some neighborhoods, no doubt, the movement northward was more rapid, in others less so, the ice in many spots, it may be for long years, seeming to be almost at a stand-still. Occasionally, perhaps, it advanced in places for a season, only afterward to retreat; again, after a while, it moved forward, once more in due time to recede, and finally to disappear from a given level altogether. Amidst these various changes, of course, the wasting border would be very irregular; owing to such mutations in broken regions, it might be extremely rugged and ragged; very similar, most likely, to an uneven and deeply-indented sea-coast, on which the ocean is making ceaseless inroads.

Associated with the steadily advancing waste of the ice-mass are two results which claim brief attention in connection with the other phenomena of the Glacial period. They should be particularly noticed since they relate to the deposits specially characteristic of the times, and serve to draw a sharp line of distinction between them. The first pertains to the drift connected with the main ice-sheet. The ice beginning to thaw, the detrital matter, which lay beneath it and is now frequently called typical drift, was uncovered on its southern limits, and in many places left substantially as we now find it. As the melting went on, and the wintry mass retreated, there would be more and more laid bare, and thus brought to light, the great underlying blanket of heterogeneous and unstratified detritus, which had been forming and taking its place all through the great winter of ages. It probably prevailed nearly everywhere beneath the main ice-mass, and is now found spread in one almost unbroken sheet over the country. This properly constitutes the lower or glaciated drift, which I have described as a sort of disguised moraine. It is a vast morainic sheet of glaciated matter, having to a large extent a uniform character all over an immense region, the materials, though of local origin and thus differing mineralogically according to localities, yet exhibiting substantially the same general characteristics, indicative of the widely extended action of ice under one all-prevailing set of conditions. Hence it should be unmistakably clear that Arctic icebergs could not have furnished the material of New England typical drift, since the latter was for the most part derived from the neighborhoods in which it is now found; while bergs of ice from the White Mountains could not have supplied it, for it is a continuous sheet, having a uniform glaciated character, spreading over vast areas lying far to the north as well as extending to the south of these mountains. So, again, on the wasting of the great ice-sheet, whatever of material it bore upon its back would be laid down upon the inferior drift as morainic deposits. The latter, as pertaining to the main ice-sheet, are comparatively limited in this country. They are strictly known as moraines proper. From their position they might be called the upper drift of the main Ice period. Being mostly composed of angular boulders they are often properly termed the angular erratic drift.

The other point demanding notice relates to the phenomena produced by local glaciers. These remnants of the main ice-mass were left in most of the elevated depressions, in which thawing would be tardy. As the great ice-sheet wasted, many streams of ice must have still remained, especially in the high lands, filling isolated valleys, taking their form and direction, doing their work and effecting results according to the lay of the region in which they prevailed. The main ice-mass probably having, as it dissolved, sudden and long retreats, followed by extended pauses, we can at once form somewhat of an estimate in regard to these local glaciers. As the dissolution went on, the time would come when there would be only such ice-streams moving for the most part eastward and westward from the Green Mountains, and in all directions from the White Mountains, and finally perhaps from the White Mountains alone in New England. Of course these local glaciers would in places erode the underlying rocks, efface north and south striæ made at an earlier time, and inscribe instead of them new characters of their own, and bear along a mass of detritus which would in many cases have a direction at right angles with the great continental sheet of typical drift. On the final melting of these isolated ice-streams, the underlying material would be laid bare, in the form of disguised moraines, while the material borne on their backs would find its place as terminal, lateral and medial moraines, and various other phenomena be brought to light, characteristic of the later Glacial times. This view serves to explain the east-west and west-east, and other varying striæ and evidences of smoothing already referred to, also the later drift material which in places overlies the main sheet, and particularly the moraines, terminal and lateral,—which are made up to a large extent of angular fragments from the neighboring heights, and were evidently formed, not by the principal mass of ice, but by local glaciers moving and sometimes radiating from New England hills and mountains.

(II.) THE TERRACE PERIOD,

Which comes next in order, might be called, according to the nomenclature of Sir Charles Lyell, the Newer Plistocene period, and the deposits made during its continuance, the Upper Plistocene formation. The designation adopted, however, is more simple, and on the whole, is perhaps freer from objection than any other. It is true that terraces belong to different times ; that some, as has been already intimated, were formed shortly after the middle of the main Ice-period ; while much of the work, which gives the terraces a striking peculiarity in their appearance, was done at a later day. Still, as the time now to come under consideration was especially characterized by the formation of terraces, it may be styled the Terrace period. Meanwhile it should be distinctly borne in mind that this and the preceding period mutually overlap ; that the local glaciers continue into the New England Terrace period, and were prominent in it; that the terraces extend back into the closing part of the Ice-period, and from it derive some of their characteristic features ; that still, as formations, the drift proper and the terraces are strikingly unlike ; and that generally the latter overlie the former. The terraces being thus superior to typical drift it may be remarked that they are strictly of two kinds, viz., fresh-water and marine ; as such they may be conveniently considered separately.

§ 1. *The Fresh-Water Terraces.*

These generally consist of two parts, (1) of clay and (2) of sand. More usually the clay is at the bottom and the sand above; still they run into each other, to a considerable extent, as was natural from their mode of formation. The clay, especially where it has not been exposed to the atmosphere, is of a deep blue color, and in many localities very remarkable for its tenacity. Many elements, varying according to local circumstances, enter into the composition of the sands, which are greatly unlike as to degrees of fineness and coarseness in different places, and even in the lower and upper portions of the same beds. Thus these fresh-water beds have a distinctive character, and are readily discriminated from the underlying Drift. If we would secure a right understanding of their varying characteristics, we must notice somewhat more in detail their mode of origin.

The summer of the ages returning in the northern hemisphere, the ice-sheet gradually melting and retreating northward, the wasting of the glacial mass would be accompanied by important results. That the thawing of the ice would lay bare what is properly known as typical drift has been already seen. But another effect of no less consequence requires special attention. From the southern border of the wasting ice-fields floods of water must flow, doing a work, part of which still remains to tell its story. While the bared drift was in some instances largely left in its actual condition, in others it was to a greater or less extent worked over, especially in its superficial portions, and in those parts known as moraines, by the waters from the wasting ice. The detrital matter, thus subjected to a new process and in a measure remodelled, took some one or several of the forms under which it is usually known as modified Drift, *i. e.*, Drift which has undergone changes of a more or less marked character. The material of the morainic masses, and of the Drift generally, where exposed, for a longer or shorter time, to the action of running water, would be sifted. The water itself, issuing from beneath the ice-mass, and passing over finely comminuted matter, must be muddy ; moving southward, especially if it came to a stand-still in some depression, it would lay down its burden as a mud-deposit. Having taken up the finest material, it no doubt usually deposited, after flowing to a considerable distance, what is now known as clay. The next finest material might not be transported so far, and ordinarily found its place as half-stratified beds of sand; the coarser being borne a less distance was left in an assorted condition; while ordinarily the coarsest of all could be moved only a very little way, and there allowed to lie in a rough, uncouth state nearly as we now find it. Accordingly clay was likely to be carried furthest, and usually to occupy the more distant depressions; meanwhile the arenaceous portion would undergo less transportation; still even this, in connection with extraordinary floods, might be borne to remote basins, and deposited above the clays. Thus the waters from the wasting ice, continuing to operate for a long while, could not fail to modify the surface, and in most valleys and over broad plains to overlay the typical Drift with one or several of the manifold forms of Drift as modified, to some of which reference has been made. These constitute in large part the fresh-water terraces, which usually slope with the streams along which they for the most part occur. Such is the rule in regard to these beds of stratified or semi-stratified clays and sands.

But in addition to this view of the subject, which is all important to a right understanding of the Terraces, there is another point, which is exceptional and still deserving of attention. Many materials were laid down, even in a more regular form than those just mentioned, and have been, either with the preceding or by themselves alone, very generally regarded as a marine deposit. A few sentences will perhaps make clear the true view of their origin. In connection with the wasting of the main ice-sheet, there was the occasional leaving behind of great heaps of detrital matter, which had been accumulated before the advancing mass of ice. There must have been from year to year, or from one series of years to another, during the Later Glacial times, alternate advances and recessions of the ice-field. Connected with the forward movements, a vast amount of matter would be in many cases pushed forward and heaped up in front of the ice-mass. On its retreat, we should expect these heaps to be left in the form of terminal moraines. In the case of narrow defiles and gorges, the accumulations of matter must, in some cases, have been enormous; and these would remain after the wasting of the ice, remain even after the ice had made a long stage of retreat. Under such circumstances, as we see at a glance, these piles of heterogeneous material must have occasionally served as barriers, as natural dams, checking up the valleys, and forming basins for lakes, broad ponds and wide river-areas. Now the waters flowing, as usual, from the wasting ice in great abundance, were likely to fill the new-formed reservoirs. These waters, issuing from the end of the wasting mass, and working over the material in their way, were necessarily turbid. Passing on with their burden of comminuted matter, they would deposit, in some places clay, in others sand, and these in beds more or less extensive, according to the area of the basins. Of course, the waters seeking the lowest depressions, must all along in their southward course lay down deposits, but most especially where they came to a stand-still. Hence some of the beds would naturally have a southern slope; while usually the most distant deposits, if made in a basin, would be horizontal and consist mainly of clay, this being the finest material, and accordingly most readily transported. It is clear that the waters might make such depositions to some extent, where only a few obstacles impeded their progress, but particularly when they were obstructed by barriers, and thus made to cover broad areas. So it is equally evident that the barriers wearing away, or being from time to time broken down, the waters would have varying levels, and the deposits reach unequal heights at different parts of the progress of the work ; at times, also, blocks of ice, loosened and detached from the end of the wasting ice-sheet, would float off, and act in their appropriate way, on a greater or less scale, in the form of ice-rafts and limited bergs.

In this wise, no doubt, a large deposition was made in places, at many different points in New England. The deposit consists, as may be inferred from what has been said, largely of clay, though in various localities it is of sand; it is also stratified, in some spots very evenly, in others irregularly, on which account perhaps most geologists have regarded it as marine. This formation, along what is now the sea-board, is very readily, (as it has been perhaps by Professor Dana in the New Haven region), mistaken for an oceanic deposit. A similar mistake has been very generally, if not uniformly, made in respect both to the horizontal and the sloping terraces, which occur in the Massachusetts, as well as in the more northerly portions of the Connecticut River Valley, in portions also of the basin of Lake Champlain, and in other parts of the Eastern States. The examination which I have been able to give to the Albany clays, and to the sands in the same neighborhood, disposes me to consider them as largely, if not altogether, of the same age, and of a like origin. A somewhat careful study of the terraces in the Connecticut River Valley, at various points, and particularly at Brattleboro and Bellows Falls, has led me to substantially the same conclusion in regard to most of them. It should be borne in mind that these deposits never contain marine remains, and that some of them also occur in valleys, and cover comparatively broad plateaus, at considerable and greatly varying heights above the ocean. The clay beds, for instance, are found in the basin of Lake Memphremagog, some 775 feet above the existing level of the sea. In a word, these beds if I understand the evidence, are clearly a fresh-water deposit, and should not be accounted, as they more usually have been, of marine origin.

This view gives a somewhat different phase to the matter from that presented by Professor Dana, in that he ascribes the main work of these times to a kind of action which must have been very subordinate at the best, and from the fact that he refers a great deal that was then done to marine agency. He says, "the region was moulded at surface largely by the action of the Connecticut valley glacier and its underflowing streams." This statement being a part of the title of his paper, is supposed to indicate a grand portion of the work. That the region about New Haven "was moulded at surface largely" by the great ice-sheet, is no doubt true; that it was so shaped by a

Connecticut valley glacier, as distinguished from the former, is hardly the fact. Besides, such a comparison is out of place, for it disposes us to look at the subject from a wrong point of view. So it may be surely questioned whether "its underflowing streams" performed so important a work as is here ascribed to them. That the waters from the wasting ice here and there, in some measure, rounded and smoothed any angular stones over which they flowed, is of course true. The very word employed, "streams," implies that they were limited, affecting a small surface, and that they were not broad expanses of water covering, moulding and shaping the whole or almost the entire surface. While willing to admit that they produced their legitimate results in the channels which they occupied, I am convinced that they worked over and modified the drift, so as to give it a stratified form beneath the glacier, only to a very small extent. A prominent tendency of a stream under such circumstances, is to wear, denude and remove. Of course, it would work over, assort, and in places partially arrange such material as lay in its way. It might, and no doubt did take up matter in its entire course, especially from beneath the end, and from the front of the glacier, and bear it to lower levels—to the levels and depressions lying at a distance from the melting ice. In them the stratified deposit would be laid down as we find it; sometimes with considerable regularity, and often very irregularly, because of the thousand breaks and eddies that were sure to occur in such a state of things; also because of the annual freshets, which would carry down large quantities of ice, block up the gorges, raise the water to higher levels in the basins, and thus cause manifold vicissitudes with all their legitimate accompaniments.

The view here presented may suggest the true origin and explanation of some of those irregularities in the stratified beds of sand, which are usually regarded as marine, and are often cited as evidence of varying oceanic currents, of the flux and reflux of the tides, of the antagonism that prevailed in estuaries, between the out-flowing streams of the main land and the in-rushing waves of the ocean. While all these kinds of action occur under their appropriate conditions and relations, and while they produce a great variety of apparent anomalies, I fail to find any satisfactory evidence that they were operative in the formation of the beds in question. Any one who has carefully watched a great freshet in spring-time; who has observed the setting back of the waters of a river, by the damming up of its channel with ice; who has noticed the changes wrought by its occasional breaking away of the ice and its subsequent obstruction by new barriers; who has patiently inspected the phenomena presented in the slow removal of the ice by thawing; who has thoughtfully noticed the successive recessions and advances made in these ways by the water for weeks; and who has afterward studied the deposits laid down in miniature, under such circumstances, over the flats; whoever has taken this course, has witnessed within a small compass some of the conditions and modes of action which were probably prevalent at a former time on a magnificent scale, and has seen the consequent irregularity of deposition, as if in connection with the ebb and flow of the tide, which is so characteristic of some of the stratified glacial deposits. Will one make a study of such freshets, from year to year, as they occur in many New England valleys; indeed, on not a few of the streams all around the globe, in the colder portions of the temperate zones; will he do this remembering that, during the waning power of the Ice-period, there were probably annual flows of far greater volume, tending thus from time to time to elevate and depress the barriers, and prevent a uniform level of the waters; will he also bring to mind such analogous conditions and agencies as naturally suggest themselves to a thoughtful observer, he need have little further trouble with the deposits in question.

If this view be substantially correct,—and whether it be or not, any one may satisfy himself, who will closely observe such action in a limited way, during a New England spring,—it certainly leads us to question much that has been advanced by Professor Dana in respect to those deposits, which he supposes were laid down in part by the ocean alone, in part simply by the waning ice-mass, and in part by the two operating in connection. As a consequence of his supposed subsidence of the land, he says, "unstratified and stratified drift" (the latter including the so-called modified drift, as well as a large part of the "alluvium" of river valleys) "were formed simultaneously, and both in the Champlain era."[1] The connection, in which these words occur, clearly shows that, in the view of the author, the ice-sheet was already largely beneath the ocean, and that the results named were effected under such a state of things. As before intimated, there is no proof of any considerable submergence at the

[1] Paper cited, p. 67.

time in question. It also seems probable that the sea was still somewhat depressed from the great previous evaporation; in other words, that the land really stood, relatively to the ocean, certainly as high as it does to-day. There is thus little or no evidence to countenance the supposition of such a marine deposition. That sediments were laid down, at given points, where the war between the ice and the ocean occurred, is no doubt true; still, if what has been advanced be correct, these certainly had place, for the most part, outside the present dry-land, and somewhere along the outer edge of the existing shoals that girt the sea-shore from Labrador to Florida.

The quotation just made brings to mind what appears to be a misconception on the part of Professor Dana. He evidently supposes that even typical Drift was deposited, nay more, he says it was "formed," in connection with the wasting of the ice-mass. Now it was mainly "formed," and took its place, at an earlier time. For the most part it was simply laid bare as the ice melted. He also seems to imply that the waters of the ocean extended largely under the ice-mass, and that as it melted, there went on beneath it various kinds of deposition simultaneously. That the sea undermined portions of the ice-sheet that lay along what was then its coast, and flowed under them, and that it also extended up some of our lowland rivers at a given period, is undoubtedly the fact. But the portion which may have been thus reached is not a tithe of New England. And that the ocean laved more than this, even at a little later time, I fail to find an iota of evidence. At just the time in question, the ocean, at least in the northern hemisphere, was probably lower than it is now, and did its work mostly outside of the present shore-line. Exterior to this line there was probably a considerable margin above what was the level of the sea, when the ice-mass in New England began to melt. Now the facts, as I understand them, occurred somewhat in this wise. *First*, and constantly, along the edge of the ice-sheet, as the wasting advanced, a confused jumble of matter previously "formed," and now known as typical drift, was brought to light. *Secondly*, beds of gravel and coarse material were somewhat assorted and partially arranged by the waters from the wasting ice. These waters bore the finer and more thoroughly comminuted sands usually to a considerable distance to lower levels, on which, *thirdly*, they laid them down in a stratified, or semi-stratified form, the beds usually sloping toward the south, though occasionally in all directions, while in some cases they were very regular. A *fourth* class of beds consists of clays, which the waters bore still further, and ordinarily deposited on low levels, and at times in basins and depressions which they were made to occupy. Thus modified Drift, or the Terrace formation, would generally occur as deposits overlying the typical Drift and more or less arranged by fresh-water.

What has been advanced suggests that the supposed action of the sea in shaping these deposits, not only in the vicinity of New Haven, but over most of New England as well, is perhaps a mere fiction of the imagination. To render this more evident, and clear up a supposed difficulty, a word or two in regard to these deposits in the neighborhood of New Haven, may be added. Professor Dana says, "in sinking an artesian well . . . 120 yards from the harbor, a bed of fine clay fourteen feet thick was struck . . . 126 feet below mean tide level. Above this clay there were the ordinary sand or gravel deposits of the New Haven region. The clay bed was evidently a mud deposit made in the harbor as it existed immediately before the deposition of the sand; and as the sand beds of the New Haven plain date from the era following the Glacial, the harbor very probably was that of the Glacial era."[1] These points are given by the author as evidence of a previous elevation. The bed of clay or mud just referred to is a sub-aerial deposit, and must therefore have been laid down when the place it occupies was above the ocean. The typical Drift of the New Haven basin having been already laid bare by the retreat of the ice-sheet, this clay-bed was no doubt the first to be deposited upon it, with somewhat of regularity, by the waters from the wasting ice lying a short way to the north. It was a mud-deposit—perhaps a broad mud-flat—and may have covered most of the basin. Remembering now that the surface of the ocean, when the ice-mass had retreated no further north than Meriden, was still much lower than afterward, say 150 feet beneath its present level, we readily see that in connection with the wasting of the ice, such a sub-aerial clay deposit would naturally find place in the lowest depression. And this could be the case without any elevation of the land. So the deposition of the sand which overlies the clay might readily, and I have no doubt did actually occur, in connection with the subsequent wasting of the ice-sheet, there being perhaps occasional times of great flow, and slight changes in the direction of the currents, of the glacial streams. We may thus conclude, without repeating the evidence in this place, that these deposits are just what

[1] Paper cited, p. 61.

should be looked for as results of the wasting ice-sheet—results which might legitimately occur, without assuming a previous elevation to account for the former, or a subsequent depression in order to the latter.

Similar deposits are found at different levels all the way up the Connecticut valley. They usually have a slight inclination toward the south, and present just the features one might expect to meet with, in case they were formed by the waters flowing from the wasting ice-sheet. Indeed, beds substantially the same in appearance and structure may be seen in most of the valleys of New England. These, in the majority of cases, slope with the streams; but in some instances, they are horizontal; thus, with other indications, affording evidence that there were at certain points obstructions, which gave rise to ponds and lakes, and so to a series of regularly stratified deposits at various heights. They are occasionally found far up among the mountains. One in Eastern Vermont occupies a basin on the Deerfield river, and is at least 1,200 feet above the sea; there is another on a branch of the Deerfield, in Hartwellville, which is 1,700 feet above the ocean. This is the highest river terrace with which I am acquainted. But there are other terraces, essentially the same in structure, which are still more elevated. Among these may be mentioned those of Franconia Notch, and of the White Mountain Notch, the highest of the latter being about 2500 feet above the existing sea-level. Thus there are terraces, between the ocean and the last mentioned height, in large numbers, and at greatly varying elevations. Scarcely two being at the same level, it seems surprising that their formation should have been referred to marine agency, especially as that of the highest would require so great, and utterly unproved, submergence of the land. Without dwelling, however, upon the points of objection which suggest themselves, let me sum up in a word:—above the typical deposit of the Ice-period, which covers New England, there is found in manifold forms what is known as Modified Drift, consisting (1) of very coarse and slightly arranged material—of drift from which the finely comminuted matter has been washed—(2) of coarse gravel assorted and rudely stratified, and (3) of the distinctly stratified clays and sands, usually designated as terraces. And all these, with other more or less varying kindred deposits, have just the characters one may presume they would have had, if formed, as they undoubtedly were, in connection with the wasting of the great ice-sheet.

§ 2. *The Marine Terraces.*

There are along the seaboard in this region, and in some more inland localities, certain stratified marine deposits, which are very distinct from the unmodified subjacent drift. In the basins of Lake Champlain and of the River Saint Lawrence, these beds are peculiarly well exhibited. They consist (1) of a fine blue clay, and (2) of overlying deposits of brown clays and sands,—the sands and clays seeming to be interstratified, and together to constitute a single distinct formation. These deposits constitute the marine terraces of the Newer Plistocene period, named Laurentian by Desor, and so called by many who followed up his investigations, though they are now frequently designated as Champlain. From the occasional presence in them of a little bivalve, the lower beds are often termed the Leda clay formation; for a like reason, the superior deposits are well known as the Saxicava sands and clays. In the underlying blue clay, which contains few organic remains, I have found in Maine, Western Vermont, and in Canada, *Leda portlandica* and *Astarte laurentina.* The evidences of life in the Saxicava beds are far more abundant. Mollusks, fish, and mammals are represented. In the basins of Lake Champlain and of the St. Lawrence, some twenty species of marine shells have been found; also the remains of seal, and of one or two species of whale.

As has been already intimated, the mountain of ice that spread over the country, from six to ten or twelve thousand feet in thickness. may have occasioned a slight depression of the land. Again, as heretofore hinted, the formation of such a mountain plateau of ice must have drawn heavily upon the ocean, and reduced it to a very low level. Meanwhile the attraction of this vast and elevated continent of massive ice would tend to draw the remaining waters of the sea in this direction; still its level, relatively to that of the land, was probably, before the ice began to melt, somewhat lower than it is to-day. But afterward, as the thawing went forward, the ocean must gradually rise, and, the continent for a while keeping its old level, cover some parts of the sea-margin which are now dry land, also extend up the low level valleys, and fill them with salt or brackish waters. Of course, under such circumstances, a deposit would be laid down on the portions covered by the sea. This might rest occasionally on solid rock, where this chanced to be bare; occasionally on typical drift, and in some places on the fresh-water terraces already considered. Such, if I mistake not, is substantially the mode in which the marine terraces were formed. Whether there were a previous slight depression of the continent, or not, of course the sea relatively to the land must have been somewhat higher than it is to-day, in order to deposit these strata.

Now, according to Prof. Dana, there was a very extensive subsidence embracing "a large part of the continent."[1] On what stable ground such a statement can be made to rest, I have up to this time failed to discover. So far as trustworthy evidence goes, this depression, if there were any, was very small in southern New England. In Brooklyn, on Long Island, a few sea-shells have been found in beds belonging to this period, some thirty feet above the ocean. In Boston and its vicinity, similar marine remains occur in this deposit. They attest that the sea, relatively to the land, was formerly somewhere between 50 and 100 or 125 feet higher than it is to-day. Diligent search, renewed at intervals through a long series of years, has failed to reveal to me any satisfactory proof of the presence of the ocean, during the terrace period, either in the Mass., or in the Vt. and N. H. portions of the Connecticut River valley. The same is true, so far as my examination has extended or I have been able to learn, of the North River basin above New York. In Maine, at Portland, and in other parts of the State, along the seaboard, also at Lewiston and in several other places a short distance inland, there is positive evidence of a relative change of level. It must have been, in given localities, about 200 feet. I have found marine remains peculiar to the period, in north-western Vermont, at a height of 430 feet. Similar remains occur on Montreal Mountain, about 460 feet above the ocean. It is said that, very far to the north, though on the border of the sea, there is evidence that the relative change of level has been much greater. Meanwhile a careful examination of Geological Reports, and an attentive scrutiny of the superficial deposits, at a great number of points between Eastern Canada and Minnesota, have failed to afford me any evidence of recent marine remains to the west of the meridian of Oswego, N. Y. Such is substantially what is known of the matter in all this region; indeed, I am aware of little additional evidence of relative change of level, or of what some regard as a continental depression.

It thus appears that a small part of New England, with a very limited portion of Northern New York and of Canada, were slightly be-

[1] Paper cited, p. 66.

neath the sea, during more or less of the Newer Plistocene times. Beyond what has been given, little additional proof of a satisfactory character has been found, either as to the superficial extent of this relative change of level, or as to its vertical amount. The degree of this change seems to have been greatest toward the east and the north-east. Whether there were a uniform increase in that direction is doubtful; exact known evidence of such increase has been, up to this time, evidently wanting. The utter failure to find recent marine remains at a distance from the sea, in Southern New England and New York, for instance in the valleys of the Hudson and of the Connecticut, while they occur in great abundance in the portions of the country certainly known to have been invaded by the sea, as the basins of the River St. Lawrence and of Lake Champlain,[1] is at least presumptive evidence against such a supposition. Now the only safe ground on which one can advocate a subsidence is that afforded by positive evidence of the presence of the sea. And of this there is none, beyond what has been virtually given. On what basis, then, has the supposition of so broad a submergence really rested? First, on the false presumption, that what is really true of one thing is necessarily true of another, which has some resemblance. Marine remains having been actually found in *certain* stratified beds of clay and sand, *all* other beds of about the same age which seem, and in points are, somewhat similar, have been regarded, without proof and in spite of evidence to the contrary, as of marine origin. Another consideration has perhaps exerted an unconscious influence in the production of this result. I refer to the necessity of getting rid of unauthorized hypotheses, after they have served the temporary purpose for which they are devised, lest they prove an incumbrance. Thus, in the present case; after the assumption of a continental elevation, with the view of accounting for one class of facts,—after the land has been lifted up in imagination, as it has been by so many geologists,—it was necessary to suppose a continental depression; the continent must be got down again, in order to the explanation of another set of facts, and in order that it may be brought into the position in which we now find it.

[1] As an evidence of the extraordinary prevalence of Plistocene marine remains in the valley of Lake Champlain, I may add that I have found them in every Vermont township bordering this body of water, between Orwell and the Canada line; also at an almost equal number of localities on the western shore, between Ticonderoga and Rouse's Point; likewise, and sometimes in great profusion, on very many of the islands that stud the surface of this charming lake.

According to Professor Dana, this subsidence which closed the "Glacial era" was the initiatory event of the next or Champlain era;[1] in other words it was a preparation for the Terrace period, the marine part of which is now under consideration,—a preparation for the laying down of beds which are sometimes called Newer Plistocene. That there should have been a slight sinking of the land, resulting from the weight of the ice, and thus perhaps a beginning of depression before the close of the Glacial period, is not unreasonable to suppose; and it may have occurred; still I find no positive evidence that such was the fact. In case a submergence were really initiated, the downward movement must have been slight in the Glacial period, while it would no doubt cease with it. That the drift was to a great extent established as we now find it, and that thus the ice had already melted above such portions of it as are now covered by marine strata, before their deposition, seems probable[2] from the general relations of the beds. So far as I can judge, after an attentive study of the matter in neighborhoods containing unmodified drift and marine deposits, the latter overlie the former without any intermixture. There is a strong line of demarcation between them; there are also various indications that, in given localities, the earlier work was ended before the later was begun; that the main mass of drift occupied substantially its existing position, before the waters of the ocean came in and began a distinct deposition of stratified material. Exceptions along the seaboard are not denied; there may have been many such; I only claim that cases of this sort should be regarded, as they really are, as exceptional, and not as constituting the rule.

But there are other localities in which sedimentary marine deposits of clay and sand rest, not directly on typical drift, but on other stratified beds which not only contain no marine remains, but lie next above the drift proper. Now what is the age of these interlopers—of these intermediate strata—which are as clearly above the unmodified drift, as they are beneath the unmistakable marine deposits? In

[1] Paper cited, p. 66.

[2] Professor Agassiz, in a recent conversation, suggested the following view of the matter;—"The ice-sheet may have receded to the present outlines of the continent, and been undermined by the ocean to the extent of the theoretical depression. The glaciation of *all* our shore islands shows how much beyond the present outlines of the continent the ice once existed. And the Arctic explorers have made us familiar with the great amount of animal life that animates the sea below the heavy ice-covering stretching over its surface."

parts at least, they are, as already intimated, terraces of fresh-water origin. They consist sometimes of clay, sometimes of sand, while occasionally there is a blending of the two; their stratification, although irregular in places, is generally distinct, and they were doubtless laid down by the waters which flowed from the wasting ice-sheet. The places they occupy were usually low plains, though in some cases they were the basins of ponds and lakes, which must have been very abundant during the later Glacial times; while often they were simply mud-flats and sand-flats, clay and sand being deposited in different parts according to the varying conditions prevalent in the neighborhood. Directly below them unmodified drift may be usually found; immediately above these fresh-water terrace beds there occur in some localities the marine deposits of the terrace period. Thus, of course, where clay rests upon clay, or sand upon sand, and there are no other indications, it is difficult to discriminate between them. But in many cases each set exists by itself, the one in places holding marine remains, and the other never, and so situated that there need be no reasonable question as to their respective modes of origin. This point having been worked out by patient observation in favorable localities, it has been my aim, so far as I have had opportunity and leisure for the work in new neighborhoods, to seek for the means of discrimination between these intermediate beds, which at first sight often seem to be identical, or at least of substantially the same age. In this direction an important task of discrimination still remains to be prosecuted in many parts of New England, upon the superficial stratified deposits lying between the level of the ocean and five hundred feet above it, and specially upon such as occur along the seaboard.

In the light of what has been advanced, I venture to suggest that many stratified deposits which have been regarded as oceanic are fresh water beds of the Terrace period, while these are here and there overlaid by true marine strata characteristic of the later portion of the same times. Thus, not a few beds which Prof. Dana calls Champlain (marine) are no doubt of fresh water origin, and were deposited toward the end of the Drift, or in the early part of the Terrace period. This is the case in various different sections of New England, and perhaps more particularly in the New Haven region. In the superficial formations occurring in and about the latter place, as Prof. Dana admits, no marine remains have been found.[1]

[1] Paper cited, p. 87.

In addition to these older beds there are possibly others lying in patches, in the same neighborhoods, which are of marine origin. Still, without special and probably long-continued examination of these deposits, it would be plainly out of the question to indicate just how much of them is due to fresh water agency, and how much, if any, to oceanic. So long as there is no positive evidence the presumption is that they are not marine. Substantially true is the same in regard to the stratified superficial deposits along the coast of Massachusetts, New Hampshire and Maine. In fact, on the sea board generally it is often exceedingly difficult, in some cases perhaps utterly impossible, if no organic remains be found, to draw the line of demarcation between these beds. Thus, as should be evident, the respective characters of these strata cannot be determined when they are simply looked at theoretically; they will by no means yield up all their secrets, if they be merely lumped off in mass. Because one is sure of the origin and use of certain layers, for instance in Maine, he having studied them critically, as they are seen in place, it does not follow of course that he knows the exact age and character of others in Massachusetts, Rhode Island, or Connecticut, simply because they happen to be Post-Tertiary and stratified. The several deposits in different localities can be known, only as there is close and accurate observation of each of them, in their respective places of occurrence. In the basins of Lake Champlain and of the River St. Lawrence, in Southern Maine and in Eastern Massachusetts, both kinds of beds occur. In some cases their discrimination is easy; while in others it is very perplexing to attempt, if it be not entirely beyond one's power, to determine with certainty to which series a given deposit belongs.

As to the length of the Newer Plistocene times a few hints should be given. The fresh water terraces, which in some localities are of considerable thickness, must have been a long time in forming. But how far these are synchronous with the marine, and how far the latter are posterior to the former, it has been impossible thus far to determine with accuracy. And as respects the two sections of the marine deposits there is still not a little doubt. The Leda clay has been usually regarded as a deep sea formation, since it holds pelagic specimens in small number. While Foraminifera, (to take what are considered as the most conclusive indications in this direction,) are characteristic of deep waters as a rule, they are yet occasionally found in those which are comparatively shallow, as, for instance, in

Boston Harbor to-day. I am accordingly disposed to recognize the blue clay in this instance, at least until further evidence is found, as a deposit made in water by no means deep, the localities containing the so-called pelagic remains being simply an arm of the sea. Thus, while an elevation followed by a depression is perhaps conceivable, furnishing another considerable element of time, I am indisposed to accept it without more satisfactory proof.

With the Saxicava clays and sands the case is somewhat different, or, at least, there need be no special doubt in regard to the main points connected with their deposition. They probably took their places when the region was nearly at a stand-still, or, it may be, in connection with a stand-still at a little lower level and a gradual elevation which followed. The thickness of the beds shows that the period of their formation must have been of considerable length. But the estimate of its duration must be greatly enhanced by the fact that the beds contain littoral shells in great profusion, and that those holding such organic remains were accordingly laid down within the sweep of the tide. One of these beds, which occurs in Swanton, Vt., at about 120 feet above the ocean, is some eighteen feet in thickness, and composed almost entirely of shells belonging to mollusks which live only along the shore. It therefore must have been a very long time in forming, for the shells are mostly perfect, while there are many indications that the animals lived and laid down their calcareous coverings where they are now found, slowly building up the shore for countless generations, as it stood still while the waters rose above it, and afterward as they retired, perhaps itself rose insensibly from beneath the sea. But this is only one instance, and at a given level. There are many similar cases at greatly varying heights through a range of some four hundred and sixty feet, at each one of which the land was long enough at a stand-still, for more or less extensive beds of littoral shells to be laid down. Now, making the shortest reasonable estimate of the time occupied in the deposition of the Leda clay,—remembering that the Saxicava beds are a shore deposit,—that thus two of these beds at different heights could not have been ordinarily formed at the same time,—that such beds in great numbers were deposited, one after another, in long succession between the existing sea level and the height of some four hundred and sixty feet,—and that there are beneath these marine terraces other deposits of a fresh water origin, which must have been a long time in forming,—we can scarcely escape the conviction that the Upper Plistocene beds afford elements indicative of a vast lapse of time.

V. THE HOLOCENE TIMES.

This name, of course, indicates that all the fossil mollusks (not Vertebrata) found in the deposits which were laid down during their continuance belong to recent species. As the term Plistocene (or Newer Pliocene) has been for the most part restricted to the Drift, and the stratified beds of clay and sand which overlie it, (for it is so employed by Sir Charles Lyell.) it may be here added that Holocene as here used answers very nearly to the "Post-Pliocene" of the same author, and thus extends to the beginning of recent times, as "Post-Pliocene" is made to do by its proposer. These times answering to certain beds of marl and peat, and representing them, may be conveniently divided into two parts, and considered in their natural order of succession.

§ 1. *The Marl Period.*

This is equivalent to what might be called the Older Holocene times, and is characterized, as its name suggests, by the extensive deposits of marl, which were largely made during its continuance. While the formation is in marked contrast with both typical and modified Drift, the period itself is not sharply separated from the preceding, as we should by no means expect it would be. These marl beds owe their origin to large accumulations of shells made in the fresh-water ponds which abounded during this period. So soon and so fast as the land was freed from its ice-covering, such ponds almost everywhere came into existence. The disguised moraine, which had been concealed by the great ice-sheet, being laid bare, a very uneven surface must have come into view. This answered to the bottom of the glacial mass, which no doubt was very uneven because of the rough, hilly nature of the region over which it moved. Now this bottom moraine consisting largely of clay, in which pebbles and sand were indiscriminately mingled, was generally well suited to retain moisture. Accordingly water would accumulate in these depressions (in fact, in all depressions fitted to hold it, whether they were more or less due to the erosion of the underlying rocks) from the moisture in the atmosphere and the continued melting of ice still lying further to the north. Such basins as were calculated to retain the water which flowed into them, might be filled, and hence there would be ponds and lakes. These overflowing, and the water taking its natural course, outlets must have been formed, and channels gradually chosen and worn. These would become the beds of rivers, flowing upon typical drift, and occasionally laying down terraces along their course, which were in most instances cut through in due time by the streams that formed them. In this way, no doubt, many ponds and lakes came into existence. And their great prevalence must have been a striking feature of the region, at the time in question. They probably originated in great abundance, on the wasting of the ice-mass, and were associated with the deposition of terraces; and they evidently continued into the period now under consideration, and became one of its marked characteristics. They would be very likely to appear in the depressions of the drift, especially when deposits of clay were first laid down as a lining fitted to form an impervious bottom.

It is not probable that animals peculiar to the time at once made their appearance. Some preparation was needful. The ponds which had been in existence during the terrace period and continued on into the one following, if inhabited while the cold was still considerable, would be suited to different forms of life, as a temperate climate began to prevail. At last, however, as the record tells us, creatures came which were of a kind adapted to the changed conditions, and prepared to bear their part in the work of the period. Thus appearing in due time upon the stage of action, they finally swarmed in all the ponds and lakes of New England. And they have left an evidence of their existence in the individual structures they reared—structures which were at once their houses, and a genuine portion of themselves,—and in the extensive deposit which was largely formed of them. Reference is made to the fresh-water mollusks, the testaceous remains of which are now found in the beds that were once filled with water, and tenanted by these living creatures. These mollusks belong principally to the genera, Cyclas, Lymnæa, Paludina, Physa, Planorbis and Pupa; while the marl beds, which are made up of their calcareous coverings, are from a few inches to eighteen feet in thickness.

As marl was perhaps the predominant deposit of the time now under consideration; as it prevails more or less extensively, in places, over nearly all New England; as it was laid down not only above the Drift but also above the Newer Plistocene beds, in many localities in which these occur; as it is thus a marked feature of the older Holocene portion of the Post-Tertiary era, it may be perhaps with propriety termed the Marl period; for marl is the most abundant and characteristic formation now known as a product of those times.

Although such remains continued to be laid down at a later day,—though they find place in limited quantities even in the present,—their deposition has been comparatively small ever since the Marl period proper came to a close. At about this time, lakes and ponds in great numbers were undergoing a change. They had come to be to a considerable extent filled; while bogs and morasses, in a large measure, took their places. Accordingly there is a more recent deposit, which we find in many places, lying above the marl beds. The instances exceptional to this statement are so few as to be scarcely deserving of notice, unless it be for their rarity, and the light they are calculated to throw on a predominant process of an earlier day. We thus see that the way was gradually prepared for a change in the prevailing order of things.

§ 2. *The Peat Period.*

Answering to this designation is what might be termed the Newer Holocene. The ponds and small lakes, which at an earlier day evidently prevailed in great numbers, having been gradually filled, the life with which they had swarmed would cease to be predominant in them, since the requisite conditions were wanting to its support, in its pristine exuberance and vigor. This change we should not expect to occur everywhere, at precisely the same point of time ; while, in some cases, ponds and lakes would remain to a considerable extent unfilled. Thus, in isolated instances, the conditions might not be materially different from what they had been, and fresh-water mollusks no doubt continued to flourish in restricted areas. On the whole, however, there is evidence of such a change as has been referred to. After its occurrence, and in connection with it, morasses, swamps and bogs came to prevail very extensively, and with them the manifold growths peculiar to such a state of things. These were various species of sphagnum and several other kinds of swamp mosses and plants. There would accordingly be laid down, as time passed on, large quantities of vegetable matter—broad and thick accumulations of bog-mosses that grew, and from generation to generation took their places as deposits—which are now known as peat-beds. These, in many cases, cover extensive areas; ordinarily they are more remarkable for their frequency, than for their superficial extent; while they usually vary in thickness from a few inches to some twenty-five or thirty feet; they are known in rare instances to reach sixty feet. Thus the growth must have been exuberant. Peat, consequently, being the predominant deposit made in New England during this portion of the Post-Tertiary era, the time may be conveniently and with fitness designated as the Peat period.

Ordinarily overlying portions of these vegetable beds, and in most instances overlaid by the superior layers of the same series, there is another deposit which is met with in given localities. It occurs extensively in New England, especially in some parts of Eastern Vermont, and particularly in Peacham. Although this deposit is usually spoken of in connection with the marl-beds, and while I am not aware that it has been referred to an exact horizon, I am disposed, in view of its apparent position, to regard it as belonging to the period now under consideration. The beds are largely composed of silex in minute particles, and are from one or two to five or six feet in thickness. For the most part, the material was derived from the silicious shields of certain microscopic animals known as infusoria. This deposit being formed gradually, and almost entirely of the flinty bucklers of these animalculæ ; as they from generation to generation passed off the stage of existence, and a single cubic inch, according to Professor Bailey, containing the remains of some 15,-000,000,000 individuals, we see that this kind of life was necessarily very active during the period of its continuance, and that it must have lasted for a considerable length of time, in order to the deposition of such masses of silicious earth.

It is usually in the peat-beds, and often at the bottom of them, that the remains of the mammoth or fossil elephant have been met with in different parts of the country. They have been found so far north as Vermont, and even in several portions of Canada. On this account, the time might be properly designated as the *mammoth* period, several species having been peculiarly abundant during its continuance, if one may judge from the fossil remains that have come to light.

A few words must suffice as to the duration of the Holocene times. The length of the marl period, or of the Older Holocene, must have been considerable, if merely the marl deposits be taken as the basis of computation. Prof. C. B. Adams, referring to the time probably occupied in the formation of a marl bed in Monkton, Vt., which is about ten feet in depth, and saying, "a long series of years is required to furnish shells sufficient for a single layer," adds: "twenty thousand years is a very moderate estimate," and the time "is more likely to have exceeded this many fold."[1] So the Peat period, which brings into view the sphagnous moss deposits, as well as those of infusorial silica, could not have been of short duration. Taking not the thickest beds as the standard, but one of twelve and one half feet, and allowing that there was each century an average deposition of half an inch of compacted matter, we have thirty thousand years as the duration of the time. Accordingly, if we remember that marl of the Older Holocene period is found some eighteen feet thick, and that there are Newer Holocene beds of peat from twenty-five or thirty to fifty and sixty feet in thickness, exclusive of the infusorial deposits, we see, after making all necessary deductions, that the Holocene times, instead of being a mere cipher, represent a work, or rather a series of works, which could have been accomplished only by processes not a little protracted. As a moderate estimate, therefore, the two periods may be regarded as fifty thousand years in length.

VI. THE RECENT TIMES.

The growth of swamp-mosses so characteristic of the Newer Holocene period in New England, did not entirely cease with its close. Both this and the deposition of marl have been continued to the present, only on a far more limited scale. Species of sphagnum and of affiliated plants had flourished and taken their places as deposits, to such an extent that the majority of the marshes, bogs and swamps were in a large measure filled with their remains. Thus these growths and their consequent deposition no longer played so important a part in this region as they had at an earlier day. Most of the depressions having reached a given level, the predominant conditions were no longer favorable to sphagnum; other and larger vegetable growths intervened, in the end gigantic trees and huge forests stood where once water plants alone, or for the most part, prevailed.

And these did their work, and they have continued to do it, even up to the present hour. By alternate growths and decays, or rather by a long succession of these natural processes, many depressions have come to be more elevated. This operation no doubt went on, so that in not a few instances, even in places which once were ponds, and afterwards marshes, many successive generations of deciduous trees made their appearance and passed away before the time was reached of which we have any distinct tradition. The sea had long before retired; for the most part the marl beds had been finished in

[1] *Second Annual Report on the Geology of Vt.* (1846,) p. 14?.

a remote past; peat had been deposited in great abundance in many portions of the country; the mammoth, so far as we know, no longer roamed the forests; while new animals had been introduced, the same perhaps that prevailed in the region, and were found in it to a great extent, when it was first visited by Europeans.

Just when human beings were introduced we know not. That they actually appeared, and were here at an early day, is evident beyond a question. Of the existence of "aboriginal man" in Connecticut Prof. Dana finds proof in the shell heaps, which occur at various points along the shore. These remains, as he says, "often lie directly upon the brown or yellow sand or gravel of the drift formation, evincing that the Indian inhabited the plains before the alluvium had been covered with, or converted at top into, soil. . . . They carry back the appearance of man in the region to the commencement of the Terrace"[1] period. Let us look at these words that we may see just what they legitimately imply. The "gravel of the drift formation," on which these shell heaps are occasionally found, needs no further comment. Substantially the same is true of the accompanying "brown or yellow sand"; it is sometimes known as modified drift, and is usually a terrace formation, in the restricted sense of the word "terrace." In the vicinity of New Haven these deposits were already in place at the close of the Ice, or in the early part of the Terrace, period. No valid proof has been as yet discovered that any marine terraces were laid down in the New Haven region. Thus, so far as satisfactory evidence goes, the shell heaps appear to rest, for the most part, if not altogether, on deposits of the closing ice, or of the earlier terrace times. But more than this; they lie directly upon them; they were placed where they are found, before the surface of the modified Drift had been converted into soil — before vegetation had to any great extent, or for a very long while, clothed the land after the Glacial period. Accordingly, there being no evidence that the New Haven region was submerged, none that it was not above the ocean at the very opening of the Terrace period, we see that these traces of man may, and, so far as we can judge from their position, actually do reach back almost to its beginning.

But how long ago was that? I answer, I do not know. Still if any one be curious to examine the evidence, which has a bearing on the question, I would refer him in part to the elements already suggested, and from point to point hinted at, in this paper. These may

[1] Paper cited, p. 108.

be briefly recapitulated, for it is not needful now to take them up in detail. Recalling the time requisite for the depositions made in the Newer Plistocene times; the work done in the two stages of the Holocene, viz.: that accomplished in the Marl period and that in the Peat period; also what has been effected since the recent times have come in; we are enabled, after making such allowances and exclusions, as a reasonable view of the facts may dictate, to form some estimate of the relative length of the era which has been in progress, since vegetation made its appearance on the brown terrace sands of the New Haven region, soon after no doubt to be followed by man. Simply allowing twenty-five thousand years for the Marl period, and the same length of time for the Peat period, we have fifty thousand years,—all this duration, while taking account neither of the Recent nor of the Terrace period, which was probably not a little extended. There is much other proof, and some perhaps of a far more striking character, furnished by different sections of the country. I have, however, preferred to confine myself to some of the more salient points of evidence furnished by this region. And I have been the more disposed here and there to gather up a hint in this direction, since Professor Dana seems largely to ignore the matter, as if he would have it inferred that all that has taken place during the Post-Glacial times could be readily compressed into a few thousand years. In saying this, I would not insist that an immeasurably long time has necessarily elapsed; one needs to guard equally against both extremes; or rather, it is better not to be over-anxious, as to whether the time has been long or short, but mainly desirous to read the facts as they are, and thus to get at the truth.

One word more on this point and I have done with it for the present. Prof. Dana in substance asserts in the extract last made, that the shell-heaps evince that the *Indian* inhabited the plains before the land was covered with soil. If by Indian he mean the Red Man, whose home was in New England, when North America was discovered and from time to time visited by Northmen, and afterward rediscovered by Columbus, many no doubt would question his statement. Does he, however, use the term loosely and in a general way, as synonymous with the expression "aboriginal man," employed by him on the preceding page,[1] no question need be raised. It now seems probable, if not clear beyond a doubt, that the Red Men were not here in the Terrace, or the Holocene period, and that thus we

[1] Paper cited, p. 104.

are not able to trace their lineage back to a time so very "old and hoary"; that, while there were Aborigines in the land long, long ago, the poor Indian was only their remote successor. The shell-heaps, the various mounds, the arrow-heads, the stone-hatchets, the earthen ware, the utensils used in netting and weaving, with the many other implements indicative of human agency, clearly show that not merely a race of Indians once occupied New England, but also that human beings preceded them, certainly one race, possibly several, some of whom were more elevated and refined than the well-known Red Men of the forest, who are often spoken of, if not as indigenous to the soil, as at least the first inhabitants of the country.

The survey now made of some of the ground occupied by Prof. Dana suggests a few closing impressions.

For these the way is in a measure prepared, since there have been passed in review many of the more prominent points comprised in the Post-Tertiary History of New England, as exhibited both in the field-book of her hills and valleys, and in the paper under examination. Details have been also given with as much fulness as the prescribed limits of this essay have allowed. Meanwhile such explanations have been thrown in as have been suggested, either by previous studies, or by the present examination of some of the more characteristic facts. Thus inferences naturally flow from the various enquiries that have been in progress.

In the first place, Prof. Dana's views of the Post-Tertiary era in New England seem to be in a considerable measure partial and inadequate. In the opening paragraph of this paper, reference was made to the favorable opportunities he has enjoyed for the geological study of the vicinity of New Haven. In examining his contribution, I have found repeated evidences of his careful observation of given series of facts. Meanwhile there are other points—additional considerations of no less moment—to be borne in mind. Although the minute study of a given neighborhood be of the utmost importance as one element toward the right apprehension of geological phenomena, it still should be remembered that this is only *one* of the many elements needful to a complete view; that it by no means necessarily brings to light the whole truth; that by itself alone it almost unavoidably leaves the student in partial darkness, and so with a distorted understanding of nature. Thus, it is not enough to study a single locality and merely explain it according to some "book-theory," no matter how profound, how able or learned in other respects its author may be. So it will not always do for one to interpret the features of all, or even of any other localities, by what he may happen to know of some limited vale. Indeed, many peculiarities of each well-trodden district can be in most instances better explained in the light which comes from the careful investigation of more perfect examples furnished by some other neighborhood, or of various classic fields combined. This must be clear, since no single area can be ordinarily expected to supply type-characteristics of all that we may wish to study within its bounds, or even of the manifold peculiarities which it is desirable to investigate, in any given line of research. These thoughts are suggested by what appears to be a fact in regard to some of the generalizations in the paper under review. The question naturally arises whether the author has not interpreted the glacial features of his own vicinity mainly according to what he has found in "the books;" whether, again, he does not to a considerable extent describe the country at large in the light in which he thus sees "the New Haven region"; and whether he might not understand even New Haven and its environs very differently, if he were carefully to study many other portions of New England, in which some features of the Post-Tertiary times have a better exhibition than in any seashore neighborhood: while they are comparatively free from certain obscurities and perplexities, which the vicinity of the ocean makes doubly uncertain.

Again, Prof. Dana's views of the Post-Tertiary era in New England seem to be in many points erroneous, and thus misleading. On such a subject as Geology no one, it is true, can know everything from personal observation. This needs ever to be borne in mind; at the same time what is not understood with certainty ought not to be published as trustworthy. Now the question may be raised whether the writer of the pamphlet under consideration has not erred in the direction suggested; whether much that he has expounded be not at least questionable: whether many of his positions be not clearly erroneous. Let me cite an instance. In teaching that glaciers, breaking, take up into themselves, and become engorged with, the detrital matter that is abraded from the underlying rocks, does he not misapprehend the nature of such ice-masses? and does not this single misconception lead to others, such as, (to mention one only,) that drift is not deposited until the glacial mass in melting disgorges the detrital matter it had before engorged? But enough; this example must plainly show that some of the Professor's statements are erroneous, and that some embody but partially the whole truth. He theorizes with all boldness, and he utters his theories often with apparently too little regard to facts. He has evidently failed to work out many Post-Tertiary problems on which he discourses, by a steady search after the truth; by an unwearied questioning of the facts, as they may be seen in the great field-book of the naturalist.

But this suggests, and leads me once more to remark, that Prof. Dana's views of the Post-Tertiary era in New England seem to be largely theoretical and formal. I do not object to hypotheses; I would not exclude theories, when there is any ground for them: I would only require that speculation be confined to facts, and in no wise allowed to outrun them. But when it is mere theory, either virtually apart from facts, or altogether without them, the case is different. As an instance, take the doctrine of Elevation, as applied by Professor Dana to the Ice period. So far as I can make out, it does not rest either actually or legitimately on a single fact. Thus I fail to find in his statements real and substantial expositions of the essential truth of nature, genuine settings forth, and so true representations of the actual processes which the manifold facts at once witness and symbolize. Seen in this light, his view of glaciers and of the Ice-period generally, is very inadequate and altogether unsatisfactory. Finding the iceberg hypothesis untenable, failing to get help from the theory of wave translation, seeing that much could be theoretically explained on the supposition of an immense ice-sheet, he appears to have boldly adopted, without having mastered, the latter view. Indeed, his adoption of it, as almost every page of his paper shows, is on negative grounds, and not from a thorough and exhaustive understanding of the practical working of the principles involved. From such an apprehension of truth, even of vital truth, the best that can be reasonably expected is a fine theory, but one that is withal formal and lifeless. Had he really mastered the view, his reception of it would have been more than its half-adoption, and would have taught him the utter uselessness of his elevation hypothesis.

I have thus frankly thrown out hints in regard to portions of the Geologic history of New England, thus freely spoken of Prof. Dana's contribution. Some of the positions advanced by him I have been disposed to commend; upon others to pass strictures, according as I have found them well-founded or not entitled to confidence. Less has been said of excellences, for they bear witness of themselves; more of supposed defects, since amidst much good, inadequate or false views are liable to be overlooked, and accordingly accepted as without spot and true. And all this has been done in the way of discussion and suggestion. Points have been considered in the best light at command. No statement has been made to stop investigation; each utterance has been put forth with a view to rouse honest inquiry; to lead each to question his positions; to get help myself, and to aid our younger geologists generally to find out on just what ground they stand. We cannot honestly adopt conclusions simply as such, but only as the legitimate outflow of premises, which as put to the test prove themselves valid. We are to endorse superstructures solely as we see the underlying foundation, and so see it as to get substantial evidence that it is able to support them. It is only as this is done, that there can be an adequate guarantee of real progress, of a healthy growth, of a living advance, which will constantly lead into closer and more intimate sympathy with nature in her vital processes. If what has been written shall aid in this direction; in case it leads the author of the, in many respects, excellent pamphlet under review, to re-examine his positions, and establish himself on a more substantial, and therefore on a more trustworthy basis; should it help those who are engaged, or such as may be hereafter enlisted, in geologic studies, to a deeper insight of the truth as it is in nature, and as it has been revealing itself from age to age in the history of the globe, the aim of the writer will be fully accomplished.

March 6, 1872.

The President in the chair. Twenty-one persons present.

Dr. Kneeland read the following extracts from letters written by Mr. John Muir, on the winter phenomena of the Yosemite Valley.

On the cold, south, or eclipsed side of valley, average from January 1 to 24, 1872, at Black's Hotel:

Average morning temperature		32° Fahr.
" noon	"	40° 5
Maximum morning	"	36°
" noon	"	52°
Minimum morning	"	22°
" noon	"	32°

Mild and delightful weather, wholly unlike the stormy December, with a little rain and snow, but mostly sunshine.

From Jan. 25 to Feb. 14, 1872.

Average sunrise temperature at Black's	28°. 92 Fahr.
" noon "	40°. 57
Maximum morning "	37°
Minimum " "	23°
Maximum noon "	49°
Minimum " "	34°
Rainfall during period	237 inches
Snowfall " "	3 "

Three days rainy, 3 cloudy, 2 snowy, 10 bright and clear.

January 24th, a terrible wind storm, coming from the north, the only direction in which a gale can enter this deep valley; bending and swaying the great pines two hundred feet high, usually so unbending, like a field of wheat, and showering their cones about like hailstones. The struggle of the Upper Yosemite fall, considerably swelled by the melting snows, was very beautiful; the wind seemed to surround it with a vast whirlpool, which tore it and scattered it about like folds of white drapery, now and then laying bare the black rocks behind. In the afternoon, the whole column was suddenly arrested in its descent about midway; it was not blown upward or bent to either side but towered in mid air, widening at the base, and doubtless turned inward toward the rock; it remained in this shape about three minutes, an irregular white cone, eight hundred feet high, stationary at the bottom, as if at the base the laws of gravitation had been suddenly suspended; then all at once it resumed its usual appearance. The force of the wind, and the natural inward air current behind the fall, were so strong as to bend the whole volume of water and curl it backward and inward, giving to the eye the appearance above described. Grand as are the Yosemite waterfalls, the Yosemite airfalls and cascades, masters even of the waters, are still more grand and wonderful.

This great storm produced no serious damage, prostrating only about a score of trees, breaking off many branches, and scattering the pine tassels and cedar plumes far and wide, and by this natural pruning exercising a beneficial influence upon the forests.

Erroneous views prevail as to the severity of the winter climate in this valley. On February 14, 1872, frogs croaked at night in the meadow shallows; upon the warm slopes of the north wall young grasses were an inch high, the sterile aments of the alders were ripe, the cedars were sowing their pollen, the early willows pushing out their catkins, azalea buds opening, flies and moths sporting in the sunshine, and ants busy about their spring work. The contrast between the north and south sides of the valley is remarkable; while on the north and sunny side it was spring, on the south side there were twelve inches of snow and midwinter—the two seasons separated only by half a mile of valley.

The latter part of January there was a magnificent ice cone two hundred feet high at the base of the upper Yosemite fall. This cone was about six hundred feet in diameter at the base, truncated, with the side next the wall deeply flattened; into its tolerably regular mouth, as into the crater of a volcano, poured whole columns of water which escaped by several irregular openings at the base. The rock behind the fall is dark-colored, but on both sides it is covered during frosty nights by frozen spray to a depth of from two inches to several feet; the width of this silvery edging of ice varies with the height, being greatest at the bottom and tapering to the top, like the fall to which it belongs. This grand ice creation, two hundred feet wide at the bottom, developed in a night, dies in a day; a few minutes after the sun falls upon it ragged blocks from a few pounds to several tons in weight begin to fall off, which in their fall echo through the valley like explosions of powder. The intervals of quiet which separate these explosions are from a few seconds to ten or twelve minutes; it sometimes happens that the sun disintegrates this ice before noon, but usually almost all day is required. The thundering and clattering of this falling ice are the common winter sounds, and the constant accompaniments of pleasant days. The ice cone is thus seen to be simply an accumulation of spray ice, solidified by pressure; it frequently attains a height of four or five hundred feet.

Tourists in California never see, and even the residents know nothing of, the magnificent vegetation of the great central plain of California; it is almost always remembered as a scorched and dust-clouded waste, treeless and dreary as the deserts along the Pacific Railroad. The foot-hills are smooth and flowing, and come down to the bottom levels in beautiful curves; their flowers do not occur singly or scattered about in the grass, but close together in companies, acres and hill-sides in extent, with their white, yellow and purple colors separate, yet harmoniously blending, and their fragrance is exquisite. Throughout the passes abound dogwood and alders, violets and ferns of great beauty. After passing the summit of the hills you come to the magnificent flower bed of the California plains, four hundred miles long and thirty miles wide, a great level ocean of flowers bounded by the snow-capped Sierras, watered by the San Joaquin and Sacramento

Rivers. The richness of this flower garden is almost beyond belief judged by ordinary standards, or even by that of Florida, the land of flowers; for every flower inhabiting Florida, on equal areas more than a hundred grow here. The flowers are not in the grasses, as on the prairies of Illinois, but the grasses are among the flowers. One actually wades in flowers, hundreds touching the feet at every step. But all this beauty is fast fading before the plough and the cattle and herds of civilization.

February and March are the spring time of the plain, April the summer and May the autumn. Spring opens early, prepared by the rains which begin in December; between May and December rains are very rare, and this is the winter of the plain, a winter of heat and drought. By the middle of May the flowers here are dead, and the leaves dry and parched; not slowly perishing, but suddenly dying before they can fade, standing erect and undecayed, with their beautiful urn-like seed vessels.

As you ascend from the sunny winter of the plain, you find another summer in the foot-hills of the Sierra; higher up another spring, and on the edge of the valley a snowy winter; descending into the Yosemite Valley, you find another spring, and then glorious summer along the banks of the Merced. Thus, in the space of a week, you pass through all the seasons in this remarkable region.

Dr. Kneeland then called attention to recent newspaper statements, that a Japanese junk had reached Alaska in a water-logged condition, having drifted two thousand five hundred miles in nine months; of twenty-six persons who had started, only three survived the sufferings which were undergone. This, if a fact, is interesting, as showing the possibility of America having been originally peopled by a similar accident.

The President remarked that several years ago the newspapers were filled with statements of Tin mines in California and Missouri, but that Dr. Jackson had told him that examination of the specimens of the supposed tin ore from Missouri, showed that no tin was to be found in that State at least. Nevertheless, a short time since a paper devoted to mining interests has asserted that many promising tin mines exist in the United States, especially in Missouri and California, and that furnaces are actually being made for tin smelting in the former State. The President asked for information from any member on this point.

Dr. Kneeland replied that specimens of the Missouri ore recently sent to the Institute of Technology for analysis, proved to contain no tin.

Dr. Brewer exhibited a beautiful Trogon, *Pharomacrus mocinno*, presented by Mr. Juan Zelidon, a gentleman engaged in collecting the birds of Costa Rica.

Dr. Brewer also stated that the Smithsonian Institute had presented a valuable collection of woodpeckers to the Society, many of them new to the collection, which already contains about three-fourths of the known species of this large family.

The thanks of the Society were voted for both gifts.

Section of Microscopy. March 13, 1872.

Prof. W. H. Niles in the chair. Thirteen persons present.

Mr. Stodder gave a short account of the recent discussion as to the structure of the Podura scale, exhibiting drawings and specimens.

Mr. R. S. Chase of Haverhill, was elected a member of the Section.

March 20, 1872.

The President in the chair. Thirty-one persons present.

At the invitation of the chair, Prof. Ch. Fred. Hartt gave an account of his recent explorations of the eastern part of the Basin of the Amazonas, and of their results, bearing more particularly on the theory of the glacial origin of the Basin, propounded by Prof. L. Agassiz.

Prof. Hartt stated briefly Prof. Agassiz' theory,—that the valley of the Amazonas is occupied by a series of beds, in the following ascending order, viz: first a bed of coarse sand, second, a series of clays, and thirdly, a heavy mass of sand-stone several hundred feet in thickness, all of which were deposited in an ice-laden, fresh water lake confined behind a gigantic moraine which stretched across the valley, several hundred miles east of the present mouths of the Amazonas. Prof. Agassiz supposed that by the bursting of the barrier the water of the lake rushed violently out, denuding away the sandstones from over the greater part of the valley, leaving only a few insignificant patches forming the table topped hills on the left bank of the Amazonas, between the Rivers Xingú and Tapajos. The diminished waters of the lake were supposed to have deposited a series of clays over the valley, and in these clays Prof. Agassiz claims to have found eratics at Ereré. Prof. Agassiz based his theory on his examination of the Serra of Ereré and its vicinity, taking that serra as a type of the system of table-topped hills. Prof. Hartt showed that the Serra of Ereré is composed of a great thickness of an extremely hard sand-stone, which dips at an angle of about 15° to 20° to the southward. At its base on the north is an immense plain, composed of quite horizontal strata. The lowest are well bedded chertz rocks, on which lie a series of shale, white, mottled and occasionally black or bluish, succeeded by thin beds of sandstone. These beds were supposed to be drift by Prof. Agassiz. Prof. Hartt found them full of well preserved fossils, *Spirifer*, *Leptocœlia*, *Streptorhynchus*, *Chonetes*. *Nuculites*, *Palæoneilo*, *Tentaculites*, *Dalmanites*, &c., indicating a lower Devonian horizon. These beds are traversed by a perfect net-work of trap dykes, which by decomposition have given rise to numerous boulders. As these Devonian beds, quite undisturbed, abut against the base of a high ridge whose strata are inclined, the conclusion seems inevitable that the Serra of Ereré is precarboniforous in age. Even if it be newer than the Devonian rocks just described there is no reason for considering it to be of glacial origin; moreover the serra does not belong to the system of table-topped hills, for Prof. Hartt found the Serra of Paranáquára, the most important of these hills, to be composed not of the sandstone as Ereré. but of a series of soft clays, clayey sands and sandy clays, well bedded, horizontal, and probably of Tertiary age. Evidences of glacial action were observed in no part of the Eastern Amazonas.

Since no trace is to be found of the great moraine; since the supposed erratics of Ereré are undoubtedly boulders of decomposition, and the serra and plain of Ereré are entirely different in structure from the table-topped hills, the theory of Prof. Agassiz seems to admit of serious doubt.

Dr. Hunt, who was introduced by Dr. J. B. S. Jackson, exhibited some seeds given to one of his patients by a Mexican, who said that they had been in his possession for over two years, and had been collected in Mexico. These seeds when placed on a heated surface, or in the hot sun, exhibited a wonderful activity, which Dr. Hunt illustrated by placing them on a warm plate, when they soon began to dance in a lively manner. Dr. Hunt said this was owing to the motions of a larva which the empty shell contained.

A mounted Jackall (*Canis aureus*) presented by Capt. A. Lewis was exhibited, and the thanks of the Society were voted for the gift.

Section of Entomology. March 27, 1872.

Mr. Edward Burgess in the chair. Twelve members present.

The following resolutions were offered by the Secretary, and unanimously adopted: —

Resolved: that in the death of our late associate, William Hales Dale, we mourn the loss of one whose many graces had endeared him to us, and whose researches in Natural Science commanded our admiration and respect.

Resolved: that the above be communicated to the friends of the deceased and inscribed upon our records.

Dr. Hagen remarked on the larvæ of the Telephoride beetle found in numbers on the snow in Somerville, March 14, by a Mr. Lawson. He thought they were the larvæ of *Chauliognathus Pennsylvanicus*.

Dr. Hagen also exhibited the larvæ of a dipterous insect, perhaps Oestrus, six specimens of which were taken from beneath the skin of a child, in various parts of the body, and at different times.

Mr. Sanborn stated that on the morning when the Telephoride larvæ referred to by Dr. Hagen were taken he had observed in W. Roxbury, while a warm snow was falling, fifteen species of insects, all on the snow, which was several inches deep; among them were Telephoride and Noctuid larvæ, and the imagines of *Capnia sp.*, *Cedidomyia salicis Boreus brumalis* and *B. nivoriundus* in abundance.

April 3, 1872.

The President in the chair. Thirty-seven persons present.

Messrs. J. J. Woodward, M. D., of Washington, D. C., and R. H. Ward, M. D., of Troy, N. Y., were elected Corresponding Members.

Messrs. Edw. J. Forster, M. D., Horace H. Watson, Francis Alger, Robt. B. Tolles, Harry B. Bailey, F. E. L. Beal, J. A. Scott, G. A. Jasper, Levi S. Burbank, Lester Goodwin, Henry S. Hubbard, Daniel B. Hubbard, Francis S. Hubbard, Dudley B. Fay, F. Hooper, S. L. Abbot, Jr., Geo. E. Rice, Francis H. Appleton and J. D. W. French were elected Resident Members.

Prof. Hartt made a communication, showing his views of the origin and formation of the valley of the Amazonas, and exhibited many views illustrating the scenery, inhabitants, and antiquities of that region.

Mr. Tyler, who had lived many years in Natal, and who was present by invitation, gave a short account of the history and present condition of Natal, and a description of the native Zulus, narrating some of their fables.

Prof. Hartt made some remarks on the similarity of the African and South American fables. Some of the latter were like old friends, as, for example, a story of a race between a tortoise and a deer.

The thanks of the Society were voted to Prof. Hartt and Mr. Tyler for their communications.

Section of Microscopy. April 10, 1872.

Mr. R. C. Greenleaf in the chair. Eight members present.

Mr. Stodder exhibited some photographs taken by Dr. Woodward with Wenham's Opaque Illuminator. This illumination is not really opaque, as some light is transmitted. A similar effect may be got with Tolles' opaque illuminator and the mirror.

Mr. Minot exhibited some micro-photographs taken by him, and explained the process.

Mr. Edward Burgess exhibited a dissecting microscope made by Carl Zeiss in Jena, and recently imported.

Mr. Greenleaf said that with a detached mirror and very oblique illumination, he thought he had resolved *Amphipleura pellucida* with a Tolles $\frac{1}{5}$.

Dr. Geo. H. Brown of Boston was elected a member of the Section.

April 17, 1872.

The President in the chair. Thirty-seven persons present.

Mr. J. A. Allen made some remarks concerning geographical variation in mammals and birds, speaking more especially in reference to the latter.

He referred briefly to the variation in size presented by individuals of the same species living at different localities, and to the general law of the decrease in size with the decrease in latitude, established some years since by Prof. Baird, in his elaboration of the materials collected by the different government surveys for a Pacific railroad route. Mr. Allen also called attention to the differences in the character of the pelage of mammals in individuals of the same species inhabiting northern and southern localities, those at the north as a general rule, having a thicker and softer coat, and more heavily clothed feet; and to the greater development at the southward of peripheral parts, as the ears and feet, especially the former.

In respect to birds, it was shown that not only the same law of diminution in general size to the southward obtains in this class as in mammals, but that there are other strongly marked coincident variations, affecting not only color but structural peculiarities. It was stated that, as a general rule, birds of the same species are much darker at the southern than at the northern borders of their respective habitats.

Mr. Allen showed that the bill and tail gradually increase in size to the southward, frequently to a very marked degree, the differences in this respect being inverse to the difference in the general size of the individuals. While the total length of the bird may be considerably less at the southward, the bill and the tail often become actually longer; but variation in this respect is more especially noticeable in long-billed and long-tailed forms. There is also a noticeable tendency to an elongation of the claws to the southward, particularly that of the hallux, which is markedly apparent in the genus Pipilo, as well as in other genera. In *P. erythrophthalmus* the differences in this respect between Massachusetts and Florida specimens is quite marked. The same fact is true in respect to the western forms of this genus, where the difference between specimens from Washington Territory and Lower California is greater than is seen in the Pipilos of the Atlantic States.

The differences in color between specimens of the same species from the interior of the continent, as compared with those from the Atlantic coast, and from the Pacific coast north of California, were also noticed, and specimens from the Cambridge Museum of Comparative Zoölogy were shown, illustrating not only the paler tints of those from the Great Plains and the interior of the continent generally, but also the greater intensity of color at the southward along the Atlantic seaboard, as well as the coincident differences in the size and form of the bill and in other features. Attention was particularly called to a series of specimens of the Baltimore Oriole (*Icterus baltimore*), in which a transition was shown between specimens from Massachusetts, (representing the average form of this species at the eastward) in which the lesser and middle coverts of the wing were bright orange, and others from middle Kansas, which had the lesser coverts, pale yellow, and the middle coverts *white*; though specimens from eastern Kansas had the lesser coverts of a deeper tint of yellow and the middle coverts of pale yellowish. In the Kansas specimens there was also much more white bordering the secondaries than in the usual eastern form. A series of sparrow-hawks (*Falco sparverius*) was also shown, illustrating not only the differences in color between specimens from the Plains and others from Eastern North America, but also the transition from the northern form of *F. sparverius* to the southern form described as *F. sparveroides* by Mr. N. A. Vigors, in 1820, from specimens from Cuba; although *F. sparveroides* has ever since been generally regarded as a species satisfactorily distinct from *F. sparverius*. In the northern form of *F. sparverius* a large rufous spot covers the greater part of the top of the head, which is entirely wanting in *F. sparveroides*. In this form the colors generally are also darker, the axillaries having the black bars predominating over the white ones, while the reverse of this obtains in the northern form. The specimens shown were chiefly from the Florida Keys and other portions of South Florida, and exhibited a gradual reduction of the rufous spot on the crown to its entire disappearance, leaving the top of the head uniformly dark blue.

In reply to a question from Prof. Hyatt as to what cause could be assigned for the general variation in the intensity of color mentioned, Mr. Allen remarked that he had long suspected that humidity had much to do with it, and that after determining the areas over which the light and dark forms prevailed, he found by reference to charts of mean annual rain-fall that the lighter forms invariably occurred in dry regions, and the dark forms in relatively humid regions.

Prof. Shaler remarked that he thought the difference in color at different localities might be an adaptation to the peculiar conditions of the vegetation, the paler tints of the plumage in the semi-desert regions better harmonizing with the scanty gray vegetation of those regions than more showy colors would; the differences hence being such as might result from the operation of the law of natural selection.

To this Mr. Allen replied that since there was generally much less differ‹ ›e in color between young birds, and in old birds soon after the autumnal moult, inhabiting respectively dry and moist regions, than between birds taken towards the close of the breeding season, it was apparent that the intense sunlight and the dry winds of arid districts do exercise a bleaching effect upon the colors of birds, and also of mammals, and is the cause of the faded and weather-worn aspect of the birds of the dry regions of the interior of the continent so especially noticeable towards the end of the breeding season.

Prof. W. H. Niles remarked that the researches of Mr. Allen were of great interest to the student of physical geography, as well as to the ornithologist and zoologist. To what extent the present geographical features and the climate govern the distribution of animal life is, as yet, but very imperfectly understood; but in Mr. Allen's published works he has given a valuable contribution to this very important part of geographical knowledge. He has deciphered the geographical range and distribution of species, and described "realms, provinces, faunæ and ornithological districts," not simply as an ornithologist, but with that clear and comprehensive knowledge of climate and physical features which gives a geographical interest and value to his work.

Other members also spoke in praise of Mr. Allen's work.

Note on the Origin of our Domestic Cat. By N. S. Shaler.

The derivation of most of our domesticated animals is so doubtful that any evidence which may serve to show the source whence they have sprung must be welcome to naturalists. Our domestic cat has been regarded as the progeny of various wild forms. The first and most generally entertained opinion was that it came from the *Felis catus* L., of western Asia and eastern Europe; but since the publication of the Zoological atlas of Rüppel this view has been replaced by that therein set forth, viz., that our domesticated form was derived from the *Felis maniculata* Rüp., of North Africa. I propose to show that there are reasons for supposing that the former view is by far the most reasonable, and that the stock of Northern Europe and America, at least, is derived from the first named of those species, although somewhat mixed, it may be, with the blood of the African form.

With the desire to fix this point I have for some time been engaged in an effort to ascertain what tendency there might be to reversionary features in our domesticated cat to either of the two sources whence it could have been derived. I have failed so far to find any very evident trace of a tendency to return to the type of the *Felis maniculata*, but have discovered a very interesting reversion toward the wild *Felis catus*, which I propose now to consider in some detail.

Obviously the circumstances which most favor the reversion of any domestic breed to their original stock are those which restore it most nearly to the wild conditions. Under the conditions of domestication an animal may acquire features of color or of form which may obscure the derivation, yet these may be easily swept away when the creature returns to the needs and struggle of a feral state. Fortunately we have in Cambridge, Mass., a large number of cats; if my calculation does not deceive me the number is to be reckoned by thousands, which are essentially wild, having no owners, rarely entering a dwelling except by stealth and in the severest weather, and feeding in the winter by the chance pickings about the areas, adding in the summer the birds they may capture. A large part of the people of Cambridge leave the city for the summer, and during this time the household cat often rears a litter and wanders away in search of food; this is constantly adding to the undesirable supply of these creatures.

Here we have all the conditions favorable to reversion, and here we find a race developed, which, in nearly all important characters closely resembles the *Felis catus*; about one in four of the semi-feral cats in the vicinity of Cambridge are colored precisely in the fashion of that species. The coloration of the *Felis catus* and of these reversionary forms is so peculiar that we cannot for an instant suppose that the correspondence is accidental. The pattern of coloration is probable the most peculiar of all the elaborate features which occur in the genus. The ground color of the body is a lightish gray covered with a profusion of stripes and bars of a blackish tinge; on the head all these run longitudinally; from the angle of the mouth a line extends downwards and backwards for an inch or more on to the throat; from the outer angle of the eye a similar crescent-shaped line leads down to the preceding, and another less distinct from the rear edge of the ear; from the lower edge of the forehead four or more bands extend backwards between the ears, widening and diverging slightly as they go on to the shoulder. Backward toward the tail the central stripe of black becomes broader and deeper black, and is continued down the dorsal aspect of the tail. The shoulders, neck and flanks are marked by wavy, broken, zebra-like bands of blackish color; generally these bands are so divided that the creature has a somewhat spotted appearance. The legs are banded with several stripes of black, those near the upper part being the most perfect. The tail is similarly banded, the stripes being really branches from the central black line, but not meeting on the central side of the tail, which like the belly itself is of a whitish hue. The beautiful figure of *Felis catus* in the atlas of Straus Durkheim's great memoir on the anatomy of the cat is, in every feature of coloration, precisely like a household cat now in my possession. Excepting the tail, which is a little longer than that of the specimen figured in the plate, the likeness is absolutely perfect.

I can throw no light upon the reversion to these markings. So far as I have been able to learn, the breed is on the whole local, though information on this point is incomplete. There seems to be some connection between coloration and size; all the specimens of males marked with this pattern which I have seen are distinctly larger than the average specimens of other colors. The tails appear also to be a little shorter and bushier in this reverted form, imitating more closely the general characters of the wild species than do the other forms.

I am inclined to think also that the females prefer males of this pattern; one specimen, colored and also brindled, now domesticated in my house, has kittens uniformly like her in point of color. It is not impossible that this coloration may prove of some small service to semi-feral cats in catching birds; these striped colors are singularly inconspicuous. The number of birds taken by these creatures has never been appreciated; there can be no doubt that during the fledgling season several hundred a day are destroyed in this fashion within the half a dozen square miles of Cambridge. It is not improbable that spread of canker worm and other insect pests is in a great measure due to the loss of insectivorous birds through the action of these pests. This is a point of sufficient importance to warrant the giving of a bounty for the scalps of these creatures that play the part of wolves against the defenceless flocks of the air.

It is not possible, however, to ascribe the reversion to this coloration to action of natural selection operating by giving these creatures an advantage in the pursuit of prey; the action is not extensive enough. It is more reasonable to regard the color as correlated with a general physical condition which adapts the whole organization to great exposure in a rigorous climate.

I should say that since I began to observe these features of coloration I have found that Prof. Agassiz has long been convinced that our domesticated species was a mixture of two stocks, one derived from the *Felis maniculata* Rüppel, the other the *Felis catus* L.

Mr. L. S. Burbank gave an account of the exploration of the Mammoth Cave by a party of geologists and naturalists from the meeting of the American Association at Indianapolis, last August.

The observations made by the zoologists of the party had been fully reported in the *American Naturalist.* He had studied more particularly the peculiar mineral forms, which, in great variety and beauty, adorn certain portions of the cave. Among them those resembling vines, flowers and wreaths are most conspicuous, and have often been spoken of as almost miraculous in the beauty and accuracy of their imitative character. They were, of course, all produced by natural causes, and these causes are not difficult to trace.

Although these forms all consist of gypsum or sulphate of calcium, there is no massive gypsum in the rock formation of the cave. It appears only in a fibrous shape, filling cracks and fissures, and as an efflorescence on the surface of the limestone of particular strata, which do not appear near the entrance of the cave. The curved fibrous masses are first seen on the long route, beyond Echo River, nearly six miles from the entrance. They first appear on the surface of a stratum of the limestone, some six feet in thickness, which is exposed on the side of the cave. As the path descends, a point is soon reached where this stratum forms the roof, and here the crystalline forms appear in great variety.

The portions of the rock where they are found contained originally a sulphide of iron or iron pyrites, which, on exposure to air and moisture, becomes oxidized, and forms sulphuric acid and an oxide of iron. The sulphuric acid decomposes the limestone and forms the gypsum, which, being soluble, is carried by the water to the surface, where it crystallizes.

The various forms are not produced, like stalactites, by a deposit from dripping water containing the mineral matter; they are developed *from within.* The deposits first made at the surface are increased by additions from beneath, which continually push out the parts first deposited, and by unequal pressure and adherence to the surrounding rock the curved forms are produced. Along lines of fracture the curved, leaf-like masses are thrown out in great abundance and variety. The rosette form results from the decomposition of nodules of the pyrites, which begins around the edges, as they are exposed at the surface, and as the chemical action proceeds towards the centre successive leaf-like layers are thrown out. Larger nodules or rounded masses give rise to a wreath-like arrangement by the same chemical action taking place along the edges in contact with the limestone.

Where the pyrites was disseminated in small grains or crystals throughout the rock, a nearly uniform coating covers the surface, or, in some places, needle-like, delicate fibres are thrown out. On some of these fibres may be seen an indication of a periodic growth, in a succession of rings or wrinkles on the surface. These rings are probably produced by an annual growth, as in the case of the horns of certain animals. During the long, dry summer of that region the growth of the fibres ceases for want of water to carry on the chemical action, and is renewed when the autumn rains appear. There is proof that this process is still going on, from year to year, in the fact that the forms may be seen in all stages of growth — in some cases just beginning where a previous coating of gypsum had been thrown off.

The thanks of the Society were voted to Mrs. W. R. Alger for a fine specimen of the female flowers of the Coco-Nut Palm.

Section of Entomology. April 24, 1872.

Mr. J. H. Emerton in the chair. Ten members present.

Mr. Sanborn called attention to a wasp's nest, presented by Luther Hills, Esq., showing a deviation from the usual plan of construction. The portion of the nest built the first year had been closed up, forming, as it were, a pedicel, to which the second year's work was attached at the mouth.

Dr. Hagen read a letter from the Baron de Selys-Longchamps, acknowledging the receipt of specimens of Pseudoneuroptera belonging to the Society's collection, and presenting a copy of his *Synopsis des Cordulines.*

Annual Meeting. May 1, 1872.

Vice-President Dr. Chas. T. Jackson in the chair. Thirty-three persons present.

Prof. A. Hyatt presented his report as Custodian for the past year: —

The first event of the past official year was of a most affecting and melancholy character.

The Rev. J. A. Swan, Recording Secretary and Librarian, whose term of service endured but little over a year, died after a short illness on the 31st of October, 1871. The Society has never before, I believe, parted from one of its officers under circumstances which appealed so strongly to the sympathy of all its members. Though not possessed of a strong constitution, Mr. Swan was gifted with a singleness of purpose and the spirit of work to a degree which I have rarely seen equalled. His devotion to the interests of science and to the purposes of this Society, induced him to tax his physical powers far beyond the safe limits of endurance. This brought on the disease from which he had previously suffered, in an aggravated form, and deprived him of the means of resisting its ravages. Suffering and pain never interfered with the performance of his official duties, and we all remember the courteous and almost affectionate interest with which he assisted every one.

These rare qualities made him deservedly popular with the members of this Society, and endeared him to its officers, who mourned his death rather as friends parting from a dear friend, than as associates losing the companion of only a year's standing.

Soon after this sad event Mr. F. G. Sanborn was elected as temporary Secretary and Librarian, and continued to perform the duties of this double office until the election of Mr. Edward Burgess, the present incumbent. This necessarily with-drew Mr. Sanborn from his position as Assistant in the Museum, and from the care of the Entomological Department for four months.

The publications have fallen behindhand on account of these various changes, and other reasons explained in my previous report, but they are, owing to the energetic management of the present Secretary, now being rapidly advanced.

The Teachers' School of Science was conceived, and has been carried into successful operation during the past winter under the patronage of Mr. John Cummings, a well known member of this Society.

After this gentleman had pledged himself to the support of this undertaking, a Committee was appointed, consisting of Mr. John Cummings, the President, Prof. W. H. Niles and the Custodian, to take the matter in charge.

Under the direction of the Committee, courses of lessons have been given on Physical Geography, by Prof. W. H. Niles, on Mineralogy, by Mr. W. C. Greenough, and on Zoology by the Custodian. The last course on Botany, by Dr. W. G. Farlow, of Cambridge, is now in progress. When this is finished there will have been thirty-three lessons given. The courses have been almost wholly tentative and experimental, but the success already attained has been most encouraging.

Prof. W. H. Niles delivered the first six. He undertook to give the more general features of the earth's surface, and then to apply these general principles to the explanation of the physical characteristics of Massachusetts. The success of this course may be judged by the average attendance, which was by about six hundred teachers of all grades, and the fact that the methods of teaching Geography in some of our public schools are now undergoing a change in favor of the more natural method introduced by him.

The necessity of actually handling and dissecting specimens obliged the Committee, after consultation with the Masters of the public schools, to confine the issue of tickets to about two for each school. This limited the average attendance at the succeeding lessons, six on Mineralogy by Mr. Greenough, and eleven on Zoology by the Custodian, to about fifty-five. The Masters and sub-Masters of the public schools have been present in large numbers, and I have noticed the same faces at every lesson, earnest in their work, and often remaining after the close of the discourse in order to gain fuller information. Specimens were distributed and studied at every lesson, and we know that in many instances the instruction was repeated at the schools.

We have, beyond a doubt, excited an interest in Natural History which must speedily effect a marked improvement in the system of public instruction in Boston, and eventually spread its influence to other parts of the country. The Committee feel that much of their success is due to the assistance they have received from Mr. Page, the Chairman of the Committee of Masters, Mr. Philbrick, the Superintendent of the Public Schools of Boston, and Prof. Runkle, the President of the Institute of Technology, who obtained from the Board of Government of that Institution the use of their new and commodious hall, which was opened for the first time at our first lesson. The materials for the course on Zoology could not have been gathered in sufficient abundance if it had not been for the extraordinary facilities for collecting Marine animals afforded the Custodian by Prof. S. F. Baird, U. S. Commissioner of Fisheries. Those for the course on Botany were furnished with equal readiness and generosity by Prof. Asa Gray, from his Botanical Garden in Cambridge. In fact, men of purely scientific tastes have everywhere manifested the deepest interest in our project, and given all the aid that was asked for by the Committee.

The expenses of the Society are represented by the use of the Lecture room at each lesson, the use of gas on one occasion, and the destruction of a few duplicate specimens broken up and distributed. These are not, properly speaking, expenses, but rather the use of our Lecture room and material for the legitimate purposes of the Society, and how largely the Society is likely to be repaid may be judged from the incidental donations which we have received.

These consist of a full suite of the Marine animals of Wood's Hole, a very full and complete collection of the fauna on the southern coast of Massachusetts, presented to the New England Collection; also an equally complete collection of the Marine animals of the coast of Maine, made at Eastport, and named by Mr. Dwinelle from the collection of Prof. A. E. Verrill, well known for his long continued and accurate work upon the fauna of that region. These collections were purchased for the Teachers' School of Science by Mr. Cummings, but the duplicates alone will be sufficient to make up the collections which are to be distributed to the schools, and the first suite of specimens, including many species yet unrepresented in our Museum, is to become the property of the Society. My visit to Wood's Hole also enabled me to obtain a very complete set of the skins of the sharks, rays, skates and other large fishes, which were collected by the vessels and men in the employ of the U. S. Commissioner of Fisheries.

Chas. J. Sprague, Esq., at my solicitation, very generously donated two hundred dollars, and other gentlemen have expressed a willingness to assist in paying the expense of stuffing and placing them in our New England Section of the Museum. The larger part of these skins are now in the hands of the taxidermist, and I hope to see them completed before the end of this summer.

In this connection, also, it is appropriate to notice the present state of our relations with the Institute of Technology. The Lecture room of the Society has been but rarely occupied by the classes of the Institute during the past year. The Museum, however, has been used more freely, especially by the Custodian, in the instruction of the class on Palæontology. No damage to the specimens has yet occurred, nor is likely to occur, except through the carelessness of the officers to whom specimens are loaned. The rent paid by the Institute, four hundred dollars per annum, though only a fair equivalent for these advantages, is really so much additional income, which the Society appropriates to its own purposes.

That the judicious use of specimens is perfectly compatible with their safe keeping, is shown by these facts, and by the present condition of the Osteological and Zoological collections. The specimens of these departments have not only been frequently used as described above, but also in the illustration of our public evening courses, and yet in no case do they show the effects of careless handling; even if a certain amount of wear and tear should take place in the course of several years, it must be remembered that the specimens loaned for the purposes of illustration are not the rarest of their kind, but such as can be easily and readily replaced by purchase.

A considerable portion of my last Report was devoted to the discussion of a proposed plan of organization. The rearrangement of the Museum in accordance with this plan has been begun by the building of suitable cases for the reception of the Ornithological Collection in the uppermost gallery of the main hall. These cases having been completed the birds are now being removed into them from the gallery and rooms below, by Mr. J. A. Allen.

Extraordinary precautions were taken in order to render these cases absolutely insect tight. The lumber was very carefully selected and kept heated while the work was going on, all joints were tongued, grooved and glued. The tops, bottoms and sides, were built into the plastering, the sashes grooved and tongued and locked by wedge-shaped bolts. The latter were invented in order to draw the sashes up tightly and firmly against the tongues at the top and bottom, and completely close the fronts of each case. Morse's patent brackets are used to suspend the shelving, which hangs upon the wall, and has no connection with the fronts. The success of these precautions is shown by the air tight condition of the cases. By suddenly opening or closing a sash one could readily crush in, or burst out, the neighboring glass panes. The resistance of the air is so great that it has to be overcome by a steady slow pressure as if one was working the handle of a piston.

With the exception of the method of bolting, and some other details, this plan is similar to that which has been successfully adopted by the Smithsonian Institution for the preservation of their valuable collection of birds, and was recommended to us by Prof. Baird.

The effort to free the infected skins from the ravages of Anthreni has been completely successful. Mr. Arthur Smith has repeatedly inspected the entire collection, bird by bird, during the winter, without finding a single living Anthrenus, and Dr. Brewer and Mr. Allen both confirm his report. The condition of some of the specimens when this movement began may be judged from the fact that they have been operated upon over twenty-five times before a cure was effected. Notwithstanding this, however, but very few specimens have been absolutely lost, only about half a dozen in all.

As soon as the birds are removed the Zoological collections will be concentrated in the first gallery of the main hall and the adjoining rooms. Many of the details of this part of the rearrangement of the Museum have been already completed, and the work can proceed with considerable rapidity. This redistribution will make room for the New England Collection, which will occupy the western end of the main gallery and the adjoining south-western room.

Our collection of Sponges has been compared and named, as far as possible, with the aid of Oscar Schmidt's types, which the Custodian was permitted to use for this purpose by the Director of the Museum of Comparative Zoology.

The Conchological Collection is rapidly advancing to a satisfactory condition. Dr. P. P. Carpenter's services were secured for two months last summer. In this short time, however, this indefatigable and experienced Malacologist named and mounted our entire collection of Bivalves, and began upon the Univalves. A considerable portion of the latter were packed up in the early part of the last winter and sent to Dr. Carpenter, who has also completed them. They are now on their way back to us. The extraordinary celerity with which Dr. Carpenter works leads me to hope that this department will be placed in perfect order before the end of the coming year. The details of his work will be found in the special report of the Conchological Department.

The Palæontological section of the Museum has also been very much improved in appearance by the exertions of the President, Mr. Bouvé, who has remounted and rearranged all the fossils from the Potsdam to the Carboniferous inclusive.

The skeleton of the whale has been prepared by Dr. Thomas Dwight, Jr., assisted by Mr. Fletcher M. Abbott. It swings from the centre of the roof, nearly on a level with the first gallery of the main hall. Its perfection, and the admirable manner in which it has been mounted, render it a most valuable and attractive ornament to the Museum.

The entire collection of Coleoptera has been placed in insect proof boxes by Mr. Sprague, and he has begun to secure the Harris collection in a similar manner. I desire, however, to call the attention of the Society to the boxes upon the table. These are experiments upon the methods of mounting and illustrating the typical collection of insects, and will probably be adopted throughout that department. The difficulties that were overcome, and amount of study and labor expended by Mr. Sprague in making these pattern boxes, can only be rightly appreciated by those who have watched their progress. One of them exhibits the ventral and dorsal aspects of a large beetle, showing all the parts appropriately named. This is be the type of the order. The other boxes contain the types of several genera and two families. The enlarged outlines of these small insects are given from the dorsal and ventral sides, accompanied by specimens having a similar position. On the right hand side of the box in each case are the characteristic parts, likewise greatly enlarged, so as to be readily seen, but each figure accompanied by its corresponding dissection. The characteristics of the family and genus are written opposite, so that the visitor sees at one glance the animal, its parts, and the family and generic characteristics. The outlines are drawn with the camera-lucida, and corrected by the most careful study, so that they are as accurate as it is possible to make them.

This is the sort of work that should be done in every department, if we would render our type collections really useful. A single assistant may slowly, and by dint of patient labor, accomplish a great deal, and in the meantime I venture to hope that an interest in what we are doing will be incited in the minds of those who are able to relieve our necessities.

We are considered a wealthy Society, and so we are, as compared with other Societies, but we also have more to do. The times in which we live, the locality, and the cause of public education, demand an amount of progress which we have not means enough to sustain. This is not only felt in the Museum but in the publications, and through them by all the Naturalists in this section.

Original investigations, which no publisher can afford to undertake, on account of their strictly technical character, have ever been the principal sources of knowledge, especially in Natural Science.

The usefulness of a Society, therefore, which is founded and carried on in the interest of Natural Science, depends largely upon its ability to furnish means of ready publication. We have succeeded in publishing several of the Memoirs that have been presented at our meetings, but others of great value have been necessarily rejected. One of these is now being published by the New York Lyceum of Natural History. Nothing can be more injurious to the progress of science in this vicinity than such proofs of our inability to assist persons who spend their lives in the pursuit of the same objects as those for which this Society was founded, and is now carried on.

PUBLICATIONS.

The Society has published this year two quarterly parts of the 14th Volume of the Proceedings, and it is hoped that in a few weeks the 3d and 4th parts will be issued, completing this volume, and bringing the Proceedings up to date. Four articles of the Memoirs have been published this year, two of which should have appeared last year. These are "The Early Stages of Terebratulina" by Prof. Edward S. Morse, and the "Osteology and Myology of Didelphys Virginianus," by Dr. Elliott Coues. Another article on the "Embryology of Limulus Polyphemus" by Dr. A. S. Packard, will be issued this week.

MEETINGS.

There have been eighteen general meetings, with an average attendance of thirty-two persons; nine meetings of the section of Microscopy, with an average attendance of ten; eight meetings of the section of Entomology, with an average attendance of eleven persons. Six Corresponding and thirty-four Resident Members were elected. Eighty-two communications have been made; of these seventeen were made to the Entomological, and twelve to the Microscopical section.

LIBRARY.

The accessions to the Library number 1667, and may be classified as follows: 424 volumes, 943 parts of volumes, 268 pamphlets, and 32 maps and charts. Prof. W. H. Niles and the Librarian have classified and arranged the Official Reports upon the various Geological surveys of the different States, and have succeeded in obtaining many Reports by purchase or otherwise, and there is now a fair prospect of completing the list. To render these Reports accessible, however, considerable outlay for binding is necessary.

During the last month quite a number of recently published works have been purchased by the Wolcott Fund and placed upon the shelves. Correspondence with the department of mines of Victoria has been opened, and a set of their publications have been received. Six Societies in Europe, and one in South America, have presented their publications for the first time.

BOTANY.

The collections in this department have been carefully examined, a work which would have been unnecessary if the cases in which the specimens are stored had been of better construction. The absence of the police on exhibition days is endangering the specimens of the California Redwood and Palmetto, which have suffered considerably from the canes and parasols of visitors. A change has also become necessary in the Lowell Herbarium, and the Curator feels it is his duty to recommend that new cases be erected for its accommodation.

COMPARATIVE ANATOMY.

The chief work accomplished during the last year has been the mounting of the skeleton of the whale (*Balænoptera musculus*), which came into the possession of the Society in October, 1870.

The specimen is one of the most perfect in the world, as may be shown by enumerating the deficiencies. There are but sixteen chevron bones (eighteen have been found in some specimens), and some of these are imperfect. The inferior epiphysis of one ulna was lost. The petrous and tympanic bones of one ear were removed from the head, and prepared to show the internal ear and were not returned to the skull. Otherwise the skeleton is perfect, and besides having the last vertebra intact, although but one-half inch in diameter, it shows the two pelvic bones and the rudimentary femora.

The Committee deemed it best to suspend the whale from the roof at such a height that a good lateral view could be obtained from the first gallery, while the superior surface could be studied from the second, and the inferior from the floor of the hall. As it would have been a matter of great difficulty, if not an impossibility, to represent the intervertebral cartilages so that each should have its proportions perfectly normal, it was decided to suppress them. Consequently the length of the skeleton does not exceed forty-five feet, which implies a loss of three feet. It is suspended about twenty feet from the floor and forty feet from the ceiling, by three wire ropes for the head, two loops, besides a single wire rope, for the spinal column. The head was suspended independently of the spinal column, though they were subsequently attached. One wire rope pierces the beak near its end, and is attached to the middle of an iron bar connecting the mandibles, which are held behind by the extremities of the two posterior ropes, each of which pierces the outer part of the squamosal. Nuts on these ropes maintain the proper distance between the lower jaw and the skull. The relations can be changed, if desired, by altering the length of the ropes from the ceiling and the positions of the nuts.

The body of each vertebra was bored in three places by a half inch drill. One hole is near the inferior border in the median line, the other two are through the upper and outer parts of the body. Wrought iron rods three-eighths inch thick and twelve feet long (except near the ends of the column) were passed through these holes, and so arranged that while most of the vertebræ were pierced by three continuous rods, there should never be more than one break in any given vertebra. The ends of the inferior rods were fastened securely together, and the couplings countersunk in the bones. Towards the end of the tail but two rods were used, and finally only one.

The anterior suspending loop passes through the bases of the transverse processes of the 14th dorsal, the second through those of the 12th lumbar, and the single rope through the body of the 10th caudal vertebra. As has been anticipated, the flexibility of the iron rods was so great that almost any curve could be obtained by regulating the lengths of the suspending wire ropes, and by introducing small wedges between the bodies of the vertebræ in those places where the curve should be most marked. The highest point reached by any of the spinous processes is at the posterior end of the dorsal region. The flippers are presented of the natural size, each bone standing apart from the others at, or near as possible, the proper distance. They are attached to the scapulæ, and these to the ribs, but the chief support is obtained by two strong wires which pass from the back of the skull to the anterior loop, holding up a transverse rod passed through the head of each humerus. The advantage of this is evident, for any sinking of this rod will tend to strengthen the skeleton by pulling the ends nearer together.

Some additions have been made to the homological series and several skeletons prepared and put aside to be mounted as soon as possible.

Among the donations received this year two deserve special mention. One is a beautiful head of a walrus, obtained by Capt. Fish, presented through J. S. Fay, Esq.; the other, the skeleton of an alligator, said to be about twelve feet long, shot in Florida and presented by H. S. Greenough, Esq.

RADIATA AND CRUSTACEA.

Work on the Hydroids and Corals has been in progress during the winter, and the preliminary arrangements for the removal of the two classes nearly completed by the Custodian.

MOLLUSKS.

Dr. P. P. Carpenter worked upon the labelling, arrangement and mounting of the shells for seven weeks and two days; the last three weeks of this time he was constantly occupied from 5.15 A. M. to 9.30 P. M. He was accompanied by an assistant, who cleaned and mounted the specimens under his direction.

A large quantity of material which had accumulated was first unpacked and distributed into genera. The Bivalves were then reviewed species by species, named, labelled, mounted and arranged in the gallery of the Shell Room. The duplicates were picked out and stored in boxes on the upper shelves. Very few originals were found, and very few even of those that Dr. Gould presented to this Society. By an arrangement with Mr. Anthony of the Museum of Comparative Zoology, Dr. Carpenter secured his services until all our fresh water bivalves, the Unionidæ, were accurately named, and Dr. Stimpson, of Chicago, who was visiting here, very kindly solved for him the equally difficult problem presented by the Cycladidæ. Besides his work on the bivalves, Dr. Carpenter also completed the Strombidæ, Cassidæ, Dolia, Volutes, and the larger Cowries and Muricidæ, by adding to the Pratt collection of these families the species of our own collection which had not been mounted by Prof. E. S. Morse.

This great mass of work which would have been the creditable result of a year's labor on the part of any ordinary Malacologist, now fills the cases of the gallery, and the families just mentioned are in the floor cases. With the consent of the chairman of the Committee, the Custodian effected an exchange with Dr. Carpenter, receiving from him a first class set of British shells, in exchange for an equivalent series from our general collection of duplicates. This collection is especially valuable, as we had no authentically named British shells, and these had been named by Dr. Carpenter, after the types of McAndrews, Bean, Jeffreys and others. With the land shells we also received a small lot of very rare Mediterranean, and many of Tristram's types from the Holy Land. The whole amounts to about 414 species.

Dr. Carpenter wrote me in full the details of the work done, and his letter is filed as usual, and can be referred to under the date of Aug. 21, 1871, No. 286½. During the past winter the same gentleman has been working upon our Univalves, a large portion of which was sent to him by Mr. Sprague. These have just been returned, and no formal report has been made upon the work, but I am able to say that about one-third of all the Univalves in the collection are finished, excluding all those previously mounted and labelled by Prof. Morse. Including these, about one-half are mounted and labelled, so that it is reasonable to expect that Dr. Carpenter, if he can be retained in our service, will be able to finish and catalogue the whole during the coming year. I have instructed Dr. Carpenter to divide the duplicates into complete sets for exchange, and sets of types suitable for presentation to educational institutions.

INSECTS.

The beginning of the present year was occupied by Mr. Sprague in completing the general collection of Coleoptera now contained in the railing cases of the upper gallery. In this were incorporated all the species from his own, Mr. Sanborn's private collection, and our miscellaneous collections. There were about one hundred species in all, including the entire family of Scolytidæ, which had to be worked out from Dr. Le Conte's monograph. All of the Coleoptera have been placed in a safe condition, and with a little care can be so maintained. They number about 10,000 specimens, and are contained in the improved style of box adopted by the Council. The New England Collection is progressing rapidly. The Cicindelidæ are completed, and the Carabidæ nearly finished.

Many species of Coleoptera have been described in our publications, especially the Journal, and Mr. Sprague has been, during a portion of his time, employed in making up a separate collection of species corresponding to these descriptions. This will be when completed an exceedingly valuable addition to our Museum, and should be followed in other departments. During this work he has found quite a number of Randall's, and some of Say's types, the latter especially having been considered lost. They are badly damaged, but still capable of identification, and therefore very valuable. The

Harris Collection has been several times re-examined, and at last a plan has been devised by which the trays can be made insect tight. This will save the Society the great expense of furnishing new boxes, and will be just as safe. A sample of one of these trays is upon the table and may be examined by the members of the Society. The work upon the type collection has already been sufficiently described in the general report.

The larger collections received during the year are as follows: from Mr. James Boll, 150 specimens of European Lepidoptera, and 300 of Coleoptera, notable for their fine condition, and the care exhibited in their preparation; and in addition to previous gifts of valuable material the bequest of his entire cabinet, consisting chiefly of North American insects, coupled with a sum of money for its preservation by our late associate, Mr. Wm. H. Dale.

Contributions of exotic specimens in small lots are chronicled from Messrs. Samuel Wells, W. H. Holden, and Benj. P. Mann, besides a fine living specimen of *Mygale Hentzii* Gir., with its "trap-door" nest, from Miss Nellie Stone of California. New England specimens, living and otherwise, have been presented by P. S. Sprague, Dr. G. F. Waters, I. G. Shute, F. A. Sherriff, A. B. Warren, F. A. Clapp, Luther Hills, Henry L. Moody, Miss C. Guild, and Mrs. McLean. *Boreus brumalis* Fitch, was found in great numbers by Mr. Moody, in Malden, upon the snow, Dec. 17th, 1871, and over fifty specimens of both sexes were presented to the Society by him. Subsequently, *B. nivoriundus* Fitch, the only other species known in this country, and new to the Society's collection, was obtained in smaller numbers and added to the cabinet by the Committee on Jan. 21st, 1872. Many of the specimens presented by Mr. F. A. Clapp are *chenilles sifflées*, carefully prepared by him in the manner recently suggested by European entomologists, by emptying the larval skin and inflating it in a current of heated air.

FISHES AND REPTILES.

The labelling of the Fishes has been finished by Mr. Sanborn, and the Reptiles remain in the same condition as they were last year. We have received from the Smithsonian Institution a valuable lot of the skins of the larger fishes of the coast of Massachusetts, which have already been referred to in the general report.

BIRDS.

The rearrangement of this department is proceeding rapidly. The attempt to place the birds according to their respective countries, in a grand faunal collection, has been abandoned. Mr. Allen devised a plan, at my suggestion, which was entirely practicable, and would have been easily completed. It was found, however, that the advantage to the Museum of having at least one of its departments arranged in faunal groups was more than outweighed by the disadvantages of such an arrangement. When assembled in faunal groups the systematic relations of animals are inconspicuous, reference to to any particular species is difficult, and among such a multitude of birds only the facts of the range of certain species over certain areas is shown. It was thought best, therefore, to place the birds systematically, so that the groups could be seen and studied together, and to supplement this with small collections, which should show how certain birds are modified according to their geographical distribution.

A number of valuable skins have been obtained by purchase from Mr. Kumlien of Wisconsin and Mr. Maynard, by exchange with Mr. Henshaw, and by donation from the Smithsonian Institution. The increase in this department has been more marked by the great variety and value of the additions than by their number. The nest and eggs of *Dendroica castanea* presented by Mr. Bailey, the eggs of the *Corvus Floridanus*, an egg of *Rostrhamus sociabilis*, one of

Ardea Wurdemanni from Florida, and a fine suite of the eggs of the *Plectrophanes ornatus* from Mr. J. A. Allen, are among the more noticeable; also a suite of skins of the Connecticut Warbler, including a fine male in the spring plumage, from Wisconsin, a fine specimen of the Mourning Warbler from the same locality, also in the bridal plumage; a fine specimen of the *Anser frontalis* of Baird, now supposed to be an unusual plumage of *A. Gambelli*, and many other additions hardly less rare and valuable. About one hundred mounted birds have been added in the course of the year to our collection in the cases.

From time to time the collections of unmounted skins in the Society's drawers have been studied, labelled, catalogued and arranged in their respective families. All of these, with the exception of the humming-birds, the birds of prey and the water birds, have thus been carefully arranged. These are as follows: 23 species of Turdidæ, 5 Sylviidæ, 5 Paridæ, 11 Troglodytidæ, 1 of Motacillidæ, 38 of Mniotiltidæ, 7 of Hirundinidæ, 16 of Vireonidæ, 1 of Laniidæ, 4 of Ampelidæ, 9 of Cœrebidæ, 64 of Tanagridæ, 66 of Fringillidæ, 30 of Icteridæ, 16 of Corvidæ, 24 Dendrocolaptidæ, 22 Formicariidæ, 62 Tyrannidæ, 32 Cotingidæ, 5 Momotidæ, 2 Galbulidæ 2 Alcedinidæ, 5 Bucconidæ, and 45 Picidæ. In all, 475 species. Some idea may be formed of the great value, when I state that of these no less than 150 are entirely new to our collection, and are not to be found in our cases of mounted birds, while others are only represented with a single exception, by a single specimen each, and all these are American birds.

The Chairman of the Committee desires especially to express his thanks to Mr. George N. Lawrence, of New York, for the assistance which he has given him in the determination of doubtful species, and also to Mr. Robert Ridgeway of the Smithsonian Institution.

MAMMALS.

This collection, which is entirely composed of skins, has been most carefully watched, and is believed to be free from Anthreni, otherwise it is in the same condition as last year.

MICROSCOPY.

This department remains in the same condition as last year.

GEOLOGY AND MINERALS.

The geological collection remains as it was last year, in fair order but not in a satisfactory condition. It is hoped that during the coming year the Committee will rearrange the collection, so as to make it more interesting to visitors and more instructive to students. The Mineralogical Collection is in perfect condition, every specimen labelled and in its proper place.

The Geological Department has been increased by specimens presented by various individuals, among which may be noticed a series from Mr. L. S. Burbank, illustrative of his paper upon the Eozoon, some lavas from Dr. S. Kneeland and a set of polished marbles from Mr. T. T. Bouvé. A magnificent specimen of rock composed of jasper and oxid of iron, weighing about a ton, brought from Lake Superior, has also been presented by the Massachusetts Institute of Technology.

The Mineralogical Department has been enriched by the presentation of various specimens during the year, of which may be particularly mentioned two large ones from Mr. F. Alger. One a huge crystal of beryl, the other a mass of rock, containing numerous beryls large and small. These were both brought from the town of Grafton, N. H., many years since, by the late Mr. Francis Alger, father of the donor. They will soon be properly placed in our entrance hall, where they will be objects of much interest.

There have been but few donations to the collection; the most important are 50 specimens of coal plants from Alleghany Co., Va., by Albert Ordway, and 40 specimens of coal shale organisms from Newcastle-on-Tyne, by Rev. E. C. Bolles.

The condition of the specimens in the collection has been greatly improved through the labors of the President, Mr. T. T. Bouvé. The Paleozoic fossils have been mounted upon tablets, the labels revised, and the specimens arranged, so as to make them more instructive to the public.

Report of E. Pickering, Treasurer, on the Financial Affairs of the Society, for the year ending April 30th, 1872.

Receipts.			
Dividends and Interest			$9,431.61
Courtis Fund Income			666.58
S. P. Pratt Fund Income.			820.00
H. F. Wolcott Fund Income			476.75
Walker Fund Income			2,466.30
Walker Prize Fund Income			265.20
Bulfinch Street Estate Fund Income			2,516.00
Annual Assessments			1,325.00
Admission Fees			125.00
J. Cumming's Donation			950.00
C. J. Sprague $200. Other subscriptions $99.26.			299.26
W. H. Dale, Bequest for Entomological Section.			500.00
Total			$19,841.70
Expenditures.			
Museum and Furniture		$1652.88	
Cabinet		1,927.63	
Library		656.27	
Publications and Printing	$2,934.29		
Less receipts	759.75		
		2,174.54	
Fuel		563.58	
Repairs of Museum		620.80	
Taxes		339.06	
Salaries		6,028.24	
Gas		65.73	
Lectures	$1,315.60		
Less Subsidy of Lowell Institute	1,200.00		
		115.60	
Teachers' School of Science		939.10	
General Expenses		879.63	
Walker Prize Fund Income		228.75	$16,191.8
Excess of Receipts over Expenditures			$3,649.89

The following is a statement of the Property of the Society, exclusive of the Cabinet and Library.

Museum Building.		
Cost of Building and Furniture	$138,989.94	$138,989.94
Bulfinch St. Estate Fund.		
120 Shares Chicago, Burl. & Quincy R. R. Co.	$15,380.75	
84 " Tremont National Bank.	10,122.00	
2 " Globe " "	257.12	
12 " Ogdensburg & Lake Champlain R.R. Co. preferred	1,281.50	
19 " Phila., Wilmington & Balt. R.R. Co.	1,038.75	28,080.12
Walker Fund.		
Notes secured by mortgage	41,105.00	41,105.00
Walker Prize Fund.		
14 Shares Vermont & Canada R.R. Co.	$1,429.25	
29 " Philadelphia, Wilmington & Balt. R.R. Co.	1,532.92	
10 " Ogd. & Lake Champlain R.R. Co. Preferred.	1,077.00	
Cash	325.64	4,364.81
Courtis Fund.		
50 Shares Globe National Bank	$6,250.00	
35 Shares Philadelphia, Wilmington & Balt. R.R. Co.	1,827.50	
$400 U. S. 5-20 Bonds	425.00	8,502.50
S. P. Pratt Fund.		
58 Shares Philadelphia, Wilmington & Balt. R.R. Co.	$3,057.25	
50 " Norwich & Worcester R.R. Co.	5,212.75	
10 " National Webster Bank	1,072.75	
6 " Boston National "	657.25	10,000.00
H. F. Wolcott Fund.		
60 Shares Philadelphia, Wilmington & Balt. R.R. Co.	$3,277.70	
28 " Ogd. & Lake Champlain R.R. Co.	3,031.25	6,308.95
General Fund.		
17 Shares Bates Manufacturing Co.	$1,700.00	
35 " Everett Mills	3,500.00	
30 " Hamilton Woolen Mills	7,500.00	
80 " Washington Mills	8,000.00	
13 " Cocheco Manuf. Co.	7,800.00	
2 " Lowell Manuf. Co.	1,800.00	
8 " Laconia Manuf. Co.	3,228.69	
4 " Pepperell Manuf. Co.	2,350.25	
1 " Amoskeag Manuf. Co.	1,400.00	
3 " Essex County Manuf. Co.	405.00	
2 " Manchester Print Works	1,550.00	
2 " Merrimack Manuf. Co.	2,220.00	
1 " New England Glass Works.	620.00	
12 " United States Hotel Co.	1,200.00	
19 " Neptune Ins. Co.	3,160,00	
18 " Boston Ins. Co.	2,160.00	
5 " Washington Ins. Co.	960.00	
141 " Vermont and Canada R.R. Co.	14,135.00	
95 " Michigan Central R.R. Co.	10,963.00	
50 " Ogdensb'g & Lake Champl'n R.R. Pref. Stk.	5,162.75	
50 " Philadelphia, Wilmington & Balt. R.R. Co.	2,732.60	
2¼ " Boston & Lowell R.R. Co.,	1,554.25	
50 " Norwich & Worcester R.R. Co.	5,150.00	
20 " National Bank of Redemption	2,465.25	
26 " Tremont National Bank	3,155.01	
50 " Atlas " "	6,046.75	
6 " Globe " "	771.38	
15 " National Webster "	1,684.00	103,373.93
Carried forward		$340,725.25

Brought forward			$340,725,25
Miscellaneous.			
Unsettled Accounts Receivable	$525.92		
Cash	$3,143.42	$3,669.34	
Less Account Payable		1,601.64	2,067.70
Total Value of Property April 30, 1872			$342,792.95

In addition to the above, the Society possesses a Cabinet and Library of inestimable value.

All which is respectfully submitted,

E. Pickering, Treasurer,

Boston Society of Natural History.

Boston, April 30, 1872.

The following were then elected officers for 1872–1873:—

PRESIDENT,

THOMAS T. BOUVÉ.

VICE-PRESIDENTS,

CHARLES T. JACKSON, M.D., R. C. GREENLEAF.

CORRESPONDING SECRETARY,

SAMUEL L. ABBOT, M.D.

RECORDING SECRETARY,

EDWARD BURGESS.

TREASURER,

EDWARD PICKERING.

LIBRARIAN,

EDWARD BURGESS.

CUSTODIAN,

ALPHEUS HYATT.

COMMITTEES ON DEPARTMENTS.

Geology.

W. H. Niles,
W. T. Brigham,
T. T. Bouvé.

Botany.

Wm. T. Brigham,
Charles J. Sprague,
J. A. Lowell.

Comparative Anatomy.

Thomas Dwight, Jr., M.D.,
Jeffries Wyman, M.D.,
J. C. White, M.D.

Minerals.

Thomas T. Bouvé,
Charles T. Jackson, M.D.,
L. S. Burbank.

Palæontology.

T. T. Bouvé.
N. S. Shaler,
W. H. Niles.

Radiates and Crustaceans.

A. S. Packard, Jr., M.D.,
A. E. Verrill,
Alex. Agassiz.

Mollusks.
EDWARD S. MORSE,
JOHN CUMMINGS,
LEVI L. THAXTER.

Fishes and Reptiles.
F. W. PUTNAM,
D. H. STORER, M.D.,
S. KNEELAND, M.D.

Mammals.
J. A. ALLEN,
THOMAS WATERMAN, JR., M.D.
J. B. S. JACKSON, M.D.

Insects.
F. G. SANBORN,
A. S. PACKARD, JR., M.D.,
EDWARD BURGESS.

Birds.
THOMAS M. BREWER, M.D.,
SAMUEL CABOT, M.D.,
J. A. ALLEN.

Microscopy.
EDWIN BICKNELL,
R. C. GREENLEAF,
B. JOY JEFFRIES, M.D.

May 15, 1872.

The President in the chair. Thirty-three persons present.

Dr. S. Kneeland read extracts from a letter from Mr. John Muir, on the effects of the earthquake of March 26, 1872, in the Yosemite Valley.

The earthquake storm in the Yosemite began Tuesday, March 26, 1872, at 2 1-2 A.M. People were shaken out of bed, and the floors shook like the deck of a vessel at sea. First shock lasted about three minutes and with great energy and motion, undiminished to the end. For the first minute no sound but the agitation of the trees. Expected "Sentinel Rock," a high isolated pinnacle, would fall, but at last from the south side of the valley opposite Yosemite falls, there came a tremendous sound. Eagle Rock had fallen two thousand feet, and was pouring in an avalanche of boulders over precipices, and through forests of fir and spruce, filling the valley with a smoke of fire and rock dust, and countless reverberations and echoes. Sky clear and moon bright, so that the outlines of the rocks, trees and meadows could be plainly seen; trees greatly agitated, in strange, indeterminate, motions; frogs silenced for the time, but before the dust had settled, or the echoes had died away, an owl began to hoot from the very edge of the fallen rocks, as if unconscious of any extraordinary disturbance. River soon after was found to be muddy from portions of its banks shaken into it, but otherwise flowed as peacefully, in the same direction, as ever. Upper Yosemite did not seem to show the slightest agitation.

First shock followed at intervals of a few minutes by sharp concussions, each attended by gentle undulations, and by occasional smooth rumbling sounds from deep in the mountains, in a northern direction, not always readily distinguishable from the heavy sounds formed at the foot of the Upper Yosemite. Second well defined shock about an hour after first, followed by another rock avalanche from the region of Eagle Rock. A third severe shock, a few minutes after sunrise, in which the movements were less sharp and quick, and a few lateral and vertical joltings, followed by a series of short undulations or quiverings, causing the light-branched and leafless oaks to whip their upper branches as if struck by a powerful force near the ground.

Rocks of size of thirty feet in diameter downward, coming to rest at a long rough slope at the foot of the vertical wall, covering a portion of a larger slope made centuries ago, destroyed a great number of trees, firs, pines, spruces, maples, laurels, etc., filling the air with a balsamic fragrance from their bruised trunks and branches. Trees four feet in diameter broken clear across in lengths of ten to fifteen feet, and cast in drifts like straws; others battered and flattened like crushed sugar canes; some had their tops cut smoothly off seventy to one hundred feet from the ground by large fragments bounding above the main avalanche like the spray of a water fall.

Other avalanches occurred in Indian Cañon, on the west side of the Cap of Liberty, and in Illilouette Cañon. The walls were not more changed by this earthquake than Mirror Lake by a passing storm. Only visible changes, a few whitish, fresh rock patches on the dark walls, and a new small rock front, capped with spires, where Eagle Rock fell. The day following was cool and calm and bright; animate nature appeared the same; some two or three were frightened out of the valley. Innumerable shocks during the 26th to 27th, but not more than fifty were noticeable, unless by persons watching for them.

First shock by far the most severe. Watched the movements of a pail of water for hours. Noticed vibrations of considerable regularity in a north and south direction, seeming to be produced by impulses from the north acting horizontally, with the velocity of a blow. North and south vibrations constantly interrupted by impulses which seemed to proceed mostly from an easterly direction. A few circular, twisting motions were noticed; the surface of the water also at times dimpled and trembled as if receiving a succession of sharp blows from below. The rumbling under-mountain sounds were distinctly heard by everybody in the valley, and always as coming from the north.

Dr. C. T. Jackson referred to the singular fact that deep mines in California are never affected by earthquake shocks.

Dr. B. Joy Jeffries spoke of, and explained the usual methods of testing patients for color blindness and interruptions of color perception in the visual field in disease.

He also exhibited and explained a model of the instrument for testing color blindness, shown by Woinow at the last Heidelberg meeting of ophthalmologists. This consists of an apparatus with a rotating disk, whose centre is black and white, next outside a ring of red and green, next a ring of violet and red, next outside of violet and green. When rapidly rotated the centre appears of course gray, *i. e.*, of black and white mixed. The *outer* ring will also appear gray to the *red* blind patient, as he can perceive gray from the two colors presented, violet and green. The *middle* ring will appear gray to the *green* blind, since he can see gray by the mixture of violet and red. The *inner* ring will appear gray to the *violet* blind, as red and green give him gray. Color blindness is the loss of perception, in whole or part, of one or more of the three energies which we call red, green and violet. Since the experiments of Maxwell, Helmholz and other physiologists are agreed that these must be taken as the three base colors of light. Dr. Jeffries also spoke of some cases of congenital microphthalmos, where, although the globe was only minute, and the place of the cornea a slightly bluer shade than the sclerotic, yet the finest shades of color could be detected, whilst vision as to shape and form was very defective.

Section of Entomology. May 22, 1872.

Mr. B. P. Mann in the chair. Ten members present.

Mr. Burgess read a letter from the Executor of the will of the late Wm. H. Dale, announcing the bequest of his insect cabinet and the sum of five hundred dollars to the Section.

Mr. Mann spoke of the activity of *Bruchus granarius* in the pupa state. The larva is very injurious to the coffee-bean in South America.

Mr. Morrison exhibited specimens of a yellow variety of *Pieris rapæ*, the Cabbage butterfly. This variety does not occur in Europe.

June 5, 1872.

The President in the chair. Thirteen members present.

Prof. Shaler made some remarks on the effects of the vertical position in man.

All the organs which compose the trunk viscera of man were originated and received their important features of form and relation in that part of the vertebrate series where the longitudinal axis lies parallel to the horizon. In this attitude the pressure of the several organs one upon the other is very slight. The lungs, heart, liver, and the abdominal viscera, the uterus especially, are weighed upon by no other masses. Their own weight impels them against the elastic abdominal face of the body. When, however, the needs of the developing hand require the change in the attitude of the body, which takes place in man, these organs which have grown up without protection against pressure are suddenly brought under its influence. It is likely that the frequency of certain diseases of the lower trunk viscera, the kidneys and the bladder, may be attributed to this action. By far the most important effect, however, is exercised upon the reproductive tract. The uterus was developed in a horizontal attitude, and when it became gravid its slightly dependent position secured it entirely against risks of displacement through the pelvic arch.

In the vertical attitude this organ, necessarily feebly attached, is brought into an extremely hazardous position with reference to this arch. The whole load of the surrounding viscera, as well as its own weight, tends to bring about an evagination. Something of the same risk, though in a less degree, threatens the anal section of the alimentary canal. As might be anticipated, there are great changes brought about in the configuration of the pelvis in consequence of this new danger. The integrity of the reproductive machinery must be maintained by the most vigorous selection. There is probably no point in the history of the mammalian series when this action is more required than in the passage from the lower mammalian to the human pelvis. Already in the anthropoid apes we find distinct marks of a change to accommodate the needs of the heavy visceral mass so often thrown into a nearly vertical position. The outlet of the pelvis becomes more narrowed, and its sides turned in such fashion as to give a greater amount of support to the weight thrown upon it. In man this contraction goes still further; not only is the outlet made so small that the fœtus escapes with difficulty, but the brain of the child is somewhat endangered by the reduced aperture and the compression it is subjected to.

The conditions of the problem are more complex than would seem to be the case at first sight. The safety of the uterus leads to the smallest possible outlet through the pelvis, the preservation of the child tends to bring about the smallest possible skull. This is in turn met by the need of a large brain. This complication of needs seems to be met as nearly as is possible in the present state of the accommodation.

The need of support for the abdominal viscera may account for some other important modifications in the human body. The change in the position of the sacral and caudal segments of the vertebral column may be explained on the supposition that it gives support to the soft parts which lie above it. While the trunk was horizontal the caudal segments could well be spared for the purposes they serve in the forms which have this attitude; when, however, the pressing needs of the vertical trunk demand all possible support, the modification of the caudal and sacral elements of the vertebral column for the purpose of giving this support, is quite a natural change. The axis of the pressure from the abdominal cavity through the pelvic opening is so oblique that the sacrum opposes it at nearly right angles. It may be urged against this view that the sacrum is so formed in woman as to exercise a rather less effective resistance to the downward pressure than in man, though that sex is in greater need of the protection. This objection is quite met by the fact that the needs of parturition would necessarily admit a less reduction of this opening in woman than in man.

The change in position and character of the sacrum and coccyx necessarily brings about a change in the position of the female organs of generation; this in turn alters the attitude in copulation. Inasmuch as sexual habits are among the most fixed of all habits, it requires some such explanation of the departure from the early mammalian usages in the exercise of this function.

The comparatively smaller size of the pelvis of Europeans leads us to believe that natural selection may still be at work in determining the adjustments of the pelvis to its new relations. All the evidence goes to show that the extreme point of reduction of the diameters has been attained. When we look for other possible changes we are naturally led to the inquiry as to the possibility of developing a capacity in the pubic symphysis for becoming separated in parturition. There seems to be a strong tendency to introduce this feature in the female of our species. The known mobility of this part of the pelvis in guinea pigs and seals, makes it seem not improbable that this occasional separation of the pubic bones may become a constant feature in the race. Though the aid it can give in parturition is small, the capacity for effecting this separation in the pelvic girdle would unquestionably make it possible to get a larger head through a smaller pelvic opening than we could otherwise do; unless, however, this weak articulation could be formed just before parturition, and strengthened afterwards, the disadvantage to the motor functions would quite counterbalance the advantage. It seems possible that this temporary relaxation of the symphysis pubis may, in turn, afford a line of partial relief from some of the serious inconveniences which menace the females of our race.

The relations of the whole question of pressures in the upright position of man to the hygiene of the body, and to the future of the race, are of the utmost importance. The rapid and almost excessive contraction of the pelvis shows that one sex at least has found the vertical attitude one of considerable danger. It seems not unlikely that this may furnish a potent argument against any change in our social system which tends to put a larger amount of labor upon woman.

An attentive consideration of this whole matter will show us that it affords an admirable exemplification of the real limits of selection in the work of differentiation. As long as the body was horizontally disposed, selection could have but slight influence upon the pelvis; with the new needs of the upright position it became immediately the seat of intense selective action, leading to very important changes. This alteration of attitude, it is true, may have been brought about with the coöperation of selective action; but the whole of the hereditary influences existing in the creature and tending to determine its mental constitution, have had a large part in the work. It was the intellectual needs which gave the hand. In getting the hand, a new attitude was forced on the body, and with this change, the result of intellectual needs, came a new series of selective actions. The inherent possibilities of intellectual development have been the guiding agents in this series of changes. Selection has condemned the failures, and so strengthened the successes in the struggle for better things.

Dr. G. A. Maack gave an account of the geology of the Isthmus of Choco, of Darien and of Panama, which he surveyed during the year 1871, in behalf of the United States Government. He exhibited a large number of photographs and lithological specimens to the Society, and presented the latter collection to the Museum.

Dr. Maack gave a detailed description of the geological structure of both the Atlantic and Pacific sides of the Isthmus. He pointed out that the mountainous system in the Province of Choco, near Limon Bay, which opens on Cupica Bay, has a geological character different from that of the Tuyra and of the Chucunaque regions in the Province of Darien, while the latter mountains differ by their parallel arrangement, as well as by their petrographical composition, from those between Panama and Aspinwall. Consequently the whole Isthmus consists of three systems differing from one another. The rocks of these three systems belong to the Tertiary period, and are of a volcanic character. They differ in this respect, that the mountains of the Province of Choco consist principally of propylite, the oldest tertiary volcanic rock, while the mountain ranges in the Province of Darien are formed of andesite, and the various peaks and domes between Panama and Aspinwall of trachyte and dolerite.

Dr. Maack called attention to the fact that the San Blas Cordillera on the Atlantic side, which lies between the Provinces of Panama and of Darien, consists of granite and syenite, like the Cordilleras of South and of North America. He said further, that tertiary strata filled with shells exist on the Atlantic side of the Isthmus, as well as on the Pacific side, and stretch across the Isthmus. These palæontological facts prove that up to the Pliocene period both oceans mingled their waters.

Dr. T. M. Brewer called the attention of the Society to the remarkable abundance of the Bay-breasted Warbler, *Dendroica castanea*, both in the vicinity of Boston and in southern Wisconsin, the present season.

They were observed in large numbers by Mr. Wm. Brewster, Mr. H. W. Henshaw and others, and quite a number of specimens obtained. Mr. Brewster thinks he met with as many as fifty individuals in a single forenoon. They were present in considerable numbers during the 26th, 27th and 28th of May. All our earlier writers speak of this warbler as one of our rarest birds, and it has been only for a few years known to be abundant in the northern parts of Maine during the breeding season.

In Wisconsin this warbler appears to have been equally abundant. Mr. Kumlien writes: "The *D. castanea*, which used to be a rare bird with us, except in the latter part of August and in September, when they return with their families, has this week been very abundant; almost any number could have been had."

It is an interesting problem to solve the question, why this bird, usually so very rare, almost unknown along this parallel of latitude, should this season be so very abundant, probably from the Atlantic to the Mississippi? The hypothesis of Mr. Brewster is at least a possible explanation, which is that this species ordinarily makes its northern migrations in long extended flights, in which it passes over large tracts of country without making any pause. It passes north quite late; is one of the very last of the migrants, and passes on to its breeding places without remaining or pausing in the section. For some reason, not to be so easily explained, it has been induced to deviate from its usual routine, and has found it convenient to make a stopping place both with us in southern New England and in Wisconsin.

In partial confirmation of this theory Dr. Brewer read an extract from Mr. Salvin's paper in the "Ibis" for April, 1872. showing that this species, in common with the Mourning Warbler, *Geothlypis philadelphia*, never occurs as a winter visitant at any point of Central America north of Costa Rica.

Dr. Brewer communicated the following paper from the authors.

NOTES ON THE BIRDS OF WYOMING AND COLORADO TERRITORIES. BY C. H. HOLDEN, JR.; WITH ADDITIONAL MEMORANDA BY C. E. AIKEN.

The following interesting notes were prepared for my own private perusal, and not designed for publication. They are possessed of too much interest to be withheld, embodying as they do the careful observations of two promising young ornithologists, who have explored, at different seasons of the year a comparatively new field. I should add that these notes were prepared, simultaneously, but without consultation, as the writers were a thousand miles apart when they were written. Mr. Holden's visit was made in summer, Mr. Aiken's experience between November 1st, 1871 and May, 1872. The notes of the latter are in quotation marks and signed C. E. A. T. M. B.

The birds and eggs upon which these notes are written were found in the immediate vicinity of the "Black Hills" in the northern part of Colorado and southern part of Wyoming Territories. That so few eggs were obtained is accounted for by the fact that my collecting did not begin until the 10th of June, 1869, and although many nests were found, yet nearly all contained young birds, instead of the wished for eggs. I am of the opinion that nearly all of the eggs are of the 2d incubation, with perhaps one exception, (*Pipilo chlorurus*), and I have no other reasons for believing that is not, than the condition of the plumage.

The character of the region of Sherman, which is 8000 feet above the sea-level, is dreary in the extreme. It consists of several level plateaus, interspersed with "cañons" and meadows. I found no birds plentiful with the exception of the Rusty Black-Birds, and it was difficult to obtain more than four or five specimens in a day.

The following specimens, fully identified, are with one or two exceptions, in my collection.

1. Turdus migratorius. Robin.

Robins were quite common. I never observed them at any great distance from the brooks along which they breed. I found a number of their nests, differing in no particular point from eastern birds except in that they were made of *sage brush*, straw and mud; the eggs were similar in many instance to eastern specimens, although at first they seemed a little darker.

"Not common during the winter; very abundant from the middle of March to the first of May, at which time they begin nesting."

—C. E. A.

2. Oreoscoptes montanus. Mountain Mocking Bird.

These are rare, only five or six specimens were observed in the course of my collecting, they sing exquisitely, their actions are similar to the Brown Thrush. They remain concealed during the middle of the day in some low thicket and on the approach of evening the males mount some high point and sing until after dusk. I have heard them making their way through thick underbrush in the middle of the day; while so doing they made a short clucking noise not unlike some notes of the Cat-bird, *M. carolinus.*

3. Hydrobata mexicana.

"Not common. Found about springs all winter."—C. E. A.

4. Sialia sialis.

Since this was in type Mr. Holden has taken one specimen near Fountain, Colorado.

5. Sialia mexicana. Western Blue-bird.

"Began to arrive about March 15th, since which I have found them rather common among scattered timber in the foot-hills. At this date (May 4th), they are seen in pairs. Iris dark brown."—C. E. A.

6. Sialia arctica. Rocky Mountain Blue-bird.

These beautiful birds were common and their action and habits are almost identical with our eastern bird (*Sialia sialis*); they seemed to breed in any place that was convenient. I found one nest containing four eggs in an old *car wheel*, another in a deserted woodpecker's hole about six inches from which lived a pair of Red-shafted Flickers and their family. The male birds perch themselves on any high point and sing as if they thought every note would be their last. Their song is truly mournful, and consists of several low notes uttered in quick succession; it can be heard a long distance.

"Saw and killed the first specimen, February 18th; from that date they continued to increase in numbers till the last of March, at which time they were very abundant. They migrate in large flocks, sometimes of hundreds, but separate into pairs about May 1st. The call-note is similar to that *S. sialis.* Prefers an open country. Iris dark brown."—C. E. A.

7. Regulus calendula.

"Saw a small flock in the foothills last November, but have not since met with it."—C. E. A.

8. Regulus satrapa.

"First seen April 23d. Rather common."—C. E. A.

9. Lophophanes inornatus.

"Common winter resident. Gregarious during the first part of winter, but since January seen only singly or in pairs."—C. E. A.

10. "Parus septentrionalis."

"Common among bushes along creek bottoms all winter. Habits and notes precisely similar to those of *P. atricapillus*. with which it would seem to be identical."—C. E. A.

11. Parus montanus.

"Seen in small flocks occasionally through the winter. Frequents shrubs and bushes on the mountain sides and is never found on the low lands. Iris dark hazel."—C. E. A.

12. Psaltriparus plumbeus.

"Small flocks seen occasionally through the winter. Frequents shrubs and bushes in the foot-hills. Iris in the male brown, in the female yellow."—C. E. A.

13. Sitta aculeata.

"Common winter resident, probably breeds in the mountains. Habits precisely like those of *S. carolinensis*. Notes differ slightly. Iris dark brown."—C. E. A.

14. Sitta pygmæa (Vig.)

"Common winter resident; most common during Dec. and Feb. Seldom seen after the first of March. Gregarious during winter. Begin to pair about the middle of April, actions similar to those of *S. carolinensis*. They search for food with the most determined perseverance among the branches of tall pine trees, creeping rapidly from one limb to another and peering earnestly into every crevice for insects. It is frequently seen perched upon a limb, and striking it with its bill after the manner of the woodpecker, moving its whole body and using its wings to increase the force of the blow. Seldom seen on the main trunk of the tree. While searching for food the whole flock keep up a continual twitter. Iris dark brown."—C. E. A.

15. Salpinctes obsoletus. Rock Wren.

In certain localities these birds were quite common. I saw many pairs with their young birds just able to fly. They prefer a cluster of rocks for their nest; this is merely a few sticks and bits of moss put carelessly together. One was placed under a rock as large as a doghouse, and in it were four young ones which scampered off while I was removing the rock. The birds become chapped and ragged, and present an odd appearance.

16. **Catherpes mexicanus.**

"Quite a rare resident in the winter. Found only in the mountains among large masses of rock, on the faces of cliffs. Has a peculiar note which one might easily mistake for the chirping of a cricket. Iris dark brown."—C. E. A.

17. **Troglodytes aedon.** House Wren.

As I was passing by a low hut dug into a hill, on the 25th of July, 1869, I saw a pair of these wrens enter the door or opening. I followed them but could not find them; as I turned to go out both birds passed me into the open air. I watched them several days and saw them go in with flies and bugs in their bills, so I entered again and hid myself in the large chimney; the birds came in and I saw one go into a small hole in the roof of sage brush. I put my hand in the hole and found there were five young ones. I remained in that vicinity some time and soon saw the young follow their parents.

18. **Troglodytes Parkmani.**

"Saw a pair, April 29th, in a bush heap."—C. E. A.

19. **Cistothorus palustris.**

"Saw it common at Cañon city, April 27th."—C. E. A.

20. **Anthus ludovicianus.**

"Saw an immense flock, May 13th, since which I have not met with it."—C. E. A., June 9th.

21. **Helminthophaga celata.**

"First noticed May 2d. Rare at this date (May 4th). Afterwards common for a short time."—C. E. A.

22. **Helminthophaga virginiæ.**

"First seen May 2d. A fine singer usually found singly on hill sides covered with brush."—C. E. A.

Since the above was in type Mr. Aiken writes that he has taken the nest and eggs of the species. It was on the ground concealed in a depression, in the manner of *H. ruficapilla.*

23. **Parula americana.**

"A single specimen killed May 11th. None others met with."

—C. E.A.

24. **Dendroica coronata.**

"Rather uncommon. First specimen killed April 29th."

—C. E. A.

25. Dendroica auduboni. Audubon's Warbler.

These were rare, owing perhaps to the lack of small trees and shrubs such as they prefer; several were shot on the rocks where they acted more like Wrens than Warblers. I could not discover any of their nests though I searched long for them.

"Rather common along the creeks in the foot-hills. First specimen secured April 16th."—C. E. A.

26. Dendroica nigrescens Bd.

"Took a male, May 6th, and on May 21st I secured a pair. Found on the cedar hills."—C. E. A.

27. Dendroica æstiva.

Arrived May 6th. Abundant along the creeks.

28. Geothlypis trichas.

"Arrived May 5th. Common in damp places covered with bushes or grass."—C. E. A.

29. Geothlypis macgillivrayii.

"Found sparsely in about the same places as the preceding. First seen, May 17th."—C. E. A.

30. Icteria longicauda.

"Arrives about May 5th, and soon becomes very common in the oak and cotton-wood thickets, on creek bottoms. Sings day and night."

—C. E. A.

31. Myiodioctes pusillus Bon.

"First seen May 14th. Common for about ten days."—C. E. A.

32. Setophaga ruticilla.

"Saw a pair May 21st, and have noticed several others since."

—C. E. A.

33. Petrochelidon lunifrons. Republican Cliff Swallow.

On my way westward I saw several pairs of these birds breeding in the eaves of almost every station house. I found large numbers breeding in the hills. They were invariably in colonies; on one occasion I found a small number breeding on an almost perpendicular cliff about 600 feet from the ground. I made my way to the top and by means of bushes, I let myself down upon a small projection about ten feet from the nests. Some were not completed and the birds flew down to the brook, and returned with small balls of mud, which they placed on their habitations and went back at once for more; after watching them awhile I broke a portion from one of the nests. The birds on returning from the stream, fluttered before it for awhile and both birds rose high in the air and did not return for some time. The next day the nest was repaired. I can see no difference in either the birds, nests, or eggs, from our eastern specimens of the same species.

"Common at Cañon City, April 27th."—C. E. A.

34. Hirundo horreorum.

These were not common. All that I saw were nesting in deserted cabins and 'dug outs.' I found young birds able to fly, and eggs which had been deposited but a few hours in the same hut; one nest in my possession is constructed principally of antelope hair.

"Also common at Cañon City, April 27th."—C. E. A.

35. Cotyle riparia.

"First noticed April 26th."—C. E. A.

36. Vireosylvia swainsoni. Bd.

"Arrived May 23. Common everywhere."—C. E. A.

37. Vireosylvia plumbea. Coues.

"Secured a specimen May 18th, since which I have taken several others."—C. E. A.

38. Ampelis garrulus.

"Rare in winter in the foot-hills, probably common in the mountains."—C. E. A.

39. Ampelis cedrorum.

"Noticed only two or three times and in the earlier part of the winter."—C. E. A.

40. Myiadestes townsendi. (Cab.)

"Common all winter. Shy and retired in its habits, inhabiting cañons or hillsides covered with cedar or piñon shrubs. Feeds during winter mostly on cedar berries, but on bright warm days it is often found on the ground beneath some bush, searching for insects. It is a beautiful singer, combining in its song the notes of the Wood Thrush, Baltimore Oriole, and Western Lark. Strange to say it sings only during the early winter. The males select their mates about the last of April. Iris dark brown."—C. E. A.

41. Collurio borealis. (Bd.)

"Noticed occasionally through the winter. Last seen March 21st." —C. E. A.

42. Collurio excubitoroides. (Bd.)

"First noticed April 5th, on open prairie. Very shy."—C. E. A.

43. Pyranga ludoviciana. Louisiana Tanager.

"I was fortunate enough to secure a fine pair of the birds. Though I saw several males, I saw but one female which I shot. The few that I saw were all on the very low bushes, and acted very much as our common Tanager (*P. rubra*) does. I am sure they breed here, though I did not find the nest. The crops were filled with insects and small seeds. The male was shot in August and had a very fine plumage.

"Arrived May 12th. Common for a short time."—C. E. A.

44. **Hesperiphona vespertina.** Bon.

"Saw several, Jan. 20th, in the foot-hills. They were very unsuspicious, and allowed me to approach within a few feet of them. Was first attracted by their clear loud whistle."—C. E. A.

45. **Carpodacus cassinii.** Bd.

"First noticed last Nov. in vicinity of Pueblo. Found them abundant at Cañon City, April 15."—C. E. A.

46. **Carpodacus frontalis.**

"Found them common along the Arkansas River, April 25 and 26. A fine singer. Gregarious."—C. E. A.

47. **Chrysomitris tristis.**

"Saw flock at Denver and Pueblo last November. Noticed several, April 26th, in company of Pine Finches."—C. E. A.

48. **Chrysomitris pinus.**

"Abundant in autumn and in spring, along creeks."—C. E. A.

49. **Leucosticte tephrocotis.** Grey Crowned Finch.

These birds are never found here in summer. They come in small flocks in the coldest part of winter. Their food is small seeds and insects. I have found some crops so full of seeds as to distort the birds. They become very fat and are good eating. In one specimen, a young male I think, the plumage is almost *black*, in fact it *is* black, except the wings and after half of the body. It is an interesting specimen. About 40 fine specimens were saved. I know nothing of their breeding places. There is no difference between the plumage of the males of the first year and the females. The old males are very beautiful.

"Saw and killed but a single specimen, a female. This bird was shot about dusk in the bed of a dry creek."—C. E. A.

50. **Poocetes gramineus.**

"The first specimen was killed April 18th. It was found common in the open country among bushes."—C. E. A.

51. **Zonotrichia gambeli.** Gambel's Finch.

The only difference I could see between this bird and our *Z. leucophrys* is in the song, which is beautiful and so mournful it made me homesick. I was unable to find their nests, though I am certain they breed in that locality in a neighboring thicket; here they roosted about four feet from the ground. Their habits are, as far as I observed, exactly similar to our eastern birds.

" Killed two about March 10th. Found in bushes along creek bottoms. Rather common."—C. E. A.

52. Zonotrichia leucophrys. Sw.

" Common wherever there is brush."—C. E. A.

53. Melospiza Lincolni. Lincoln's Finch.

While unpacking my birds on my arrival home, I came across one of these specimens. I have no note in regard to it, the birds are seldom found there, and I do not know anything in regard to the habits of the western variety. The bird is now in the collection of C. E. Aiken.

54. Melospiza melodia. Song Sparrow.

These were common, and several were saved in different states of the plumage. I can see no difference in the western birds from the eastern.

55. Spizella monticola. Tree Sparrow.

I have a fine male of this species shot in January, 1869. I saw none during my stay there, and as the above bird was sent to me without any notes, I can only say that it is found there in the coldest weather, and is not common and goes in very small flocks.

"Abundant winter resident, but had all disappeared by May 1."

—C. E. A.

56. Spizella socialis. (Bon.)

" Rather common. First seen April 21st."—C. E. A.

57. Junco oregonus. Oregon Snowbird.

A few of these straggle to this locality in very cold weather. They are in very small flocks and feed on small seeds, until, like the Grey Crowned Finch *(L. tephrocotis)*, they become very fat. Two males in my collection were shot in January, 1870.

" Noticed frequently through the winter, and was very common during March, and the first of April, but by the first of May only a few straggling females were seen, and soon even these had disappeared."—C. E. A.

58. Junco caniceps.

" Very rare during winter, but common in March, and a few remain at this date, (May 3d). No females of this species observed."

—C. E. A.

59. Junco annectens.

"Abundant during winter and early spring. A few females still remain."—C. E. A.

60. Junco hyemalis.

"None seen until about March 20th. From that date they were common about three weeks and then disappeared."—C. E. A.

61. Junco hyemalis var. **Aikenii.**

"Rare during winter. Rather common during the latter part of Feb. and first part of March, but before April 1st all had disappeared. During winter the males only were seen, but the females were most numerous during spring. More commonly seen singly, or in companies of two or three, than the preceding races."—C. E. A.

"The iris in each of these birds varies from a bright reddish to a dark brown. The whole five races mingle indiscriminately in the same flock, and it is very unusual to see a flock of any considerable size composed of any one variety."—C. E. A.

62. Chondestes grammaca. Lark Finch.

These were common, going in small flocks of 10 or 15 individuals, as our White Throated Sparrow sometimes does. They prefer the willows along the water courses. I could not find their nests, though the birds were at all times abundant. I think the western are lighter, as a general rule, than our more eastern specimens.

63. Calamospiza bicolor. Lark Bunting.

The first time I saw one of these birds fly up I exclaimed, "what a curious *Bob-o-Link*," their actions are almost identical, except that Lark Buntings are gregarious. I found them plentiful in certain localities, in flocks of 50 to 100 individuals. They run rapidly on the ground; when feeding the males often rise twenty feet from the ground, and while suspended as it were in the air, they utter several peculiar and musical notes. These being finished they fly to the ground and continue feeding. I was not able to find their nests.

64. Cyanospiza amoena. Lazuli Finch.

Rare and shy. I found a pair who had a nest somewhere in the vicinity, but so shy were they that I could not kill them for nearly a week. I killed four specimens, among them one fine female. I know nothing of their habits beyond the fact that they fly well. They seemed to be at home both in the tops of small trees and in the sage brush, where I killed them all. I procured them all within a radius of fifty feet and did not observe any in other localities.

"First seen, May 2d."—C. E. A.

65. Pipilo arcticus. Sw.

First seen April 2d. Common wherever there is brush. The call note is very unlike the "chewink" of our eastern species, but their song is similar. Iris varies in color from ochraceous yellow to vermillion red. Usually lighter at outer edge.

66. Pipilo chlorurus. Green Tailed Finch.

I never saw this bird but that I thought of our Cat Bird. I have seen it going through the bushes with its tail up and making a great noise. They go over the rocks in the same way, looking at every thing, stopping at the least noise, and jumping from rock to rock with the greatest ease. They were not common, though as many could be obtained as was desirable. I found one nest containing two eggs, one of which is partly broken. The bird slid from her nest on my approach and did not make any complaint. I have some specimens, evidently young birds, but whether of the previous year or not, I am unable to tell. I think, however, that two broods are raised.

"First seen and killed, May 2d. Keeps in thick bushes close to to the ground, and is rather shy."—C. E. A.

67. Pipilo mesoleucus.

"Saw and killed a pair on a barn yard fence, near Cañon City, April 16th. The owner of the place informed me that the same pair had been about all winter, taking refuge in the barn during severe weather. No others seen." — C. E. A.

68. Eremophila cornuta. Sky Lark. Western variety.

I have a fine male of the species shot in January, 1870. Their habits are in every way similar to eastern birds. I do not think they breed here.

"Abundant winter resident. Numbers began to diminish about March 15th. May 1st, single birds only seen occasionally; probably breeding, though no nests have been found." — C. E. A.

69. Molothrus pecoris.

"Saw several flocks last fall." — C. E. A.

70. Agelaius phœniceus. Red-wing Blackbird.

A few of these were seen with the Rusty Blackbirds. A young male was shot, showing that they breed here; they are plentiful, no doubt, on Laramie Plains.

"A common summer and winter resident. — C. E. A.

71. Xanthocephalus icterocephalus.

"Noticed a few April 27th. Said to be a very common summer resident." — C. E. A.

72. Sturnella neglecta. Western Lark.

Although I saw a number of these birds, I was unable to discover a single nest. I am certain they breed here, as large numbers could be found at any time in June and July. They were very shy, and I had some difficulty in getting a dozen or more specimens. One bird (which was destroyed by fire on the 9th of October, in the Academy of Science) was almost white. It was not an albino, but was doubtless rendered so by the sun, as I have other birds affected in a similar way. Their song is so different from our eastern birds as to leave no doubt in my mind of the existence of two species.

"Very common summer resident. Seen occasionally in flocks during winter. Notes numerous and varied, but all different from *S. magna.* The songs of different individuals differ quite as much from each other as from our eastern variety, however." — C. E. A.

73. Icterus bullocki. Bullock's Oriole.

I saw but five or six of the birds; they were generally in the tops of the higher pines. I saw no females whatever, though I shot everything that looked like one. I think they breed here, though I was unable to find a nest. I did not hear the males utter anything that could be called a song; nothing except a few coarse notes.

74. Scolecophagus cyanocephalus. Brewer's Black-bird.

"Abundant in fall and spring." — C. E. A.

75. Scolecophagus ferrugineus. Rusty Blackbird.

These were very common. I found them breeding in low, marshy places (which were few), and had no difficulty in getting all the eggs I wished, though many of the nests contained young ones. Their actions are identical with eastern specimens, except that many nests were placed on the ground, while others were on low bushes. I have both birds and eggs in my collection.

76. Corvus cryptoleucus. White-necked Raven.

"Very common along the base of the mountains." — C. E. A.

77. Corvus americanus. Common Crow.

These were not common, though I found several pair, and their nests containing young ones. They build on the low bushes in the gullies. On one tree I counted twenty-seven deserted nests. One was captured alive and made a great pet at the "Sherman House."

78. Picicorvus columbianus. Clark's Crow.

Except on one occasion, I saw but very few of these birds. One day as I was making my way towards "Cheyenne Pass," I saw large flocks of these birds coming from the south; this was in August.

They were very shy at times. They flew low, and again they mounted high in the air. I had an excellent opportunity to observe one fine male as he sat on a tree above me. He kept up a constant rattle while there, which sounded to me like the noise produced by drawing a stick over a slat fence. He was very restless, and did not remain in the same position more than an instant. I do not think they breed in this portion of the Black Hills, though they may in the more thickly wooded portions.

"Rather common in the foot-hills during winter, but goes into the mountains on the approach of spring, and at this date, May 1st, has disappeared. Known here as the Piñon Jay. Usually seen hanging from a branch extracting seeds from the pine or piñon cones. I have only seen it singly." — C. E. A.

79. **Gymnokitta cyanocephala.** Maximilian's Jay.

"First seen February 20th. Have noticed them only in flocks in the cedar hills. They are very shy of approach, and on the report of a gun rise in a compact flock and fly to a considerable distance." — C. E. A.

80. **Pica hudsonica.** Magpie.

These were common, though shy. They breed early in June, or latter part of May. The nest is placed on a low bush, the young remain in company with their parents, and thus form a small flock. They devour the eggs of small birds, and seem to be very apt in finding them. A beautiful male is in my collection, shot in December, and four young, shot June 10th, showing that they do not migrate on account of temperature.

"Common everywhere. Feeds on seeds, insects and carrion. A cunning bird, generally disliked on account of its mischievous propensities, but admired for its beautiful plumage. It is said that they often pick and worry a weak sorebacked animal to death, pick out the eyes of lambs, rob the nests of other birds, etc. It is capable of the most harsh and defiant tones, as well as those that are soft and even musical. Many notes are almost human, and it seems at times to be conversing confidentially with its mate. It is easily domesticated, and may be taught to repeat words and sentences. The irides in specimens taken last fall were blue; in all birds killed this spring they were brown; in the young they are bluish gray.

"The nest, which is quite a curious structure, is usually placed in a small scrubby tree about ten feet from the ground. They commence to build about the last of March, and the eggs are laid two or three weeks later. The foundation of the nest is of twigs firmly cemented with mud. On this is placed the nest proper, which is composed of finer twigs plastered with mud, and lined with fine rootlets. Outside of this a wall of dead twigs is built up from the foundation and arched over the top; the whole structure forming a rounded mass from one to three feet in diameter. The entrance is an inconspicuous hole in the side. Full number of eggs eight. Young begin to fly about June 1st."—C. E. A.

81. Cyanura macrolophus. Long-crested Jay.

"Common summer and winter resident. Does not descend to the plains, but prefers the rough timbered country of the mountains." — C. E. A.

82. Cyanocitta woodhousei. Woodhouse's Jay.

"Common resident. Found along the foot of the mountains in brush thickets, where they breed. Nest composed outwardly of dead twigs, then of fine roots, and lined with fine rootlets or horsehair. The eggs, four or five in number, are laid about May 1st. They are of a light bluish-green color, with the reddish-brown specks thickest at the large end. Their average length is 1.06 inches, breadth .80 inch." — C. E. A.

83. Tyrannus carolinensis. King Bird. Bee Martin.

I saw several of these flycatchers, though they are by no means common, but one nest was found containing three eggs. As I wished to obtain the full set, I determined to leave the nest for a few days; the next day it was destroyed by a magpie. The nest was placed near the top of a small tree, and resembled in every particular that of the eastern birds.

"Common summer resident. First seen May 5th." — C. E. A.

84. Tyrannus verticalis. Arkansas Flycatcher.

"First seen May 5th, since which it has been common. Found everywhere, but is most common about fields." — C. E. A.

85. Tyrannus vociferans. Cassin's Flycatcher.

"Found in the same places as the preceding. First observed May 12th." — C. E. A.

86. Myiarchus mexicanus. Ash-throated Flycatcher.

"One specimen secured May 21st." — C. E. A.

87. Sayornis sayus. Say's Flycatcher.

"First seen April 20th. Found generally on the prairies, but not common." — C. E. A.

88. Contopus borealis. Olive-sided Flycatcher.

"Killed a bird of this species May 30th." — C. E. A.

89. Contopus richardsoni.

"Arrive May 6th. Very common by the 25th." — C. E. A.

90. Empidonax pusillus.

"Arrived about May 20th." — C. E. A.

91. Empidonax obscurus.

"A single specimen obtained May 3d, in oak brush." — C. E. A.

92. Panyptila melanoleuca.

"First seen at Cañon City April 18th. Specimen obtained May 6th." — C. E. A.

93. Antrostomus nuttalli.

"Heard several on the eve of May 13th." — C. E. A.

94. Chordeiles popetue.

"Common. First seen May 23d." — C. E. A.

95. Ceryle alcyon.

"Rather a rare resident." — C. E. A.

96. Selasphorus platycercus. Broad-tailed Hummer.

These little birds were quite common on one occasion, while skinning a hawk. I threw a piece of flesh into a small dead tree near me. In an instant three of these birds were poised before the meat mistaking it no doubt for some gaudy flowers.

But one nest of these birds was found. It contained two young ones about a week old. They were preserved in alcohol. The female was also procured. I was struck by the *wisdom* of these birds in placing their nest. A small tree had fallen over the brook, which was here eight feet wide. On one of the under branches was placed the nest, in such a way that the trunk of the tree would effectually keep out the rain and snow. The nest was lined with a species of cotton obtained in the vicinity.

"Very common. First seen May 5th." — C. E. A.

97. Geococcyx californicus.

"A rare summer and winter resident. Have taken a single specimen." — C. E. A.

98. Picus harrisi.

"Common during winter. Rare during summer. Nest with four eggs secured May 26th." — C. E. A.

99. Picus gairdneri.

"Common during winter. None seen since April 1st." — C. E. A.

100. Sphyropicus varius. Yellow-bellied Woodpecker.

I was only able to find two specimens of this bird, one of which had built its nest in a pine stump, in company with a house wren (*Troglodytes aedon*), who occupied a deserted hole with her family in the same stump. I think these birds (*S. varius*) are common in the more thickly wooded portions of this region. The birds, as far as I could see, do not differ materially from specimens shot in the east.

101. Melanerpes erythrocephalus. Red-headed Woodpecker.

Of this species I only obtained a single specimen, a male. I have no doubt but that it breeds there, though everyone was surprised when I shot the bird. I can see no difference between this specimen and others obtained in Illinois.

"Common. Did not make its appearance till May 20th." — C. E. A.

102. Melanerpes torquatus.

"Not noticed this spring till May 6th. Rather common in the foot-hills, where they are preparing to breed (June 1st)." — C. E. A.

103. Colaptes mexicanus. Red-shafted Flicker.

These birds were quite abundant. They seemed to seek the low, short trees along the creeks and small streams rather than the large pines. A number of their nests were found, containing from four to five young ones. They nest in the decayed pines almost exclusively, the female performing the greater share of the labors of incubation. The male cries almost constantly, and shows great anger at anyone approaching the nest. As soon as the young are a few weeks old they climb to the opening of the excavations and greet their parents with loud and not unmusical notes. I have often been amused to see five of their little heads sticking out from a hole at once. They remain quite late, as the weather there is beautiful until January. Young ones but a few days old were found June 15th.

"Found in winter along the creeks at the base of the mountains; in summer everywhere." — C. E. A.

104. Falco sparverius. Sparrow Hawk.

These were quite common. They lived on the smaller species of sparrows and mice. I see no difference between them and our eastern species, either in habits or color.

105. Haliaetus leucocephalus. Bald Eagle.

A few were seen flying at a great height. At the station called "Cannon" a fine pair were seen which had been captured in the vicinity.

106. Bubo virginianus. Great Horned Owl.

I was not successful in my attempts to get a full plumaged male of this species. They were quite common, and no doubt breed in that locality. They preferred the thickest pine trees, where they remained concealed during the day. A full sized young bird was shot in August out of a pine tree. It was devouring a small animal at the time. Its crop was filled with pieces of birds and animals. I frequently saw them flying in the air pursued by a flock of blackbirds. They seem to have particular resting places, like some hawks, to which they resort to devour their prey. On being driven from one tree they fly to another familiar place, and then back again. I was unable to find any nest.

107. Otus wilsonianus. Long-eared Owl.

But a single specimen was seen and shot on a low bush. A lot of magpies were on the same bush, and did not seem either to molest or be afraid of it.

108. Athene hypugaea. Burrowing Owl.

A specimen was shot with some "prairie dogs," though they are rare in the Black Hills. The above was the only one secured. They are very common on the lower plains.

109. Zenaidura carolinensis.

"Abundant on the plains, breeding in low bushes and on the ground. Begin to arrive about the first of April, and are very abundant by the last of the month." — C. E. A.

110. Tetrao obscurus. Dusky Grouse.

There were but few of these birds to be seen during the summer, probably on account of their breeding. I saw several females and their young, which greatly resemble the young of the *C. cupido* (Pinnated Grouse). In the fall they go in flocks and rest on the ground, though some seem to prefer the trees. I did not get their eggs, but found many young ones. Their flight is similar to *C. cupido.*

"Said to be a common resident in the mountains." — C. E. A.

111. Pediocaetes columbianus. Sharp-tailed Grouse.

None were seen in summer. A few seem to pass the winter here. A fine male shot January, 1870, is in my possession. They are not common in the hills, though they are more so on "Laramie Plains."

"Common in certain localities. Found in brush along the creeks."
— C. E. A.

112. Centrocercus urophasianus. Sage Cock.

There are many of these in winter, though they retire to breed in summer. They roost in circles on the ground. I have seen a patch of ground fifteen feet in diameter completely covered with their excrements. I think they resort to the same place many nights in succession, unless disturbed. I heard their "booming" several times. It seemed to come from a very great distance. A very fine male in my collection weighed four and one-half pounds before skinning. Their flesh becomes tainted with the sage on which they feed, and renders them disagreeable to some palates.

"Common in the northern part of the territory." — C. E. A.

113. Lagopus leucurus.

"Said to be common on the Snowy Range. The following description of the nest was given me by an old miner, who claimed to have found one near the top of the range in June. Nest composed of leaves and grass, placed on the ground among bushes on a side hill. Eggs fourteen in number, light bluish-brown spotted with dark brown." — C. E. A.

114. Grus americanus.

"Seen occasionally during their migrations." — C. E. A.

115. Grus canadensis.

"Common during the migrations." — C. E. A.

116. Ardea herodias Linn.

"Common summer resident." — C. E. A.

117. Botaurus lentiginosus.

"A single specimen observed."— C. E. A.

118. Ægialitis vociferus. Kill-Deer.

I saw four of these birds around a small mud puddle which was caused by a recent rain. They flew off on my approach, and I saw no more of them. They were not common, as the country is not such as they prefer.

"Very common since March 1st. Lay four eggs among the gravel in the vicinity of the water." — C. E. A.

119. Ægialitis montanus.

"Found in pairs in the table lands." — C. E. A.

120. Gallinago wilsoni.

"Common during the migrations. A few remain through the winter." — C. E. A.

121. Recurvirostra americana.

"Have seen a fine pair killed on the Arkansas River this spring."
— C. E. A.

122. **Tringoides macularius.**

"Common summer resident. A few remain during the winter."
— C. E. A.

123. **Numenius longirostris.**

"Common on the prairies where it breeds." — C. E. A.

124. **Rallus virginianus.**

"Obtained a male, with its nest and seven eggs, June 4th." C. E. A.

125. **Bernicla hutchinsi.**

"Killed one specimen in December last." — C. E. A.

126. **Anas boschas.** Mallard Duck.

One day as I was hunting something to eat, as I was nearly starved, I came to a small stream about three feet wide. This had worn a path through the meadow about six feet deep, so that the surface of the water was hid from sight. As I was about to step across I heard a great fluttering, and a large duck rose in the air, which I shot at once. I was surprised to find it an old friend, in the shape of a Mallard. On going to the spot from which she rose, I found a brood of young ducks which scampered off. I was too hungry to skin the duck, so I made a fire and eat it. I saw one other female and her brood.

"Have observed the following ducks." — C. E. A.

127. **Dafila acuta.**
128. **Nettion carolinensis.**
129. **Querquedula discors.**
130. **Querquedula cyanopterus.**
131. **Spatula clypeata.**
132. **Chaulelasmus streperus.**
133. **Mareca americana.**
134. **Aix sponsa.**
135. **Fulix affinis.**
136. **Fulix collaris.**
137. **Aythya americana.**
138. **Aythya vallisneria.**
139. **Bucephala americana.**
140. **Bucephala albeola.**
141. **Erismatura dominica.**
142. **Hydrochelidon plumbea.**

"Found a dead specimen of this bird June 1st, after a severe hail-storm." — C. E. A.

The thanks of the Society were voted to the Smithsonian Institution for the gift of one hundred and eighty bird-skins to the Society's Museum.

June 19, 1872.

The President in the chair. Twenty-five persons present.

Prof. Edward S. Morse read a paper on the oviducts of the Terebratulina. The hearts of Cuvier were demonstrated to be oviducts, as Hancock and Huxley had insisted. The eggs, discharged from the sinuses in the pallial membrane and floating freely in the perivisceral cavity, were seen to gather at the trumpet-shaped mouth of the oviduct, and were watched as they slowly passed through the tube and issued from the extreme orifice. In conclusion Prof. Morse insisted on the relationship of the Brachiopoda with the Vermes, which he had long advocated. The paper will appear in full in the Memoirs of the Society, Vol. II, Pt. 2.

Mr. F. W. Putnam thought that now-a-days naturalists are too ready to take a single character as solving a question in the classification of animals, and as a caution alluded to the case of Lepidosiren, a genus of fishes allied by several characteristics to the Batrachians, and formerly placed in both classes by different naturalists. He suggested that the Brachiopoda might similarly present both molluscan and vermian characteristics, though of course he did not question the able observations of Prof. Morse.

Prof. Morse replied that he could not allow the Brachiopoda a single real molluscan feature not common to many other annelids also.

The following paper was presented: —

Geographical Variation in North American Birds.

By J. A. Allen.

Probably the birds of no equal area of the earth's surface are better known than those of North America north of Mexico, or of the whole continent southward even to the Isthmus of Panama. No museums in the world, probably, possess so large suites of specimens of single species as there are of North American birds in the Museum of the Smithsonian Institution and in the Museum of Comparative Zoology, nor from so many localities. In many instances single species are represented by hundreds of specimens collected at frequent intervals throughout their known range. Those contained in the Smithsonian Institution have been most carefully elaborated by Prof. Baird and others, whose reports upon them have justly acquired a world-wide reputation for their thoroughness and accuracy. Those in the Museum of Comparative Zoology have also been carefully studied.

Briefly, then, what are the facts and the general results that have followed the investigation of this exceptionally large amount of material? What are the allowable inferences, and what general principles have been apparently established? To answer these questions as briefly as may be is the object of the present remarks,—premising, however, that the formerly current opinions respecting the rank of a certain class of forms heretofore generally regarded as specific have been radically modified. Intergradation has been frequently traced between widely different forms, a gradual coalescence in scores of instances having been positively established, and rendered extremely probable in a large number of others.

In North America geographical variation exhibits two marked phases:—(1) a differentiation with differences of latitude and elevation, and (2) differentiation with differences of longitude; which, for convenience, may be termed respectively latitudinal and longitudinal variation.[1] In respect to both, differentiation occurs in different degrees in different groups, in accordance with their general tendency to variation, or, as it were, in proportion to their normal degree of plasticity. In regard to variation with latitude the modifications are apparently more general than in what I have termed longitudinal variation. In latitudinal variation the differentiation affects not merely color, but size and the details of structural parts, whereas

[1] See Bull. Mus. Comp. Zool., Vol. II, pp. 229-247, *et seq.*, April, 1871.

color appears to be the main element affected by longitudinal variation. The fact of variation in size has been conceded as a general law by the majority of at least American ornithologists and mammalogists since it was so fully established by Prof. S. F. Baird in 1857 and 1858, in his admirable reports on the mammals and birds of North America, published in the series of Government Reports on the explorations and surveys of the various Pacific Railroad Routes. Prof. Baird then and subsequently[1] called attention to the fact of the greater length of the tail in several species of birds at certain localities, and cites instances of the larger size of the bill at southern points, and the paler color of the plumage of the birds of the Plains and the arid peninsular of Lower California. All his subsequent works have furnished numerous citations of similar variation with locality, but instead of insisting upon any common tie connecting these phenomena as the result of general laws, they were viewed as evidences of specific differentiation. The differences are, indeed, so great between many of the forms now known to intergrade that it is not surprising that they were regarded as different species when known from only a few examples, apparently unconnected by intermediate forms. Subsequently, however, it has been found that they are not trenchantly separated, intermediate forms so linking them together that they can be only vaguely diagnosed. These connecting links, inhabiting — at least in the breeding season — localities intermediate in geographical position and in climatic conditions to those frequented by the more extreme forms, suggest an intimate genetic relationship and a differentiation mainly or wholly through climatic influence, or the diverse conditions of environment.

Latitudinal variation presents the following phenomena, which are of such general occurrence that even the exceptions, if such there really be, are exceedingly few.

1. *As regards Size.* There is a general reduction in the size of the individual from the north southward, amounting not unfrequently to as high as ten to fifteen per cent. of the maximum size of the species. The reduction is much greater in some species, and in some groups of species, than in others, but is almost invariably considerable and easily recognizable.

2. *In respect to the Bill.* The variation of the bill is somewhat inverse to that of the general size, as a rule the southern forms having generally relatively, and often absolutely, larger bills than north-

[1] Amer. Journ. Sci. and Arts, Vol. XLI, 1866.

ern ones, the increased size taking different proportions in different species and different styles of bill. Those of a stout, thick, conical form generally increase in general size, but especially in thickness. Those of a slender, attenuate form become slenderer and relatively longer at the southward, with a decidedly greater tendency to curvature.

3. *In respect to the Claws.* A similar increase in size is apparent in the claws, especially in that of the hallux, at southern localities, perhaps less marked and less general than the increase of the bill, with which it evidently correlates.

4. *In respect to the Tail.* A marked elongation of the tail at the southward has been noticed in many cases, both in Cape St. Lucas birds (*Baird*) and in those of Florida.

5. *In respect to Color.* The differences in color are especially obvious, and may be reduced to two phases of modification:—(*a*) a general increase in intensity at the southward, and (*b*) an increase in the extent of dusky or black markings at the expense of the intervening lighter or white ones; or, conversely, the reduction in size of white spots and bars. Under the general increase in intensity the iridescence of lustrous species becomes greater, and fuscous, plumbeous, rufous, yellow and olivaceous tints are heightened in species with the color continuous in masses. Under the repression of light colors the white or yellowish edgings and spots on the wings and tail become more or less reduced, and frequently to a great degree, in species barred transversely with light and dark colors; the dark bars widen at the southward at the expense of the white or lighter ones, sometimes to such an extent as to greatly change the general aspect of the species, as is the case in the *Ortyx virginianus* of the Atlantic States, and in other well known species. Also under the tendency to the increase of dark colors, longitudinal streaks and blotches on a light ground increase in extent and intensity of color.

In respect to longitudinal variation, the differences appear to be mainly those of color, and to hold a direct relationship to the humidity of the climate. On the arid plains of the middle and western portions of the continent the annual rainfall is less than half that of the eastern half of the continent, while a rainy belt occurs on the Pacific coast, stretching northward from near the mouth of the Columbia River to Alaska, over which the annual rainfall is double that of any portion of the eastern half of the continent. Taking the species that present a nearly continental range, we find that almost invariably they pass gradually into the pallid forms of the interior at the eastern edge of the arid plains, the greatest pallor being developed in the driest regions, as the peninsular of Lower California and the almost rainless belt along the Colorado River, and northward along the eastern base of the Sierra Nevada Mountains; that on the Pacific slope they again reassume nearly the tints of the eastern form, but more to the northward, over the above-mentioned rainy region, they acquire a depth of color far in excess of what the species presents in the Atlantic region. This coincidence of bright and pale tints, with the relative humidity of the locality is certainly suggestive, if not demonstrative, of the relation of cause and effect between these two phenomena, since the same rule is traceable over large portions, at least, of the Old World; the Scandinavian forms, for instance, being darker colored than the conspecific races of Central Europe, and these again darker than those of Northern Africa and the adjacent regions. Humidity alone, or in conjunction with greater intensity of light, seems equally well to account for the increase of color to the southward. Yet, from the well known bleaching effect of sunlight, intensified by reflection, upon the colors of animals living upon sandy islands, and seabeaches, and desert interior regions, it seems doubtful whether the larger share of modification in intensity of color in birds may not be due to humidity alone, or to humidity and a high temperature together, rather than to intensity of light.

In regard to the enlargement of peripheral parts at the southward, it seems not unreasonable to suppose that the increase of temperature in stimulating the circulation in these exposed members may have something to do with it, especially in view of the evidence afforded by mammals, which in general present climatic modifications parallel with those of birds.

Whatever may be the cause of the above modifications of structure and color at different localities, we certainly find the following coincidences: I. In accordance with the increase in the intensity of color in individuals of the same species from the north southward, in the northern hemisphere, the brighter colored species in genera represented in both the temperate and tropical regions occur, as a general rule, at the southward; the same fact holding good also for sub-families. In cosmopolitan genera, families, etc., the tropical species are almost always brighter colored than the extra-tropical ones. All the most gorgeously colored families of birds are either exclusively tropical or semi-tropical, with generally the outlying species more plainly colored than the average for the family. II. In accordance with the increase in the size of the bill at the southward, all the species that have this member enormously developed are tropical or semi-tropical, not only such families as have the beak at its maximum of development, as the toucans and hornbills, but in all groups in which it is unusually large, the extreme development is reached in the intertropical regions. III. In respect to the tail, with very few exceptions, all long-tailed forms reach their highest development within or near the equatorial regions.

The facts indicated above in respect to the inosculation of forms formerly regarded as specifically differentiated, will evidently require modifications of the hitherto accepted nomenclature. Evidently many of these forms are so strongly marked that they should be in some manner recognized in nomenclature, though admittedly of less than specific rank. Most naturalists now practically recognize as species such groups of individuals as are not known to graduate by nearly imperceptible stages into any other similar group; and as varieties, such groups of individuals as occur at certain localities, or over certain areas, which differ more or less from other groups inhabiting other (generally contiguous) localities, with which there is evidence that they do, more or less fully, intergrade. Convenience seems to demand such a course, in order to enable the naturalist to specify what particular variety or race of a species inhabits a given section of country—a method, in fact, already more or less generally practiced.

Finally, what is the bearing of these facts of geographical variation upon the question of origin of genera and species? Having approached the subject from a geographical standpoint, my own impression of the importance of the conditions of environment in modifying the characteristics of animals may have unduly impressed me; yet that they exercise a greater influence than is currently recognized I think must be admitted. How, for instance, can natural or sexual selection satisfactorily account for the occurence of pallid forms in arid, semi-desert regions, and of brighter colored forms in contiguous humid districts, or the generally increased intensity of color southward, and its maximum development only toward and within the tropical regions? In many cases, it is true, the change in color may be protective, as it doubtless is in the assimilation of the pale tints of birds and other animals inhabiting arid plains to the generally gray color of the vegetation and the earth itself in such localities; yet, as the resemblance of the birds of these arid districts when young or in fresh plumage to those of the adjoining regions at the same season is much greater, as a general rule, than at the end of the breeding season, we have thus palpable evidence of the direct modification of color by environing conditions. Again, it is hard to see how the intenser and darker shades of the iridescence of the *Quiscali* in the South Atlantic and Gulf States, or their slenderer and more decurved bill, or the greater breadth of the transverse black bars on the breast of the southern form of *Ortyx virginianus* can be in the one case any more "protective," or in the other give greater facility in obtaining food, than the different colors and the differently proportioned beaks of the northern forms of these species; or of what advantage the large claws and long tails can be at southern localities rather than at northern. The variation in color is not apparently any better explained by sexual selection than are the other modifications by natural selection, for it is hardly supposable that sexual selection should act in so uniformly an accelerated degree toward the southward, or so generally from arid regions toward moister ones. On the contrary, it is just this gradual and general modification over wide areas that apparently points to climatic influence as the differentiating cause. There is, further, frequently a closer assimilation of the sexes at the southward, as among the *Icteridæ*, through the greater increased brilliancy of the female as compared with the male, which is rather the reverse than otherwise of what is commonly supposed to be the result of sexual selection.

Freely admitting, however, that both natural selection and sexual selection are causes of modification in the gradual differentiation of animals, I am led to regard them as secondary rather than primary elements, and that climate and other environing conditions take a larger share in the work than the majority of evolutionists seem willing to admit. Evidently no single law will explain all the phases of modification by descent, and in addition to those above alluded to, doubtless what Hyatt and Cope, among American zoologists, have termed the laws of acceleration and retardation are among the other causes of the modification. In birds, even, phenomena are apparent that cannot be strictly admitted into the category of geographical or climatic variations, but seem to singularly combine some evident features of this character with a retention of a few embryonic characteristics, especially in respect to coloration, of allied intergrading forms, as occurs in some of the birds of the middle portion of the

North American continent as compared with those of the eastern portion. Again, in respect to insular regions, while the above mentioned general laws of climatic variation are there evident, certain other exceptional modifications obtain, that seem to specially characterize those regions.

A word, in conclusion, respecting hybridity:—When comparatively few instances were known, in which specimens combined in various degrees the characters of two quite distinct forms, their synthetic character was generally explained by the theory of hybridity; but the irrefragibility of the evidence now at hand in proof of the intergradation of such forms over large areas,—the transition being so gradual as to occupy hundreds of miles in the passage, — and also coincident with a similarly gradual change in the conditions of environment, together with the demonstrable evidence of the power of climatic influence, seems to furnish a far more satisfactory explanation of these perplexing phenomena. But an advocate of the theory of hybridity might still assume that this gradual transition over a wide area is no objection to the theory, since the gradual fading out of the impression of contact in either direction from the line of junction of the respective habitats of two forms is just the result that would be anticipated from such a sexual intermingling of the forms in question. But the real objection to the theory — granting the possibility of hybridization on such a gigantic scale, which seems really improbable — is, that widely different forms occur also at different points in latitude, between which each successive stage of gradual differentiation can be readily traced, where hybridity can scarcely be supposed to account for the gradual change. Furthermore, gradual differentiation is now known in so many cases that it amounts to the demonstration of climatic variation as a general law, by means of which a species may be safely predicted to take on a given character under certain specific climatic conditions. If the theory of hybridity be urged to account for the intergradation of forms occurring at localities differently situated in respect to latitude, as has sometimes been done, it evidently falls under the weight it has to support; and yet there seems to be little better evidence in its behalf in cases where the intergrading forms happen to be differently situated in respect to longitude.

To describe in detail, or even to give illustrations, of geographical modification would require more space than would be proper to use in this connection, especially since a preliminary exposition of the facts upon which the preceding generalizations have been based, has already been presented in two papers in the Bulletin of the Museum of Comparative Zoology (Vol. II, No. 3, April, 1871, and Vol. III, No. 6, June, 1872).

The Committee on the Walker Prizes offered their report on the essays presented on the "Darwinian Question," which was accepted. A first prize of one hundred dollars was awarded to Prof. E. D. Cope; and a second prize, fifty dollars, to B. F. Ferris.

The thanks of the Society were voted to Mr. C. M. Tracy, for two fine Ornithorhynchus skins.

October 2, 1872.

The President in the chair. Forty-one persons present.

Dr. I. T. Hunt, Messrs. Oliver H. Perry, Chauncey Thomas and F. W. Lincoln, Jr., were elected Resident Members.

Prof. N. S. Shaler gave a brief account of the geology of Martha's Vineyard and Nantucket. He thought there was unmistakable evidence of recent depression along the coast of these islands, and alluded to the explanation of the movements involved in alterations of the level of shore lines, which he offered to the Society several years ago.

The following paper was communicated by Mr. J. A. Allen,

Partial List of the Summer Birds of Kanawha County, West Virginia; with Annotations. By W. D. Scott.

The following list gives the result of about two months of field work (from the middle of June till the middle of August) on the bird fauna of a portion of Kanawha County, West Virginia. During this time eighty-six species of birds were noted or taken. In this connection I should mention my indebtedness to Mr. William S.

Edwards, a resident of the place, for valuable notes and other aid. Coalburgh, the point at which the notes were made, is situated on the Kanawha River, in the County of this name, about twenty miles from the junction of its sources, the Gauley and New Rivers. The country here presents many features, such as narrow valleys hemmed in by moderately high mountains, which make the bird fauna very interesting. This consists of a mixture of Alleghanian and Carolinian types, and birds of other faunæ were also noted, as will be seen in the appended list. The mountains are but a low spur of the Alleghany Range. They can hardly be called mountains, as they attain a height of not more than seven hundred feet above the level of the river. This elevation is, however, great enough to make a very decided variation in the temperature and surrounding conditions from those of the valley, and hence affords some interesting facts relative to the local distribution of the species through the same area of country. The birds of the Alleghanian fauna generally are found on the mountain sides and tops, and those of the Carolinian fauna in the valleys. Of course, in so small an area, birds of both the above mentioned faunæ were found in either of the localities, but the above seemed to be the general rule.

Certain species which have an extended range over several faunæ were found to differ very appreciably, in regard to the intensity of coloring and the like, from their more northern or southern types. As instances, the two following may be cited as being well-marked. The Carolina Wren (*Thryothorus ludovicianus*), which is restricted in its northern range by the Carolinian fauna, is very much paler than the Florida form of that species, and the Quail (*Ortyx virginianus*) presents a form about half way between the Massachusetts and Florida forms, as regards coloring. In the list will be found other illustrations of geographical variation.

TURDIDÆ.

1. **Turdus migratorius.** Rather rare. One specimen taken and two others noted. Found mostly on the mountains. Breeds.

2. **Turdus mustelinus.** Rather common and very tame. Found everywhere. Breeds. The song of this species was rather weaker than that of the same bird in Massachusetts.

3. **Galeoscoptes carolinensis.** Common. Found mostly in the valleys. Breeds.

SAXICOLIDÆ.

4. **Sialia sialis.** Quite common. Found mostly in the bottoms. Breeds.

SYLVIIDÆ.

5. **Polioptila cærulea.** Rare. But half a dozen were seen or taken during the time spent here. Breeds.

PARIDÆ.

6. **Parus atricapillus** var. **carolinensis.** Common. Found everywhere. Breeds. Smaller than our more northern *Parus atricapillus.* Song much weaker and more broken. The bill averages in most specimens longer and more acute than in the true *P. atricapillus*, but these are the chief appreciable differences.

7. **Lophophanes bicolor.** Common. Found everywhere, but most abundantly in the valleys. Breeds.

SITTIDÆ.

8. **Sitta carolinensis.** Rather rare. One specimen taken and four others noted. All that were seen and taken were on the mountains. Probably breeds.

TROGLODYTIDÆ.

9. **Thryothorus ludovicianus.** Abundant. Some were found on the mountain sides, but they were by far more abundant in the valley. Breeds. The young were taken fully fledged, the last of June. As before stated this species is here represented by its most northern form, and is much paler than individuals of the same species taken in Florida.

SYLVICOLIDÆ.

10. **Mniotilta varia.** Very common and found everywhere. Breeds. The specimens taken average rather darker than those collected in Massachusetts.

11. **Parula americana.** Quite common. Found mostly on the mountains. The yellow of the breast extends farther down than in the more northern form of this species.

12. **Helmitherus vermivorus.** Not rare. Found mostly in thickets along the river bank and but few on the mountains. Breeds.

A young female bird of this species was taken June 25th, in the down, which had the black and brown stripes of the head clearly defined.

13. **Helminthophaga chrysoptera.** Rare. A single individual of this species was taken on the mountain, and six others along the river banks.

14. **Dendrœca pennsylvanica.** Rare. Not seen till August, when three individuals were taken along the river banks. From its not having been seen earlier it probably does not breed, and those taken were supposed to be on their way south.

15. **Dendrœca cærulea.** Rare. Found mostly on the mountain sides and in two cases in the valley. Young were taken fully fledged and seemingly taking care of themselves as early as June 29th. This species confines itself almost exclusively to the beech trees, which are here abundant.

16. **Dendrœca dominica.** Two individuals, ♂ and ♀, were taken by Mr. W. S. Edwards about the middle of July of this year. They were taken within three days of each other, and near the same locality, so they may possibly breed. This is the first record of their occurence in this locality, being typical birds of the Louisianian fauna.

17. **Dendrœca æstiva.** Not common. But found generally distributed. Breeds.

18. **Seiurus aurocapillus.** Rather rare. Found mostly on the mountains. But six individuals were taken during the summer, and all of these were appreciably more intense in color than those taken in Massachusetts in *spring*.

19. **Seiurus novaboracensis.** A single bird of this species was taken August 8th, and no others were noted.

20. **Seiurus ludovicianus.** Abundant. Found in damp places generally, but mainly along the edges of the river where it has many of the habits of our smaller sandpipers. Breeds.

21. **Geothlypis trichas.** Rather rare. A few (five) were noted or taken.

22. **Oporornis formosus.** Common. Found in the valley and lower half of the mountains. Breeds. Young were obtained fully fledged June 18th.

23. **Icteria virens.** Rather rare. But one instance was noted of its occurrence in the mountains, and then at no great distance up. Breeds. Young were taken about July 1st, fully fledged, and only

differing from the mature birds in having a large spot of lead color on the yellow of the breast. By the last of July this spot assumes the form of a band, and about the first week in August the birds leave here for the south, the young still retaining the lead colored band.

24. **Wilsonia mitrata.** Common. Found everywhere, but most abundant on the lower half of the mountains. Breeds.

25. **Setophaga ruticilla.** Abundant. Found mostly on the mountain. Breeds. Brighter plumage was observed in the young and females than at the north.

TANAGRIDÆ.

26. **Pyranga rubra.** Common. Found mainly on the mountains, where it breeds. The adult males were not appreciably more intense in color than in Massachusetts, but the specimens taken in two cases out of three, had red feathers mixed with the black wing coverts, a variety found but rarely at the north.

27. **Pyranga æstiva.** Apparently rare. But two individuals, both females, were procured during the summer.

HIRUNDINIDÆ.

28. **Hirundo horreorum.** Common. Found everywhere. Breeds.

29. **Hirundo lunifrons.** Common in localities. Found mostly in the bottoms. Breeds.

30. **Cotyle riparia.** Common in localities. Found about the high banks of the river, where it breeds.

31. **Cotyle serripennis.** Rare. A single specimen taken.

32. **Progne subis.** Abundant. Found everywhere, breeding in houses put up for their use. A single instance of a colony breeding in a hollow tree in the forest was noted.

VIREONIDÆ.

33. **Vireo olivaceus.** Very common. Found most abundantly on the mountains. Breeds.

34. **Vireo gilvus.** Apparently rare. But two were taken. Probably breeds.

35. **Vireo noveboracensis.** Rather rare. Found equally distributed. Breeds.

36. Vireo flavifrons. Common. Found most abundantly on the mountains. Breeds. Young taken fully fledged June 24th. The yellow on the breast was very light in the young birds, though plainly discernable. The specimens taken, eight in all, average smaller than those taken in Massachusetts.

AMPELIDÆ.

37. Ampelis cedrorum. Apparently rare. But a single individual was taken, and no others were seen.

FRINGILLIDÆ.

38. Chrysomitris tristis. Common. Found mainly on the mountain sides. Breeds. The song was much softer and more melodious than at the north.

39. Spizella socialis. Common. Found about equally distributed. Breeds. Young taken fully fledged June 15th.

40. Spizella pusilla. Apparently rare. But two specimens taken and one other noted. Found all three on the mountains.

41. Melospiza melodia. Rather rare. Two taken and two others noted. Breeds.

42. Goniaphea ludoviciana. Apparently rare. Two pairs taken on the mountains.

43. Cyanospiza cyanea. Common. Found mostly in the valley. Breeds.

44. Cardinalis virginianus. Common. Found mostly in the valley. Breeds.

45. Pipilo erythrophthalmus. Common. Though not a single individual of this species was taken or noted in the valley, it was quite common on the mountains.

ICTERIDÆ.

46. Molothrus pecoris. Rather rare. But three were noted in the valley.

47. Agelæus phœniceus. Not common. Found in the valley. Breeds.

48. Sturnella ludoviciana. Apparently rather rare. But one small flock was noted in the valley. Breeds.

49. Icterus baltimore. Common. Found mostly in the valley. Breeds. Young taken fully fledged June 15th.

50. Icterus spurius. Rather rare. Found only in the valley. Breeds. A female taken was in marked contrast to females taken in New Jersey, being much brighter.

51. Quiscalus purpureus. Rather rare. Found mostly in the valley. Breeds.

CORVIDÆ.

52. Corvus americanus. Common. Found everywhere. Breeds.

TYRANNIDÆ.

53. Tyrannus carolinensis. Common. Found everywhere. Breeds.

54. Myiarchus crinitus. Common. Found mostly in the valley. Breeds.

55. Sayornis fuscus. Very common. Found everywhere. Breeds.

56. Contopus virens. Not very common. Found almost exclusively on the mountains. Breeds.

57. Empidonax acadicus. Rather common. But not easy to obtain, as they frequent the more secluded parts of the forest, where, though often heard, they are rarely seen. The note is of two measures. The first rather prolonged and soft, while the second is very short and sharp and quickly given. It does not at all resemble the note of *E. minimus*, being much louder and clearer. *E. minimus* was not seen during the time spent here.

ALCEDINIDÆ.

58. Ceryle alcyon. Rather rare. But one was taken and three others noted.

CAPRIMULGIDÆ.

59. Antrostomus vociferus. Heard once during the summer and a single specimen was procured on the mountains.

60. Chordeiles popetue. Noted once in the valley.

CYPSELIDÆ.

61. Chætura pelasgia. Apparently rather rare. Two were taken and a few others seen.

TROCHILIDÆ.

62. **Trochilus colubris.** Common. Found in gardens and in the woods everywhere about the trumpet-creeper. Breeds.

CUCULIDÆ.

63. **Coccygus americanus.** Apparently rare. All the individuals, two in number, were taken on the mountains. A young one was taken fully fledged July 9th.

64. **Coccygus erythrophthalmus.** A single young one was taken on the mountains, in July. No others noted.

PICIDÆ.

65. **Picus villosus.** Rather common. Found only on the mountain. Breeds.

66. **Picus pubescens.** Very common. Found equally distributed. Breeds.

67. **Hilatomus pileatus.** Not uncommon. Found mostly on the mountains. Breeds.

68. **Centurus carolinus.** Apparently rare. But three, one adult and two young, were taken. All on the mountain. No others were noted.

69. **Melanerpes erythrocephalus.** Common. Found only on the mountains. Breeds.

70. **Colaptes auratus.** Common. Found mostly on the mountains. Breeds. The immature birds had the feathers of the top of the head mixed brown and red. In two cases this marking was very strong. An immature female (sex noted by careful dissection) had a dark cheek-patch differing only from that of the mature male in having gray feathers mixed with the black. In an adult female the outlines of the cheek-patch could be plainly seen.

STRIGIDÆ.

71. **Bubo virginianus.** Aparently rare. Once noted.

72. **Scops asio.** Often heard about twilight. None taken.

73. **Surnium nebulosum.** One individual noted at dusk, flying low over the river.

FALCONIDÆ.

74. **Buteo pennsylvanicus.** Common. Found mostly on the mountains. Breeds.

CATHARTIDÆ.

75. **Cathartes aura.** Quite common. Seen everywhere. Probably breeds.

COLUMBIDÆ.

76. **Zenædura carolinensis.** Common. Found mostly in the valley. Breeds.

TETRAONIDÆ.

77. **Bonasa umbellus.** Rather common. Found mostly on the mountains. Breeds.

PERDICIDÆ.

78. **Ortyx virginianus.** Common. Found mostly in the valley. Breeds. As before mentioned, they are here appreciably smaller and much darker than individuals of the same species found in Massachusetts, and form a type half way between this and the Florida type.

SCOLOPACIDÆ.

79. **Philohela minor.** Common. Found in damp places generally. Breeds.

80. **Tringoides macularius.** Rather common. Found along the river. Breeds.

ARDEIDÆ.

81. **Ardea herodias.** Rather rare. One taken along the river.

82. **Ardetta exilis.** Taken by Mr. Woodruff at Charleston, twenty miles below Coalburgh, therefore probably occurs here.

83. **Florida cærulea.** Mr. William H. Edwards informed me of the occurence of this species several times in this vicinity.

84. **Butorides virescens.** Common. Found along the river and on the creeks. Breeds. This is another species differing from our more northern specimens in being much more highly colored and approaching the Florida form.

ANATIDÆ.

85. **Aix sponsa.** Common. Breeds.

86. **Lophodytes cucullatus.** One was taken August 9th; an immature female.

Mr. F. W. Putnam alluded to a paper read by Col. J. W. Foster at the late meeting of the Association for the Advancement of Science, held at Dubuque, in which Col. Foster called attention to what he considered as the typical form of the crania of the mound building race of the Mississippi Valley.

An abstract of this interesting paper will be found in the *American Naturalist*, and Mr. Putnam would not dwell upon the results there given, but he wished to call attention to the character of several crania which he had obtained in person from the mounds near Dubuque, after the session of the Association, which were nearly all of the long, low arched type, one being a much flatter skull than any mentioned by Col. Foster.

Twenty-one of the mounds described to the Association in a paper by Mr. Woodman were opened by Mr. Putnam and friends, and in three only were found skeletons, which were greatly decayed and showed very great age. One mound contained three, and perhaps four, skeletons, the other two only one each.

Mr. Putnam further called attention to the fact that the mounds in the various parts of the Mississippi Valley contained the short, high crania, as well as the long, flattened form, and he had been much interested in making a comparison with the shape of the skulls found in the mounds, and the representations of the human head in carvings and pottery found in the mounds not only, but in Central America and Peru and other parts of South America, where the same two types are represented. He thought that this great similarity in the carvings and pottery, taken in connection with the long and short skulls, which were probably contemporaneous in the several widely separated localities, was a very strong indication of the same early race of men having been widely distributed over the American Continent; performed very extensive migrations from the south to the north, and, perhaps, the northern tribes in great part returned again to the south, centering finally between Mexico and Peru, and there attaining their greatest development; afterwards amalgamating with other races, or otherwise losing their distinctive characters.

In the discussion that followed, Dr. J. B. S. Jackson and other members called attention to the fact that the identity of the ancient Peruvians with the Mound Builders had been suggested by former observers; to which Mr. Putnam replied that he did not lay claim to any discovery regarding that point, as he well knew for a long time archæologists had been impressed in a general way with the great resemblance between the ancient races of America, but that he only wished to call attention to the fact that the *two types of skulls were found in the several localities*, which, taken in connection with the carvings and pottery, would indicate that such a unity of this early race was probable, though he well knew how little dependence could be placed on the form of the skull alone, as both the long and short skulls were more or less common to all races.

October 16, 1872.

The President in the chair. Thirty persons present.

The following paper was presented:—

Notes on the Birds of Southern Iowa. By T. Martin Trippe.

While the local lists of the avi-fauna of various localities along the Atlantic seaboard are not wanting to aid the ornithologist in determining the distribution and migration of birds in those regions, there are very few such lists from points west of the Alleghanies, and still fewer from trans-Mississippi localities. Indeed, the natural history of the region beyond the Mississippi has as yet been studied by explorers and travellers, rather than by stationary observers. Hence, although our knowledge of the geographical distribution of the fauna and flora of these vast regions is daily increasing, yet it is still very fragmentary and imperfect. Correct catalogues of the animals and plants of limited areas from all points of the far west, with exact and careful biographical notes on the species, are therefore very much to be desired, and no apology is necessary for presenting bare lists of species, which, although uninteresting to the general reader, possess great value to the specialist, and are, indeed, the only means by which he can arrive at correct results in this branch of natural history.

The following notes comprise the result of the author's observation during a period of nearly two years in Southern Iowa. It is not pretended that the list is complete, but it is believed to show pretty fairly the main characteristics of the avi-fauna of that region, especially as regards the land birds. As great care has been taken to state nothing as a fact which is not the result of the author's personal observation,—except in a few instances, all of which are specified,—it is hoped that the list will be proportionately valuable to the systematic ornithologist.

Some description of the localities in which the notes were taken is necessary to a correct understanding of the list. One year was spent in the southwestern part of Mahaska County; the other in the north eastern part of Decatur County, the latter point being fifty or sixty miles southwest of the former. Mahaska County lies in the valley of the Des Moines River, the principal stream of the State, and is nearer the Mississippi than to the Missouri. Decatur County, on the other hand, is midway between the rivers, and lies just west of the dividing ridge. Both counties are well timbered, possessing a far larger proportion of woodland than most of the counties, even those contiguous. At the same time there are many wide, level and rolling prairies; thus affording favorable opportunities for the observation of both forest and prairie-loving species. There are no lakes nor ponds in either, with the exception of a few scattered pools along the water-courses and on the prairies, and hence water-fowl, although found at times in considerable numbers about the Des Moines, are not abundant nor generally distributed. Hence the list is very incomplete in this respect, but with regard to the land birds it would be difficult to find more favorable stations for observation throughout the State.

Although but a short distance apart, and possessing almost exactly similar physical characteristics, there are some differences between the two localities. These are, chiefly, the abundance of Warblers in Mahaska County, and their scarcity in Decatur; the presence in the latter of certain species not found in the former, *Zonotrichia querula*, *Spizella pallida*, *Vireo Belli*, *Salpinctes obsoletus*, and one or two others; and the abundance in Decatur County, and scarcity in Mahaska, of a number of birds whose range is mostly to the westward, over the plains, while there is a corresponding abundance in the latter, and scarcity in the former, of some birds whose range is toward the east. Hence it is probable that the high, treeless prairie forming the water-shed between the two great rivers, which extends north westwardly through Wayne, Lucas and Clarke Counties, forms a sort of natural barrier, which many species do not pass. This conclusion is further borne out by the abundance of sylvan birds of all descriptions in the woods in Mahaska County, the thickets and forests in May and June being fairly alive with Thrushes, Warblers, Vireos, Titmice, Nuthatches and scores of other birds, while in Decatur County, in the same season, the quiet and silence of the woods is very apparent. There is also a perceptible difference in the floræ of the the counties, one being considerably more eastern in its aspect than the other.

In comparing the fauna of the States bordering on the upper Missouri with that of Atlantic States on the same parallel, it should be borne in mind that the climate of the former is somewhat more severe than that of the latter; hotter in summer and colder in winter, although the mean annual temperature varies very little. Hence we should be led to expect more northern species in winter, and more southern species in summer, and this we find to be the case. The temperature of the spring and fall months, however, correspond very nearly with that on the coast, and the migrations of the birds occur very nearly at the same times, with the exception of a few species which arrive very early or depart very late.

Of the one hundred and sixty-two species enumerated in the list, ninety-two were observed breeding, or in such numbers during the breeding season as to admit of no doubt of the fact. Of this number eighty-five were common, and seven rare. Eight or ten additional species undoubtedly breed here, though in such small numbers as to have eluded observation. Of the migratory species forty-five were abundant or common, and twenty-four scarce or rare.

On comparison with the avi-fauna of the same latitude on the Atlantic coast, we find but fifteen species breeding abundantly here, that do not also breed there, and of these eight are found a little further south in the east, and two formerly existed there, but have now become extinct, leaving but five species as characteristic of this region as distinct from the Atlantic coast; an astonishingly small number, when we consider the immense difference in longitude. The similarity between the migratory birds is equally striking, there not being over ten or twelve species peculiar to the western region. There is, however, some difference in the number of individuals of the same species.

The nomenclature is from Baird's P. R. R. Report.

1. **Cathartes aura.** Abundant; breeds. Arrives early in April or late in March, and remains till late in October, or even November.

2. **Falco anatum.** I saw a pair of hawks in April, in Decatur County, which I took to be this species, though possibly they were not. I had a good view of them, however, and could hardly have been mistaken.

3. **Falco columbarius.** Seen a few times in Mahaska County, in fall only.

4. **Falco sparverius.** Abundant; breeds. Next in abundance to the Marsh Hawk. It arrives in the middle of March, and stays till the middle of autumn. During the latter part of summer, when the young have become strong on the wing, I have frequently seen scores of these birds sitting on the telegraph wires at distances of fifty or a hundred feet apart for half a mile or more.

5. **Accipiter fuscus.** Seen quite often in fall, but never during the breeding season. This hawk follows and preys upon the flocks of wild pigeons that visit the country chiefly in early spring and fall. I have shot it in the act of devouring a full-grown pigeon, which it had just caught and killed.

6. **Buteo borealis.** Common; breeds; resident. Seen chiefly about the timber.

7. **Archibuteo sancti-johannis.** Common from the middle of November to the middle of March. Prefers the timber, but is frequently seen far out on the prairies.

8. **Nauclerus furcatus.** Not very common; breeds. Seen only in Decatur County. Arrives early in April; leaves in late summer.

9. **Circus Hudsonicus.** Abundant; many breed. Arrives late in February, and remains till winter.

10. **Haliætus leucocephalus.** Seen only in winter, and then infrequently.

11. **Pandion carolinensis.** Seen once in spring, in Decatur County.

12. **Bubo virginianus.** Not common. Seen but a few times, in winter only.

13. **Otus wilsonianus.** Seen a few times in fall only.

14. Syrnium cinereum. A very large bird was killed at Oskaloosa, in Mahaska County, which, from the description given to me by the person who shot it, must have been this species.

15. Syrnium nebulosum. Common; breeds.

16. Nyctea nivea. Seen on several occasions in Decatur County, in the dead of winter, skimming over the wide prairies. A farmer, resident in the county for twenty years, told me that it only appeared in hard winters, which occur about every six or seven years.

17. Conurus carolinensis. A resident of Decatur County told me that he had several times seen a flock of Parrots in the southern part of the county, on a tall, dead cottonwood tree, known by the neighboring people as the "Parrot-tree," from its having been frequented at intervals by the same flock for several years, and that he had shot one of them on one occasion.

18. Coccygus americanus. Not common; breeds.

19. Coccygus erythrophthalmus. Not common; breeds.

20. Picus villosus. Common; breeds; resident.

21. Picus pubescens. Common; breeds; resident.

22. Sphyrapicus varius. Rather common; breeds; migratory.

23. Hylatomus pileatus. Seen once or twice in spring, in Decatur County.

24. Centurus carolinus. In winter very abundant in Mahaska County; far less so in Decatur. A few breed in the former, but none observed in the latter in summer.

25. Melanerpes erythrocephalus. Very common; breeds.

26. Colaptes auratus. Abundant; breeds.

27. Trochilus colubris. Common; breeds.

28. Chætura pelasgia. Not common in Mahaska County; very abundant in Decatur; breeds. Arrives late in April, and seen as late as September 20th.

29. Antrostomus vociferus. Abundant; breeds. Remains till the middle of September.

30. Chordeiles popetue. Abundant; breeds. Seen as late as September 30th.

31. Ceryle alcyon. Not common; breeds,

32. Tyrannus carolinensis. Abundant; breeds.

33. Myiarchus crinitus. Abundant; breeds.

34. Sayornis fuscus. Abundant; breeds.

35. Contopus virens. Abundant; breeds.

36. **Empidonax minimus.** Breeds in large numbers in Mahaska County; far less abundant in Decatur.

37. **Turdus mustelinus.** Common; breeds.

38. **Turdus Pallasii.** Not very common; spring and fall.

39. **Turdus Swainsonii.** Not common; spring and fall. In his "Notes on the Birds of Iowa" Allen reports *T. fuscescens* as being very common in Western Iowa; but in the course of two years' careful observation in the southern part of the State, I have never seen or heard a single individual of this species.

40. **Turdus migratorius.** Common; breeds. Not as familiar as the robin of the East. In spring and fall it is more abundant than in summer, though many remain to breed. Not seen in winter.

41. **Sialia sialis.** Abundant; breeds.

42. **Regulus calendula.** Common; spring and fall.

43. **Regulus satrapa.** Seen but rarely, in late fall.

44. **Anthus ludovicianus.** Abundant; spring and fall.

45. **Mniotilta varia.** Abundant in Mahaska County; far less so in Decatur; breeds.

46. **Parula Americana.** Common in Mahaska County, but not seen in Decatur; does not breed.

47. **Geothlypis trichas.** Common; breeds. The Mourning Warbler being very abundant during summer in Minnesota, directly north of here, I watched very closely during spring, expecting to find it on its northward migration, but did not see a single individual.

48. **Icteria viridis.** Common in Decatur County, where it breeds; not seen in Mahaska County.

49. **Helminthophaga pinus.** Abundant; breeds.

50. **Helminthophaga chrysoptera.** A single specimen taken in May, in Mahaska County.

51. **Helminthophaga ruficapilla.** Common; spring and fall.

52. **Helminthophaga celata.** One specimen taken in Mahaska County, in May.

53. **Sciurus aurocapillus.** Common; breeds.

54. **Sciurus ludovicianus.** Common, arriving in the middle of April. Some remain to breed, the rest going north. It forms a very neat nest of twigs and grass, which it usually conceals under the roots of a tree overhanging a steep bank or ravine. Its song is different from that of *S. noveboracensis.*

55. **Dendrœca virens.** Common in Mahaska County, in spring and fall, but not observed in Decatur.

56. Dendrœca canadensis. Seen a few times in spring, in Mahaska County only.

57. Dendrœca coronata. Common; spring and fall.

58. Dendrœca Blackburniæ. Seen a few times in spring, in Mahaska County only.

59. Dendrœca pennsylvanica. Abundant in Mahaska County, where many breed. I was not able to find its nest, thovgh I frequently saw them collecting materials for it. Observed in Decatur County only in spring.

60. Dendrœca cærula. Common; breeds.

61. Dendrœca striata. Common, spring and fall, in Mahaska County; not seen in Decatur.

62. Dendrœca æstiva. Common; breeds.

63. Dendrœca maculosa. Rather common in spring in Mahaska County; not seen in Decatur.

64. Myiodioctes mitratus. One taken in May in Mahaska County.

65. Setophaga ruticilla. Abundant in Mahaska; less so in Decatur; does not breed.

66. Pyranga rubra. Abundant; breeds.

67. Hirundo horreorum. Not seen in Mahaska County. In Decatur County I observed them in a single locality. The farmer, in whose barn they had taken up their quarters, told me that a single pair had appeared five or six years before, and raised a brood, with which they returned the next summer. The little colony had grown from that time, till there were thirty or forty, and have now begun to frequent other barns in the neighborhood. They are quite as tame and familiar as the same bird in the East.

68. Hirundo lunifrons. Very abundant; by far the commonest species of swallow. Breeds in some localities in large numbers.

69. Hirundo bicolor. Common; spring and fall.

70. Cotyle riparia. Common; breeds.

71. Progne purpurea. Common; breeds.

72. Ampelis cedrorum. Common; breeds.

73. Collyrio borealis. Very common in Mahaska County, in fall and winter; less so in Decatur County; does not breed.

74. Collyrio ludovicianus. Common; breeds. Arrives in February and leaves in September. The hedges of osage orange are its favorite resort and nesting place.

75. Vireo olivaceus. Common in Mahaska County; much less so in Decatur; breeds.

76. Vireo gilvus. Common; breeds.

77. Vireo Bellii. Breeds abundantly in Decatur County, where it is the commonest species of Vireo, but not seen in Mahaska. It arrives in the second week in May, and is seldom seen after the middle of August. In its habits it bears a strong resemblance to the White-eyed Vireo, preferring the thickets and underbrush, rather than the trees. Its notes are quite different from those of any other Vireo, being somewhat like those of the bluebird in early spring, but quicker and more hurried.

78. Vireo flavifrons. Common; breeds.

79. Mimus carolinensis. Common in Decatur County; less so in Mahaska; breeds.

80. Harporhynchus rufus. Common; breeds.

81. Salpinctes obsoletus. A specimen taken in October, in Decatur County, and several others seen. Not observed in Mahaska County.

82. Cestothorus stellaris. Not common; breeds.

83. Troglodytes ædon. Abundant; breeds.

84. Certhia americana. A few observed in fall and winter, in Mahaska County, but none in Decatur.

85. Sitta carolinensis. Common; breeds.

86. Polioptila cærulea. Common; breeds.

87. Lophophanes bicolor. Abundant; resident throughout the year.

88. Parus atricapillus. Common; breeds; resident.

89. Eremophila cornuta. Abundant; breeds, and nearly resident, being absent only a few weeks in the depth of winter, some few remaining even then. It nests early in May, occasionally as late as the 25th. The nest is composed of grass, and is placed on the ground. The male frequently relieves his mate in the task of incubation. The young birds remain with their parents till fall, when they gather into flocks of from ten to one hundred or more.

90. Chrysomitris tristis. Common; breeds.

91. Ægiothus linaria. Seen in considerable numbers in the depth of winter, in Mahaska County.

92. Plectrophánes lapponicus. Abundant. Disappears in the middle of April.

93. Plectrophanes nivalis. A few occur every winter, but abundant only in severe seasons.

94. **Passerculus savanna.** Not very common; breeds. An inhabitant of the bushy margins of pools and water-courses on the prairies.

95. **Coturniculus passerinus.** Abundant; breeds.

96. **Coturniculus Henslowii.** Common; breeds. Prefers the edges of hazel copses, while the preceding haunts the open, grassy prairies.

97. **Chondestes grammaca.** Rather common; breeds. Arrives late in April, and departs in August. The song of this bird is exceedingly loud and sweet.

98. **Zonotrichia Gambellii.** A specimen shot in spring, in Decatur County, agrees precisely with Baird's description.

99. **Zonotrichia albicollis.** Abundant; spring and fall.

100. **Zonotrichia querula.** Abundant in Decatur County in spring and fall; not observed in Mahaska. This beautiful sparrow is one of the commonest of the Fringillidæ that pass through Decatur County in fall and spring, associating at such times with the other sparrows and finches, and frequenting similar haunts. Its notes in the fall are a simple loud chirp, not distinguishable from that of the white-throated sparrow, and, occasionally, a low, sweet warble; in the spring it has a curious song, beginning very much like that of the latter bird, but ending with a few harsh, drawling notes, sounding like a faint mimicry of the scream of the night hawk, and totally unlike the first part of the song.

101. **Junco hyemalis.** Rather common in the spring and fall; in winter less frequent, many of them going south to avoid the extreme cold.

102. **Spizella monticola.** Common; spring and fall; but, as is the case with the last, many go south during the depth of winter.

103. **Spizella pusilla.** Abundant; breeds.

104. **Spizella socialis.** Common in Mahaska; breeds. Seen but seldom in Decatur.

105. **Spizella pallida.** Common in spring, in Decatur County, but not seen in Mahaska. This bird frequents the thickets and copses along the margins of woods, and has somewhat the habits of the redpoll, feeding on the buds of the elm and other trees in early spring.

106. **Melospiza melodia.** Abundant in spring and fall, but not observed to breed. Shy and retiring, — a complete contrast to the eastern song-sparrow.

107. Melospiza palustris. Common; spring and fall; breeds in small numbers, most of them going further north, or to other more suitable localities.

107*. Melospiza Lincolnii. Common; spring and fall, in Decatur County; not seen in Mahaska.

108. Passerella iliaca. Common, spring and fall, in Decatur County; but seldom seen in Mahaska.

109. Euspiza americana. Very common; breeds. Arrives early in May, and leaves in August.

110. Guiraca ludoviciana. Abundant; breeds.

111. Cyanospiza cyanea. Abundant; breeds.

112. Pipilo erythrophthalmus. Abundant; breeds. Arrives in the latter part of March, or early in April; much earlier than in the Eastern States.

113. Dolichonyx oryzivorus. Abundant; breeds. The bob-o'-link arrives early in May, the males coming some days in advance of their mates. At this season I have frequently seen flocks composed of hundreds, without a single female among them, feeding on the seeds of the dead weeds and grasses, on the open prairie, frequently taking wing, and wheeling about like so many blackbirds before alighting again. While on the wing their singing is so loud as to be audible at a great distance, and the chorus of hundreds of voices rising and falling on the wind forms a melody quite as agreeable to the ear as their bright and strongly contrasted colors and graceful evolutions are to the eye. When the time comes for them to pair, a little later, the scene is frequently very amusing. I have seen fifty males surrounding a single female, all singing as though their very lives depended upon it, and when she, bewildered by the multitude of suitors, would seek relief in flight, all would rise on the wing, and pursue her with the most vehement songs and protestations of love. Very many go further north, but a considerable number remain to breed, nesting in the borders of grainfields and meadows in preference to the prairies; though many breed in the latter. In August the young reed-birds are quite common. Although abundant in certain localities, this bird is rather irregular in its distribution, as I saw but few in Mahaska County.

114. Molothrus pecoris. Common in Decatur County; less so in Mahaska; breeds. Disappears in July and reappears in September.

115. Aglaius phœniceus. Common; breeds. I never saw *Xanthocephalus icterocephalus*, nor could I hear of its occurrence in this part of the State.

116. Sturnella magna. Abundant; breeds. Migratory in its habits, great numbers passing southward about the middle of October.

117. Sturnella neglecta. If this bird is merely a variety of *S. magna*, it certainly is a very remarkable one. Not having examined a sufficient number of specimens, I am not qualified to judge; and, indeed, should hesitate to do so in any event, after such competent authorities have pronounced on the question. Careful observations for the last two years, however, have convinced me of the following fact, viz: that there are two varieties or species of the Meadow Lark in Southern Iowa, that possess totally different songs and notes, and that these differences are constant. The common lark, *S. ludoviciana* is, here, by far the most abundant; its notes are *precisely similar* to those of the same bird in the East, and its habits, also, nearly or quite the same. The Western Lark, *S. neglecta*, on the contrary, *never* utters the peculiar, long-drawn whistle of the common species, — at least I never heard it, — and it has a number of notes which the latter never utters, one in particular which resembles a note of the red-winged blackbird. The western lark, like the common species, has a rapid chatter, but so different in every bird that I have heard, that the difference was at once appreciable; indeed it is more striking than the resemblance. The western lark is here quite a shy, timid species, comparatively to the other at least, which is as tame as the bluebird or chipping sparrow. The former is never heard after the first of September, although it arrives as soon, or a little before the other, viz., early in March; while the latter remains till November. I have never heard a bird whose notes were intermediate between the two.

Here, then, we have the remarkable fact of two varieties — if they are such — of the same species, existing side by side, seldom or never mingling, and each preserving its peculiar notes and habits; yet resembling each other so closely in form and plumage, that the most experienced ornithologists are unable to draw the dividing line between them.

118. Icterus spurius. Rather common; breeds.

119. Icterus Baltimore. Rather common; breeds.

120. Scolecophagus ferrugineus. Abundant in spring and late fall. Never seen in very large flocks, but generally in parties of from ten to thirty. Its favorite resorts are roads and cattle yards, where it picks up the fallen grain.

121. Quiscalus versicolor. Very abundant, breeding familiarly in the village streets and gardens. It does not appear to damage the corn to any extent.

122. Corvus carnivorus. A resident of Decatur County who had become familiar with the raven in the Northwest, assured me that he had occasionally seen it in this county.

123. Corvus americanus. Abundant. Many breed; but it is far less common in summer than in spring and fall. A few remain all winter.

124. Cyanura cristata. Abundant; breeds; resident.

125. Ectopistes migratoria. Occurs irregularly, chiefly in spring and fall, sometimes in large flocks. Not observed to breed.

126. Zenaidura carolinensis. Abundant; breeds. Arrives early in April and stays till late in October.

127. Meleagris gallopavo. Not uncommon; but from its being constantly persecuted, very shy and vigilant.

128. Cupidonia cupido. Abundant; breeds. The prairie hens retire to the wilder parts of the country to breed, returning towards the more thickly settled regions on the approach of cold weather. The sharp-tailed grouse, *Pediocaetes phasianellus*, rarely, I believe, comes much further south than the north line of the State in Iowa, although in Nebraska it not uncommon as far south as the Platte River.

129. Bonasa umbellus. Abundant; breeds.

130. Ortyx virginianus. Abundant; breeds.

131. Grus americanus. Quite a number seen in fall, in Decatur County. Said to have been quite common formerly.

132. Grus canadensis. Vast numbers pass over in spring and fall. Said to have bred in the marshes, before the settlement of the country. Its appearance in autumn, in large numbers, is usually the precursor of cold weather.

133. Ardea herodias. Seen occasionally in spring.

134. Botaurus lentiginosus. Abundant; breeds.

135. Butorides virescens. Common; breeds.

136. Charadrius virginicus. Abundant; spring and fall.

137. Aegialitis vociferus. Abundant; breeds.

138. Gallinago Wilsonii. Rather common; spring and fall. I have never seen the woodcock in southern Iowa, though assured that it occurs very rarely. Allen gives it as a common bird in the western part of the State.

139. **Machorhamphus griseus.** Not common; seen in spring only.

140. **Tringa maculata.** Very abundant in spring and fall. In wet seasons many of the level prairies are converted into shallow ponds, that attract great numbers of this and the two following species.

141. **Tringa Wilsonii.** Common; spring and fall.

142. **Ereunetes petrificatus.** Common; spring and fall.

143. **Gambetta melanoleuca.** Rather common in spring and fall.

144. **Gambetta flavipes.** Common; spring and fall.

145. **Rhyacophilus solitarius.** Abundant; breeds.

146. **Tringoides macularius.** Abundant; breeds.

147. **Actiturus Bartramius.** Abundant; breeds. On its first arrival the bird is rather shy, but soon becomes tame and familiar.

148. **Limosa fedoa.** Seen occasionally in spring only.

149. **Numenius longirostris.** A few seen in spring in Decatur County, where I was informed that it formerly bred quite commonly.

150. **Porzana carolina.** Seen occasionally, and only in spring.

151. **Anser hypaboreus.** Common, spring and fall. Rarely alights.

152. **Bernicla canadensis.** Spring and fall. Formerly stayed to breed.

153. **Anas boschas.** Common in spring and fall. A few remain all summer and breed. Said to have been in large numbers formerly. *A. obscura* I have never seen in Iowa.

154. **Dafila acuta.** Not common; spring and fall.

155. **Nettion carolinensis.** Abundant in spring and fall.

156. **Querquedula discors.** Abundant in spring and fall. The mallard, the green-winged teal, and this species, are the only ducks that are at all abundant, far outnumbering all the other species together.

157. **Aix sponsa.** Rather common; breeds.

158. **Fulix collaris.** Rather common; spring and fall.

159. **Pelecanus erythrorhynchus.** Seen occasionally in spring.

160. **Hydrochelidon fissipes.** Observed about pools of water on the prairies in May only.

161. **Co ymbus torquatus.** Observed occasionally in spring flying northward.

162. **Podilymbus podiceps.** Rather common ; spring and fall.

Many species which undoubtedly occur, and which I believe I have seen, are omitted from the list, not having been taken, or identified beyond the possibility of mistake. Of these are, *Accipiter Cooperii*, *Buteo lineatus*, *B. pennsylvanicus*, *Scops asio*, *Empidonax flaviventris*, *Cistothorus palustris*, *Sitta canadensis*, *Carpodacus purpureus*, and many species of water-fowl, common throughout the Western States in spring and fall.

Prof. E. S. Morse gave an account of the various opinions held by naturalists as to the systematic position of Dentalium and showed that in many characteristics the genus approaches the tetrabranchiate cephalopods. Prof. Morse also spoke of the structure of Rhynchonella, which he had observed alive in the Gulf of St. Lawrence. He exhibited a specimen preserved in alcohol, in which the arms were still protruded, thus confirming the correctness of Prof. Owen's views as to their power of extension.

Prof. Shaler exhibited a two-fanged tooth from a sperm whale, an anomaly perhaps due to reversion.

The Secretary read the following extracts from a letter by Mr. C. W. Lovett relating to a supposed case of the death from fright of a night heron : —

"As Mr. Edward Ames, of this city, (a gentleman well known to me), and some others were passing through one of the Marshfield meadows, a qua bird, or night heron, was surprised on the edge of a small brook which they were about to jump. As the bird arose, within some eight or ten feet, Mr. Ames gave a loud yell, at the same time jumping the brook, when to his surprise the bird fell to the ground lifeless. Upon examining the bird there appeared to be no wound or hurt upon any part of the body, which seemed to be in a perfectly healthy condition.

"Mr. Ames, from whom I received this statement, informed me that he had been previously told that the bird could be frightened to death in this manner, and that this information induced him to try the experiment.

"Perhaps it would not be out of place for me to state that I have often brought these birds to ground from a great height with a small fowling piece and very fine shot, and have at times wondered at the absence of blood on the feathers, or signs of a shot-hole. May it not be possible that the report of the piece alone caused their death?"

Section of Entomology, October 23, 1872.

Mr. P. S. Sprague in the chair. Seven members present.

The Secretary stated that three field-meetings had been held during the summer, which were fairly attended. The vicinities of Dorchester, Peabody, and Waverly were explored and many captures made.

The following paper was read: —

On the Larvæ of the Hemerobina. By Dr. H. A. Hagen.

The following communication I beg to be considered as a preliminary report on the history of the immature states of the Neuroptera, belonging to the family of the Hemerobina, intended to be published as a part of the illustrated Catalogue of the Museum of Comparative Zoology in Cambridge. The plates are finished by Mr. Konopicky; preliminary descriptions have been sent for publication to Europe, with the invitation to communicate to me the material scattered in European collections, so that I can use all material known for the illustrated catalogue. I now intend to report on two groups only, *viz.*, the Ascalaphina and Myrmeleonina. There are published satisfactory descriptions of only two species of Ascalaphus, *Ulula MacLeayana*, by Landsdown Guilding, 1827, and *Ascalaphus Macaronius*, by Brauer, 1854. Of four other species short notices are given. I am able to describe sixteen species, ten of which I have before me, belonging to eight genera. Of Myrmeleon five species are described besides the well known *M. formicarium*, four by Brauer (*Myrmeleon formicalynx*, *Formicaleo tetragrammicus*, *Dendroleon pantherinum*, *Acanthaclisis occitanica*), and one by Mr. Emerton (*Myrmeleon immaculatum*). Of the two species of Palpares, and one of Myrmecaelurus, short notices are given by Brauer. Percheron, in his description of *Palpares libelluloides*, has confounded two species together, *P. libelluloides* and *A. occitanica*. The latter species is also shortly noticed by Leon Dufour and Perris. A doubtful notice of *Palpares Hispanus* is given by Rosenhauer. I have noticed twenty-one species, nineteen before me, belonging to nine genera.

Of the thirty-seven species described in both groups, fifteen belong to Europe, five to Asia, one to Australia, three to Africa, thirteen to America, four of them, all Myrmeleonina, to the United States.

The larvæ of the two groups are easily separated from all others by their more flattened, broad body; larger head; mandibles inside with strong teeth, three in number (only in two cases four or one); by more or less elongated lobes on the sides of the thorax and abdomen, often provided with hair pencils; by the presence of seven eyes, one always on the underside; by short and minute antennæ; by the labium divided in two lobes; and by the hind legs, having the tibia and tarsus united without articulation. The two latter characters have been entirely overlooked, and the latter is, so far as I know, not to be found in any other genus of the Hemerobina.

On the whole, the Myrmeleonina are more uniform and alike than the Ascalaphina. Besides the prothoracic stigma, there is on the first eight segments of the abdomen on each side a stigma, the first pair on the dorsum, the others on the sides of the segment.

In the Ascalaphina we find either all eight on the ventral side, or the first, or the two first, placed above. The side lobes are generally longer on the Ascalaphina, varying between two or one on each side of the segment. In the Myrmeleonina there are generally tubercles, provided, more or less, with bristles, recalling the locomotive organs of the Annulata. The last segment of the abdomen is elongated cylindrical in all Ascalaphina; short, and provided with different kinds of spines in the Myrmeleonina; but one genus of the latter, Dendroleon, repeats the form of the Ascalaphina. Concerning the habits of these insects, the remarkable fact of the ant-lions making pit-falls or funnels in the sand to catch their prey, was well known centuries ago. It is far more interesting that this manner of living considered long ago as belonging to all species, was proved by Brauer to be only an exception, perhaps only occurring in the genus Myrmeleon. Indeed, only four species, two of Europe, two of the

United States, are known to be pit-fall makers, and to move backwards. In Patagonia and in the Galopagos Islands pitfalls have been observed, but the larva is not known. The others go forwards, or both forwards and backwards, but never construct pit-falls.

The eggs of the Myrmeleonina are unknown, those of the Ascalaphina are fastened in two series on the stems of plants, but in Ulula, are placed in circles on the extremity of a twig, which the female encircles nearer the base with a kind of fence, to protect the brood from intruders. The bodies forming this fence are secreted by the female, and are, I believe, similar to the pedicels on which the eggs are borne in Chrysopa, the difference being that in Ulula the eggs are placed at some distance from the pedicels, instead of on them. This remarkable fact, observed by Landsdown Guilding, should be studied again. I was able to observe that Ascalaphus in hatching changes the skin, just as Osmylus and Chrysopa. This phenomenon occurs in none of the so-called Pseudoneuroptera, and forms a striking difference between the embryo of the Hemerobina and Odonata. So far known, all the species spin cocoons for transformation, and do not previously break off the mandibles, as Osmylus.

It would perhaps be too soon to give a general view and a synopsis of the larvæ of all the Hemerobina. There are known, besides the seventeen genera belonging to the Myremelonina and Ascalaphina, the larvæ of only ten genera, mostly the result of the admirable energy of Dr. F. Brauer of Vienna, viz., Mantispa, Coniopteryx, Osmylus, Sisyra, Drepanopteryx, Hemerobius, Micromerus, Chrysopa, Hypochrysa and Nemoptera. The twenty-seven genera now known in the larval state represent not half of the genera actually published, and as many of the most aberrant forms belong to the unknown, viz., Nymphes, Stilbopteryx, Polystoechotes, and others, it is to be presumed that a synopsis actually drawn up would be very soon imperfect by new discoveries. Nevertheless, the larvæ now known agree in several important characters, perhaps not unworthy to be noticed here. All known larvæ of Hemerobina possess the mouth parts fitted for sucking. In connection with this arrangement the posterior part of the alimentary tract does not serve for the ejection of digested materials; it is closed and transformed into a spinning organ. The structure of the mandibles and maxillæ, the latter playing in a deep groove of the former, is well known, but it is overlooked that both have a series of very fine teeth, opposed to each other, serviceable for a kind of mastication in the interior of the captured animals. The two channels of the mandibles lead directly to the œsophagus, the part where the mouth is commonly placed is here closed by a membrane going from the base of the labrum to the base of the mentum. The knowledge of this fact is important, as there has been always a mistake concerning the labium and its palpus. Indeed, the upper lip is connected with the head, as usual, by the basal border; the front border is free, and sometimes greatly projects, as in Acanthaclisis and Coniopteryx. The mentum is often not separated from the head, sometimes merely by a suture, and perhaps not moveable. The under lip has retained its original form; it is separated into two lobes, taken always for the first joint of the palpus by authors. The palpus is only 3-jointed. The maxillary palpus is always wanting.

The structure of the prothorax is rather remarkable, being divided into three segments, free and articulated together. I believe that these parts should be considered as præscutum and scutellum. Brauer calls them intermediate segments. The middle part, the prothorax, bears the legs; the part between the prothorax and the head is always free, sometimes strongly developed, a real segment, and nearly as long as the other parts of the body together, as in Nemoptera. The part between the prothorax and mesothorax is even free and separated, and bearing on each side a conspicuous stigma. I believe the structure of the prothorax to be a prominent character of the larvæ of the Hemerobina.

The meso- and metathorax of different form and size, show mostly on each side on the dorsal plate a kind of scar, a somewhat hyaline spot. This is, without doubt, the place where the wings are to be preformed in the interior of the larva.

The legs are remarkable by position and structure. The base being always placed as near the side border as possible, the legs are very distant from each other. The coxa is strongly developed and turned inwards. The tarsus has only one joint, and is sometimes not separated from the tibia. There are two claws, rarely but one, and between them, in several genera, a more or less developed pulvillus, consisting of plantula and arolium. The abdomen has nine segments, decreasing in breadth to the tip. All except the last on each side with a stigma; in several genera, the first, or the first and second pair, placed on the dorsal plate of the segment. More or less developed lobes, often provided with bristles or hair pencils, are placed on the sides of the thorax and the abdomen, strongly recalling, as stated above, the locomotive organs of the Annulata.

The last segment of the abdomen is often of a different shape and construction, for help in locomotion, or other purposes. One genus, Sisyra, living in the water, has on the ventral side of the first seven segments of the abdomen false legs, developed as gills, recalling the form of lower Crustacea. The skin is generally scabrous or warty, and covered by hairs, bristles and spines of different structure, and scales, similar to those of the Lepidoptera.

The eggs are always of an oval shape, usually with a little knob containing the micropyle. The embryo opens the eggs with an egg-burster like a saw, and changes the skin in hatching. The larva moults several times, and spins for transformation a silky or paper-like cocoon, with the spinnerets on the tip of the abdomen. The size of the cocoon is often remarkably small for the size of the imago. The nympha is inactive, and breaks open the cocoon for transformation with its great hatchet-shaped mandibles, the skin remaining in the opening. A pink egg-shaped body, probably belonging to the spinning organ is ejected by the newly transformed imago, at least, in the Myrmeleonina. All larvæ of the Hemerobina are very rapacious, and therefore beneficial.

The Hemerobina may be divided into the following subfamilies.

1. **Myrmeleonina.**

Mandibles long, inwardly arcuated, with three teeth; antennæ shorter than the mandibles. Body flat, broad, large; hind legs stout, short, tibia and tarsus connected; claws large, two in number; no pulvillus. To this group belong the Myrmeleonina and Ascalaphina, the latter with flat lobes on the thorax and abdomen.

2. **Nemopterygina.**

Mandibles short, inwardly arcuated; antennæ short; prothorax strongly elongated; body flat, broad. No pulvillus between the two claws.

3. **Osmylina.**

Mandibles long, outwardly arcuated; antennæ short; body elongated; a small pulvillus; two claws.

4. **Sisyrina.**

Mandibles long, outwardly arcuated; antennæ longer; body elongated, slender; abdomen with seven pair of ventral gills; tarsi with only one claw, no pulvillus.

5. **Hemerobina.**

Mandibles long or short, inwardly arcuated; antennæ longer; body elongated; two claws; a well developed pulvillus.

Here belong Drepanopteryx, Hemerobius, Chrysopa, Hypochrysa.

6. **Mantispina.**

Mandibles short, straight, approximated; antennæ longer; body elongated, slender; two claws with pulvillus.

7. **Coniopterygina.**

Mandibles short, straight, covered by the upper lip; antennæ longer; body elongated; two claws with pulvillus.

Examining these subfamilies in regard to the principal characters, we have the following result: —

1. *Mandibles.* Covered by the upper lip in Coniopterygina, free in all the other genera. Toothed inside in Myrmeleonina; without teeth in the others. Arcuated inwardly in Myrmeleonina, Nemopterina, Hemerobina; arcuated outwardly in Osmylina, Sisyrina; straight, approximated in Mantispina, Coniopterygina.

2. *Antennæ.* Shorter than the mandibles in Myrmeleonina, Nemopterina, Osmylina; longer in the others.

3. *Legs.* Tarsus connected with the tibia in the hind legs in Myrmeleonina; free in all others. One claw in Sisyrina; two in all others. No pulvillus in Myrmeleonina, Nemopterina, Sisyrina; pulvillus more or less developed in all others.

Perhaps this notice may induce American Entomologists to give more attention than heretofore to this interesting subject, and to try to discover the immature states of the American genera. Mr. F. G. Sanborn has raised the imago of Meleoma from the cocoon. The nympha skin and the cocoon are alike in Chrysopa. The discovery of the larva of Polystoechotes would be a good step forwards, and could not be difficult if imagos are kept in confinement. Several other genera belonging to America would, perhaps, advance our knowledge in an interesting manner, if the larvæ were known.

November 6, 1872.

The President in the chair. Twenty-four members present.

Dr. Kneeland gave an account of his recent visit to the volcanoes of the Sandwich Islands, the active craters of Mauna Loa and Kilauea on Hawaii, and the extinct crater of Haleakala on Maui.

The crater of Kilauea was active in the south lake, the surface of the melted lava being about two hundred feet below the rim, boiling and heaving like an ocean, and throwing up blood-red jets about forty feet high from the central portion. A fortnight before his visit it had overflowed the rim, and a week after his visit it overflowed a second time, while the summit crater of Mauna Loa was in full activity.

He gave an account also of the ascent to the summit crater by the first party which went up, some days before the one whose account has been published in *Silliman's Journal*, and who saw the phenomena when grandest. Though obliged to leave the party himself, he had the advantage of notes taken by his brother-in-law, who was the first to gain the summit. After a fatiguing ascent they found the lava rising like a silvery fountain, estimated at two hundred and fifty feet high, from a central depression in the floor of the crater, which did not exist at the time of Capt. Wilke's visit; the time taken for the lava to fall from its highest point was seven seconds; the lava did not flow out of the crater down the mountain side, but fell back into the crater, forming a small fiery lake. The flow commenced on Friday, August 9th, and the light he saw from Haleakala a few days after, not knowing, however, that the summit crater was active. Most of the eruptions from Mauna Loa have been from points considerably below the summit; and in the two or three which have occurred in the summit crater during the last fifty years, the fires have either suddenly subsided, or when visited have presented simply a smoke without apparent fire. This, therefore, is the first display from the summit crater that has been visited either by natives or foreigners since the missionary occupation of these islands.

He described also his ascent to the extensive crater of Haleakala, the largest known, being twenty-seven miles in circumference, and on an average two thousand feet deep. The scene of utter desolation presented by this crater he thought must resemble the exterior craters of the moon; he exhibited in this connection photographs of Haleakala and the lunar crater Copernicus for comparison.

He exhibited also specimens of the recent flows from Kilauea, which did not apparently differ from the lava of other flows collected by Mr. Brigham.

Dr. Kneeland also spoke of several theories which had been proposed to account for the phenomena of volcanoes.

Mr. Brigham said that the last regular eruption of Mauna Loa was in 1868, while that described by Dr. Kneeland seems to be merely a temporary activity, which, however, it is possible may burst forth with much greater violence. He then described the usual condition of the crater which he had visited with the late Mr. Horace Mann. Mr. Brigham remarked that it was very difficult to account for the jet of lava described by Dr. Kneeland, for while the fountains hitherto observed have been situated below some basin of molten lava, upon which their existence evidently depended, this fountain was at the summit of the mountain.

Dr. T. Sterry Hunt spoke of the various theories which had been proposed to account for the phenomena of volcanoes.

After alluding to the now discarded chemical theory of Davy, he referred to that view which supposed a centre in igneous fusion, covered by a thin crust. This, for various reasons, is now rejected by the best physicists, who are led to regard the earth as having a crust of several hundred miles in thickness, if not indeed solid to the centre. To conciliate this condition of things with the phenomena of volcanic eruptions, the notion of a portion of the original igneous mass still remaining in a liquid condition between the solidified centre and the crust, has been maintained by Hopkins and Scrope, but is far from satisfactory. There is, however, still another view which was put forward by Keferstein and by Sir John F. W. Herschel in 1834 and 1836, and for the past fourteen years had been repeatedly set forth, explained and developed by the speaker. According to this hypothesis the seat of volcanic activity is to be sought not in still uncongealed portions of the once liquid globe, but in deeply buried sedimentary strata, which, permeated by water and brought into a state of igneo-aqueous fusion, generate by the chemical reactions between their heterogeneous elements, both the gaseous and the liquid products of volcanoes, as well as the various plutonic rocks. This was maintained by Dr. Hunt in the *Canadian Journal* for May, 1858, the *Quar. Geol. Journal* for November, 1859. in *Silliman's Journal* for May, 1861, and more recently in the *Geological Magazine* for June, 1869, in a paper "On the Probable Seat of Volcanic Action."

In these various papers, and elsewhere, the relations apparent between volcanic and plutonic phenomena and great accumulations of sediments were insisted upon. It was maintained that the action of internal heat upon these would result not only in the softening and chemical change of the lower part of these sediments, but also in a softening of the underlying floor of older crystalline rocks; thus establishing a line of weakness or of least resistance in the earth's crust coincident with that of the great accumulations of sediment. From this, it was claimed, it would result that the wrinkling or corrugation of the earth's crust due to a contracting nucleus would be determined along the lines of great sedimentation.

The source of heat required to produce these effects was assumed by Herschel (as previously suggested by Babbage) to be the incandescent nucleus of the globe, a view in which the speaker had acquiesced. Keferstein, on the contrary, rejecting an internal source of heat, had supposed it to be generated by a chemical process in the sediments, which he compared to a fermention. Very recently Le Conte has proposed a view which unites the two, supposing the internal heat to set up a chemical action in the buried sediments, which once commenced, may augment their temperature even to the fusing point. It was maintained by Dr. Hunt that the chemical actions which would take place in the buried sediments would be of a nature rather to absorb than to give out heat, and such views were hence to be rejected. It seems, however, probable that the seat of volcanic activity is to be found at depths where the heat derived by conduction from the nucleus would not be adequate to produce the effects required, and there still remained the hypothesis that the heat might be in part generated by local physical causes. This was, it is believed, first suggested by a member of this Society, Mr. George L. Vose, in his able and scholarly little book, entitled Orographic Geology, published in 1866. He there, while recognizing with Sorby the conversion of mechanical force into chemical action, insists that "the enormous pressure generated by the folding of masses of rocks, the depth of which is measured by miles," is an agent capable of producing great changes, and declares the causes of the conversion of sediments into plutonic rocks like granite to be "*mechanical compression, with the heat and chemical action which proceed therefrom;*" adding, in a note, in allusion to the view which explains these changes by heat conducted from beneath, "we should prefer to get the heat needed by the compression which accompanies the disturbance of the strata where metamorphism occurs." [*Orographic Ge-*

ology, pp. 129, 130.] This view of Vose is confirmed by the late researches of Robert Mallet, communicated to the Royal Society of London in June, 1872, who concludes that "as the solid crust sinks together to follow down the shrinking nucleus, the *work* expended in mutual crushing and dislocation of its parts *is transformed into heat*, by which at the places where the crushing sufficiently takes place the material of the rock so crushed, and that adjacent to it, are heated even to fusion. The presence of water at such points determines volcanic eruption." This view of the source of heat is supported by experiments on a large scale undertaken by Mallet.

Dr. Hunt, while admitting mechanical pressure, as explained by Vose and Mallet, to be an important source of subterranean heat in the crushed and deeply buried strata, remarked,

1st. That these, from their depth, are already at an elevated temperature, so that the heat thus developed comes in to supplement that derived by conduction from an igneous centre.

2d. That it is the heat from this latter source, which, as he has endeavored to show, by establishing lines of least resistance in the crust, localizes the effect of the contracting nucleus, and determines the region in which the folding and crushing of the crust, with attendant elevation of temperature, shall take place.

3d. The seat of this process being in stratified sediments, which, besides water, include, in many cases, compounds of chlorine, sulphur and carbon, the origin of the steam and the various gases which accompany volcanic eruptions, is explained without supposing an introduction of water to the fused mass from an exterior source. With the contributions of Vose and Mallet the theory of plutonic and volcanic action advocated by Kefersteiu, Herschel and the speaker, would seem to be well nigh complete.

November 20, 1872.

The President in the chair. Fifteen members present.

Dr. Kneeland described a trout breeding establishment near Truckee, Cal., which he visited last June. He also gave a brief account of the fauna of the Sandwich Islands, which he described as American rather than Asiatic. Dr. Kneeland presented a number of specimens illustrating his remarks.

The Secretary read a letter from Clarence Sterling, Esq., giving an account of a visit to the Brandon frozen well during July last. The water in the well was, as usual, found frozen over.

The thanks of the Society were voted to Mr. F. Rolfe for a fine specimen of African gazelle, and to Mr. Charles Ruggles for a number of bird-nests, eggs, and other specimens.

Section of Entomology. November 27, 1872.

Mr. Edward Burgess in the chair. Eleven persons present.

Dr. J. L. Leconte, of Philadelphia, who was present, introduced Mr. J. R. Crotch, of England, who, he said, proposed to spend some time on the western coast of America, collecting its little known insect fauna.

Mr. Crotch then described his process of collecting Coleoptera, which had been suggested by Chevrolat. Instead of alcohol or other fluid, the use of which is so inconvenient to the travelling collector, sawdust, carefully sifted so as to be free from dust, is used. The specimens taken during the day are packed loosely with this sawdust in pill-boxes, which are easily labelled and packed away until wanted for study. If the insects are large they should be dried by the fire, or in the sun, or the sawdust may be slightly moistened with alcohol or carbolic acid. Coleoptera, such as Lixus, covered with a bloom, of course must be pinned on the spot.

Mr. Crotch also said that collectors in England fasten the cyanide of potassium in their collecting bottles by pouring plaster of Paris over it, which prevents the cyanide from deliquescing, and soiling the specimen, and is sufficiently porous to allow the escape of the vapor.

Dr. Hagen said that some fifteen years ago Dr. Leidy had stated that the female of *Perthostoma aurantiaca* carried her eggs in a simple layer glued to the upper side of the hemelytra, until they were ready to hatch, and then dropped the whole layer. Such a habit is exceptional among the Hexapoda. Dr. Hagen said it was difficult to conceive how the female placed her eggs in this manner. As such specimens are not rare in the summer, it would be easy to observe the habits of these insects, and to hatch the eggs. He exhibited specimens of the *P. aurantiaca* with the attached eggs. He possesses some cast similar layers of eggs from the Himalayas; the eggs in one of these layers have all hatched.

He also showed a number of specimens of *Achlysia*, the nympha of *Hydrachna*, attached by the head to different parts of the body and legs of *Perthostoma* and *Belostoma*.

December 4, 1872.

The President in the chair. Twenty-four persons present.

Dr. C. T. Jackson gave the following results of an analysis of meteoric iron, etc.

Analysis of Meteoric Iron from Los Angeles, Cal.

The original mass is stated to have weighed eighty pounds, and was seen to fall. A slice of it weighing thirty-seven grammes was presented to me by Mr. E. N. Winslow, of Hyannis, Cape Cod. The specific gravity, taken on the whole piece, was 7.9053. The polished surface of the specimen acted upon by diluted nitric acid, instead of presenting the usual Wiedmanstatian figures, exhibited innumerable minute scales of Schreibersite, pretty uniformly mixed with the iron, giving the surface a sort of micaceous appearance.

One gramme was sawed from the specimen for analysis, and was dissolved in nitric acid. The insoluble matter when reduced by the blowpipe gave of metallic tin 0.01 per ct. The oxide of iron separated by succinate of ammonia in the presence of chloride of ammonium when burned, redissolved in nitric acid and reprecipitated by ammonia, gave on calculation, from the peroxide, metallic iron 80.74 per cent. The nickel, precipitated by potash, washed dried, and ignited and weighed, gave on calculation, metallic nickel 15.73 per ct. Phosphorus and other undetermined matters then weighed 3.52 per ct. This analysis shows that this iron is certainly of meteoric origin.

Dr. Jackson then alluded to the various theories of meteorites, and spoke of their great abundance in the western United States and in Mexico. Dr. Jackson also spoke of the remarkable absence of fossil meteorites, none having been found even in Tertiary strata, until a recent discovery said to have been made in Greenland, in basaltic rocks.

Capt. N. E. Atwood spoke of the distribution of the common squid (*Ommastrephes sagittatus*). Sixty years ago the squid was extremely abundant at Provincetown, Cape Cod, but began about 1847 to become less plenty until in 1867 he had been unable to find a single specimen. Since that date, however, a few had been found, and this season they suddenly appeared in countless numbers. A century ago the squid was quite abundant on the Grand Banks of New Foundland, from which they had disappeared by his boyhood, but lately had become somewhat abundant, and this year extremely so, as at Provincetown.

In the course of remarks called forth by Capt. Atwood's communication Dr. Packard stated that a colossal squid had been taken by the crew of a Gloucester fishing vessel while upon the Grand Bank. Its longer arms were ten feet in length. He had taken a photograph of the beak to Prof. Steenstrup, Director of the Museum at Copenhagen, who identified it as belonging, without much doubt, to *Architeuthis dux* Stp. The specimen in the Copenhagen Museum had come from near the Bahamas.

The jaw of a squid, probably twenty to thirty feet in length, presented by Capt. Atwood to the Essex Institute, had also been identified as probably *Architeuthis monachus* of Steenstrup. This was called by the Danes "Sea Monk." It has been found driven ashore on the coast of Denmark. He had also seen, by the kindness of Prof. Steenstrup, a large cuttlefish at the Copenhagen Museum just brought in from Iceland. Its longer arms measured about twelve feet in length.

Dr. Packard exhibited drawings and gave a brief account of a new species of Bopyrus found by Dr. Gissler in the branchial cavity of a Hypolite found in New York harbor. It was allied to the *Bopyrus squillarum* of Europe, but differed in some important particulars. The minute male was found with its head under the basal gills of the female.

He also noticed briefly the development of *Gelasimus pugnax* Smith, from Ft. Macon, N. C. For the identification of this species he was indebted to Mr. S. I. Smith. He had studied the embryo just previous to hatching. It seemed to agree, as regards the end of the abdomen, with that of Sesarma, and was of the usual zoëa form previous to the first moult, particularly as regarded the anterior claws. He thought the differences between these feet were produced comparatively late in larval life.

Dr. Brewer announced the gift of a rare goose (*Anser frontalis*), from Gardner Brewer, Esq.

The donation of a porpoise by Capt. Atwood was also announced.

December 18, 1872.

Vice-President R. C. Greenleaf, Esq., in the chair. Eleven members present.

Dr. J. Curtis, of the U. S. Geological Survey, gave an account of a visit made to the Yellowstone National Park, in Wyoming Territory, last summer, describing briefly its scenery, geology, etc. Dr. Curtis also presented a number of specimens from that region.

January 1, 1873.

The President in the chair. Twenty persons present.

Capt. C. M. Scammon, U. S. Rev. Marine, was elected a Corresponding Member.

Messrs. George B. Shattuck, M.D., Thomas P. James, Allston G. Bouvé, Henry L. Moody, James Dwight and E. Prebble Motley were elected Resident Members.

The President read extracts from a letter from Dr. C. F. Winslow relating the discovery of human remains in Table Mountain, Cal.

In 1856 I made a communication to the Society in relation to human remains found at the depth of many feet below the surface of Table Mountain in California. Within three years Prof. Whitney has called the attention of the scientific world to other remains found in placer drift at a great depth beneath the surface of that mountain. The depth at which the first were found was, if I remember correctly, one hundred and eighty feet. Those described by Prof. Whitney were found at one hundred and thirty feet, and some distrust as to their identity has been entertained in certain scientific quarters. The verification of such discoveries is all important to the interests of science, and I take great pleasure in communicating another fact to the Society of the same character; and in order that the record may in this instance be placed beyond dispute, I have requested my informant to substantiate his statement made to me in due legal form before a notary public.

During my visit to this mining camp I have become acquainted with Capt. David B. Akey, formerly commanding officer of a California volunteer company, and well known to many persons of note in that State, and in the course of my conversation with him I learn that in 1855 and 1856 he was engaged with other miners in running drifts into Table Mountain at the depth of about two hundred feet from its brow, in search of placer gold. He states that in a tunnel run into the mountain at the distance of about fifty feet from that upon which he was employed, and at the same level, a *complete human skeleton* was found and taken out by miners personally known to him, but whose names he does not now recollect. He did not see the bones in place, but he saw them after they were brought down from the tunnel to a neighboring cabin. All the bones of the skeleton apparently were brought down in the arms of the miners and placed in a box, and it was the opinion of those present who examined them that the skeleton must have been perfect as it laid in the drift. He does not know what became of the bones, but can affirm to the truth of this discovery, and that the bones were those of a human skeleton, in an excellent state of preservation. The skull was broken in on the right temple, where there was a small hole, as if a part of the skull was gone, but he cannot tell whether this fracture occurred before the excavation or was made by the miners. He thinks the other bones were perfect. He thinks that the depth from the surface at which this skeleton was found was two hundred feet, and from one hundred and eighty to two hundred feet from the opening cut or face of the tunnel. The bones were in a moist condition, found among the gravel and very near the bed rock, and water was running out of the tunnel. There was a petrified pine tree, from sixty to eighty feet in length and between two and three feet in diameter at the butt, lying near this skeleton. Mr. Akey went into the tunnel with the miners, and they pointed out to him the place where the skeleton was found. He saw the tree in place and broke specimens from it. He cannot remember the name of this tunnel, but it was about quarter of a mile east of the Rough and Ready tunnel and opposite Turner's Flat, another well known point. He cannot tell the sex of the skeleton, but it was of medium size. The bones were altogether, and not separated, when found.

On the same level at which this skeleton was found, but from other tunnels, Mr. Akey saw many bones of animals taken, but no other human remains. Among these remains were mastodons' teeth and bones of smaller animals than mastodons, the names of which he does not know. Petrified wood was very common, and pine cones, and pitch, and bark were found at these levels and among the gravel.

Overlying these placer deposits and organic remains was volcanic matter consisting of lava or of "honey-combed" material.

Many other details in connection with the above Mr. Akey has communicated to me; but the main point, *the discovery and identification of a complete human skeleton in placer at two hundred feet below the surface of Table Mountain* and overlaid with volcanic matter is that alone which I wish to communicate in confirmation of the preceding discovery of similar organic remains, first made known to the scientific world by myself, and subsequently substantiated by the accounts of a similar discovery by Prof. Whitney.

This is to certify that the foregoing statements made to C. F. Winslow, M.D., were taken from my mouth and written by him in my presence, and I affirm to their correctness in every particular.

D. B. Akey.

Bear Gulch, W. T., Sept. 18, 1872.

Witnesses:

John H. Osborne.

Abraham Haner.

January 15, 1873.

The President in the chair. Twenty-four persons present.

The Rev. R. C. Waterston read a letter from Galen Clarke, Esq., giving an account of some explorations in the region of the Yosemite Valley.

I have made two excursions up into the high Sierras this past summer. One of the trips was up into the Mt. Lyell group. It is in this group of mountains that the Merced has its rise, and flows down through the Yosemite Valley. The Tuolumne and the San Joaquin Rivers also rise here at the foot of Mt. Lyell, also some small rivers which run east into Mono Lake and Owen's River. I went with Mr. John Muir, of Yosemite, for the purpose of examining the great snow fields in that group, and to ascertain if there were still any evidences of living glaciers there.

From the observations which we made and the local tests which we applied, we are positive that there are several glaciers in that group which are in constant slow motion. We drove a line of stakes across, and found that they had moved, a month after. Their length may average about a mile, and their width, perhaps, half as much. Their depth is uncertain, but from appearances it must be several hundred feet.

Mr. Muir has spent much time during the past three years in exploring the mountains adjacent to the Yosemite, and in studying the forms of the cañons, and mountain formations, and the great agency which the glaciers have had in giving them their present shape.

Here in the Mt. Lyell group we learn the first rudimentary lessons in the great work of glaciers, and after studying them we are better prepared to understand their agency in the formation of the Yosemite and other cañons of the Sierra Nevada. When we see the great number of streams of ice, and their great depth, carrying along great quantities of rock, grinding and wearing as they are crowded onward, and all concentrating into one great flow, like so many streams of water uniting to form a vast river, — we cannot but feel impressed with their wonderful agency in forming the Yosemite and other great cañons and lakes in the Sierra Nevada. Everywhere above the Yosemite and on each side we find the great moraines of boulders, and the polished and striated rocks, showing the direction of the flow as plainly as if it were flowing at the present day.

I also went with Mr. Muir to explore the great Tuolumne Cañon, which from the Hetchy Valley below to the great meadows and soda springs above, a distance of over twenty miles, had never been explored by any white man, and its general character was entirely unknown.

After examining the region around the headwaters of the Yosemite Creek, which forms the Yosemite Falls, we went directly to the Hetch-Hetchy Valley, which may be called the counterpart of the Yosemite on a smaller scale. The highest fall in this valley is eighteen hundred feet, but not perpendicular. It is a very beautiful valley, and probably will be more visited in future years. At its upper part we left our horses and packs, took our blankets and a few days' provisions on our backs and started for the primeval forest.

It was one of the most interesting trips I ever made, although a very hard and fatiguing one. Almost every moment was one of great interest throughout the whole distance of over twenty miles. The walls of the cañon are from three to four thousand feet above the river, — not perpendicular, but standing back at an angle of about sixty degrees, — and nearly the whole distance worn and polished by glaciers from top to bottom. There is but one place in the whole distance where it widens out into a valley of trees and grassland. Most of the distance the steep mountain sides come clear down to the water on both sides of the river. Sometimes we had to wade up the river, there being no foothold on the rocks on either side. In many places we climbed over immense boulders, which had fallen from above. One boulder formed a bridge across the river. In other places we crawled on our hands and knees under the chaparrel bushes, which were so thick we could not get through them otherwise. It became so fatiguing that we left our blankets and went on without them, and spent one night without blanket, coat nor provisions.

We found quite a number of very beautiful waterfalls, on a small scale, in the main river, and some very fine small falls on some of the side cañons. Near the upper part of the cañon we found some of the finest and largest cascades I ever saw. In two different places the whole river plunges down over the glacier-polished and carved, rocky bed, for a distance of nearly half a mile in each place.

The main part of the cañon must remain inaccessible to most tourists, but I think we can, perhaps, make a trail into the upper part, so that a visit to these beautiful cascades and the splendid scenery around will be possible.

All the upper portion of the Sierra Nevada Mountains is very interesting. From the top of Mt. Lyell or Mt. Dana may be seen hundreds of different mountain peaks, mantled with snow, with infinite variety of form and finish. The views are too full of sublime grandeur to be described.

Mr. Waterston also spoke of the peculiar rounding of blocks of granite by the intense heat of the great fire of Nov. 9th. The rounded outline of these blocks recalls the dome-like mountains of the Yosemite, and he suggested that similar causes produced these phenomena in both cases.

With regard to Mr. Waterston's interesting comparison of the rounded surfaces resulting from the exfoliation of granite blocks by the action of artificial heat to the rounded outlines due to concentric lamination, seen in the great granitic domes of California, Dr. Sterry Hunt expressed an opinion that the cause of the phenomena in both cases was the same.

When angular blocks of a homogeneous, uncleavable, brittle substance, like granite, trap-rock or glass, are exposed to changes of heat and cold, the layers of equal temperature established within the mass, instead of conforming to the exterior surface, will necessarily be curved, and the exfoliation naturally resulting from unequal expansion or contraction will give rise to rounded outlines. Prof.

Shaler, in a communication to this Society, on Feb. 3, 1869, attempted to explain in this way the concentric lamination of granite (long since described by Von Buch), referring it to movements of contraction and expansion in the mass caused by the changes of the seasons. Dr. Hunt had elsewhere defended this view of Shaler's (*Amer. Jour. Sci.*, July, 1870, p. 88), and called attention to the fact that the divisional planes are conformable to the present surfaces of the granite masses, and moreover that they are not confined to eruptive granites, like those of Rockport, Mass., and Biddeford, Me., but are equally well seen in the granitic gneisses of the White Mountain series; as for example, near Augusta, Me., and Berlin Falls, N.H., where a nearly horizontal lamination intersects the almost vertical, but obscurely marked, stratification of the rock. To the action of this process on a small scale is due the rounded and boulder-like forms of detached masses of granite, which are often found resting upon or near the parent rock. Of these there is a remarkable display in many places near the frontier of Maine and New Brunswick. A similar concentric structure is very generally seen in the weathering or superficial alteration of angular masses of rock, the lines of chemical change within which become more and more rounded in receding from the surface, in obedience to the same law which we have noticed in the conduction of heat, and which applies equally to the penetration of meteoric waters, which are in this case the agents producing the alteration.

Dr. Kneeland observed that their peculiar form must have been given to the domes of the Yosemite before the glacial period, as they are beautifully polished and striated; and showed that the Royal Arches, so called, indicate that the concentric structure of these granitic mountains extends to a great depth beneath the surface.

Dr. T. M. Brewer exhibited the specimen of *Anser frontalis*, lately shot in North Carolina, and presented to the Society by Gardner Brewer, Esq. This is the fourth specimen known, and is interesting in showing some variations in the direction of *A. gambellii.*

Section of Entomology. Jan. 22, 1873.

Mr. P. S. Sprague in the chair. Eight persons present.

Dr. Hagen returned the Neuroptera and Pseudoneuroptera belonging to the Harris collection, and presented the following report on these groups.

REPORT ON THE PSEUDONEUROPTERA AND NEUROPTERA OF NORTH AMERICA IN THE COLLECTION OF THE LATE TH. W. HARRIS. BY H. A. HAGEN.

ODONATA.

1. Tramea Carolina L. Hag. Syn., 143, 1.

No. 137. ♂ ♀, East Florida, Mr. Doubleday; ♂, New York. Mr. Calverley.[1]

The specimen from New York by Mr. Calverley, probably from Brooklyn, marks the most northern locality known for this species; formerly I had seen it from Bergen Hill, N. J., near New York. A specimen from Nantucket Island in the collection of the Cambridge Museum, taken by Mr. Edward Burgess, is the most northerly Tramea known, but is probably *T. abdominalis* Rbr.

2. Celithemis Eponina F. Hag. Syn., 147, 1.

No. 42. ♂ ♂ ♂, Mr. Oakes, Ipswich; Dedham, Aug. 1, 1829; Mt. Auburn, Aug. 15, 1849.

Massachusetts is the northern limit for this species known to me, and Rock Island, Ill., the western limit.

3. Plathemis trimaculata De Geer. Hag. Syn., 149, 1.

No. 16. ♂ ♂ ♂, *Lib. Lydia* Drury; *trimaculata* De Geer, F.? Borders of ponds, July, 1826; North Carolina, June; Cambridge, June 20, 1833.

No. 19. ♂, *Lib. trimaculata* F. (Say's determ.)[2]? *pruinosa*, Harr. Cat., July, 1826. No. 126. ♀ ♀ ♀, New York, Calverley.

No. 19 is the *Lib. Lydia* Say, Journ. Acad. Phil., VIII, 20, 5.

[1] In this report the paragraph following the name of the species represented in this collection, contains Dr. Harris' own notes, indentifications, &c., copied literally from his catalogue, and begins with his number.

[2] In Harris' own catalogue every determination made by Th. Say is written with red ink; represented here by "Say's determ." The u after the number signifies that the specimen is unique.

4. Libellula pulchella Drury. Hag. Syn., 153, 8.

No. 3. ♀, Milton, June 1821.

No. 14. ♂ ♀ ♀ ♀, *Lib. pulchella* Drury; *bifasciata* F.; *versicolor?* F. Borders of ponds, July 1, 1826; New York, Calverley.

It is the *Lib. bifasciata* Say l. c., 20, 6.

5. Libellula quadrimaculata. L. Hag. Syn., 150, 1.

No. 81. ♀, u., *Lib. ternaria*, ♂, Say; Stow, Mass., Mr. Randal. See the following species.

6. Libellula semifasciata Burm. Hag. Syn., 151, 2.

No. 80. ♀, u., Stow, Mass., Randal. ♀ ♀, Cambridge, 1851; New York, Mr. Calverley.

In the catalogue the numbers 80 and 81 are united by Say by a brace, with the determination, "*Lib. ternaria* MSS., ♀ ♂ (new Neur., MSS., 24)."

The two specimens (both with u) are very important, because they are certainly the types described by Th. Say. He gives the locality Massachusetts, and adds, p. 22, "I have not seen any other specimen than the sexes sent me by Dr. Harris for examination."

Farther my statement, Syn., p. 151, that Say confounded two species in his *L. ternaria*, is found correct, the male belonging to *L. quadrimaculata*, the female to *L. semifasciata* Burm. Besides it is curious, but true, as no other specimens exist in the collection, that the specimen described as a male by Say is in reality a female. This fact is proved moreover by Say's description,—"inferior process hardly one-third as long as the others," which agrees very well with the female, if the anal valves are taken for the inferior process. In the male it is half, or more than half, as long as the superior.

Say states that *L. ternaria* in some characters resembles *L. quadrimaculata* L. of Europe, but the latter has not the terminal wing bands. Apparently it was unknown to him, that the variety *L. prænubila* Newm. possesses terminal wing bands, and Harris' specimen belongs to this variety.

As Say's *Lib. ternaria* confounds two species, and as the male described by him is a female, I believe Burmeister's name preferable, indeed it is very likely that his description was published before Say's; at least it was published at the same time.

L. quadrimaculata is in America a northern species, common in the Saskatchawan district; in Wisconsin, where it makes migrations, on Lake Michigan, just as in Europe; Rock Island, Ill.; Ogden, Utah; Snake River, Idaho; Bridger Basin, Wyoming. The locality Stow, Mass., is the most southern limit known. The variety *L. prænubila* is more rare, and, as in Europe, stronger developed in the female. *L. semifasciata* is a decidedly more southern species, and it is remarkable, that Stow, Mass., is its most northerly limit known.

7. **Libellula exusta** Say. *Lib. Julia* Uhler, Hag. Syn., 153, 7.

No. 55. ♂ ♀. *Lib. exustus* (*sic*) Say MSS. (Say's determ.) Dr. Smith, Sutton.

Say, loc. cit., 29, 18, describes only the male, and adds, "I have not seen the female. From Dr. Harris." The specimen in the collection is also surely a typical one. *Libellula Julia* Uhler (Hag.) is identical with *L. exusta.* When Mr. Uhler described his species only one specimen in bad condition from Ft. Steilacoom, Puget Sound, was known. Later the species was discovered in Racine, Wis., and in Massachusetts, and its identity stated by Mr. Uhler. The western and northern specimens from Puget Sound, Lake Winnipeg, and even from Maine are larger, the basal longitudinal spots on the wings smaller, in the posterior wings not covering the triangle. The mature male has the thorax above bluish, and the abdomen, except the apical half, always blackish. The typical *Lib. exusta* has two pale bands on the thorax, which are not bluish in the adult; the abdomen entirely bluish; the basal longitudinal spots reaching the arculus and filling the triangle in the posterior wings. Nevertheless I am unable to discover specific characters, and consider both forms as belonging to the same species. Indeed I was at one time inclined to consider the southern and smaller *L. deplanata* Rbr. as belonging to the same species, just as we find sometimes in Sicily common northern European species, only half size. But a more detailed examination gives some differences in the genital parts, which I consider of importance enough to separate the two species.

The left hind wing of the male in the collection shows a rare and interesting monstrosity in the formation of the triangle.

8. **Libellula deplanata** Rbr. Hag. Syn., 154, 10.

No. 56. Dr. Smith, Sutton. Var. ♀, Mr. Nuttall, Pennsylvania.

The specimen from Sutton is no longer in the collection; the variety is the true *L. deplanata.* Harris seems to have doubted in the same manner as I have if the two species are really different. It is worthy of remark that *L. exusta* is the representative species of the European *L. fulva* in North America. I have never seen specimens of *L. deplanata* from Massachusetts; Pennsylvania is now the most northern limit.

9. Libellula auripennis Burm. Hag. Syn., 155, 11.

No. 138. ♂, East Florida, Mr. Doubleday; ♀, New York, Mr. Calverley.

"Much like *Lydia* Drury, II., pl. 47, 1, but is smaller. It reresembles also Nos. 21 and 68 (*Lib. quadrupla*), but is not the same." I suppose the specimen from New York, Calverley, is from Brooklyn; this locality and Bergen Hill, N. J., are now the northern limit for this southern species.

10. Libellula quadrupla Say. Hag, Syn., 157, 16.

No. 21. ♂ ♂, *Lib. quadrupla* Say MSS., male, see No. 68 (Say's determ.), Milton, Mass. Borders of ponds, July, 1826.

No. 22. ♂, immature, same locality.

No. 68. ♀ ♀, *Lib. quadrupla* Say MSS., female, see No. 21 (Say's determ.), Cambridge, Bethune.

Say describes the species from Massachusetts; the sexes were sent by Dr. Harris. Of course the specimens in the collection are types.

11. Mesothemis longipennis Br. Hag. Syn., 178, 7.

No. 140 ♂, No. 141 ♀, both New York, Mr. Calverley.

This is a more southern species, New York (Brooklyn) in the east and Chicago in the west are the most northern limits.

12. Mesothemis simplicicollis Say. Hag. Syn., 170, 1.

No. 50. ♂, *Lib. simplicicollis* Say MSS. 36, Aug. 10, 1832.

Say, l. c., p. 28, 16, adds, of the male, — I have but one specimen. . . Dr. Harris sent me a specimen for examination. As the male fragment in the collection is marked H, there is no doubt that it was the type. Massachusetts seems to be the northern limit for this species.

13. Diplax Elisa Hag. Syn., 182, 15.

No. 131. ♂ ♀, Cambridge, May 10, 1838. New York, Mr. Calverley.

14. Diplax ornata Rbr. Hag. Syn., 182, 16.

No. 139. ♂, East Florida, Mr. Doubleday.

15. Diplax Berenice Drury. Hag. Syn., 178, 8.

No. 8. ♂ ♀ ♀, *Lib. Berenice* Drury, var. (Say's determ.). Not so, *Julia* mihi (Harr.). Milton, June 20, 1821. New York, Mr. Calverley, ♀.

No. 9. ♀ ♀, *Lib. Berenice* Drur. (Say's determ.). Milton, June 20, 1821; New York, Mr. Calverley.

The specimens No. 8 are the typical male and female; the females No. 9 are the second form of the female described and figured by

Drury. There is no doubt that both forms belong to the same species; Harris in his note to No. 8 considered them different. As Say stated that he received a specimen from Dr. Harris, the specimens in the collection are to be considered as types.

16. Diplax vicina Hag. Syn., 175, 4.

No. 6. *Lib. rubicundula* Say MSS. (Say's determ.). ♂ ♀ ♂.

The catalogue mentions the following six specimens: Milton, 1820, Sept. 30, 1821; Sept., 1829; ♂ ♀, Oct. 7, 1837. There are only four specimens in the collection, the same number as stated by Mr. S. H. Scudder, Proc. B. S. N. H., x., p. 221. Two of them have labels written on apparently newer paper and marked ♂ and ♀. Apparently those are the specimens taken Oct. 7, 1837. Of the two remaining the male is *D. vicina*, the female is probably *D. rubicundula* Say. I say *probably*, and it is stated to be so in Mr. Scudder's very elaborate paper, but as the specimen is in very bad condition, even the vulva lamina wanting, there is no absolute certainty. But I believe Mr. Scudder's determination is the right one, as is his supposition that it is probably the specimen received by Mr. Say. Mr. Scudder's statement that *L. ambigua* Rbr. was referred by me erroneously to *L. rubicundula* is also right. Apparently this was some *lapsus calami* as *L. ambigua* is also referred by me to *L. albifrons* Chp.

17. Diplax rubicundula Say. Hag. Syn., 176, 6.

No. 6. ♀ ♂, *Lib. rubicundula* Say; New York, Mr. Calverley.

The female is spoken of above from Massachusetts, belonging to one of the three first given dates. The New York specimen is a fragment of a male.

No. 7. ♂, fragment from Maine, belongs probably here.[1]

18. Diplax albifrons Chp. Hag. Syn., 177, 7.

No. 5. ♂, *Lib. rubicunda* Say MSS., var. (Say's determ.). Milton, June 20, 1821.

The specimen is a fragment of an immature male, belonging, as I believe, to this species.

19. Diplax semicincta Say. Hag. Syn., 176, 5.

No. 7. ♀, *Lib. semicincta* Say MSS. (Say's determ.). Milton, 1820, and a later addition, Maine, Randal, ♀ ♂.

Of the Maine specimens only a fragment of the male exists, belonging to *D. rubicundula*. The female taken in 1820 is *D. semi-*

[1] The description of *Lib. rubicundula* in Harris' Corresp., p. 326, belongs to this species, but apparently not to the specimens now in the collection.

cincta, a fragment without the head, but as Say only describes the male, it cannot be his type. There is in the collection a male with a red label and printed number 219, perhaps a later addition.

20. **Diplax minuscula** Rbr. Hag. Syn., 182, 18.

No. 142. ♂ ♀, East Florida, Mr. Doubleday.

21. **Perithemis tenera** Say. Hag. Syn., 185, 1.

No. 49. *Lib. tenera* Say MSS. 42 (Say's determ.). Milton, July 10, 1831.

As the fragment of the specimen is labelled u, and as Mr. Say ascribes his species to Massachusetts, it may be the type. It is the female of the well known race (?) of *P. domitia*. The male is *L. tenuicincta* Say.

There are in the Harris collection some nymphæ belonging to Libellula, and some nympha skins of Diplax. They were placed without any indication near *Pl. trimaculata*, to which species the nymphæ does not belong, as I know that of this species, and near *Lib. exusta*, the nympha of which is still unknown. Near the Libellula nymphæ, on the bottom of the box, was a pencil mark "N. Y."; perhaps it is the locality.

CORDULINA.

22. **Macromia transversa** Say. Hag. Syn., 135, 1.

No. 72. ♂ ♀, *Lib. transversa* Say MSS. (Say's determ.). *Didymops Servillei* Rbr. Randal, Stow, Mass.

As Say described this species after a male specimen sent by Dr. Harris, the specimens in the collection have a typical value.

The larva was placed in another box; I supposed long ago that it belonged to this species, and in the Cambridge Museum is the imago and the nympha skin placed in the same bottle, making the identity probable. The larva is described by Dr. A. S. Packard, 1st Ann. Rep. Insects Mass., 1871. Stow, Mass., is the most northern limit for the species known.

23. **Epitheca forcipata** Scudder, Proc. B. S. N. H., x., p. 216.

No. 148. ♂, *Lib. tenebrosa* Say (Harris' determ.). Maine, Mr. Randal, 1836.

The description of Mr. Say shows clearly that the species cannot be his *L. tenebrosa*, as presumed by Dr. Harris. Baron De Selys Longchamps having Mr. Scudder's type decided it to be identical with *C. chalybea* Hag. Syn., 138, 7 (without description) from Nova

Scotia. Other localities known are Maine, New Hampshire and Ft. Resolution, Hudson's Bay. This species imitates closely *Ep. arctica* Zett. from Europe, and perhaps *E. semicircularis* De Selys, l. c., p. 61, 37 (described from a single male from the Gulf of Georgia, in the Cambridge Museum), is only a race of the same species.

24. Epitheca ? obsoleta Say. Hag. Syn., 136, 2.

No. 1. *Lib. obsoleta* Say MSS., 38 (Say's determ.), Milton (meadows), 1820.

Say's type was "a female specimen, sent for examination by Dr. Harris." As the only specimen in the collection is a female, and labelled u, it is doubtless the type seen by Say. I may add that the same specimen is the type of Baron De Selys Longchamps, as the Society, with the liberal wish to aid the work of this well known naturalist, allowed this treasure and some similar rare ones to be sent to Belgium. All have been returned uninjured, or, rather, in the same poor state as they were when sent.

This is one of the rarest and most interesting North American species. Besides the specimen from Indiana described by Mr. Say, only three other specimens are known, all seen and studied by me. The female in Harris' collection; the type of *Lib. polysticta* Burm. (*Didymops obsoleta* Hag. Syn.) now in my collection, which is a male from New Orleans, and thirdly the female from Rock Island, Ill., described by Mr. Walsh as *Cordulia molesta*. The latter was destroyed by the Chicago fire, and was studied by me in 1868 at the author's home. I should state that Mr. Walsh was induced by an omission in my Synopsis to overlook the identity of his species with *Didymops obsoleta* Say and Hagen, as I said in the short diagnosis of the genus, p. 135, — "tarsal nails bifid, the branches equal." I was aware that this character applied only to the first species, but I forgot to mention its absence in the second species. At that time only having before me the specimen of Burmeister, an immature male in very bad condition, I did not like to found on such insufficient material a new genus, and put them therefore in the genus I believed to be the most suitable. The species is really an aberrant one, and even Baron De Selys Longchamps in his excellent work (Synopsis de Cordulines, p. 47) having before him both sexes (Harris' and Burmeister's types) preferred to refer them provisionally to Epitheca, as even in this pair the reticulation is not identical.

25. Cordulia Uhleri De Selys, l. c., p. 40.

No. 77. ♂, *Cordulia*, Randal, Stow, Mass.

This male, the only one known, and in very bad condition, has been in Baron De Selys Longchamps' hands, and besides this the very imperfect fragments of the female, from New Jersey, in Mr. P. R. Uhler's collection.

This beautiful species imitates by the spotted border of the wings *E. obsoleta*. For both species new and more perfect specimens are necessary to determine surely their position.

26. Cordulia cynosura Say. *C. lateralis* Burm. Hag. Syn., 139, 15.

No. 75. ♂, *Lib. cynosura* Say MSS. (Say's determ.). Randal, Stow, Mass.

Say describes only the male from Massachusetts, sent to him by Dr. Harris. Of course the specimen in the collection is a typical one, and agrees with the type of *C. lateralis* Burm., now in my collection, as stated in the Synopsis and by Baron De Selys Longchamps, l. c., p. 36. I preferred to use Prof. Burmeister's name in my Synopsis, assured by his type, and in the case of this species, as in some others, it is difficult to settle the question of priority. Prof. Burmeister's book has on the title page 1839, but at this time it was the common practice in Europe to postdate all books. I cannot decide if it was done in this case, and I am sure that I did not see the book before 1839. Say's paper was published in 1839, and probably simultaneously with Burmeister's. The fact that the former was *read* in 1836 gives the author's names no claim to priority.

M. le Baron De Selys Longchamps agrees, l. c., p. 38, with my doubts about the difference between *C. cynosura* and *C. semiaquea* Burm., and he adds, — "et je pense qu'il sérait préférable de ne les considérer que comme deux races." I have seen *C. cynosura* from Massachusetts, Ohio, Illinois, Pennsylvania, Louisiana, Florida, and *C. semiaquea* from Massachusetts, District of Columbia, Georgia, South Carolina, Florida. *C. semiaquea* is the *Tetragoneuria semiaquea* Syn., 140, 1, and *T. diffinis* Syn., 141, 3, is only a variety of it, according to Baron De Selys Longchamps, as well as *C. complanata* Rbr.

The variation in size, color and basal spot of the wings is considerable, and a careful study of the species a decided necessity.

27. Cordulia lepida De Selys l. c., p. 30, No. 14.

No. 79. ♀, Randal, Stow, Mass.

This interesting new species seems not very rare, and is known now from Maine, Massachusetts, New York, New Jersey, Maryland.

I possess the immature stages raised by Mr. K. T. Jones, of Portland, Me. It is the smallest species of Cordulia known.

AESCHNINA.

28. **Anax Junius** Drury. Hag. Syn., 118, 1.

No. 127. ♂, *Gomphus Junius* Drury, Milton.

Massachusetts is the northern limit for this widely spread species, common throughout the United States, from the Atlantic to the Pacific, and in the West Indies, Mexico, Kamschatka, China, the Sandwich and Society Islands.

29. **Epiaeschna Heros** F. Hag. Syn., 128, 20.

No. 13. ♂ ♀ ♀, *Aeschna Heros* F.; *multicincta* Say, Journ. Acad., Vol. 8, p. 1. Milton, June 15–30, 1823, ♂ ♀; Sept. 1822, ♀; New York, Mr. Calverley, ♀.

In the collection is the pair from Massachusetts and the female from New York. Massachusetts is the northern limit known for this species. A description of *Ae. Heros* is given by Dr. Harris, Corresp., p. 326.

30. **Aeschna clepsydra** Say. Hag. Syn., 122, 5.

No. 45. ♂, *Ae. clepsydra* Say MSS. (Say's determ.). Milton, Aug. 1, 1828; Cambridge, July, 1832; Aug. 15, 1836.

There are two specimens in the collection; the other specimen indicated belonging to the next species. Perhaps a species with a northeastern habitat, common to Maine, Massachusetts, extending to New Jersey and Maryland, and in the west to Illinois, where they seem more rare.

31. **Aeschna constricta** Say. Hag. Syn., 121, 4.

No. 45. ♂.

The specimen belongs to one of the three dates given above. The species is more common and more widely spread than the foregoing one.

32. **Aeschna janata** Say. Hag. Syn., 125, 11.

No. 2. ♂ ♀, *Ae. janata* Say MSS. (Say's determ.). Milton, meadows, May 10, 1828; June, 1821; June, 1823.

Say describes the species from Massachusetts, and adds, — "sent to me by Dr. Harris. I have not seen the female." Of course the specimen is to be considered as type.

The species is very rare. I have never seen it in Europe, and even here only two pairs, one in Harris' collection, the other in the

Cambridge Museum, both from Massachusetts, and a male from the White Mountains, N. H., Shurtleff, in the B. S. N. H. collection.

33. **Gomphaeschna furcillata** Say. Hag. Syn., 131, 25.

No. 52. ♂ ♂, *Libellula* (*Gomphus*) *furcillata* Say MSS. (Say's determ.). Dr. Smith, Sutton.

Mr. Say described only the male from Massachusetts. He had seen only the individual sent for examination by Dr. Harris, and as the male in the collection is labelled u, it is doubtless the type. There is in Harris' collection a male labelled 15 June, 1855, a later addition.

The species is very rare. In Europe there is only the male type described by Rambur, now in the collection of Baron De Selys Longchamps; the female has never been described. There is a female from Brookline, Mass., June 8, 1864, in the B. S. N. H. collection. In the Cambridge Museum there is a male labelled Sept., Druid Hill (locality unknown to me), a female from Massachusetts, and another from Detroit, Mich., August. I was told that the species is common near the Detroit River, and had nymphæ given to me probably belonging to this species. Perhaps it is a northern species.

34. **Neuraeschna vinosa** Say. Hag. Syn., 130, 24.

No. 71. ♂, *Ae. vinosa* Say MSS. (Say's determ.). Cambridge, Aug. 15, 1832.

Described by Mr. Say from Massachusetts, from a Harris specimen. Of course it is to be considered as type.

Whether the name of Mr. Say was published before that given by Prof. Burmeister, *Ae. 4-guttata*, is, as I have stated, not yet decided. This species ranges from Maine to Tennessee, and seems not very rare. It is the representative species of *N. Irene* of Europe.

There is a fragment of Aeschna larva, young and not determinable, in the collection.

GOMPHINA.

35. **Hagenius brevistylus** Selys. Hag. Syn., 114, 1.

No. 51. ♀, *Gomphus* (*Ictinus*) *raptor* Harris MSS. Imago and pupa. Dr. Smith, Sutton. There is also another pupa in the collection.

The specimens are very important, as the curious pupa, formerly thought by me to belong to *Petalura Thoreyi*, is shown to belong to this remarkable species, which seems to have a wide habitat, for I have seen specimens from the upper Wisconsin River, and from Texas, and many localities between these, and pupæ also from Kansas.

36. Gomphus exilis Selys. Hag. Syn., 108, 23.

No. 4. ♂ ♀, June, 1821, and Dr. Smith, Sutton. *Ae. fraterna* Say MSS. (Say's determ.).

The specimens are surely not Say's *Ae. fraterna*, as the description and size do not agree, though Mr. Say himself named them. Say's types were not from Massachusetts, nor were they communicated to him by Dr. Harris. Apparently his determination was made later and was an error of memory.

37. Cordulegaster Sayi Selys. Hag. Syn., 115, 1.

No. 73. ♂, *Ae. obliqua* Say MSS., var. (Say's determ.).

Note by Dr. Harris: — "Say thought it a variety of his *obliqua* but it is a different species." Randal, Stow, Mass.

Say describes a male variety of his *Ae. obliqua*, sent by Dr. Harris. Of course the male in the collection is the type, agreeing with Say's diagnosis. The type of *C. lateralis* Scudder is identical with Harris' specimen. In my Synopsis I erroneously referred Say's variety to *C. maculatus*.

38. Cordulegaster maculatus Selys. Hag. Syn., 115, 2.

There is in the collection a male specimen, No. 73, not indicated in the catalogue, perhaps a later addition, belonging to this species. Both species seem to be rare.

A fragment of a Gomphus nympha, without label, is in the collection.

CALOPTERYGINA.

39. Calopteryx maculata Beauv. Hag. Syn., 57, 4.

No. 44. ♂ ♂ ♂, *Calepteryx opaca* Say MSS. (Say's determ.). See No. 43.

Mr. Oakes, Ipswich; North Carolina, Prof. Hentz; New Jersey, Mr. Calverley, ♂; Cambridge, June 25, 1841, ♂ ♀; the female is numbered 46.

No. 43. ♂ ♂, *Calepteryx opaca* ? Say MSS. var. ? (Say's determ.). Mr. Hentz, Northampton, June.

No. 46. ♀ ♀ ♀ ♀ ♀, *Agrion virgo* ? Drury (Harris' determ.). *Cal.* ? *materna* Say MSS. (Say's determ.). Milton, June; North Carolina, Prof. Hentz; Dr. Smith, Sutton; New Jersey, Mr. Calverley.

Say, l. c., 32, 2, gives the locality Massachusetts for his *C. opaca*, and adds, — "for this species I am indebted to Dr. Harris." Of course the specimens No. 44 are types. The males, No. 43, are immature. All these specimens belong to *C. maculata.*

Calopteryx maculata is a species spread over the whole United States east of the Rocky Mountains. I have seen a great number of specimens from Maine to Florida, and from Illinois to Texas. I have seen some females from Illinois and Maine which differ in the coloration of the wings, and are more similar to the European *C. virgo.* Nevertheless the males of the same localities, even found together with such females, are not different from *C. maculata.* It would be interesting to have further observations on this variety.

40. Calopteryx æquabilis Say. Hag. Syn., 58, 5.

No. 53. ♂, *Calepteryx æquabilis* Say MSS. (Say's determ.). Dr. Smith, Sutton.

No. 54. ♀, *Cal.* ? *fugitiva* Say MSS.; see No. 74 (Say's determ.). Dr. Smith, Sutton.

No. 74. ♀, *Cal.* ? *fugitiva* Say MSS. var., see No. 54 (Say's determ.). Dr. Smith, Sutton.

The male, No. 53, and the female, No. 54, agree well with Say's description, and as he gives the locality Massachusetts, and adds, — "a female specimen, *also* sent me by Dr. Harris," there is no doubt of the typical character of the specimens in the collection. I have seen the species from Hudson's Bay, Maine and Massachusetts, and they are surely identical with the specimens from Hudson's Bay, quoted under *C. virginica* in my Synopsis, from Baron De Selys Longchamps' collection. At the time the Synopsis and the Monograph of the Calopterygines were published I had seen no specimen. Even now the specimens from Georgia, in the British Museum, and from Virginia, quoted by Drury, should be examined again. The name given by Say has the priority over the name given by Westwood to Drury's species.

There is a young larva of a Calopteryx in the collection, the only I have seen until now from the United States.

41. Hetærina americana F. Hag. Syn., 60, 5.

No. 47. ♂ ♂, *Agrion* (*Lestes*) *basalis* Say MSS. (Say's determ.). See No. 48. Pickering, Salem.

No. 48. ♂, *Agrion* (*Lestes*) *basalis* Say MSS., ♀ (Say's determ.). See No. 47. North Carolina, Prof. Hentz, and Cambridge, Randal.

No. 77. ♀, *Agrion* (*Lestes*) *insipiens* Say MSS. (Say's determ.). Milton, borders of ponds, July, 1826.

All these specimens belong to *Hetærina americana*, and as Say gives the locality Massachusetts, it may be that the type is among them. At least in Say's description nothing is given to believe the contrary. Of No. 48 only the male from North Carolina is in the collection, and the Cambridge specimen is lost. The latter only was seen by Say, as he stated the specimen to be a female.

AGRIONINA.

42. Lestes eurinus Say. Hag. Syn., 70, 10.

No. 20. ♂, *Agrion* (*Lestes*) *eurinus* Say MSS. (Say's determ.). Borders of ponds, Milton, July, 1826.

Say describes the species from Massachusetts from Dr. Harris' specimen; of course the specimen in the collection is a typical one. This is the only specimen of this interesting species I ever saw, either in Europe or America. The inferior processes are wanting in the specimen.

43. Lestes rectangularis Say. Hag. Syn., 66, 2.

No. 10. ♂, *Lestes triangularis* Say MSS., 50 (Say's determ.). June 20, 1821, Milton, labelled u. A later addition, New York. Mr. Calverley, ♀.

Say describes them from Indiana and Massachusetts. In the collection is a male from New York, not marked in the catalogue, but undoubtedly *L. rectangularis*.

44. Lestes unguiculata Hag. Syn., 70, 11.

No. 10. ♀, New York, Mr. Calverley. See the previous species.

No. 132. Var. ♂, New York, Mr. Calverley.

The specimens are not in very good condition, but, I believe, belong here.

45. Lestes hamata Hag. Selys' Synops., Lestes, 16, 7.

L. forcipata Hag. Syn., 71, 13.

No. 132. ♂, Cambridge, Aug. 1, 1838.

No. 10. ♀, Milton, June 20, 1821, labelled u.

46. Argia putrida Hag. Syn., 96, 44.

No. 11. ♂, *Agr. hastata* Say's determ.

47. Agrion civile Hag. Syn., 88, 28.

No. 17. ♂ ♀, New York, Mr. Calverley; No. 146, ♀, New York; a pair from Massachusetts, in bad condition, hardly recognizable.

48. Agrion Ramburii Selys. Hag. Syn., 76, 5.

No. 17. ♂ ♀, New York, Mr. Calverley.

There are ten specimens of Agrion in the collection, eight numbered 17, and two, 11 and 146, nearly all fragments, some of them difficult to determine surely. Apparently they do not agree with the determinations given in the catalogue, and are probably later additions for the lost original specimens. No. 11 is marked "*Agrion* (*Lestes*) *hastata* Say MSS., stigma in the other sex distant from the edge of the anterior wings (Say's determ.), one specimen, Milton, meadows, June 20, 1821." This agrees very well with the male of *A. hastatum* (*anomalum* Rbr.), but the only specimen, No. 11, in the collection is a male of *A. putrida.*

No. 17 in the catalogue is marked *Agrion* (*Lestes*) *verticalis* Say MSS. (Say's determ.). See No. 41. The other specimens are: — Milton, low grounds, June 10, 1825, ♂ and var. ♀ ; also both ♂ and var. ♀, North Carolina; 17 and var., Maine, R., 1836; New York, Mr. Calverley, ♂ ♀. Now there are just eight specimens numbered 17, but the two from North Carolina are *Argia putrida* ; from New York are five stead of two, and none of them agreeing with the specimens from North Carolina, or with Say's description; from Massachusetts there is a pair, but also not agreeing.

The No. 41 of the catalogue, *A. verticalis* Say var. MSS., 55 (Say's determ.), Milton, meadows, June 20, 1827, is marked *lost* by Dr. Harris. I do not know Say's *Ag. verticalis*, but apparently Say confounded the sexes; his male is the female; his female is a male.

No. 46 bis. "*Agr. hastata ?* Say MSS., if the other sex has the stigma in the upper wings detached from the margin." (Say's determ.) This is not in the collection.

In the catalogue one hundred and four specimens are indicated in 61 numbers; there are now one hundred and ten specimens remaining, belonging to 57 numbers (41, 46 bis., 78, 139 lost) and to 48 species. Of the 110 specimens 46 are fragments, and of the others some are in bad condition. Mr. Say describes 41 species, and among them 20 from Massachusetts, sent to him from Dr. Harris. Of all of them, typical specimens agreeing with Say's description are in the collection, except *Lestes rectangularis.* Some of the types are apparently very rare species, and even now unique or nearly so. Besides this the types of the two species described by Dr. Harris are in the collection.

CORRODENTIA.

1. **Termes flavipes** Kollar. Hag. Syn., 3, 1.

No. 17. *Termes domesticus* Harr. Cat. On fences and in the house, Milton, May 25, 1825. Male imigo winged.

No. 57. *Termes.* Milton. Decayed wood and trees, October 1, 1822. Full-grown worker.

No. 61. *Termes agrarius* Harr. Cat. Cambridge, May 1, 1831. Under stones.

Two winged females, two soldiers and two young workers.

This species was fifty years ago introduced with plants into the imperial hot-houses at Schoenbrunn, near Vienna. No attention was given until suddenly the hot-houses were found dangerously injured, and the wooden flower-tubs tumbled in pieces. The hot-houses were rebuilt in iron, but the Termes still remains. This species was described by Kollar as *T. flavipes*; later by Haldeman as *T. frontale.* It seems to live every where in the United States east of the Rocky Mountains, from Cleveland, O., and Springfield, Ill., to Florida and Matamoras, Mexico. So far as I know the species has only been twice observed here as an obnoxious one; in the first case, described by Mr. S. H. Scudder, the grape vines in a hot-house near Salem, Mass., were destroyed by them. The second case was more serious; in Springfield, Ill., all the spare copies of the publications of the Legislature were stored up in a closed room in the State House, and remained unexamined several years, when one day all the copies were found destroyed in the most thorough manner by *Termes flavipes.* One of these books is in my possession, a precious gift of the late Benjamin D. Walsh. I think the public should know that these insects at certain unforseen times can grow to be a formidable enemy to the country for years, and may damage property to the extent of millions of dollars. The very similar species in the southwest of Europe, *Termes lucifugus*, known to live there long ago, became suddenly, in the years 1830 to 1850, exceedingly destructive, and all kinds of remedies were tried with little success. Now, although found there, they do not do much damage. Five years ago our species was scarce around Cambridge, but in June, 1871, suddenly they appeared everywhere in such numbers that the newspapers mentioned them several times. They are found everywhere in the Botanical Garden, in the old fences around the Observatory and near the Museum of Comparative Zoology. I also found them destroying the posts near the sluice on the milldam on Mystic Pond, near Winchester, and in many other places.[1]

If the insect should invade the libraries of the Institutions just mentioned the damage and loss would surely be enormous, and it would seem desirable that their superintendents should know that such animals, living so near their treasures, may suddenly become a terrible pest. I may remark that Harris' note to No. 18, that he finds them at Milton, in his house, is the first statement of the Termes entering houses here. In the Botanical Garden I saw them in swarms, in June, 1871, on the steps leading to the herbarium house, and near the Museum I discovered an old board twenty feet from the building, covered with them in all stages, so that I was able to make fine specimens for exhibition.

2. Psocus venosus Burm. Hag. Syn., 40, 5.

No. 15. *Psocus gregarius* Harr. Cat.; *P. phaleratus* Harr. MSS. Milton, Aug. 1, 1829.

There is in the collection one specimen in bad condition, and also a specimen from New Hampshire. Harris' description is given in his Corresp., p. 329. He also gives as a locality Cambridge, Sept. 7, 1837, and says they are gregarious and found on the trunks of trees, or on fences. This custom is common with many species of the genus, but so far as I know always with only one sex. The species has a very wide distribution throughout the United States, from Maine and northern Illinois southward even to Mexico and Cuba.

3. Psocus purus Walsh. Proc. Acad. Philad., 1862, 361.

No. 69. *Psocus* (described), Cambridge, Aug. 15, 1832, on side of house; on window in privy, Sept. 1; Oct. 20, 1836. *Ps. lucidus* Harr. Corr., p. 328.

There are in the collection eight specimens belonging here; one labelled u, only a fragment; two males, one marked ♂ on the label; one nympha with ? on a label. The others have no numbers; one is labelled, "♂, numerous on fences," and two, ♂ and ♀, Sept. 6, 1837; only fragments of wings remaining. The male has the number 129 with a ? (see below). There is also a paper with eggs and the fore wing, labelled, "♀ laying eggs, Sept. 6."

The specimens, though in very bad condition, are sufficient to

[1] A few days ago Mr. Clark, the well-known maker of astronomical instruments in Cambridge, assured me that this insect lives in his workshop near the furnace, but has never entered his house. He has observed several years the process of raising in the summer, and the biting off the wings by the imago.

prove their agreement with the type of Mr. Walsh in my collection, and with his descriptions. Perhaps it is not superfluous to state that *Psocus perplexus* Walsh is different from this species. The specimens correspond with Harris' description in the Corresp., p. 328, and the dates given are Sept. 20, 1836, and Sept. 6, 1837. Of the last Harris says, — "On fences, nidificating in cracks; young, and active pupæ all feeding on the wood together."

There are two small pieces of wood in the collection with eggs, one on the pin of the female taken Sept. 6, 1837, and the other, together with the fore wing of a ♀, labelled Sept. 6, and the note by Dr. Harris, "♀ laying eggs." These egg cases are very extraordinary; they are placed in a small cluster about one-sixth in. long by one-half in. broad, of perhaps thirty, generally four in a row, close together, like the cells of a honey-comb, and are composed of a gray excretion resembling very fine gray sand. Each case has the form of a somewhat compressed cylinder, the greatest diameter being one-sixtieth of an inch, the height being the same. The top of the cylinder has a little ledge inside to prevent the cover, which is united to the cylinder by a hinge, from falling in. Some of the cases contain a dark, metallic colored, iridescent shell, the others being empty. The whole arrangement is entirely different from any thing described or known to me in the case of European species of Psocus. It seems difficult to understand how the abdomen of the female can contain so many eggs, for these were apparently laid together; but the statement of so distinguished an observer as Dr. Harris, — "female laying eggs," I think must be accepted until it is proved that he was in error. Related species are known to lay a small number of eggs on leaves, which they cover with a kind of web; while Harris' eggs and cases appear to be hymenopterous or hemipterous, and, were it not for his statement, I should have believed that the Psocus was merely feeding on another's eggs. It is surprising that Harris does not mention the eggs in his description of the species. (Correspondence, loc. cit.).

4. **Psocus striatus** Walker. Hag. Syn., 11, 9.

No. 129. *Psocus frontalis* Harr. MSS. Cambridge, on fence north of Mr. Newell's garden, in the college grounds, Sept. 1 and 9, 1837.

There are seven specimens in the collection, two ♂, four ♀, and a variety, of which only a few fragments remain. The species, fully described in Harris' Corresp., p. 330, is certainly *striatus* Walker, but concerning the variety, which is not rare here, I have still some doubts whether it belongs really to the same species, as stated by Harris.

5. Psocus sparsus Hag. Syn., 8, 1.

No. 60. *Psocus infuscatus — nubilus*, lost ?, with the remark of Mr. Say, — "I have not studied this genus." June 1, 1830. On fence, Cambridge, Aug. 1, 1837, and in college yard, on fence, ♂ ♀ Sept. 8, 1837.

There are six specimens, mostly fragments, that labelled n, only legs, the females only wings. The specimen marked Aug. 1, 1837, has on the label "described the same day."

The types in my collection from Washington and Maine, all females, have darker colored wings, but I possess females colored like Harris' specimen, also from Maine and from Gorham, N. H. As Harris' specimens are in bad condition, and my material is not sufficient, I can only state now that his species is very near *Psocus sparsus*, and probably identical. The description in Corresp., p. 332, does not decide the question.

6. Psocus lugens Hag. Syn., 9, 2.

No. 130. *Nubilus*, *infuscatus* (later both words erased). ♂ and ♀ on fence of my house (Cambridge), swarming Aug. 1, 1837; also in Newell's garden, in college grounds, on fence, Sept. 9, 1837.

In this collection is a female fragment, and another fragment with same number and *Psoc. punctipennis* on the label. There is no doubt about the identity with my species from Washington.

7. Elipsocus signatus Hag. Syn., 9, 3.

No. 123. Cambridge, June 21, 1835.

This species is described in Harris' Corresp., p. 332, as *Ps. gracilis.* He adds justly, — "it may perhaps hereafter be proper to separate this from the other species under a new generic name; I have only seen two specimens." Of both these, fragments with wings are still in the collection, proving the identity with my specimen from New York.

8. Psocus quadrifasciatus Harr. Corresp., p. 331.

No. 128. *Psocus quadrifasciatus* Harr. MSS. Cambridge, on fence north of Mr. Newell's garden, in college grounds, Sept. 9, 1837, in great numbers.

A paper having contained ten specimens is present, but with only small fragments of wings. This species seems very similar to my *Psocus madidus*, Syn., 12, 12, from New York, described from a specimen in bad condition. Perhaps it is the same.

9. Psocus pusillus Harris' Corresp., p. 331.

There is no such species in the collection nor in the catalogue.

Harris' Catalogue includes fifteen numbers for the Corrodentia (represented by thirty-nine specimens), only one, No. 70, wanting, but most of the others are only fragments. The Psocus described by him and published in his Correspondence are all to be identified by the types, except *Psocus quadrifasciatus* and the missing *Psocus pusillus.*

PERLINA.

1. Pteronarcys Proteus Newm. Entom. Mag., vol. v., 177, 3. (Not Hagen.)

No. 118. *Perla generosa* Harr. (*Pteronarcys* Newm.). Maine, Randall, 1836.

There are in the collection two specimens, one, a half destroyed male with the end of the abdomen just in condition to prove the identity with Mr. Newman's type in the British Museum, the other only parts of the wings.

The species of the genus Pteronarcys, all but one belonging to the North American fauna, are somewhat difficult to recognize. As the authors describing them, viz., D. Newman, Burmeister, Pictet, Walker, Newport, and Gosse, had, in every case, but few specimens before them, and as the real specific characters are only given for a few species, and often for but one sex, it is easily understood that they cannot be rightly determined by succeeding students. When I made the synopsis of the North American species, I had before me types of Walker's species, given to me by the British Museum. But as some of them, as I found in a later visit to London, do not belong to Mr. Newman's species, as I supposed before, I was misled, and made some errors in the diagnosis of the species. Now the material before me is more extensive, at least for some species, and it will perhaps be convenient to give here a short notice of the species belonging to this interesting genus, especially as just the species represented in the Harris collection has been the starting point of most of the confusion.

Pteronarcys Newm.

I. Pteronarcys Proteus Newm., l. c.

The British Museum possesses the types described by Mr. Newman. There are two males (agreeing in the formation of the last ventral segments with Harris' specimen), and a female, all from Trenton Falls, N. Y., collected by Mr. Doubleday. The other specimens placed with them by Mr. Walker, andquoted in his catalogues, are, one male of *Pt. nobilis*, from Trenton Falls, a male from N. York, and one from the Mackenzie River, both not belonging to *Pt. Proteus*. I am indebted to Mr. R. M'Lachlan for a new examination of the types, also for many other details given in this notice. The male specimen given to me in 1857, was believed to be one of Mr. Newman's types of *Pt. Proteus*, but belongs to *Pt. regalis*. I possessed at the time a female from the Red River of the North agreeing well with the male, and described both in the Syn. 14, 1, as the true *Pt. Proteus*. The male is the smallest specimen of *Pt. regalis* I have ever seen, and as it was not spread, and was in very bad condition, I did not recognize the fact that it is undoubtedly the same species as the type of *Pt. regalis* I also received from the British Museum.

As I have now before me only fragments, and as *Pt. Proteus* does not exist in any American collection seen by me, I can only give a short notice. The two males in the British Museum measure, length 34 mm., expanse of wings 56 mm. The ♀ type is 52 mm. long, and the expanse of wings is 70 mm. Another male in Prof. Westwood's collection in Oxford, also typical, is smaller, the wings expanding only 52 mm. Harris' specimen is of the same size as the types in the British Museum. The diagnosis can only be imperfect, as the greater part of the abdomen, and other important parts, are wanting in the specimen before me.

Male dark fuscous above and below; head with a transverse furrow before the anterior ocellus, spots outside of the posterior ocelli yellow; basal border of the antennæ behind extended in a broad, short tooth; prothorax a little broader behind; anterior and lateral borders straight, with right, but not sharpened, angles; hind border a little arcuated, the yellow median line narrow; legs and setæ dark brown, the setæ a little paler at the base; wings smoky, veins dark with smoky clouds; abdomen with the ninth ventral segment with the disk sparsely punctured on each side with a hollowed scar; the tenth bifid, spoon-shaped, brown; penis ? wanting; the last dorsal segment seems to have a rounded, somewhat hairy middle spot, but the abdomen has been nearly destroyed.

I have no doubt that the specimen truly belongs to *Pt. Proteus*, although the knees are not yellow, as Mr. Newman says. The diagrams made by myself from the types in London, shown to be right by Mr. M'Lachlan's examination, agree well with the Harris specimen.

Female. The vulvar scale is small, entire and triangular, differing in this respect from all the other species. The two conical appendages described in my synopsis, belong to *Pt. regalis*. The *Pt. Proteus* of Pictet is a different species, and may be *Pt. Pictetii* Hag. I can not decide now whether Mr. Gosse's species described in the *Canadian Naturalist*, p. 232, belongs here.

Nympha, ♂, full-grown. Length 30 mm. (without setæ).

Antennæ blackish, middle third yellowish, and the apex also lighter colored; basal border of the antennæ produced into a conical lobe, viewed from above nearly equilateral triangular; prothorax half longer than broad, the anterior angles produced laterally into hollowed lobes, anteriorly, and at tip, somewhat rounded; sides very slightly arcuated, a little wider behind, hind angles without conspicuous lobes, slightly produced behind, as the hind border of the prothorax is slightly notched each side, and straight in the middle; lobes of the thorax large; in the mesothorax, the hind border of the lobes, oblique; segments 1 to 8 on each side, with a strong triangular apical hook, bent towards the tip of the abdomen, last segment pointed sharply, the point straight; setæ stout, short (10 mm.), dark, the apical half yellowish, but the tip again darker, blackish. The color of the body and legs is brownish gray, the claws yellowish, black at tip; palpi short, darker at tip; antepenultimate ventral segment with a short incision on the middle of the apical border.

Communicated by Dr. A. S. Packard, labelled "probably Siskiyou Co., Cal., J. Hallman." Another ♂ nympha from Vermont, C. J. Allen also from Dr. A. S. Packard, 26 mm. long, is in color, shape and details, almost identical. The only differences apparently arise from its not being full-grown, and are not important. The anterior angles of the prothorax are not so produced; straighter anteriorly, the sides straighter; the hooks on the segments shorter, and not so much bent backwards.

II. Pteronarcys californica. Newport, Hag. Syn., 16, 5.

Dark fuscous above, the forepart of the head rufous; abdomen and body beneath pale orange; antennæ and legs dark fuscous; setæ pale at the base; wings obscurely hyaline; veins blackish; maxillary palpus nearly as long as the head; antennæ inside at the base, with a small plate, ending behind in a sharp tooth; prothorax a little broader than the head, and a little broader behind than before, anterior border and sides nearly straight; hind border arcuated; the narrow, yellow middle line broader at the ends.

Male. The ninth ventral segment straight at the tip, not covering the tenth, on each side a scar before the tip; middle part horny, transversally striated; the tenth dorsal segment with two transverse knobs; penis long, the base bifid above, with a rectangular hook beneath, and a membranous lobe before the tip and above it.

Female. The eighth ventral segment convex, produced at the tip into two conical processes, straight inside, oblique outside, reaching half way over the ninth segment, separated by a rounded notch.

Length, inclusive of the wings, 35 – 45 mm. Exp. of the wings 65 – 85 mm. I have seen 12 specimens, 10 ♂ and 2 ♀, from Ogden, Utah, caught in June, and from a river tributary to the Great Salt Lake, all preserved in alcohol, also a female from Lake Winnipeg, collected by R. Kennicot.

I have some nymphæ from the Ogden River, Utah, probably belonging to this species; taken Sept. 15th. Length 31 mm.; brown, tibiæ yellowish, with darker knees; antennæ inside of the base, with a small plate, ending behind in a strong tooth; prothorax a little broader behind, the four angles each produced into a sharp tooth; hind border of the mesothorax and metathorax nearly in a straight line with the wing covers. Last dorsal segment produced in a long, straight, conical process. (Male.)

Another nympha from Washington Territory, between Rock and Cascade Mountains, is nearly 40 mm. long, and seems to be nearly full-grown. The wing covers of the mesothorax are more curved behind; the last dorsal segment has a similar, but shorter, process, bent up a little; the eighth ventral segment shows the beginning of the vulvar lobes; the tibiæ are darker. (Female.)

I sent a pair to Mr. M'Lachlan, and he writes that the type in the British Museum resembles those from Ogden in its wings, but belong to *P. californica.* Some specimens from California in his collection, also belonging to the same species, have the wings very smoky and almost opaque.

After a new examination of the description of *Pt. biloba* Newm., from Trenton Falls, N. Y., and the diagrams of the type made by me in London, after the type, I believed this species to be identical with *Pt. californica*; at least I could not find any specific differences. The bifid vulvar lobes agree well with my diagram, but of course not exactly alike, as the Ogden specimens are preserved in alcohol, and the type is dry; but I observed that those parts are somewhat changed in shape by drying, in a female of *Pt. californica* from Mr. M'Lachlan's collection sent over for examination. Nevertheless, as Mr. M'Lachlan insists that *Pt. biloba* is a different species, we must wait for a more detailed description. I have never seen in any collection, here or abroad, any specimen, except the type of the former from Trenton Falls, of *P. biloba* or *P. californica*, from the United States east of Utah.

III. Pteronarcys nobilis Hag. Syn., 15, 4.

Dark fuscous above; the spots outside the posterior ocelli black, shining; basal border of the antennæ very narrow, a little broader in the middle; prothorax a little broader than the head, sides straight, front and hind border a little arcuated; the angles sharpened; the yellow median line broader at the ends; antennæ and legs dark brown, knees yellowish; body below orange in the middle; setæ dark, a little paler at the base; wings smoky, veins dark, with clouds.

Male. The ninth ventral segment black, shining, inflated and elongated toward the setæ, the tip notched; last dorsal segment with two black, horizontally placed appendages, somewhat thicker at the rounded tip; penis as in *P. regalis*, but I cannot see it from above.

Female. The eighth ventral segment straight at tip, perhaps a very little produced in the middle third; there are no appendages (as I described with a ? in my Synopsis), but the parts are not in good condition.

Length, with the wings, 31 – 34 mm.; expanse of wings 55 – 66 mm. I possess a pair from New York, formerly in Winthem's collection, and I examined a male from Trenton Falls, N. Y., in the British Museum.

A male from Knoxville, Tenn., in my collection, belongs, perhaps, to a different species; but having seen only this one specimen, its abdomen also not in good condition, I should not like to decide this question. It differs in being of much darker color, especially the wings, which are smoky black, except the apical third of the hind wings, which is dark gray. The orange patch on the under side of the abdomen is much smaller, and is only indicated on the thorax; the knees are dark; the prothorax is smaller in front, the sides more oblique, the hind border more arcuated, the angles more sharpened. The anal parts seem to be similar, so far as can be observed. The size is larger. Expansion of the wings 66 mm.

IV. Pteronarcys Pictetii Hagen.

P. Proteus Pictet, Perl., 128, 1, pl. xxix, f. 1 – 6.

Male in bad condition, having been before in alcohol.

Dark fuscous, spots outside the posterior ocelli dark brown, basal border of the antennæ narrow, with an obtuse process in the middle; prothorax as broad as the head, sides straight, hind border a little arcuated, angles sharp; yellow median line faintly marked; legs pale brownish; abdomen dark fuscous, above, in the middle, and below orange; wings somewhat clouded around the veins, but their color is altered by alcohol; setæ brown, paler at the base; the ninth ventral segment similar to that in *P. nobilis*, covering the tenth segment, but smaller and pale brown; the upper appendages with the tip bent upward; penis as in *P. nobilis*.

Female. Similar to the male; wings dirty hyaline, a little smoky around some veins, with a small brown pterostigma; the eighth ventral segment produced in the middle, with a quadrangular notch at the tip, forming two triangular teeth.

Length, with the wings, 45 – 48 mm; expanse of wings 80 – 84 mm. The female is from Pennsylvania, the male was labelled Meadville, in the north of Pennsylvania, but this locality is not certain, as some of the lot, to which the insect belonged, proved later to be from Texas. I am indebted for the male to Mr. B. P. Mann.

The female was described in my Synopsis as *Pt. regalis* and the locality given, Philadelphia, belongs only to the specimen. I believe to this species belongs a female in alcohol from Minnesota, mentioned in my Synopsis as probably *Pt. biloba.* The vulvar notch is narrower, and its angle not so sharp.

I believe this species is Pictet's *Pt. Proteus;* the locality and the size are just the same, and his figure of the male appendages seems to agree very well, when viewed from above. I have not seen his type, but the darker apical part of the wings would apply better to the Tennessee specimen, which is the only Pteronarcys I have seen with the apical part of the hind wings so much darker.

V. Peteronacys regalis Newman. Entom. Mag., vol. v., 176, 1.

Dark fuscous, with a grayish tinge above; spots outside the posterior ocelli pale brown; basal border of the antemæ broadest in the middle, making a blunt rounded angle; prothorax broader than the head; sides straight, hind border arcuated, angles sharply produced; yellow median line broader at the ends; antennæ and legs dark brown; setæ brown, paler at the base; wings grayish hyaline, veins blackish, more or less darkly clouded, principally in the forewings around the pterostigma and the basal border; abdomen brown, beneath, in the middle more or less yellowish or orange.

- Male. The ninth ventral segment inflated, pale brown, shining, covering the tenth, notched at the tip deeply; upper appendages horizontal, short, triangular, somewhat depressed before the rounded tip: penis as in *Pt. nobilis.*

Female. The eighth ventral segment cut straight at tip, sometimes with a fine median longitudinal furrow or impressed line; two small triangular processes, widely distant from each other at the tip of the segment, which are yellowish or dark, and membranous; last dorsal segment with a round darker spot near the base.

Length, with the wings, 40–60 mm.; exp. of the wings 75 to 106 mm. I have before me seventeen specimens from the Saskatshawan River; both sexes from the Red River of the North by R. Kennicott; from Ware, Hampshire county, Mass., both sexes, among them the largest female seen (length 60 mm., expanse 106 mm.); from Maine a male; from Michipicoten Isl., Lake Superior, a female collected by Mr. Barnston, together with a nympha; a nympha skin from Massachusetts; a male, the type, from Martin's Falls, Hudson's Bay; and the male, spoken of under *Pt. Proteus*, from New York, both from the British Museum; I also examined a number of other specimens in the British Museum. Of the eight specimens mentioned by Walker, five are females, the others males, one given to me.

The nympha is forty mm. long; grayish brown; spots outside of the posterior ocelli, and the basal border of the antennæ as in the imago; the angles of the prothorax more produced; setæ yellowish; last dorsal segment prolonged into a sharp point; the eighth ventral segment with a small incision in the middle of the apical border, an indication of the female organs. A smaller nympha from the Sandhill River, Minnesota, length 25 mm., has the tip of the last segment slightly bent upward.

There is no doubt that this species is really *P. regalis*, Newm., as I was able to compare my specimens with the types in the British Museum, besides they agree well with the description. Farther I have no doubt that *Kollaria insignis* Pictet, Hag. Syn., 16, 6, is the same species. I have not seen his type (in the Vienna Museum), but the figure and the description agree in every respect. The maxillæ and their palpi are somewhat longer in this species than in the others, but are, I believe, not so different as to justify the formation of a new genus. If such a separation should be made, the different form of the genital parts of the male and female would give, perhaps, more suitable characters. I may add, that Mr. R. M'Lachlan had the same opinion concerning the identity of *K. insignis* and *Pt. regalis*.

VI. Peteronarcys reticulata Burm.

This species is the only one now known which does not belong to the American fauna; it is found in eastern Siberia, Barnaul, Nertschinsk, Irkutzk, and according to Burmeister also in Hungaria. Mr. M'Lachlan has lately given, Ann. Soc. Ent. Belgique, Vol. XV. p. 51, a full description and figures of the sexual organs. The species, by the shape of the genital parts of the male, is related to *P. regalis*, by those of the female, to *P. californica*.

The following species of the Perlina contained in the collection are so much injured, that a determination is nearly impossible. Of most of them only wings remain, often only parts even of them, and all the important parts for determination are wanting. Some of them are undescribed species, and are new to me; but I should be unwilling to describe new species from such fragments.

2. Perla abnormis Newm. Hag. Syn., 17, 1.

No. 24. *Perla immarginata* Say. ? Milton, Aug. 1821; June 15, 1828; Randall, Maine; pupa ?

There are, besides the nympha skin, four specimens, and one surely does not belong here. One specimen (♀) has only wings preserved, the others have fragments of the body; but it seems probable that all three belong to *P. abnormis*. The description of *P. immarginata* does not agree with the specimens, but Say's species is still unknown to me.

The nympha skin seems too small for this species, and differs from the skins in my collection. Another nympha skin, Conway, New Hampshire, Aug. 10, 1850, belongs perhaps to this species.

3. Perla isogona Say. MSS. (Say's determ.).

No. 66. Sutton, Mass. Dr. Smith.

Only wings of a large species (forewing 25 mm. long) related to *P. lycorias* of my Synopsis. I know no other specimen.

4. Perla spec. nov.

No. 67. Sutton, Mass. Dr. Smith.

A female, thorax and head wanting. The wings have a faint yellow tinge, the median vein and its branches dark brown; legs yellow, femur and tibia outside and inside brown ; setæ stout, black ; abdomen brown, apical border of the segments yellow; the apex beneath brighter yellow, the antepenultimate ventral segment prolonged in the middle into a lobe, reaching nearly the tip of the following segment; the lobe beneath with a somewhat deeply impressed median furrow; forewing twenty mm. in length. I know no other specimen. This species is very near to *P. flavescens* Walsh, but a little larger, and the lobe in *P. flavescens* female is described as semicircular, and to cover one half of the next segment. I have only one female of *P. flavescens* before me, agreeing with Walsh's description. The specimen in Harris' collection is nearly related to *P. flavescens.*

5. **Perla fulvovittata** Say. MSS. (Say's determ.).

No. 62. Pennsylvania, Mr. Nuttall; another specimen from Maine, 1831, Randall, is wanting. Only fragments of two wings are preserved. The species is related to *P. varians* Walsh, perhaps identical.

6. **Perla semifasciata** ? Say ♂ uncertain. (Say's determ.)

No. 30. Milton, palings, Aug. 1, 1821.

Only fragments of the wings belonging to a smaller species of Perla ; perhaps the specimen stated as different and numbered 24, belongs here.

7. **Chloroperla brunneipennis** ? Walsh.

No. 30. ? North Carolina, June.

There are fragments of a female belonging, perhaps, to this species.

8. **Perla vitticollis** Harris.

No. 119. Maine, Randall, 1836.

A fragment of male and a female ; the species is related to *P. decipiens*, Walsh.

9. **Chloroperla bilineata** Say.

No. 120. *Sialis bilineata* Say, Maine, 1836, Randall.

Only fragments of wings ; perhaps belonging to Say's species.

10. **Isopteryx Cydippe** Newm. Hag. Syn., 30, 1.

No. 120. One specimen from Maine, Randall, 1836 ; another from New Hampshire, Leonard, in bad condition, probably belong to this species.

There is a later addition with a red label, No. 113, not marked in the catalogue, a small immature species of Perla.

11. **Taeniopteryx maura** Pict. Hag. Syn., 35, 4.

No. 31. *Nemoura convoluta* Say MSS., (Say's determ.) *Taeniop-*

teryx maura Pict. (Harris determ.) Milton, palings, in the day time, May, 1821; March 15, 1822; Cambridge, March 1, 1835; April 9, 1835; March 30, 1855; Maine, Randall; Alabama, Feb., Hentz.

There are three fragments in the collection, one from Maine, the others probably Cambridge. One specimen has thorax and head; probably all belong to *T. maura*.

12. Nemoura perfecta? Walker.

No. 23. *Nemoura debilipennis* Say MSS., (Say's determ.). Dublin, N. H. Mr. Leonard.

This specimen is marked *lost* by Harris, but another from Maine, Randall, 1836, is added with the remark: "I refer this species to this number doubtfully." A small Nemoura, in tolerable condition, perhaps Walker's species.

Harris' catalogue includes for Perlina ten numbers, belonging to twelve species, none of them to be considered as types of a described species. The twenty-three specimens are only fragments.

EPHEMERINA.

1. Ephemera decora Walk. Hag. Syn., 28, 1.

No. 82. *Ephemera* (*Baetis*) *maculipennis* Harr. ♀ imago.

No. 84. *Ephemera maculata* Harr. ♂ subimago; both from Maine. Randall, 1836.

2. Ephemera natata Walk. Hag. Syn., 39, 4.

No. 82. *Eph. maculipennis* Harr. ♂ subimago.

No. 83. *Eph.* (*Baetis*) *maculatus* Harr. ♀ subimago; both from Maine, Randall, 1846.

The two species are united in the monograph by Mr. Eaton, with *E. simulans* Walk. and *E. guttulata* Pict. Not having now the opportunity to examine again the types, I can say nothing, besides my notes made in the British Museum. The types of *Eph. Hebes* were wanting even in 1857 in the collection. The type of *E. decora*, a male, I believed to be identical with my *E. decora* from New Haven, Conn., but it measured twenty-eight mm. in the expansion of the wings, and my type only twenty-six mm. The type of *E. similans* is a male subimago, (as I presumed in my visit in London, 1861, and not a female as I stated in my Synopsis). The type of *Pal. notata*, a female subimago, I believed identical with my specimen from Chicago. Neither Mr. Eaton nor I examined Pictet's type, a fragment without abdomen, locality unknown. If, as Mr. Eaton stated, *E. decora*, *similans* and *natata* are the same species, and I confess to have doubts still about *E. decora*, he has apparently not seen the species described by Walsh and myself as *E. decora*. I may add, that I possess a third North American species from New York very similar to *E. Danica* Müller.

3. Hexagenia limbata Guér. Hag. Syn., 14, 5.

No. 87. *Ephemera* (*Baetis?*) *costalis* Harr., Randall, Maine, 1836.

Male imago and the nympha skin. Harris refers here his No. 62, probably erroneously for No. 63, because No. 62 is his *Perla fulvovittata*. Of his No. 63, *Ephemera* (*Baetis*) *irregularis* Say MSS., (Say's determ.), from Dublin, N. H., Mr. Leonard, almost nothing is left on the pin, except a part of the mesothorax, similar to *H. limbata*.

No. 32. u. *Ephemera* (*Baetis*) *fuscicostata* Say MSS. (Say's determ.), Milton, 1821. Part of the thorax and the basal border of the anterior wing, agreeing with *H. limbata*.

No. 37. u. *Ephem.* (*Baetis*) *confusa* Say, MSS. (Say's determ.), Milton. Marked lost by Harris; a fragment only on the pin; perhaps the same species.

4. Hexagenia spec.

No. 33. *Ephemera* (*Baetis*) *Eurinus* Say MSS. (Say's determ.) Milton, June 15, 1821, u, female.

Perhaps this is a female of *Hexagenia bilineata* Hag. Syn., 41, 4, but I have never seen a similar one; the wings are more yellowish, the femora of the forelegs have a black spot outside at the tip. Long. 20 mm. ; exp. of the wings 52 mm.

5. Baetis spec.

No. 34. *Ephemera* (*Baetis*) *ammœnicauda* Say MSS. (Say's determ.). Milton, June, 1871 ; a female, abdomen and hind legs wanting.

I know no specimen except this fragment; expanse of the wings 34 mm.; *Baetis femorata* Walsh, has a similar coloration of the wings, but is surely different by the reticulation, as in *B. ammœnicauda* the costal space of the forewings has a single row of quadrangular cells. The reticulation of the hind wings agrees with *Siphlurus* Eaton.

6. Baetis spec.

No. 83. Alabama, Febr., Hentz.

The only specimen, a male subimago, was placed as var. ? of *B. reticulata* (*E. decora.*) The species I cannot determine from the imperfect specimen.

7. Baetis spec.

No. 65. *Ephem.* (*Baetis*) *luteipennis* Say MSS. (Say's determ.). Sutton, Mass. Dr. Smith, marked lost by Harris.

A fragment of a female belonging to a small species on the pin.

8. Potamanthus nebulosus Walk. Hag. Syn., 52, 3.

No. 86. *Ephemera* (*Baetis*) *terminalis* Harr. Maine, Randall, 1836.

No. 35. *Ephemera* (*proper*) *bispinosa* Say MSS. (Say's determ.). Milton, June, 1821 ; April 15, 1825; Maine, Randall, 1836.

A male subimago from Milton. This species is synonymous with *P. odonatus* Walsh, and I should have believed it to be *Eph. cupida* Say, if Say himself had not otherwise determined the species.

9. Ephemerella spec. ?

No. 35. Maine.

A male subimago in tolerable condition, belonging to a small species; perhaps it is the subimago of *E. excrucians* Walsh.

10. Heptagenia maculipennis Walsh.

No. 85. *Ephemera tenella.* Maine, Randall, 1836.

A male imago, probably belonging to this species.

11. Cloe undata Pict. Hag. Syn., 53, 2.

No. 64. *Ephem.* (*Cloeon?*) *B. deripticostata* Say MSS. (Say's determ.). Dublin, N. Hampshire, Mr. Leonard; Cambridge, July, 1835.

Two female imagines. *C. fluctuans* Walsh, is the same species, and his *C. ferruginea* is perhaps the male.

12. Cloe spec. ?

No. 40. *Baetis leuconeura* Say MSS. (Say's determ.). Milton, May 1, 1826.

There is a fragmentary subimago with the basal part of the wings strongly colored in the costal space and beneath. It seems rather too large for the unknown subimago of the foregoing species. There is also the nympha of a Baetis in the collection.

There are in Harris' Catalogue sixteen numbers belonging to this family, referring to ten, perhaps twelve species, now represented by twenty-two specimens. Most of them are fragments, of five nearly nothing but a little bit of the thorax remain. There are no specimens of typical value among them. The Ephemerina, always a most difficult family for preservation, is nearly the worst preserved group in Harris' collection.

PHRYGANINA.

1. **Phryganea cinerea** Walk. Hag. Syn., 252, 1.

No. 95. *Phryganea humeralis* Harris. ("uncertain," note by Mr. Say). Dr. Pickering, Salem; and Maine, Randall, 1836.

There are two specimens, of course that marked u was the first, and perhaps Dr. Harris' name refers to this specimen (see below *Phr. interrupta*). The specimen from Maine, only wings, is a male of *Phr. cinerea.*

2. **Phryganea interrupta** Say.

Limnophilus interruptus Hag. Syn., 256, 7.

No. 95, the specimen from Salem, Pickering; a male, only wings and some fragments of legs. I had not before seen this species, but two females in the Cambridge collection agreeing with Mr. Say's description and figure, show that his species belongs to the genus Phryganea. I have seen no male, but I believe the fragment in the Harris collection, from the neuration of the wings, and the largely dark colored hind-wings, belongs here.

3. **Phryganea vestita** Walk. Hag. Syn., 263, 2.

No. 122. Cambridge, June 15, 1834, New York, Mr Calverley.

Four specimens in bad condition, two ♂, and two ♀. *Ph. commixta* Walk., is the male of this species.

4. **Phryganea improba.** Hag.

No. 133. *Phryganea.* Catskill Mts. N. York, June 15, 1843, Mr. H. Gray.

A female, only fragments, but agreeing with the specimens in my collection. Perhaps it is a more northern species; my specimens are all from the Saskatshawan River and Hudson's Bay, by R. Kennicott.

5. **Neuronia pardalis** Walk. Hag. Syn., 2502, Harris Corresp,, p. 333.

No. 125. *Phryganea.* N. Hampshire, Mr. Leonard.

♂ ♀ in bad condition. This beautiful species is rare ; at least I have only seen the types in the British Museum, a pair in Mr. Atwood's, and the pair in Harris' collections, and a female from the White Mts., N. H., in the Cambridge collection. The genital parts in Harris' specimens are fortunately well preserved.

6. **Neuronia dossuaria** Say.

Limnophilus dossuarius Hag. Syn., 255, 6.

No. 102. *Phryganea plurifaria* Say MSS. (Say's determ.). Dublin, N. H., Mr. Leonard.

In the catalogue, the number 102 is marked u, but in the collection none of the three specimens has the u on the label, as is usual in the collection of Dr. Harris. Perhaps this specimen was lost. The three specimens preserved are only wings, labelled ♂ ♂ ♀. I believe, from Say's description, that this is his *Ph. dossuaria*, a species never seen before by me, and related to, but different from, *N. concatenata* Walker. I possess some specimens from Massachusetts, with the wings even less spotted than the N. H. specimens. Say's specimen was also from Massachusetts. If the specimens in Dr. Harris' collection do not form a third species, and I believe not, although it is not possible to decide certainly by fragments, Say must have mistaken his own species.

7. Neuronia stygipes Say.

No. 103. *Phryg. stygipes* Say MSS. (Say's determ.). Dublin, N. H., Mr. Leonard.

This is a new and interesting species, resembling in coloration *N. clathrata* of Europe. I possess specimens from Maine and New England. Perhaps *N. ocelligera* Walk. is a synonym.

8. Neuronia ocellifera Walk. Hag. Syn., 252, 7.

No. 88. *Phryg. semifasciata?* Say, Milton, June 1, 1826; May 15–30, 1827. A male agreeing with my specimen.

9. Neuronia postica Walk. Hag. Syn., 257, 6.

No. 88. Same locality as before, a male in tolerable condition, and four other specimens mostly but wings and legs.

10. Neuronia semifasciata Say. Hag. Syn., 250, 5.

No. 89. *Phryg. semifasciata var.* Say (Say's determ.). Milton, June 5, 1823; May 15, 1827. ♂ ♀ only wings.

The three last mentioned species are surely different, but a new study of them with a good fresh material, is necessary.

11. Limnophilus argenteornatus Say.

No. 92. *Phryganea argenteornata* Say MSS. (Say's determ.). May 15, 1825. Sutton, Mass., Dr. Smith.

There are two specimens, a female labelled N. H., and a fragment. To the latter different legs are glued on the same label (with 1, 3 and 3 spurs), though the other identical in wings has the normal number 1, 3 and 4, spurs. Perhaps the legs belong to the specimens of Hallesus, placed in the collection just before No. 92. The species, which I possess from N. England, is a Limnophilus, related to *L. elegans* Curtis. If Mr. M'Lachlan had not stated that the type of *L. indicans* has 1, 3 and 3 spurs, I should believe it to be this species.

12. Limnophilus subguttatus Walk. Hag. Syn., 261, 23.

No. 93. *Phryg. intaminata* Say MSS. (Say's determ.). May 15, 1827; New York, Mr. Calverley.

A female without abdomen. I believe the species identical with *L. indivisus* Walk., and very nearly related to *G. fulvus* Rbr.

13. Limnophilus pudicus Hag. Syn., 262, 26.

No. 97. *Phryg. elongatulus* Say MSS. (Say's determ.). Cambridge, May 25, 1849.

No. 98. *Phryg. sericea* Say var. (Say's determ.). May 1, 1826; May 25–30, 1827; New York. Mr. Calverley.

There are of No. 97 four fragments, mostly wings, one labelled N. H. Of No. 98 only a ♂ from N. H. Say believes the last one to be a variety of his *Ph. sericea*, a still unknown species. At least, *P. sericea* must be very nearly related. Harris added to No. 98, "probably *Phr. dossuaria*, Say," apparently an error. The specimens No. 100, u, *Phrgg. dislocata* Say MSS. (Say's determ.), from Dublin, N. H., Mr. Leonard; and No. 105, u *Phryg. debilipes* Say MSS. (Say's determ.), same locality; are marked lost by Dr. Harris.

A specimen without any label, apparently a late addition, is a male of a small species related to *G. pudicus*, perhaps new.

14. Limnophilus plaga Walk. Hag. Syn., 263, 28.

Of No. 97? are fragments of the wings (one hind wing not belonging to this species) from N. H. The identification is not entirely sure, but very probable.

15. Hallesus hostis Hag. Syn., 266, 3.

No. 91. *Phryg. subfasciata*? Say. *P. radiata* Say (Say's determ.), and a note in pencil, "probably *S. interrupta* Say." June 1, 1829; Cambridge, June 14, 1849; July, 1849; one later addition, N. Conway, N. H., Aug. 10, 1853.

Seven specimens, six only wings.

16. Hallesus guttifer Walk. Hag., Syn. 266, 4.

No. 90. *Phryg. subfasciata* var., Say (Say's determ.). N. H., Mr. Leonard.

17. Hallesus Argus Harris Corresp., p. 333.

No. 107. *Phryganea Argus* Harr. Maine, Randall, 1836.

A female in very bad condition. This species is apparently rare; I possess a female from Massachusetts, from Baron Osten Sacken, and saw a third specimen in the collection of the Entomological Society in Philadelphia. It is one of the most beautiful American species.

18. Hallesus vittatus Harris.

No. 108. ♀ *Phryg. vittata* Harr. Maine, Randall, 1836.

I suppose this species identical with *Hall. amicus* Hag. Syn., 265, 2; only the colors faded; but I am not entirely sure of it.

19. Platyphylax subfasciatus Say.

Enoicyla subfasciata Hag. Syn., 269, 5.

No. 93. N. York, Mr. Calverley.

The specimen is a later addition to *L. subguttatus* (*Phryg. intaminata* Say), and, as I believe, Say's species. The spots on the wings are not well developed.

20. Platyphylax coagulata Say.

No. 94. *Phryg. coagulata* Say MSS. (Say's determ.) Dec., 1828; Dublin, N. H., Mr. Leonard.

Three fragments, one from N. H.; this species is one of the latest in the season. It appears in Cambridge, in November. Perhaps *E. difficilis* Walk., Hag. Syn., 268, 5, is a synonym.

21. Platyphylax irroratus Fabr.

En. intercisa Hag. Syn., 268, 2.

No. 101. *Phryganea obsoleta* Say MSS. (Say's determ.). Two fragments from Dublin, N. H., Mr. Leonard, and from Maine by Randall. Mr. M'Lachlan states that this species is the type of *Phr. irrorata* Fabr.

22. Goniotaulius spec.?

No. 106. *Phryganea quadrula* Say MSS. (Say's determ.). Dublin, N. H., Mr. Leonard. Only a fragment, two fore wings, and a leg with three spurs, probably the intermediate leg. A small species. Expanse of wings 23 mm.; the wings white, hyaline, apical border brown, but the color divided; a quadrangular blackish spot on the thyridium. I do not remember to have seen a similar specimen; the neuration is as in *Goniotaulius*.

23. Neophylax concinnus Say.

No. 104. *Phryganea undatula* Say MSS. (Say's determ.). Dublin, N. H., Mr. Leonard. Fragment of a male, two wings and the abdomen. I possess of this beautiful small species a female from Andover, easily to be identified by the striking coloration of the wing. The antepenultimate ventral segment of the male has a basal spine as long as the segment.

24. Apatania nigra Walk. Hag. Syn., 270, 1.

No. 109. ♂ ♀ *Phryganea modesta* Harr. Maine, Randall, 1836.

The species is well defined by the sabre-shaped appendages of the male.

25. Mormonia spec.

No. 110. *Phryganea* (*Sericostoma?*) *hispida* Harr. Maine, Randall, 1839.

Only fragments of a wing. The species is very nearly allied to *M. togata* Hag., 273, 1, but the fragments are not sufficient for determination. Perhaps they belong to a male, and my specimens are a little larger and females.

26. Hydropsyche morosa? Hag. Syn., 271, 2.

No. 96. *Leptocerus nubilus* Say MSS. var. (Say's determ.). May 15, 1825, and 1827. N. J., Mr. Calverley.

Fragments of all three specimens, but not in a condition for a sure determination.

27. Polycentropus cinereus? Hag. Syn., 293, 6.

No. 99. *Leptocerus alternicornis* Say MSS. (Say's determ.). Milton, June 1, 1826; May 25–30, 1827.

There is a male in bad condition, probably belonging to this species. An addition with ? from Maine wings of a *Hydropsyche*, and a specimen without label, perhaps belonging to *P. cinereus*.

28. Polycentropus? spec.

No. 134. *Phryganea*. Cambridge, June 19, 1843.

Fragments of wings, belonging probably to this genus.

29. Chimarrha aterrima. Hag. Syn., 297, 1.

A specimen with a red label, No. 135, not mentioned in the Catalogue.

30. Macronema zebratum. Hag. Syn., 285, 5.

No. 113. *Leptocerus variegatus* Harr. Cat. 1.—*hieroglyphicus*. Say MSS. *variegatus* preoccupied. (Say's determ.) Dublin, N. H., Mr. Leonard. Three specimens in bad condition.

31. Setodes exquisita Walk. Hag. Syn., 280, 1.

No. 116. *Leptocerus maculicornis* Harr. June 1, 1829, and Maine, Randall. Two fragments and the antenna of the third one.

32. Setodes ignita? Hag. Syn., 281, 5.

No. 115. *Leptocerus*; July 10, 1823; May 1, 1828; June 1, 1829; Aug., 1834. A fragment and a specimen probably belonging here.

33. Setodes micans Hag. Syn., 283, 13.

No. 114. *Leptocerus*. June 10, 1831; Aug. 15, 1835.

Two fragments probably belonging here.

34. Leptocerus? spec.

No. 112. *Leptocerus tarsatus* Say MSS. (Say's determ.). Sutton, Mass., Dr. Smith.

Only fragments of wings, probably belonging to this genus.

35. Leptocerus niger L. Hag. Syn., 277, 4.

No. 147. *Phryganea* (*Mystacide*). Cambridge, on alder leaves near water.

Only fragments of wings.

36. Molanna cinera? Hag. Syn., 276, 2.

No. 111. *Psychomyia? convoluta* Harr. Maine, Randall, 1836.

Fragments of the wings from two specimens, probably belonging to my specimens.

There are cases of five different species of Phryganid larvæ in the collection belonging to Heteropalpoidea, one to Hallesus, another probably to Limnophilidae. One case labelled Europe belongs probably to *Stathmophorus fuscus*. There are 34 numbers for this family in the Catalogue, representing 36 species with 78 specimens. Nearly all are fragments, only few in better, although very poor, condition There are besides the two types of Harris' descriptions some very remarkable species in the collection. Of Say's types, so far as I see now, they are very few, perhaps only of a negative value, indicating, that is, that some species do *not* belong to those described by Say. This family has been badly injured since 1867, when I first saw the collection.

SIALINA.

1. Corydalis cornuta Latr. Hag. Syn., 192, 1.

No. 25. *Corydalis cornutus* L. House in eve. July, 1822, ♂ ♀ ♀ from Capt. Mellus, July 7, 1822; ♂ from Miss M. A. Crehore; July 20, 1827.

Fragments of a ♂ and ♀.

2. Chauliodes pectinicornis L. Hag. Syn., 189, 1.

No. 27. *Chauliodes pectinicornis* L. May 25, 1827; July, Aug., 1821; June 10, 1827; September 20, 1829. N. Carolina, June, N. York, Mr. Calverley.

Fragments of the wings of four specimens, among them those from N. C. and N. Y.

3. Chauliodes rastricornis Rbr. Hag. Syn., 189, 2.

No. 36. *Chauliodes denticornis* Harr. Cat.; with note by Say, "Can this be the ♀ of *pectinicornis*? L." Milton, on fences, June 1, 1822.

Some fragments of the wings and the broken head.

4. Chauliodes serricornis Say.

Ch. maculatus Hag. Syn., 191, 6.

No. 38. *Chauliodes serricornis* Say. On fences near water, May 25, 1826; June 12–15, 1824.

In my synopsis I changed *C. serricornis* for another species, probably erroneously; three fragments in the collection.

5. Sialis infumata Newm. Hag. Syn., 188, 1.

No. 39. *Sialis Maurus* Say MSS. (Say's determ.). On surface of stagnant water, May 1, 1826.

There are four fragments in the collection, one from Maine.

The family of Sialina has five numbers in the catalogue, representing five species with fourteen specimens, all nearly entirely destroyed.

HEMEROBINA.

1. Dendroleon obsoletum Say. Hag. Syn., 225, 2.

No. 124. *Myrmeleon* N. H., Mr. Leonard; N. York, Mr. Calverley.

The specimen from N. York in good condition, the other a fragment.

2. Myrmeleon abdominalis? Say. Hag. Syn., 226, 3.

No. 145. N. York, Mr. Calverley.

Probably belonging here.

3. Myrmeleon tectus? Walk. Hag. Syn., 232, 15.

No. 144. *Myrm. roscipennis?* Burm. E. Florida, Mr. Doubleday.

Walker's type is also from Florida, by Mr. Doubleday, and the identity very probable.

4. Polystoechotes punctatus F. Hag. Syn., 206, 1.

No. 26. *Hemerobius irroratus* Say. Houses, July, 1825, from Miss Crehore.

Three specimens, one from N. H.; it is very remarkable that this species is found from the Atlantic to the Pacific, and from Canada to the Gulf of Mexico, everywhere not uncommon.

5. Chrysopa spec.

No. 28. *Chrysopa perla?* L. 1820; July 1, 1821.

Only a fragment, perhaps *C. nigricornis*, and two cocoons of a species without number; one cocoon is the largest I have ever seen, nearly 5 mm. in diameter.

6. Hemerobius tutatrix A. Fitch. Hag. Syn., 202, 8.

No. 29. *Hemerobius mononeurus* Say MSS. (Say's determ.). May 1, 1823, on windows.

Two fragments, only wings, probably belonging here.

7. Mantispa brunnea Say. Hag., 207, 1.

No. 143. *Mantispa brunnea* Say. East Florida, Mr. Doubleday.

Two fragments. I described in the Synopsis, p. 208, two broad yellowish lobes on the tarsi of the intermediate legs, but I find that these lobes are nothing else than the pollinia of an Orchidaceous plant, perhaps a Plantantaria. I possess now two Lepidoptera with similar lobes.

There are for the Hemerobina eight numbers in the catalogue, representing seven species, with fourteen specimens, mostly eaten. There are no typical specimens.

PANORPINA.

1. Panorpa lugubris Swed. Hag. Syn., 241, 1.

No. 59. *Panorpa scorpio* F. N. Carolina, Nov., Prof. Hentz.

Three specimens, ♂ ♀.

2. Panorpa debilis Westw. Hag. Syn., 243, 6.

No. 58. N. Hampshire, Dublin, Mr. Leonard.

Two specimens, fragments, probably this species.

3. Panorpa rufescens Rbr. Hag. Syn., 241, 2.

No. 58. *Panorpa fasciata* F.; *confusa* Westw. Aug. 10, on gooseberry bushes, Milton, 1832; and var. Maine, Randall, 1836. Cambridge, Mt. Auburn, Aug. 1834; N. Y., Calverley.

Six specimens, more or less injured.

4. Panorpa nebulosa Westw. Hag. Syn., 243, 7.

No. 117. ♂ *Panorpa maculata* Harr. Maine, Randall, 1836.

5. Bittacus stigmaterus Say. Hag. Syn., 247, 5.

Geneva, Ill., Mr. LeBaron; not in the catalogue.

6. Boreus nivoriundus A. Fitch. Hag. Syn., 240, 1.

No. 135. 2♂, 2♀. Washington Co., N. York, Dr. A. Fitch.

7. Boreus brumalis A. Fitch. Hag. Syn., 240, 2.

No. 136. ♀. Washington Co., N. York, Dr. A. Fitch.

The family is represented in the catalogue by six numbers, and seven species with eighteen specimens. The two species of Boreus are valuable types.

There are in the collection,

Odonata . .	48	species,	110	specimens.
Corrodentia . .	9	"	39	"
Perlina . .	12	"	23	"
Ephemerina . .	12	"	22	"
Phryganina . .	36	"	78	"
Sialina . .	5	"	14	"
Hemerobina . .	7	"	14	"
Panorpina . .	7	"	18	"
	136	species,	318	specimens.

Of the 318 specimens, 154 are only fragments of the others, but few in tolerable condition.

The portions of Harris Collection belonging to the groups mentioned in this Report, contain even now nearly one-fifth of the number of species described in my Synopsis for the whole United States, and nearly the number given at that time for New England and New York. From this fact alone, the collection is very important, and especially so as the exact date and locality is given for most of the specimens. The collection contains a considerable number of species, formerly only known from Canada, and even from the northern parts of it. Most of these are from the White Mountains and Maine, but some even from Massachusetts, where nobody would have believed their existence. Besides there are a number of types of species described by Say, nowhere to be found, since Say's own collection was destroyed. It is remarkable that some of the species in Harris' Collection seem to be of the greatest rarity, only represented by isolated specimens in other collections; some are even now uniques.

The collection of a so eminent an entomologist as Dr. Harris, is, by itself, a treasure, and not only a national treasure, but one in whose preservation the whole scientific world is interested. The coming generation will not be able to understand why sufficient care was not taken from the first to preserve a collection so invaluable as completely as possible. I am happy to be assured, however, that further destruction is not to be feared.

Most of Harris' catalogue names are published in his list of Neuroptera, in Hitchcock's Report, second edition, 1835, p. 580 – 582.

February 5, 1873.

The President in the chair. Eighteen persons present.

The donations received since the last meeting were announced, and the thanks of the Society voted to the Smithsonian Institution for a collection of Muridæ, illustrating Dr. Coues' monograph of that group; to the Massachusetts Poultry Association, for two varieties of the hen, and to Mr. C. E. Aiken, for a number of bird-skins from Colorado.

February 19, 1873.

The President in the chair. Fifty-five persons present.

The President congratulated the Society on the presence of the Members of the American Institute of Mining Engineers, whom he hoped would favor the Society with some of the results of their studies.

Prof. Blake spoke of the extinct glaciers of the Sierra Nevada, and of the present dessication of our Western country, contrasting so strongly with the great amount of aqueous precipitation which formerly was the condition of the existence of these glaciers. Prof. B. S. Silliman, Prof. R. W. Raymond and Dr. Sterry Hunt, also discussed the phenomena in question and their causes.

Prof. Raymond also gave a short description of the geysers of the Yellowstone Park, explaining their mode of action and their structure.

Vice-President Jackson, who had been called to the chair by the President shortly before, thanked the gentlemen who had spoken for the pleasant manner in which they had occupied the evening.

Section of Entomology. February 26, 1873.

Mr. C. S. Minot in the chair. Nine members present.

Mr. B. P. Mann was elected Secretary of the Section.

Mr. J. H. Emerton exhibited a species of Mygale from California, in its trap-door nest. The spider was living, although it had taken no food for six months.

Mr. Emerton described the manner in which the cover of the nest is held down. The spider faces the hinge, and fastens the fangs of its mandibles into the cover, also taking hold with the claws of the palpi, and the first two pair of legs. The third pair of legs, which are very strong and have their tarsi spined, and the last and longest pair are bent outward against the tube. The spider seems to remain most of the time in this position. When an attempt to open the cover is made, the spider resists with great power, and as the cover is gradually lifted, first withdraws its mandibles, and then its legs, the longest last. Finally, when nearly drawn out of the nest, the spider lets go its hold and drops back.

Mr. Emerton also described the spinning organs of spiders, and referred particularly to their structure in those making a curled web, — the Ciniflonidæ of Blackwall.

In front of the first pair of spinnerets in this family there is a pair of small organs, the nature of which has been disputed. Blackwall (Linn. Trans., XVIII. p. 223) states that the spiders draw silk from them. Mr. Emerton had, by dissection, found these organs provided with external tubes, as in the other spinnerets, into which ducts passed from the abdomen. He had been unable to trace these ducts to their end. The spider first spins an ordinary web, which it then covers with a tangled and curled thread. In spinning this, one of the hind legs is placed across the abdomen, so as to cover the forward spinnerets, the tarsus, which is very spiny, resting on the opposite leg. By a rapid motion of this leg the thread is drawn out, tangled and attached to the web.

A fine collection of European Coleoptera, presented by Mr. Ernest Papendiek, was exhibited. The collection contained a number of rarities, and was the result of several years' labor in Europe. The thanks of the Section were voted for the gift.

March 5, 1873.

The President in the chair. Thirty-three members present.

Prof. Charles H. Hitchcock spoke of his views of the Classification of the Rocks of New Hampshire.

There are five great formations in this State, each of which is capable of considerable subdivision. In the present state of knowledge we must use only local names for the subdivisions, and employ the appellations for the larger groups with considerable hesitation. Mineral structure, while important, can never carry the weight of paleontological evidence. Commencing with the lowest, the following are the groups.

I. *Laurentian*? A. Porphyritic gneiss. B. Bethlehem gneiss. C. White Mountain or andalusite gneiss. D. Breccia of Franconia.

II. *Labradorian*. A. Common granite of the White Mountains. B. Spotted granite. C. Ossipyte. D. Dark compact labradorite. E. Dark compact orthoclase. F. Red compact orthoclase. G. Reddish crystalline orthoclase. H. Syenites of Exeter and Tripyramid.

III. *Huronian*. Talcose and auriferous conglomerates. Green schists. Whitish schists. Feldspar and talc.

IV. Mostly *Cambrian* (?) A. Mica schists of Rockingham County. B. Merrimac group. C. Coös group. D. Clay slates. E. Green granite. F. Mt. Mote conglomerates.

V. *Paleozoic*. A. Helderberg limestone. B. Clay slates.

In order properly to understand the relative relations of these groups, the Labradorian series should be first discussed. This group is developed most erfectly between Franconia and the Maine line against Conway. The several members constitute one horizontal series of formations, the lowest resting upon the upturned edges of all the parts of Group I. The area may be compared to that of an isolated sea. Upon the rocky floor there seems to have been first an overflow of a reddish, rather coarse granite. Neither of these rocks show marks of stratification. Ossipyte is a compound of labradorite and chrysolite. This, and the succeeding layers of compact feldspar, appear to be stratified, and in many cases to overlie the granites with scarcely any dip. The series is cut by the syenites upon Tripyramid mountain in Waterville. The highest mountains between Saco and Pemigewassett rivers are capped by either the labradorite or compact orthoclase. Examples are the Lafayette range, Mts. Flume, Liberty, Twin and Carrigain, some of them over 5000 feet above the level of the ocean.

It follows from the general horizontal disposition of these masses, that the valleys of this mountain region are to be compared with the ravines of West Virginia and other countries where the strata constitute an elevated plateau. Several of the mountains mentioned above show four divisions of the group. The lowest is generally outermost as seen upon the map, and the highest band is most central and least abundant of all.

Of the Lowest series, the porphyritic gneiss is the most marked. Two or three bands of this formation pass southerly from the White Mountains, one of these probably across Massachusetts into Connecticut. Its greater age than that of the other series is inferred from the occurrence of several bands of andalusite and granitic gneisses, very similar to each other, upon both flanks. The central rock is along the water-shed of the State, though the ridge does not carry higher mountains than some of the adjacent schists. Two bands of this porphyritic gneiss terminate at the edge of the mountain region, being covered up by the Labrador group.

The Bethlehem gneiss in its typical areas has an east and west strike, and seems to rest upon the group just mentioned, as seen in a section from Dalton to Mt. Lafayette. The strata are monoclinal, and it is therefore difficult to know whether the axis is anticlinal or synclinal. If the formation is the same with the gneiss at Berlin, the structure may be anticlinal. The prevailing rock is characterized by the presence of a talcose appearing mineral in connection with the mica.

The relations of the andalusite gneiss to the other members of the first group are not clear. It occurs on both sides of the porphyritic gneiss anticlinal in the south part of the State, and seems therefore to be the newer of these two series. It also flanks the anticlinal of supposed Bethlehem gneiss in Berlin. These considerations make it probable that the andalusite gneiss is newer than both the others.

The evidence of its inferior position to the Labrador group is very decided. It appears in four or five places in deep valleys, beneath the granite in the area of the overflow. The south-westerly course of the strata in the main range of mountains is interrupted by the granite, but reappears in Tamworth, Sandwich, etc., showing that the gneiss is covered by the granite. In the valley of Dry or Mt. Washington River, about five miles from Mt. Washington, there is a limited synclinal of ossipyte resting upon the upturned edges of the andalusite gneiss. The granites usually lying between the two rocks are wanting in this valley. The upper rock is nearly horizontal, while the gneiss dips 60° N. W.

The Franconia breccia contains fragments of the porphyritic and andalusite series, and, as it lies on both sides of the common granite in the shape of mountains, it is surmised that it underlies the latter. Some gneiss is connected with it in Eagle Cliff. The third series has been known as the metamorphic part of the Quebec group of Canada; but it is better to call it Huronian, as suggested by Macfarlane, Credner and Hunt.[1]

Careful sections across this formation in Lyman show green cupriferous schists at the base, with conglomerates composed of fragments of the same. The series is capped by a light colored schist, weathering white, having the following composition : Silica 75.20, Ferric oxide 3.28, Alumina 6.07, Magnesia 2.80, Potash 3.04, Soda 9.86. In the valley of the Upper Ammonoosuc there is a siliceous rock somewhat resembling this schist. It adjoins genuine Huronian schist on the one hand and Labrador felsite upon the other, and is probably of

[1] Prof. H. D. Rogers seems to have understood that this system of rocks must be distinguished both from the Laurentian and the Paleozoic. My recollections of a conversation with him in 1858 are expressed in Proc. Amer. Assn. Adv. Sci., 1859, p. 322, where the disagreement between the Pennsylvania and Canada Surveys in respect to the age of the talcose rocks is spoken of. In Proc. of this Soc., Vol. VI., p. 143, Geol. Pa., Vol. II., p. 745 et. seq., the difference between the Huronian rocks and the metamorphosed Paleozoic is clearly expressed. The former are stated to constitute a system overlying the Gneissic and beneath the "Primal." The talcoid and chloritic schists of the southern strata are also compared with the Huronian rocks of Michigan. But the name of Huronian is not employed in the descriptions, so far as I can ascertain. The system, however, is clearly recognized in the Southern States, and the credit of the recognition should be given to Prof. Rogers. I remember distinctly that in the conversation alluded to, these formations in the Southern States were spoken of as probably identical with those in Michigan, then recently denominated Huronian by Logan. Prof. Rogers seems to have regarded the New England talcose rocks as altered Paleozoic, and the credit of their identification with the Huronian certainly cannot be given to him.

Huronian age. It stands nearly vertical, adjacent to horizontal masses of feldspar. The exposures were carefully examined, and seemed to us to indicate that the vertical strata had been elevated since the deposition of the horizontal measures. No other exposures yet seen throw any light upon the relations of the Huronian to the Labrador. Our impression is that the Labrador rocks are the oldest.

No fossils have been found in any of the series next in order. A large part of Rockingham county is underlaid by a mica schist. It extends into Belknap county, or to Winnepiseogee river east of the Merrimac river, and west of the latter stream it lies in synclinal valleys of the older gneiss. The southeastern border is flanked by a range of syenite similar to that found in Quincy, Mass. The Merrimac group is a convenient term to represent the quartzites and fine grained mica schist following the Merrimac river below Lowell. It occupies the entire country between the Exeter syenite range and the ocean, and resembles the mica schist so much that they were formerly supposed by us to be identical. Some of the ledges resemble those yielding fossils elsewhere.

The Coös group deserves extended mention. It embraces the "calciferous mica schist" of eastern Vermont, the hard mica schist of Essex county, Vt., the softer slates of northern Coös county, together with the various slates and schists holding staurolite as far as Massachusetts and adjoining Connecticut river, and various patches of andalusite slate on Mount Washington, Mount Monadnock, Mount Kearsage in Warner, Rochester, etc. A large number of sections crossing these rocks in the two States were exhibited, the object of which was to illustrate a suggestion of Dr. Hunt that the calcareous rocks of Vermont may be identical with the staurolite members in New Hampshire. The sections also indicate that a quartzite and hornblende schist constitute the basal members of the Coös group. The latter is the band of rock immediately overlying the gneiss at Shelburne Falls, Mass., as described by me before this Society in 1858,[1] and the two varieties of mica schist then spoken of belong to the same group.

On account of the folded character of our New England formations, the sections just alluded to show numerous cases of inverted synclinals. A typical section shows parallel bands of Huronian rocks, the one along Connecticut river and the other near the Green Moun-

[1] Proc., Vol. vi., p. 330.

tain range, and narrow bands of clay slate adjacent between them. This slate seems to rest upon the Huronian and to underlie the Coös group, which occupies the rest of the area between the two talcose ranges. The Coös range in New Hampshire is often folded beneath the Huronian, and is contiguous to gneiss upon the east. Its quartzite is often isolated from the other members of the group. Its lithological character and occurrence in mountainous masses, remind one of the hyaline Potsdam quartzite at the west base of the Green Mountains.

Some of the clay slates have been mentioned. Other long and narrow ranges lie upon the Huronian and Coös group, some of which carry veins of auriferous quartz. Interesting remnants of it occur upon Mount Pequawket, near North Conway. The geological structure of Mounts Pequawket and Mote is peculiar. They border the valley of the Saco. At their base is the common horizontal granite of the Labrador series, capped by perhaps two hundred feet of spotted granite. Upon the first of these peaks are two fragments of slate, neither of them a mile in length. The conical summits of both mountains consist at the base of a conglomerate almost exclusively composed of fragments of slate. Upon Mount Mote there are also andalusite slate, red feldspar and labradorite pebbles in it. The proportion of pebbles diminishes in ascending Mt. Pequawket, and they are small and few at the summit. The paste is a feldspathic granite. Upon Mount Mote there is a large amount of a greenish granite connected with the conglomerate. The character of the imbedded pebbles proves these conglomerates to be more recent than the clay slates, and they are certainly the newest rocks about the White Mountains.

Fossil corals have been found in Littleton, which resemble those described in the Geology of Canada as occurring about Lake Memphremagog. A slate is associated with them which may be of similar age, — the Helderberg. A very large area of this slate occurs in Dalton. Mr. Huntington has recently discovered more perfect specimens of the corals in the town of Flagstaff, Maine.

These facts indicate that the New Hampshire formations will afford us conclusions of immense importance when properly explored. The study of the crystalline schists of New England has been neglected so much in the past, that less is known of the geology of the long settled States of the east than of the newer but flourishing commonwealths of the interior. Let us hope that the true order of succession of eozoic rocks will soon become as familiar as the names of the New York system of paleozoic formations.

Dr. C. T. Jackson said that he was commissioned to make the geological survey of N. H. in 1840, and that the work was finished in 1844, the results being embodied in a quarto report with maps and sections.

The geological map was to have been colored, but want of time prevented; however, the limits of the different rocks are clearly shown by lines. He was pleased that Prof. Hitchcock had found so few additions or corrections necessary in the map. He had not found in place the gneisses or granite containing labradorite, which Prof. Hitchcock had succeeded in doing, nor had he noticed the fossil corallines discovered by Prof. Hitchcock in the impure limestones of Lancaster, N. H.; these he believed to belong to the Vermont system properly, and thought no inference concerning the age of the White Mountains could be drawn therefrom.

The supposed fossils of Prof. Rogers in the metamorphic slates of the White Mountains, had been shown to be andalusite macles, and he had inferred the old Silurian age of this formation from similar rocks in Maine, where characteristic fossils had been found.

Dr. Jackson believed the classification proposed was hypothetical to a great extent, and that sufficient reason for the adoption of the New York nomenclature was not shown; nevertheless he was gratified with Prof. Hitchcock's attempt at a new classification of the rocks of New Hampshire.

Dr. Sterry Hunt alluded to the notion for a long time held by American geologists that the crystalline schists, both of the Green Mountain and White Mountain series, were strata of Paleozoic age, altered in some unexplained manner.

Dr. Hunt had, since 1870, controverted this view, and had shown that in eastern North America, in various localities, uncrystalline strata containing the remains of the first or so-called primordial paleozoic fauna include fragments of these more ancient crystalline schists, which are really pre-paleozoic or eozoic. In this class he includes the Laurentian, the Huronian or Green Mt. series, the White Mt. series (once called by him Terranovan, for which he has since suggested the name of Montalban), and the Labradorian or Norian (the Upper Laurentian of Logan). He considers that there may probably be found other distinct series besides these four among the eozoic crystalline strata of North America, where stratigraphical breaks, great unconformities and extensive denudation in eozoic times are evident. He objected to giving the name of Cambrian to any of these eozoic formations, since the rocks to which this term was applied by Sedgwick included only uncrystalline sediments holding the first and second faunas, and containing paleozoic forms nearly to their base in Great Britain, where they rest on crystalline strata. Similar crystalline rocks are elsewhere in that region directly overlaid by the strata of the second fauna, and were hence, in opposition to the views of Sedgwick and Phillips, erroneously regarded by Murchison as the altered equivalent of the missing Cambrian strata, so that the name of Cambrian became wrongly applied to a series of eozoic or pre-Cambrian schists, apparently of Huronian age.

As regards the Norian, which had once been joined by the Laurentian, Dr. Hunt had elsewhere shown that we had reason for suspecting that it might be more recent than the Huronian, and possibly than the Montalban, a conclusion which appeared to be confirmed by the facts made known by Hitchcock. He alluded to the interest attaching to the seeming fact that chiastolite schists occur at two horizons in the White Mts., one with the great White Mt. series of gneisses and mica-schists; which, according to Hitchcock, are overlaid successively by a Norian, and by a second series of chiastolite and staurolite schists. He congratulated Prof. Hitchcock on the zeal and industry with which he had pursued this difficult investigation, and believed that by adopting, as Prof. Hitchcock has done, the view that all these rocks are of eozoic age we escape the insuperable difficulties which environed their study so long as they were regarded as altered paleozoic sediments.

Dr. Jackson announced the death of one of the original members of the Society, Dr. Henry Coit Perkins, of Newburyport. Dr. Perkins first proposed the formation of the Society, and drew up the original prospectus in 1828, which was signed by him, by Dr. Bemis, of Chicopee, and by Francis Alger and the speaker, and later by Dr. Amos Binney. Dr. Binney actively engaged in procuring more signatures, and in 1830 succeeded in founding this Society.

Dr. Perkins made many original investigations on the light of the stars and comets, and of the Aurora Borealis. He also was engaged in the study of microscopic animals and plants, which occupied his attention at the time of his death. These studies were pursued from the pure love of science, and entirely free from ambition, Dr. Perkins rarely published his results. He was twice elected President of the Mass. Medical Society, and was a Fellow of the Am. Academy of Arts and Sciences, and one of the trustees of the Peabody Academy of Science, at Salem.

Dr. Brewer exhibited a pair of rare buntings from Cal. (*Plectophanes maccownii*), presented by C. E. Aiken, Esq., to whom the thanks of the Society were voted.

Section of Microscopy, March 12, 1873.

Mr. Bicknell in the chair. Twelve persons present.

Mr. Bicknell exhibited the formation of crystals of silver under the microscope in a very simple way. A small quantity of a solution of nitrate of silver in water is placed on a glass slide, and into this liquid a few small pieces of copper wire are dropped. Crystals of silver begin at once to form, creeping across the field of view in a very beautiful manner. When the crystalization has proceeded far enough the pieces of copper wire may be removed, and the crystals of silver gently washed *on the slide*, and, after being well dried, can be mounted either dry or in balsam as permanent objects.

Mr. Stodder read a paper by Dr. Pigott in the Monthly Microscopic Journal for February, on the scales of the *Lepisma saccharina*, and exhibited scales with Tolles' objectives $\frac{4}{10}$, and immersion $\frac{1}{10}$ and $\frac{1}{18}$, with oculars A and $\frac{3}{4}$.

With the $\frac{4}{10}$ objective the scales showed the appearances which formerly were the test of the best instruments; with the $\frac{1}{10}$ the black ribs were sharply defined, with light beads in the interspaces. The $\frac{1}{18}$ showed admirably all the various appearances described by Dr. Pigott, with many others; in fact, almost every one present saw something different from the others, or else described the same appearances with different words. The principal variation from Dr. Pigott's descriptions was in the colors, but his observations were made by day instead of by gaslight, and, furthermore, the objective used by Dr. Pigott was not perfectly corrected for chromatic aberration, while Tolles' $\frac{1}{18}$ was corrected as accurately as possible — perfect accuracy in this respect being, doubtless, impracticable — nevertheless giving sharp definition of the black lines and beads.

Mr. Stodder said he had examined the scales with the same lenses by direct sunlight, which thus shown are most beautiful objects, crowded with "beads" tinted with all the colors of the spectrum. The "beads" measured 49,000 to the inch, by the same means used by Dr. Pigott. Are these "beads" real or illusory? From the fact that minute particles of powdered glass and the like, give perfectly distinct bead-like images, Mr. Stodder believed the existence of real spherules on the scales not proved.

March 19, 1873.

The President in the chair. Twenty-six members present.

The President announced the recent death of the celebrated Botanist, Dr. John Torrey, an Honorary Member of the Society for over thirty-two years.

Dr. T. Sterry Hunt was requested to prepare an account of the life of Dr. Torrey, which was read at a subsequent meeting.

Dr. John Torrey died of pneumonia at his home in New York, on the 10th of March, 1873, in the seventy-seventh year of his age, having been born in that city on the 15th of August, 1796. Choosing the medical profession, he graduated as doctor of medicine in 1818, and in 1824 was appointed professor of chemistry, mineralogy and geology in the Military Academy of West Point, but resigned his post in 1827, to accept the chair of chemistry and botany in his *alma mater*, the New York College of Physicians and Surgeons, of which he discharged the duties most acceptably until his resignation in 1855. During the greater part of this time, he occupied also the chair of chemistry and natural history at Princeton, to which he was named in 1830, resigning it only in 1853, when he was made chief assayer to the United States assay-office, a post which he held, constantly discharging its duties, till his death. He was also, for the latter years of his life, a trustee and a professor of Columbia College, to which, in 1860, he presented his large botanical library, and his extensive and valuable herbarium. He however retained the use of these during his life-time, and making his home near them, in the college where they were deposited, spent many hours daily in the last years of his life, in the study of his favorite science; for while his official duties have made him known to the world outside as a chemist and mineralogist, it is on his botanical labors that his scientific fame will chiefly rest.

He early gave himself to the study of botany, and as long ago as 1819 published a catalogue of the plants growing within a radius of thirty miles of New York. Fifty years later his botanical friends celebrated the anniversary of its publication, by a banquet given to the Nestor of their science, in the decorations of which the *Torreya taxifolia*, belonging to a new genus of Taxacea which had been named for him, was not forgotten. A Flora of the Northern and Middle States in 1824, a remarkable monograph of the Cyperacea in 1836, the Flora of the State of New York, in two volumes, in 1842–44, with various Botanical Reports of the results of United States exploring expeditions from 1828 to 1858, comprise the chief part of his published contributions to botany. He moreover edited with his friend, Dr. Asa Gray, the Flora of North America, and has, we believe, left behind him a large amount of manuscript notes on botanical subjects, nearly ready for publication.

But while thus doing such a vast amount of original work in this department of natural history, he was wont to say playfully, that botany was his amusement, and chemistry and mineralogy his profession, as they had been his first love. In the early part of his professional life, he published several valuable papers relating to these studies, including observations and analyses of various American minerals, but although he never abandoned such pursuits, and habitually spent more or less time in chemical work in his laboratory, he in subsequent years gave us little or nothing of his results. His great familiarity with the literature of chemistry and mineralogy, his fertile mind, and his acute powers of observation, fitted him nevertheless, to be an investigator of a high order. The patient scrutiny with which he examined any new mineral substance, calling in the aid alike of chemistry and the microscope, was the delight of those who were admitted to his confidence. That he did not elaborate the results thus obtained and give them publicity, is to be ascribed in part to his great modesty, which led him to under-rate the value of his observations, and in part to the fact that his time out of the laboratory was chiefly given to his botanical investigations, which divided his allegiance, and deprived mineralogy and chemistry of many precious contributions which, it is to be feared, are now lost, and must await a second discoverer. An example of this occurred in a long and carefully written letter, containing observations on the varieties of iridosmine from our Pacific coast, sent to the writer of this notice, with specimens for verification, some two years since. When urged to publish his facts, Dr. Torrey declined, saying that they were too insignificant.

The moral nature of Dr. Torrey was one of rare excellence and beauty. An engaging frankness, a genial humor, a generous sympathy and a child-like simplicity of manner, with a happy religious faith, endeared him to all who were so fortunate as to be admitted to his intimacy; and he was always ready to extend a helping hand to young aspirants in science, who never sought in vain his council or his aid. He retained to the last a lively interest in all his scientific pursuits. Such a man could never grow old in heart, nor were his powers apparently enfeebled by advancing age. In November last, the writer listened to him with delight, as he turned from learned and judicious comments on a recently published chemical treatise, to his microscopic studies on certain sands, where his keen vision had just made discoveries which had eluded the scrutiny of younger eyes; nor was it until a few weeks before his end, that illness obliged him to relinquish his daily attendance at the assay-office. He died as he had lived, quietly, surrounded by an affectionate family, and cheered by the hopes of a Christian. His name is written imperishably in the history of American botanical science, and his monument is Torrey's Peak, that lofty summit of the Rocky Mountains which bears his name, and rises side by side with Gray's Peak, named for our other great botanist, his life-long friend and fellow-worker, who can alone do justice to the story of the long, busy and useful life of Dr. John Torrey. T. S. H.

The following paper was presented: —

The Systematic Position of the Brachiopoda.

By Edward S. Morse.

To Japetus Steenstrup,

Who first recognized the Annelidan Affinities of the Brachiopoda, this Contribution is respectfully dedicated.

Preface.

To the systematic zoölogist it is instructive to mark the changes that have taken place in the classification of animals within the last thirty years, changes not only resulting from further knowledge of the internal structure of animals, and of their embryology and early stages, but changes resulting from a new interpretation of data previously well known.

Up to comparatively recent times, such distinguished authorities as Agassiz, and Vogt, have suggested the association of the Vorticellidæ[1] and Foraminifera[2] and the Ctenophora[3] with the Mollusca.

Not only were these additions rejected, but already have been removed the Cirripedia, and the shell-bearing Serpula, Spirorbis, and other forms originally grouped with the Mollusca. Are we now to believe that this work of elimination has ended? If further dismemberment of this perplexing branch is to take place, one would naturally look for it in that association of classes called the Molluscoi-

[1] Louis Agassiz, Essay on Classification. 8vo. ed., p. 108.
[2] Ibid., p. 113.
[3] Carl Vogt, Zoologische Briefe.

dea, first separated by Milne Edwards, and afterwards adopted by Dana, with pregnant suggestions as to its value as a group by itself.

Recently Kowalewsky, Kupffer, Schultze and others, have assailed the Tunicata, and demonstrated their kinship with the lower Vertebrata through Amphioxus. Leuckart has long maintained that the Polyzoa have no sort of relation to the Mollusca, but belong to the Vermes, and recently the distinguished Gegenbaur, in the second edition of his Outlines of Comparative Anatomy, not only assigns the Polyzoa to the Vermes, but places there also the Tunicata. And now in this paper I wish to show that in every point of their structure, the Brachiopoda are true worms, with possibly some affinities to the Crustacea, and that they have no relations to the Mollusca, save what many other worms may possess in common with them.

In nearly every case the unnatural association of certain groups with the Mollusca has been due entirely to superficial resemblances, to "formal analogy," as Forbes would say.

The same reason that first led conchologists and zoölogists to include Spirorbis and Serpula and the Cirripedia, as well as the Foraminifera, with the Mollusca, namely, the presence of a calcareous shell, also brought the Brachiopoda into the same category. But while there was some resemblance between the cases of certain tubicolous Annelids and the shell of Vermetus, or the flattened form and lateral shells of Anatifa, and the lamellibranchiate shell, or the chambered shell of certain Foraminifera and the Nautili, there was but little to suggest an affinity with the lateral lamellibranchiate shells, in the dorsal and ventral plates of the Brachiopoda.

The mere possession, however, of a calcareous shield of some sort, whether in one piece, or several pieces, whether a tubular or a chambered shell, furnished sufficient reasons for most zoölogists to include creatures bearing such shelly coverings with the Mollusca. Hence we find Lamarck, at one time placing Anomia and Discina together. And Cuvier, allowing the accepted views of the time to lead him astray, forsook his principles based upon internal structure, and regarded the relations of the Cirripedia as molluscan.

It is amusing now to look back and see with what quiet resignation the conchologists (for such they were rightly called) permitted the removal of those forms which possessed no shelly covering, with what stolid indifference they allowed other unprotected forms being forced upon them, and with what obstinate pertinacity they withstood the removal of such groups as possessed a limy shell.

Says Mr. G. B. Sowerby, the great English conchologist, after Thompson had so clearly shown that the Cirripedia were crustaceans and not molluscans; "Without describing the facts, or entering upon the arguments, with which he (Thompson) supports this opinion, we must be permitted to say that we do not think he has fully demonstrated it; at the same time, considering that, as far as we hitherto knew, the Cirripeds were all attached, the circumstance of their being free when very young accounts well to our mind for the fact of each species being found attached to peculiar situations, which would only be compatible with the notion of their being at one time free agents, and possessed of an intuitive volition, determining their choice of situation." ![1]

Every worker knows how blindly one will work, when his mind is imbued with the accepted views of the subject, when he does not dream of questioning what he has always been taught to believe, particularly when those teachings come from the highest authorities. Even so distinguished a naturalist as Prof. Huxley, after he had re-repeatedly observed the external openings of the oviducts in Rhynchonella, confesses that "pre-occupied with the received views on the subject (namely, that oviducts were hearts), I at once interpreted them as artificial."[2] In the same way Prof. Owen thought he saw a minute perforation at the extremity of the intestine of Terebratula, where no such opening exists. As Lingula, and Discina had an anal opening, it was quite natural to believe that the other Brachiopoda formed no exception to the rule.

Many elaborate investigations of the Brachiopoda had been made by such eminent naturalists as Cuvier, Vogt, Owen, Hancock, Huxley, Davidson, Lacaze-Duthiers, Gratiolet and Carpenter, and in all their memoirs no doubts had been expressed as to their molluscan nature; therefore, on commencing the study of the Brachiopoda, thirteen years ago, I had no more doubt of their molluscan character, than of the vertebrate character of birds, and attempted only to show more closely the homologies which I believed existed between the Brachiopoda and Mollusca. When at last they had been forced into the place where I believed they rightly belonged, the result of that work was published in the Proceedings of the Essex Institute,[3]

[1] Sowerby, Genera of Shells.

[2] Huxley, Proc. Royal Soc., London, Vol. VII., p. 113.

[3] Classification of the Mollusca based upon the Principle of Cephalization. Proc. Essex Inst. Vol. IV. 1865. And Silliman's Journal, Vol. XLII, July, 1866.

and afterwards republished in Silliman's Journal. The fact that in that paper the Brachiopoda were turned up side down, and end for end, shows the violent methods resulting from faith in accepted views. It is a simple matter of justice to myself that I make this confession, and I may also say that my studies of the Brachiopoda have been made, not for the purpose of describing new species or genera, to show their geographical distribution, or to tabulate the number of species known, but simply and solely, to determine their affinities ; and that some weight may attach to the radical views here advanced, I may, with satisfaction, state that my investigations on the subject embrace a series of observations on the anatomy and early stages, of Discina, from an immense mass of material in alcohol furnished me by Prof. Verrill. I have also carefully studied living Lingula, Rynchonella, and Terebratulina, and the early stages and embryology, of the latter.

Some of these investigations have already been published, and I had hoped to present them all before publishing this paper, but as some time will be required to prepare the results, and the necessary plates on Lingula and Discina, I am reluctantly compelled to present this first.

Introductory Considerations.

The changes here proposed in the removal of the Brachiopoda from the Mollusca, and their association with the Vermes, make necessary a comparison between the Mollusca, as now restricted, and the Vermes.

Many naturalists now hold the opinion that the Mollusca are descended from the Vermes. Indeed, it would seem from the rapidly accumulating data that the Vermes underlie the whole animal kingdom, with the exception of Protozoa. Only on this hypothesis, that the Mollusca are derived from the Vermes, can we understand the otherwise strange assemblage of characters displayed by such Mollusks as Chiton, Dentalium, Pneudermodon.

In our comparisons we are justified in selecting as typical Mollusca[1] those groups which have remained unchanged the longest.

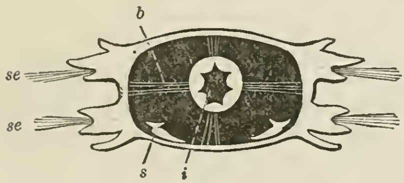
[1] We leave out of consideration the Polyzoa, since they are not only related to the Brachiopoda, but because they are regarded as worms by Leuckart, Gegenbaur, and many others, and also the Tunicates, regarded by many naturalists as forming the base of the vertebrate series; others placing them with the Vermes, and by all separated from the Mollusca proper.

A typical Lamellibranch, and a typical Gasteropod, will be admitted by all, as best representing this branch, for while other groups have widely changed since their first appearance in past ages, we find the Lamellibranch and Gasteropod of the lower Silurian as typical as present existing forms, *e. g.*, Modiolopsis, Avicula, Murchisonia, Pleurotomaria, and from the tracks and tubes, and still later setæ, we are safe to assume that the Annelids were as characteristic of their classes in past geological times, as at present.

We cannot compare the Trematodes and Turbellarians, with the Nudibranchiate Mollusks, for however much resemblance some may see in their adult condition, as among the Planarians,[1] certain characters of external symmetry in common, their respective embryos are identical with their respective divisions, the one being annulated, the other developing a foot, and a nautiloid shell.

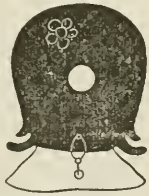
Leaving these out of consideration, then, and taking the dominant characters displayed by the Vermes on the one hand, and the Mollusca as cited on the other, we have in the Vermes, a form, whose length is much greater in proportion to its breadth than in the Mollusks; the

Fig. 1.



Transverse section of Annelid after Carus.

Fig. 2.



Transverse section of molluscan archetype after Carus.

b. bands suspending intestine in perivisceral cavity. *i.* intestine. *s.* segmental organ. *se, se.* setæ.

worms being drawn out as it were, the Mollusk being concentrated. The worm is perfectly bilaterally symmetrical, depressed, flattened or circular, the dorsal and ventral regions so near alike in many cases, as to be distinguished with difficulty, and the body never flattened laterally. The Mollusk is also bilateral, but often asymmetrical, the dorsal and ventral regions are very unlike, and the body almost always flattened laterally. This latter character is so marked, more especially among the Lamellibranchiata, as to have led Prof. Agassiz

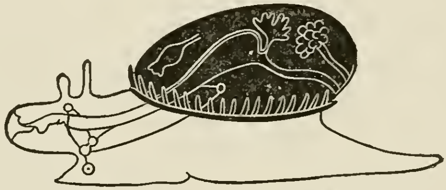
[1] Girard placed the Planarians with the Mollusks.

to apply the term *laterality* as distinguishing the Mollusks, while the term *tergality* was applied to the whole Cuvierian branch of Articulates. Agassiz has also called attention to the fact that while the display of structure is upon the sides in Mollusca, it is upon the back in the Articulata, though numerous and important exceptions occur in both groups.

In the worm, the locomotor muscles are intimately connected through the entire length of the body with the integumentary system, especially on its dorsal and lateral walls (Rolleston). In the Mollusk, on the contrary, the locomotor muscles are connected ventrally with a specialized creeping disk, the foot.

In the Mollusk, with few exceptions, the viscera are carried above the foot in a protruding chamber.

Fig. 3.



Molluscan archetype from Carus.

In the worm, the symmetry of the body is never disturbed by the viscera. The tegumentary envelope, when separate from the body proper, forms at most a projecting, or an everted collar about the head, and, in a few instances, a continuous free membrane along the sides of the body. In the worm this envelope, and adjoining parts possess chitinous outgrowths in the shape of scales, rarely a shell, but commonly setæ, the latter being a marked character of the Vermes.

In the Mollusk the tegumentary envelope is prolonged, and oftentimes continuous, forming a sack or mantle, inclosing a conspicuous cavity, and protecting the gills. Hence the name Saccata, proposed by Prof. Hyatt. Setæ, or scales, are not present; while the possession of a calcareous shell, composed of one or more pieces, furnishes the only material to nine-tenths of those who study them. In the worm the plates, when present, and the thickened integument, are perforated with minute tubules, a character not possessed by the Mollusk.

In the worm, the digestive canal is straight, rarely convoluted, and suspended freely in the perivisceral cavity. (See Fig. 1, *b*.)

In the Mollusk, the intestine is always convoluted, not suspended freely in the perivisceral cavity, but intimately blended, or united with other organs.

In Vermes there is a peculiar depuratory apparatus characteristic of all. In the Annulata this apparatus takes the shape of bilaterally symmetrical tubes, in pairs, opening externally and communicating with the perivisceral cavity by distinct independent infundibilform orifices. (See Fig. 1, *s*.)

In the Mollusca, with exception of certain Cephalopoda, nothing of the kind is found, and where such communication does exist between the organs and the surrounding medium, it is by means of simple orifices in the walls of the cavity.

In the Vermes, especially in the Annulata, a nerve collar is found, from which start two parallel chains of ganglia, oftentimes widely separated.

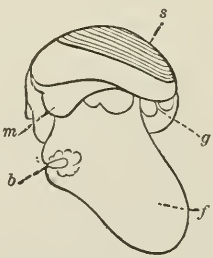
In Mollusks there is also a nerve collar surrounding the œsophagus, and no double chain, but nerves are thrown out to the sensory, motor, and parieto-splanchnic regions. Hence the names Homogangliata, and Heterogangliata. In the Annulata, with the exception of the Discophora, the generative products are set free in the perivisceral cavity, receiving from the fluid therein contained, certain nourishment. In Mollusks this never occurs, though in certain Cephalopods the products of the generative organs are set free into a compartment of the perivisceral cavity, and from there find egress through the oviduct.

With the exception of the Octopoda, the oviduct is single. In the latter group there are two oviducts bilaterally symmetrical, all of these features being vermian.

In Vermes the embryo never possesses a single or double shell, and with few exceptions is distinctly annulated,[1] while among the Mollusks, even when devoid of a shell in the adult, the embryo early develops a shell composed of one or two pieces.

Other differences of minor importance might be mentioned as separating distinctly the typical worm, from the typical Mollusk, but the leading characters here pre-

Fig. 4.



Embryo of Lamellibranchiate.

s, shell; *m*, mouth; *f*, foot; *b*, byssal gland; *g*, gills.

[1] See "Note," p. 10.

sented sufficiently indicate the wide divergence of the two great Divisions.

NOTE. The annulated embryo of the worms is characteristic of most of them, from the Rotifer to the highest Chætopod. In all, the body is generally divided into a few transverse segments. In the Lamellibranchiate and Gasteropod the embryo early develop the velum, or foot, projecting from a bivalve, or a nautiloid shell. In Chiton the larva is annulated, according to Loven. Pneumodermon, among the Pteropods, has the body banded by transverse circles of cilia. In Dentalium the larva resembles that of a true worm.

The affinities of Dentalium are not clearly understood. It was placed among the Annelids by Cuvier and Lamarck, and then among the Mollusks by Deshayes and De Blainville, as Gasteropods. Since then they have been bandied about from one end of the series to the other. Lacaze-Duthiers,[1] who has made the most thorough investigation of them, makes a separate class, Solenoconchia, with their affinities mostly among the Lamellibranchiates. Huxley places them with the Pteropods, on account of the rudimentary head, neural flexure of intestine, presence of epipodial lobes, and the character of the larva. With all these diverse relations, I would suggest that they certainly bear some relations to the Tetrabranchiate Cephalopods, in the numerous and retractile tentacles, the dorsal turn of the shell, and the strict identity between a peculiar bilateral cartilaginous body which occurs in the head of Dentalium, as well as in the head of *Nautilus pompilius.*

Having thus connoted the leading features characteristic of each Division, our next object is to inquire whether all the characters of major and minor importance possessed by the Brachiopods are not held in common by the worms, and are in no wise possessed by the Mollusks.

General Proportions of the Body.

In Mollusks, while we may have the body divided into a creeping disk, and a visceral portion, the visceral portion usually carried above in a protruding chamber (See Fig. 3), or the mantle prolonged behind, to form the tubes, we do not have the body constricted transversely, forming a thoracic, and an abdominal portion. We do not find such a feature as a caudal appendage, nor are the Mollusks ever attached, save by the adhesion of the calcareous shell, or by the byssus. Among the lower worms, as, for example, some Rotifera, certain forms are fixed by their posterior portion. In the Rotifera, as well as in the tubicolous Chætopods,

[1] Annales des Sciences Naturelles, 1856–57.

the body is in most cases distinctly divided into a thoracic portion, and an abdominal, or caudal portion. In Pectinaria the caudal portion is separated from the body by a deep constriction, and is apodous. In Serpula, Protula, and Lysilla, the separation of the body into two regions is strongly marked. In *Sabellaria alveolata*, the caudal portion is very long, cylindrical, and apodous.

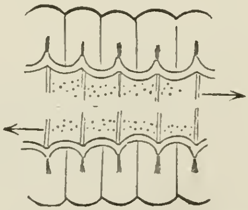
Fig. 5.

Young Rotifer.

In the Brachiopods, the body is also distinctly divided into a thoracic and caudal portion. The caudal portion varying greatly in function and character, in different groups. In some, this portion is very short, and firmly fixed to some point of support. In Rhynchonella and Terebratulina it is capable of sustaining the body, and of twirling it round in various directions, or more correctly the peduncle appears to be firm and elastic, and the body is capable, by certain muscles, of twirling round upon it. In other Brachiopods, as in Discina, the peduncle, or caudal portion, has its special set of muscles, attached to the outside of the ventral plate, and its cavity is in direct communication with the perivisceral cavity by an azygos opening.

In *Lingula pyramidata* (and I presume the other forms of Lingula will present no essential difference) the peduncle is nine times as long as the thorax, free, active in its vermian contortions, and possessing the power of fabricating a sand tube. The thorax also possesses this power. (See figures 1 to 7 in Plate I.) Not only is the body often enveloped in a sand case, but this species of Lingula has the power of covering the bottom of any vessel in which it may be confined with a sinuous sand tube, precisely similar to the tubes made by Terebella, and allied forms under like circumstances. (See Fig. 7, Plate I.) Though the peduncle of Lingula is capable of varied and rapid movements, is partially annulated, shows a constant circulation of the perivisceral fluid within, is possessed of mucous pores, yet no trace of setæ are seen upon its walls, and this is in

Fig. 6.



Portion of peduncle of *Lingula pyramidata* showing annulations and circulation of fluid within.

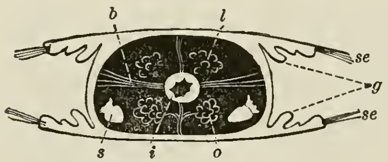
accordance with what we see in worms, that those segments without appendages or setæ are the caudal ones.

A prominent character of the higher worms is the annulations, or rings marking the body. In the Gephyrea, however, this feature is not so obvious as in the peduncle of Lingula, while in many of the lower worms, *e. g.*, Chætognatha, Nematoidea, Acanthocephala, there are no segments, and in the Rotifera the segmentation is external. Therefore the absence of this character in the Brachiopoda is unimportant.

The presence of more than one segment in the Brachiopoda is possibly marked in Rhynchonella, where two pair of segmental organs, or oviducts, occur. In Lingula, also, a deep constriction occurs just back of the posterior occlusor muscles, a membraneous partition at this point tends to separate the perivisceral cavity, and the stomach has a corresponding ridge upon its walls. All these features certainly suggest segmentation. The arrangement of the muscles in Lingula into distinct sets, first the anterior occlusors, then the posterior occlusors, next the external, central and posterior adjustors, and finally the divaricator muscles, suggests segmentation of the body, as seen in the Arthropods. This feature is less marked in Discina, though still apparent, and with their external peduncular muscles one might, with propriety, theoretically form a number of rings.

The dorsal and ventral symmetry is a distinctive character in worms. This symmetry is often so complete as to render the determination of above and below a matter of great difficulty, and, as in Sternaspis, a source of confusion. (See transverse section of Annelid, Figure 1.) The same feature is likewise characteristic of many Brachiopoda, particularly with Lingula, where these regions externally are almost precisely alike, and where single valves of Lingula are found fossil, or their impressions are seen upon the

Fig. 7.



Transverse section of Lingula.

b. bands suspending intestine in perivisceral cavity. *i.* intestine. *s.* segmental organ. *o.* ovaries. *l.* liver. *g.* gills. *se, se.* setæ.

rocks, it is almost impossible to determine whether they are dorsal or ventral.

No one, however, would mistake these regions in the Lamellibranchiate, or Gasteropod.

In the Brachiopoda, with the exception of Lingula, there is a a great concentration of the body, quite unlike anything seen in the Vermes. Lancaster, however, describes, in the Annals and Magazine of Natural History, a worm, *Chætogaster vermicularis*, one of its chief points of interest being the exceedingly small number of segments, four or five only.

Many Rotifera are also highly concentrated, or cephalized, with dorsal and ventral flattening, and with a chitinized integument.

As to this concentration of parts in the Brachiopoda, it would be strange indeed if the worms alone should not show this concentration of structure in some of their forms. This same diversity occurs in all the other groups, as in the Crustaceans, the highly cephalized Brachyurans, and the elongated Macrourans, and among the Cirripeds, the concentrated and flattened Coronula, and the long pedunculated Anatifa. Or among the Echinoderms, the flattened Mellita or Scutella, and the worm-like Holothurian. Or, again, in the Lamellibranchiates, the concentrated Isocardia and the attenuated worm-like Teredo. Other examples might be given in the Polyps, Ctenophoræ, Gasteropods, Insects, Fishes and Reptiles.

Concentration, or cephalization of a structure, while modifying the character and functions of parts, and even obscuring their ready interpretation, can in no wise affect the relation of the animal sustaining such features, though it may account for certain peculiarities attending such conditions, in the same way that parasitism may account for the absence of certain organs, characteristic of related forms.

Integumentary Organs.

In Mollusks the tegumentary envelope is almost always extended to form a sac, or mantle, which is open below, sometimes resting like a cap upon the back, or better, extending itself in a wide membrane about the viscera, or it may hang upon the two sides of the body, split below in a median line, but not on the sides.

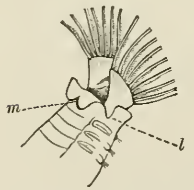
This envelope, or mantle, usually secretes a shell composed of carbonate of lime, and is attached to it by special muscles in limited areas, so that when these are separated, the envelope is found to have no sort of connection with the inner walls of the shell secreted by it, from which the shell readily drops. This feature renders possible the formation of pearls, by irritating substances or parasites, finding their way between the mantle and shell.

The molluscan shell is never perforated with tubules passing perpendicularly through, from one surface to the other, nor are there any minute ramifications of the mantle, or, other portions of the soft parts, entering the substance of the shell, and consequently no adhesions of the body, save by the special muscles above alluded to.[1]

In the Annulata the integument is rarely ever extended beyond the limits of the body. When this is the case, it forms a broad membrane bordering the thorax, as in Protula, *Serpula crater* (See Plate I., fig. 10), and others, or it surrrounds the head in a collar, often everted, *split upon the sides* and *notched in the median dorsal region*, and separated in a *median line below*. In *Protula Dysteri*, a broad membrane borders the lateral aspect of the thorax, from which the setæ spring. In *Serpula crater*, the membrane borders the thorax *diagonally, being free at the posterior dorsal region of the thorax.*

In Brachiopods we have an extension of the tegumentary envelope from above and below, enclosing the arms. This membrane is also *split upon the sides*, and is directly to be compared with the cephalic collar in certain tubiculous annelids, as Sabella, for instance, where it differs only in degree. In Sabella the cephalic collar does not cover the bilobed arms, but it is a split upon the sides, and notched in the median dorsal line. In many Brachiopods there is also a notch in the median line, and the genus Pygope of Link, the notch divides the collar into two lobes, which afterwards unite, leaving a hole, or space in the shell. In other words, this membranous collar covers simply the base of the arms in those worms possessing it. While in the Brachio-

Fig. 8.



Showing cephalic collar of Sabella.
m. median dorsal notch.
l. lateral notch-

[1] In his work on the Microscope, Dr. Carpenter has described, as peculiar to Anomia, an irregular net work of minute tubules, running parallel to the surface of the shell, scantily distributed in the inner layers, but very abundant in the outer layers. In his last edition of this valuable work, Dr. Carpenter explains the character of these minute tubules, and refers them to the action of a parasitic fungus. Mr. Mark Stirrup, at a meeting of the Manchester Philosophical Society, England, exhibited sections of various shells, and showed that in Anomia, the ramifying tubules were produced by a fungoid growth.

pods the collar covers and protects the arms, which, however, may partially project, as in Terebratulina and Lingula, and wholly so in *Rynchonella psittacea*, as I observed last year.[1]

Furthermore this pallial membrane, or cephalic collar of the Brachiopods, is not to be compared to the mantle in the Mollusca, as pointed out by Dr. Carpenter in 1854. In a paper on the peculiar arrangements of the sanguiferous system in Terebratula, and other Brachiopods,[2] he says : "The membrane which is commonly spoken of as the *mantle*, and which may be stripped from the shell by the use of sufficient force to overcome its adhesions, must, I maintain, be considered as really its *inner layer* only ; for I find that an outer layer exists, so intimately incorporated with the shell as not to be separable from it without the removal of its calcareous component by maceration in dilute acid. When thus detached, this outer layer is found to be continuous with the membrane lining the perforations in the shell." I have observed that when the test[3] is removed in *Lingula pyramidata*, the perivisceral cavity is often exposed, of such extreme tenuity is the inner lining membrane.

From a figure and description given by W. Baird,[4] of a peculiar worm case *Terebella flabellum*, the cephalic collar might have had the proportion of many Brachiopods, in being broader than long. He describes the orifice of the tube as being circular, and says, "the most characteristic feature, however, in the structure of this tube, is the fan-shaped expansion of filaments at its upper orifice. This orifice is circular, and has on its dorsal surface a projecting lip, or kind of hood, which extends beyond the mouth for a short distance, whilst from the ventral side springs another lip or hood."

Dr. Dawson[5] represents the worm case of *Vermilia serrula* from the Gulf of St. Lawrence, in which there is a marked thoracic enlargement.

In a few worms only, do we find dorsal scales, as in Polynoe, or posterior and ventral scales, as in Sternaspis, and when these occur, they are chitinous, as in Discina. In Brachiopods the dorsal, and ventral shells, or plates, are unlike anything we know of in worms. Their composition and structure, however, their dorsal and ventral

[1] American Journal Science and Art, Vol. IV., Oct., 1872.

[2] Proc. Royal Soc., London, Vol. VII., p. 32.

[3] The test of this species, when dried, wrinkles and folds together like the scutæ of Lepidonotus.

[4] Journal Linnæan Soc., Vol. VIII., p. 157, pl. 5, figs. 1, 2.

[5] Canadian Naturalist, Vol. V., p. 24.

arrangement, the fact that in Lingula and Discina and allied forms the shells have their borders free all round, while in those that interlock at their posterior margins, there is no ligament to act upon them, as in the lateral shells of the bivalve Mollusk, all these features together preclude the possibility of any comparison between them and the molluscan shell. It is, therefore, more natural to regard the Brachiopod shell as a dense and thickened integument, to be compared to similar regions in the Arthropods and in the worms, simply as dorsal and ventral plates, and from certain considerations to follow, we believe this relationship will be admitted. The presence of nearly fifty per cent. of phosphate of lime in the test of Lingula, both recent and fossil, is a feature peculiar to the hardened integuments of the higher Arthropods, and entirely unlike anything found in the molluscan shell. In the hardened integument of Crustacea, tubular pores exist, which according to Dr. C. De Morgan[1] are organs of general, or special sensibility, as he finds in many cases the tubules surmounted by hairs.

He says, " The shell canals are comparatively fine, more resembling coarse dentinal tubes, but they are lined by a sheath, and have contents prolonged from the vascular layer. The relations of the contents of the tubes to the internal integuments, may be shown by tearing away the latter from the shell, when the contents will often be drawn out of the canals; and it may be seen that they are prolongations of the outer layer of the integument, enclosing the elements of the vascular layer within their cavities."

In the Annelida, also, there appears a system of minute pores, and Kölliker (we copy from Claparède) asks whether they are not homologous to the tubular pores (*porenkanäle* of the Germans) of the Arthropods, or whether they may not be compared to the apertures of the cutaneous glands, such as those discovered by Mr. Leydig in the Piscicolæ. To this, M. Claparède says, positively, that the two categories of pores exists in the Annelida. Those which serve for the discharge of certain secretions seem to exist in all species. He says, furthermore, that the canalicular pores are much smaller, and much closer together, *and do not correspond with glands*, and that they *occur only* in the species with a *thick cuticle*, and not even in all these.

In the test of most Brachiopods, similar minute tubular canals

[1] On the structure and functions of the hairs of the Crustacea. Phil. Trans., London, Vol. 148, p. 897.

exist. They do not open outwardly, at least, not so far as known at present. In the test of *Lingula pyramidata,* they are exceedingly minute, and closely crowded together. Dr. Gratiolet has also observed them in the test of *L. hians.* In Discina I have failed to find them. Dr. Carpenter,[1] who is one of the highest authorities on the subject, states that these tubules are intimately connected with the vascular layer, which sends cœcal prolongations into each one of them. Hancock questions this view, and states that from his observations, the cœcal processes spring from the reticulated layer of the pallial membrane, though he admits the constant presence of corpuscles in the cœca, which strongly resemble the blood corpuscles.

Hancock, in speaking of the tubules, says : "The best mode of investigating these organs is to dissolve the shell, and then they are exposed in various stages of growth, adhering to the margins of the mantle. They are arranged in rows, and are cylindrical, with the distal extremity obtusely rounded, and are pedunculated from the first; the peduncle is long and narrow; the cœca at the extreme edge are small, but rapidly increasing in size backward; the terminal, or enlarged portion, is almost constantly stuffed full with the so-called blood corpuscles. When observed in this way, these organs have very much the character of secerning follicles, but what function they really subserve is difficult to determine; it may be that they have something to do with the growth and reparation of the shell, though it is not easy to understand how. They are probably, as suggested by Prof. Huxley, the homological representations of the vascular processes that penetrate the test of the Ascidian; and if so, it would seem likely that they have lost much of their functional importance; and, in fact, their entire absence in forms closely allied to those in which they are highly developed, augurs that they are not of high functional importance." Albany Hancock, on the organization of the Brachiopoda. Trans. Phil. Soc., London, Vol. 148, p. 837.

See also Prof. W. King, on the Histology of the test of class Palliobranchiata. Trans. Royal Irish Acad., Vol. XXIV, part XI, 1869. In some observations on the early stages of Terebratulina, I found the tubules in the very youngest stages of the shell.[2]

Claparède states that only worms with a thickened integument have those peculiar canals, and not even all these, and accordingly we find in Brachiopods, as worms with a thickened and indurated integument, that while many possess these canalicular tubes, in others they are quite absent.

[1] Proc. Royal Soc. London, Vol. VII., p. 32.

[2] Memoirs, Boston Soc. Nat. Hist., Vol. II.

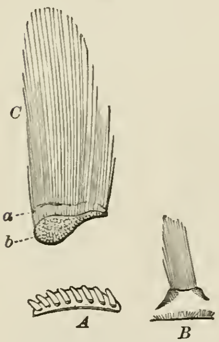
It seems then reasonable to believe that some sort of relation exists between this marked feature of the Brachiopod test, and similar features in the worms and Crustacea. In the Brachiopods these tubules may have undergone some functional change, but until otherwise proved, they must be regarded as a distinct vermian character.

In a large sipunculoid worm from Panama, kindly loaned me by Prof. Verrill, the inner lining membrane sends minute cœcal processes into the integument, which is much thickened. There is possibly here some relationship.

We also find in the Annelida mucous pores. This character must be common to all those animals secreting mucus from the surface, whether Mollusk, or Annelid; and as the peduncle of Lingula is glairy with mucus, we should naturally expect to find them present. This I easily succeeded in doing in living Lingulæ, using a $\frac{1}{6}$ inch objective of Powell and Leland. They were very minute, and closely crowded together. Their presence has never before been observed. The test of Lingula was also very glairy, but whether the mucus, which appeared to cover it, was exuded from the test, I could not determine.

Setæ.

Fig. 9.



Chiton spiculosus Gray.

A. side view of Chiton, magnified. *B.* side view of one tuft of bristles in the girdle. *C.* a tuft of bristles largely magnified. *a.* line of girdle. *b.* base of tuft.

In Mollusks, locomotion is effected mainly by a special organ, the creeping disk or "foot." There is never secreted hairs, spines or setæ.

In the embryo of some Lamellibranchiates, there is said to occur two or three little spines, which are arranged along the ventral median line.

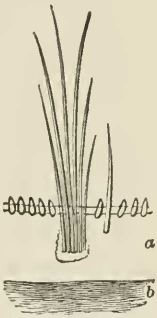
In some species of Chitons, tufts of stiff spines issuing from the girdle have long been known.

Whether these spines are homologically related to the setæ of worms, remains to be seen. From a cursory examination of them, they appear to be modifications of the minute pavement-like granules that occur in the girdle of many Chitons.

In *Chiton spiculosus* Gray, (alcoholic) from Gaudaloupe, kindly loaned me for examination by Mr. Bland, the tufts of spines readily separated from the girdle; the whole tuft is closely united together, and seems to be almost entirely superficial. The following figures represent an outline of the species, with a tuft separated and enlarged as well as a single tuft, as it appears upon the girdle, showing as well the minute spines which project from the exterior border of the girdle. The bases of the spines in the tuft are abruptly truncated.

A section of the girdle of *Amicula Emersoni* shows the shorter granules, which are but slightly embedded, as well as the longer spines, which are more deeply seated, and one spine intermediate between the long and short ones, which is again only partially embedded. These all arise from the homogeneous cartilagineous portion of the girdle, and do not reach to the muscular layer beneath, from which they are entirely separate. They are therefore probably immovable, save what mobility attends the folding of the girdle.

Fig. 10.



Amicula Emersonii

a. cartilaginous layer. *b.* muscular layer.

In worms, there is found, as characteristic of the higher as well as many of the lower groups, the production of setæ, or bristles, which perform important service in locomotion. Claparède says, in regard to the setæ of worms, that "some authors regard them as enclosed in a sac, which is only an invagination of the integument; others think they are formed in an internal follicle, and only secondarily arise to the surface. This second opinion only is correct. In certain cases (in Hesione and others, for example), the whole bundle issues in a compact form through a single pedal aperture, but in others, the seta has its own orifice; this is the case especially with the flabelliform bundles. The pore from which each seta issues is not previously formed, but is perforated by the seta itself."[1] Mr. Lancaster regards the setæ in the earth worm as secretions of the so-called setigerous gland.

The arrangement of these setæ in worms is usually upon the sides, in two series, above and below.[2] They are moved by muscles, and not only have the power of protrusion, but freely swing back and forth.

A marked feature of the Brachiopods is the peculiar setæ fringing

[1] In Pectinaria, a transverse row of long ones project forward from the head. In Sternaspis, nine bunches project from the borders of each scutum behind.

[2] See translation of introduction to Claparède's paper, Ann. Mag. Nat. Hist., 3d Series, Vol. xx., p. 344.

the borders of the extended membranes. (See Plate I.) As in worms, they are arranged upon the sides and front, in two series, above and below. (See Fig. 7, and compare with Fig. 1) and are also secreted by regular follicles, each seta protruding from the follicle singly, or, in some cases, two or three setæ issuing from the same orifice. In the fixed Brachiopoda, they have only a limited power of motion. In these forms they are very short in the adult, but very long in the young, even much larger than the animal, as I have repeatedly observed in young Terebratulina, Rhynchonella, and Discina; in the latter genus, even exceeding the length of the animal three or four times. In the errantian Brachiopoda, as in *Lingula pyramidata*, the setigerous follicles are entangled in a mesh of muscular fibres, and locomotion is effected chiefly by them; the setæ swinging freely back and forth, the dorsal plate oscillating from side to side, as first noticed long ago in another species of Lingula, by Carl Semper.

In Discina, the setæ are very long, and crowded together. According to Fritz Müller, in the early stages of a species of Discina, from the east coast of Brazil, the animal not only has the power of swimming, but uses the larger pair of setæ thrust out behind, to push itself along. He says these bristles have great freedom of motion, sometimes thrust out horizontally, and again crossed to opposite sides.[1]

In the Annelid Arenicola, the first few anterior segments are setigerous only. They bury themselves in the sand, forming a sand tube, loose and not adhering, a tube which leaves room for the ramified branchia to display, and the setæ, by arching over the branchia, protect them, and prevent the sand in which they are buried, from falling in upon the gills.

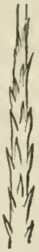
Lingula pyramidata also protects the gills in the same way, as I have repeatedly observed in specimens kept in confinement. When buried in the sand, the dorsal and ventral shells considerably separated, the setæ are brought together in such a position that their extremities meet, and the sand is thus kept back while the water freely enters.

In worms the setæ are often of various kinds in the same individual. A similar diversity is seen in the bristles of Discina. The setæ of the embryo worm are peculiar in being very long, strongly

[1] Reichert and Du Bois-Reymond's Archiv, 1860, p. 72.

barbed, and deciduous. In the young of all Brachiopods thus far observed, the setæ are also very long, as above remarked. And Fritz Müller has shown that in the embryo of Discina there are also remarkably *barbed* setæ of great length, which are *afterward discarded.* Alex. Agassiz has also called attention to the fact, that in Paleozoic worms the setæ were barbed.

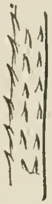
Fig. 11.



Nerine cirratulus.

Deciduous seta of larval worm, *Nerine cirratulus*, from Claparède.

Fig. 12.



Discina.

Deciduous seta of larval Discina, from Fritz Müller.

Tube Building.

The fabricating of sand tubes for the protection of the body is not a characteristic feature of Mollusks. Lima builds a peculiar "nest" in attaching pebbles and fragments of shells together by byssal threads, and imprisoning itself in that way. Gastrochœna also forms a flasked-shape cavity, in which it lives, and from which it has no means of withdrawing. These features in Mollusks may be said to bear only a remote resemblance to the tube building of worms.

In worms, the building of tubes is a prominent feature of several groups, from the lowest to the highest.

Certain Rotifers, after attachment by their caudal portion, fabricate a sand tube into which they retract. (See Fig. 5.)

Many sipunculoid worms occupy the dead shells of Dentalium, Littorina and other shells, and partially close the aperture, and even extend it by a mud tube of considerable density.

Of great importance, however, in these comparisons, is the fact that those worms, which are edentulous, which have the body divided into two regions—the thoracic and caudal, and which have a bi-lobed lophophore, the two arms often appearing spirally twisted, surrounding the mouth, and supporting ciliated cirri, are all famous tube builders. Sometimes the case is gelatinous or chitinous, often the tube is calcareous, deposited in successive lines of growth, and resembling the shell of the Gasteropod ; but more frequently the tube is made of fine sand, mud, bits of shell, and coarsor debris that the builder meets with. When Terebella is kept in confinement in a bowl or dish, it covers the bottom of the vessel with an irregular sand tube. When I first found *Lingula pyramidata* buried in the sand shoals of Beaufort Harbor, North Carolina, I was surprised to find them living free in the sand, and not attached by their peduncle as I had supposed. My astonishment was greater to find that the peduncle was sheathed in a sand tube. When this tube was broken or removed from the peduncle, they promptly formed another one. The shell, nearly to the anterior margin, would often be enclosed in this sand case. When the peduncle was broken off, a bulb of sand would soon be agglutinated to protect the broken end, and not only sand was used, but bits of seaweed; and in one case a little stick was incorporated in this structure.

I brought home with me to Salem, Mass., a number of living specimens, and these were kept alive in large bowls, from June till October, by imitating as far as possible their natural surroundings. They would often protrude above the surface of the sand, and instantly jerk back when alarmed.

On emptying the sand from the bowl one day, great was my surprise to find that all of the Lingulas had covered the bottom of the bowl with large irregular sand tubes, cemented to the sides and bottom of the dish, the tubes running over each other, and presenting precisely the appearance as that produced by Terebella and allied forms when kept in dishes in this way. (See Plate I., Fig. 7.)

In this place it is proper to state that the peduncle of Lingula is highly mobile. When removed from the sand it twists and turns in all sorts of worm-like contortions, and in Plate I., accompanying this paper, some actual sketches are given of different individuals, showing the various contortions of the peduncle, as well as the character of the sand tubes. Fig. 6 shows a portion of the peduncle of *Lingula pyramidata*, drawn from life, showing its annulated character. The direction of the corpusculated fluid circulating through the central cavity is indicated by the arrows.

Muscular System.

In respect to the muscles of the integument, the Brachiopods bear the closest resemblance to the worms.

In worms, the muscles of the integument are arranged in two layers, transverse and longitudinal, producing a reticulated appearance. The same arrangement is distinctly seen in the perivisceral walls of Discina and Lingula, as well as in the peduncle of the latter. In the early stages of Discina, the reticulated appearance produced by the two layers of muscles is particularly noticeable.

The presence of a ponderous dorsal and ventral plate, so peculiar to many Brachiopods, accounts for the extraordinary muscular apparatus to control their movements, as well as to move the body upon the peduncle, in those forms that are attached. This muscular apparatus is unlike anything we find in the worms, though the powerful retractors of many sipunculoid worms, with their broad expanded bases, recall similar features in certain muscles of the Brachiopods. The massive character of the muscles is more like the Lamellibranchiates, save that in the latter the muscles are transverse, and their only function seem to be to close the shell, their relaxation allowing the elastic ligament within or without the shell to force or pull the shells open, as the case may be. In the Brachiopods no such ligaments are seen, the dorsal and ventral plates being opened, as well as closed, by special muscles. In one group of Brachiopods the plates interlock at their posterior margins, and are restricted to opening and closing in a vertical line. In Discina and Lingula the plates do not interlock, and their posterior margins are free, the dorsal one lapping some way over the peduncle; it can therefore swing freely back and forth, or oscillate from side to side, as observed by Carl Semper in *L. anatina*, and by myself in *L. pyramidata*, in its acts of crawling, or burying itself in the sand. (See Plate I., with references.)

Perivisceral Cavity and Circulatory System.

In the higher worms, the perivisceral cavity is lined by a delicate membrane noticed by Rathke, Quatrefages, Claparède, and others. Delle Chiaje designated it the *tunica peritoneale.*

In some worms having a rudimentary vascular system, according to Claparède, this membrane is ciliated, and prompts the circulation of the perivisceral fluid. This fluid in worms appears to be corpusculated and nutritive blood. Most worms appear to possess an extensive vascular system which contains a colored, but not a corpusculated fluid ; this is the pseudo-hæmal system of authors.

In Brachiopods, also, the perivisceral cavity is lined by a delicate membrane, which in Terebratulina and Rhynchonella is strongly ciliated, as I have plainly observed in living individuals.

In Lingula this membrane appears to extend into the pallial sinuses, as is probably the case with other Brachiopods. At all events, the circulation in Lingula is induced by ciliary action, as can be plainly seen through the transparent shell of *Lingula pyramidata*, and this fluid is that of the perivisceral cavity, and is corpusculated.

Carl Semper,[1] in his studies of *Lingula anatina*, says, that in that species there is no heart proper, and that the blood is propelled through the vessels by vibratile cilia. As early as the year 1862, he gave particulars, and has repeatedly insisted upon this anomalous state of things.

To John B. Macdonald, however, belongs the credit of first calling attention to these peculiarities in Lingula.

In the year 1861, Mr. Macdonald[2] announced the discovery "of a determinate circulation of spherical and violet-tinted corpuscles in all the ramifications of the pallial sinuses, not dependent on the contractions of a pallial cavity, but upon the undulations of a ciliary lining."

The vascular system described by Hancock, with a vessel upon the dorsal surface of the intestine, I have never succeeded in studying satisfactorily. In *Lingula pyramidata* I have not been able to find the vescicle upon the back of the intestine, but the vessel I have clearly made out. In Discina I have made out the vescicle. This difficulty of finding a heart has been shared by others. Carl Semper could not find it, and Dr. Lancaster in the February number of the Annals and Magazine of Natural History for 1873, p. 93, says in regard to *Terebratula vitrea*: "I entirely failed to convince myself that the organ regarded by Mr. Hancock as a heart really has the function of one in *T. vitrea*. I repeatedly opened fresh specimens with rapidity, in order to witness its contractions, if any, but never saw such contractions ; nor could I find vessels in connection with it, nor evidence that it had muscular walls. Dr. Krohn, of Bonn, had equally been unable to obtain evidence that this curious little dilatation has the function of a heart."[3] From injected specimens of Lingula, and from observations on living Terebratulina and Rhyncho-

[1] Zeitschr. für Wissensch. Zoöl., XIV., p. 424.

[2] On the Physiology of the Pallial Sinuses of the Brachiopoda. Trans. Linnean Soc. XXIII., p. 373, plate XXXV.

[3] In a late study of living Terebratulina I observed a distinct circulation going on in the sinuses of the pallial membrane, but whether these currents were induced by ciliary action I failed to make out. The fact, however, that the delicate membranes in the perivisceral cavity are clothed with cilia, I clearly established.

nella, the various membranes, called by Huxley and Hancock the gastro-parietal, ileo-parietal, and lateral parietal bands, are found to be vascular, and the circulation taking place within these membranes may be looked upon as representing the pseudo-hæmal system of authors.

These membranes intimately invest the oviducts, and in Rhynchonella the circulation of this system can be seen following the spaces between this membrane and the outer walls of the oviduct.

The red corpuscles in Lingula occur in the perivisceral fluid. Other bodies of a fusiform shape, some elongated and others nearly round, are also met in the perivisceral fluid. These are amœboid in their appearance, and may be seen bending and turning as they course through the more delicate ramifications in the pallial membrane.

All these features I hope to figure in my memoir, now in preparation, on Lingula. The colored corpuscles are similar to those which occur in the perivisceral fluid of the Sipunculoid worms, as well as in Glycera, and other worms, noticed by Claparède.

According to Lacaze-Duthiers, the two systems of circulation are remarkably distinct in Bonellia and Sipunculoid worms, and he queries whether the Brachiopods *do not possess the same two systems.* Claparède says: "L'immense majorité des Annélides ne présente pas de mouvement ciliare dans la cavité périviscérale, sauf à l'entrée des organes segmentaires. Je ne connais, pour ma part, le vêtement ciliare périviscéral que dans les groupes suivants: chez tous les Aproditiens, chez tous les Glycériens, chez tous les Polycirrides, chez les Tomoptéridiens, et enfin chez une petite Térébelle assez anormale (*Terebella vestita*). Chose frappante, toutes ces Annélides, à l' exception de la petite Térébelle et de l'*Aphrodita aculeata*, sont complétement dépourvues de vaisseaux. Or, de ces deux exceptions, l'une, l'Aprodite, est un animal à système vasculaire dans tous les cas rudimentaire, appartenant à une famille d' ailleurs toute anangienne, l'autre, la Térébelle, appartient à une famille en général vasculaire, mais dont une tribu cependant, celle des Polycirrides, est anangienne. Je dois, en présence de ces faits, regarder le mouvement ciliare périviscéral comme une fonction vicariante de la circulation, chez les Annélides dépourvues de système circulatoire proprement dit."[1]

[1] Mém. de la Soc. de Phy. et Hist. Nat. de Genève. Tome XIX., 2d part, p. 329.

In the Brachiopods, therefore, particularly in Lingula, where the vascular system appears to be quite rudimentary, the presence of a ciliated perivisceral coat is to be expected.

It must be confessed that much work has yet to be done in clearing up the obscurity which still exists in regard to the circulatory system of the Brachiopods. What little is known about it, however, points to vermian affinities.

Digestive System.

In worms, the digestive tract usually takes a direct antero-posterior course without convolutions. There are, however, marked exceptions to this rule.

In the Sipunculoid worms, the intestine is not only convoluted, but in many of them the anus terminates in front. In a curious worm, described and figured by Philippi,[1] under the name of Hæmenteria, an anterior vent is described.

In those remarkable worms, Phoronis and Crepina, whose external outlines in every particular so closely resemble the Hippocrepian Polyzoa,[2] the anus terminates in close proximity to the mouth.

In the Acanthocephali, the digestive tract is said to open into the general cavity of the body in some, while in others it ends in a cœcal sac.

In Temnocephala,[3] a Trematode worm, the cœcal processes from the stomach are much like those in young Brachiopods.

Among the Rotifera, in some groups the female has the œsophagus terminating in a cœcal stomach. The anus, when present, terminates anterior to the caudal portion. The Turbellarians are also devoid of an anus.

The anomalous features here presented by some worms, in the absence of an anus, or the possession of a cœcal stomach, and the anterior termination of the anus, are fully repeated in the Brachiopoda. In one entire division of the Brachiopoda, represented by Terebratula, the stomach terminates in a cœcal sac. In Terebratulina the alimentary tract is closed posteriorly. Nor has the slightest

[1] Acad. delle Sci. di Torino, series II, tom. x.

[2] In Phoronis the oviducts with bilateral openings also terminate in front. Its bilobed lophophore, reddish circulating fluid and embryonic stages all resemble the Brachiopoda. In fact, Phoronis represents an important connecting link between the Polyzoa and the worms.

[3] Zeitschrift für Wiss. Zoöl., Vol. xx, p. 307.

trace of an anus has been detected in Thecidium, Waldheimia, Rhynchonella, and several other genera that have been examined. In the very early stages of Terebratulina, I have seen the rejectamenta escape from the mouth, and in no case has the appearance of an anal perforation been discovered. In Terebratulina, the alimentary tract pursues a direct antero-posterior course without convolutions, while in Lingula and Discina the anus terminates anteriorly on the right side. In Lingula, the intestine makes a few turns, while in Discina it makes a single turn to the right.

In many worms, diverticular channels often spring from the lateral walls of the intestine. In certain worms the liver appears as protrusions of the alimentary canal.

In Brachiopods the liver is composed of masses of cœcal ramifications which in young Terebratulina, Rhynchonella and Discina, commence as simple diverticular channels of the stomach.

In *Lingula pyramidata*, an examination of these cœca to their extremities revealed the presence of diatoms and other food, showing that the contents of the stomach enters these diverticular processes, and that the process of digestion is carried on in these parts, as in the lower worms. The fact that in young Rhynchonella, a distinct *peristaltic action* is seen going on in the hepatic cœca strengthens this supposition. While the brown hepatic lines are arranged parallel to the longer axis in the cœca in Terebratulina, in Rhynchonella they are curiously arranged in a spiral manner.

In the higher worms, the intestine is freely suspended in the perivisceral cavity, and held there by delicate membranes which spring from the parietes of the body. (See Fig. 1.)

In Brachiopods, the intestine is likewise suspended freely in the perivisceral cavity by delicate membranes which. spring from the parietes of the body. These membranes were called by Huxley, the gastro-parietal, ileo-parietal, and lateral parietal bands. (See Fig. 7.)

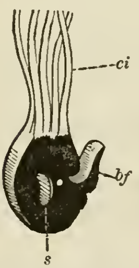
Cephalic Region.

In many of the tubicolous Chœtopods, as well as in Phoronis, the head is furnished with a tuft of ciliated cirri. Sometimes these appear to surround the mouth in a single circle, as in the marine Polyzoa, and in certain fluviatile forms. In others, they spring from arms, spreading like two fans in some, while in others, each arm is developed into a closely wound spiral of several turns. These spring from what has been called a cartilaginous base. In *Protula media* Stimpson, each arm makes a single graceful turn. The cirri springing from these arms, are often highly and beautifully colored, sometimes each cirrus is banded with brown.

In those with a closely wound spiral arm, as in *Amphitrite ventrilabrum*, the outer margin of the arm at the base of the cirri, is bordered by a delicate membranous frill, possibly corresponding with the calyx in Polyzoa, but precisely identical with the brachial fold in the arms of the Brachiopoda, as will be seen by reference to the sections to be presently given.

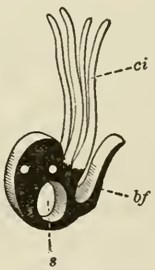
In the Brachiopods, the two arms springing from the head are to be directly compared to similar parts just described in the worms. They also spring from a cartilaginous base, and sustain ciliated cirri, and in Lingula, Discina and Rhynchonella, they are developed in a closely wound spiral, as in Amphitrite. Furthermore in Rhynchonella, they can be unwound and protruded from the pallial cavity as I had the good fortune to observe in living Rhynchonella from the St. Lawrence.[1] (By instantly dashing the strongest alcohol upon the specimen, I was enabled to preserve it with the arms extended.) In Lingula the arms can be partially unwound, and what is very significant, the cirri in *Lingula pyramidata* are banded with light brown, as in certain species of Sabella.

Fig. 13.



Transverse section of arm of *Amphitrite ventrilabrum.*

Fig. 14.



Transverse section of arm of *Lingula pyramidata.*

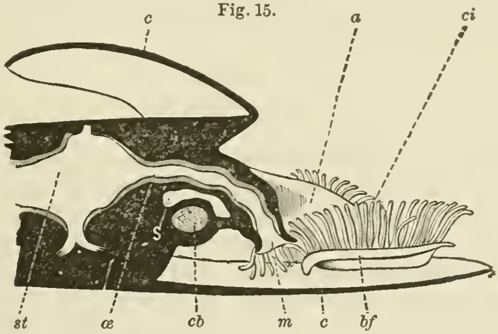
ci. cirri. *bf.* brachial fold. *s.* sinus.

The cirri in Brachiopods show a rapid circulation through their transparent walls. They are employed to secure particles of food, which they convey to the mouth, and in every respect they are strictly identical with similar organs in the Annelids. A transverse section of the right arm of *Amphitrite ventrilabrum*, Fig. 13, and of the right arm of *Lingula pyramidata*, Fig. 14, is here presented. These sections are, in each case, taken midway between the base and extremity of the arm. They much more closely resemble each other, than corresponding sections of two Brachiopods resemble each other.

[1] Am. Journ. Science and Arts, Vol. IV, Oct. 1872. Otto Frederic Müller, according to Von Buch, also saw Rhynchonella gracefully uncoil its arms.

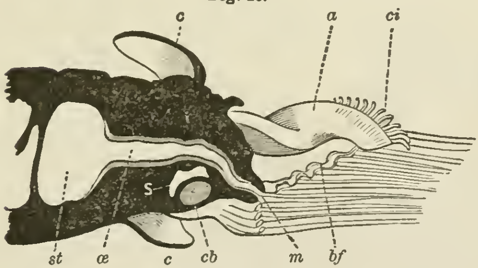
In Lingula the brachial sinus is quite large, while in Amphitrite, it is smaller. The brachial fold in the former is wider. The differences between the two, however, are differences of porportion of parts simply. In certain Polyzoa, just as in that curious worm, Phoronis, the cirri spring from a horse-shoe-shaped lophophore, hence they are called hippocrepian Polyzoa. In the early stages of Terebratulina, I have shown that at first the lophophore is circular, as in the lower Polyzoa, and afterwards the hippocrepian character reveals itself.[1] It was important to learn whether the mouth opened between the

Fig. 15.



Longitudinal section of anterior portion of Lingula.

Fig. 16.



Longitudinal section of anterior portion of *Amphitrite ventrilabrum*.

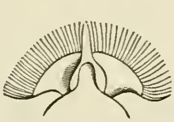
m. mouth. *œ.* œsophagus. *st.* stomach. *a.* arm. *ci.* cirri. *bf.* brachial fold. *cb.* cartilaginous base of arm. *s.* sinus leading to arm. *c. c.* cephalic collar or pallial membrane.

[1] Morse. Early Stages of Terebratulina. Mem. B. S. N. H., Vol. 1. These observations have since been confirmed by Dr. E. Ray Lankester in Annals Mag. Nat. Hist., February, 1873, on the young of *Terebratula vitrea*.

outer and inner folds of the arms, in those worms possessing these appendages, as in the Polyzoa, Phoronis, and the Brachiopods. I sought in vain the works of Claparède, Quatrefages and others, for a figure of a longitudinal section through the mouth of some worm of this character. Mr. Alex. Agassiz kindly gave me a large specimen of the *Amphitrite ventrilabrum*, from the Bay of Naples, and I made a careful longitudinal section through the head (Fig. 16). The right arm was developed in a closely wound spiral of several turns, and greatly exceeded the length of the left one. I have shown the latter, however, as it presents a clearer view of the twist and character of the arm, as well as the crenulated membrane, or brachial fold which borders the base of the cirri. In this section, as well as in the accompanying one of *Lingula pyramidata*, the cirri are partially removed, as they form a confused tangle, and thus obscure the parts that are desired to be shown.

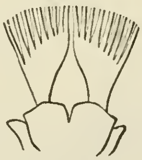
The mouth is bordered by two membranous lips, which in the Brachiopods are highly sensitive and movable in all those thus far examined. The mouth in Amphitrite, as well as in other worms of that nature, is placed in the same relation with the head, and points downward, as in the Brachiopoda. The almost membranous shells have been removed, and the dorsal pallial membrane is turned back, to correspond in position with the dorsal cephalic collar in Amphitrite, which is normally turned back, as in Sabella and Serpula. In other respects the sections are correct drawings of their leading features, and are in no way modified to resemble each other. I have lettered the parts alike, and their almost absolute identity may be readily seen without further comments. The relations insisted upon as existing between the cephalic collar of the Annelids possessing it, and the pallial membranes of the Brachiopods, are well shown in these sections. Even the relative position of the base of the dorsal cephalic collar in the worm, corresponds to the same parts in Lingula and Discina, the dorsal one springing from the head in advance of the ventral one. See also Fig. 8, p. 14.

Fig. 17.



Head of Discina.

Fig. 18.



Head of Sabella.

Figures are here given of a young Discina, Fig. 17, and of a

Sabella, Fig. 18, to show the similarity of the cephalic arms in the two. In one the portions are concentrated, while in the other they are drawn out.

Dr. E. Ray Lankester,[1] in an exceedingly interesting sketch of *Terebratula vitrea*, compares its arms and cirri, to the gills of a Lamellibranchiate. In this comparison he is certainly wrong, for the gills of the Lamellibranch develop upon the sides, and in Sphærium and other genera, towards the posterior end; while the cirri, with the arms sustaining them in the Brachiopods, are strictly cephalic. Had he compared the arms of the Brachiopod with the membranous palpi of the Lamellibranch, he would have come nearer the true affinities, for these form folds above and below the mouth, are united partially on their inner margins as I have observed in Unio and other genera, and in some species are very long.

Renal Organs.

Claparède has noticed that in the segmental organs of many worms a portion of the tube is glandular, and he has reason to suppose that the glandular portion represents the renal organ. Whether Claparède is right in his conjectures or not, it is interesting to recall the fact that years previous to this statement, Huxley suggested that the glandular portion so very conspicuous in the oviducts of Brachiopods was of a renal nature.[2]

The slightest examination of the oviducts of Brachiopoda shows the tubular portion not only glandular, but colored, as in the oviducts of worms. This portion is also intimately connected with the vascular system, and whether renal in its nature or not, the closest similarity exists between these portions and similar parts in the segmental organs of Annelids.

Nervous System.

The general plan of the nerve system in the Vermes appears to be that of a nerve collar surrounding the œsophagus, sending off a ventral cord in a median line of the body. In the lowest worms there seems to be simple cephalic ganglia without the ventral cord. In Sipunculoid worms a single cord running along the ventral portion of the body sends off delicate threads at right angles to it. In the higher worms the ventral cord is longitudinally divided into two symmetrical halves. In some worms there appears only a slight space

[1] Annals and Mag. of Nat. Hist. Vol. XI, Fourth Series, No. 62, p. 93.
[2] Hancock, ibid., p. 822.

separating the two halves; in others the ventral cord is distinctly separated, but united at each segment by transverse threads, as in Sabella, or its two halves may be united by ganglionic enlargements, which sometimes correspond to the number of segments. In the Hirudinæ the ventral ganglia are fewer in number than the segments. In Aphrodite and Polynoë, according to Grube, there are more ventral ganglia than segments.

It was at one time believed to be typical of the Articulata that each segment was characterized by a ganglionic enlargement of the ventral cord, and it was supposed to be particularly so with the higher Annelids. Claparède calls attention to the fact that this is not so in all cases, *and especially in relation to the cephalic and thoracic ganglia.*

In the Nemerteans the ventral cord is widely separated, and runs along each side of the body, and without ganglionic enlargements. There appears to be, therefore, various conditions of the nervous system, in which there is in some a simple œsophageal collar; in others, a ventral nerve cord, which may be single, or divided into two lateral halves, sometimes widely separated, sometimes nearly approximating, with, or without, ganglionic enlargements or threads connecting them. In some worms accessory pedal ganglia are found.

In the Brachiopoda we have two lateral ventral cords, widely separated, and connected at the œsophagus by ganglionic enlargements, which send off threads to the pallial membranes, and to the various muscles.

In Lingula these lateral threads seem to be double, connected by commissures. In Discina, whose nervous system I have more especally studied, the nerve cords are bilaterally symmetrical, and widely divaricating. There are no ganglionic enlargements during their course to the posterior end of the body, but in their track sending off delicate threads, which in Lingula blend with their muscular fibres, or pass round the muscles blending with their exterior fibres. In Discina these lateral nerve cords terminate by ganglionic enlargements in the last two posterior muscles. These nerve cords were correctly interpreted by Cuvier and Owen though mistaken for arteries by Hancock. This error was corrected by Dr. Gratiolet, in his study of *Lingula hians*;[1] and while studying Discina, before becoming aware of Gratiolet's researches, I found these supposed

[1] Jour. de Conchyliogie. 2 Serie. Vol. IV, p. 162.

arteries to be nerve cords, and traced them to their posterior ganglionic enlargements.

Respiratory Apparatus.

The pallial membrane in the Brachiopoda sustains the principal respiratory apparatus. It is in this membrane that the larger vessels occur, and as I shall show in my memoir on Lingula, the pallial membrane is divided into oblique transverse sinuses, which run parallel to each other. From these arise numerous flattened ampullæ, which are highly contractile.

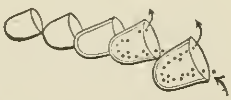
The circulating fluid courses in regular order up and down these sinuses, entering each of the ampullæ in turn.

Vogt and Owen were quite right in their determinations of these organs. They represent the branchiæ of Lingula; but from the contractile nature of the ampullæ, and their almost certain contraction in alcohol, they have escaped the notice of others who have studied specimens in which the ampullæ were inconspicuous.

Thus Hancock was unable to find them in the two species of Lingula, studied by him, and says, "The bladder-shaped enlargements of the lateral pallial sinuses, alluded to by Dr. Vogt, are nothing more than swellings occasioned by the contraction of the pallial, or marginal fold, which, pressing upon the extremities of the sinuses, throw their walls into wrinkles, and hence their peculiar appearance." [1]

These ampullæ are very conspicuous in living Lingulæ. On one side of the dorsal pallial membrane in an ordinary specimen there are twelve sinuses, having in the aggregate eighty-five ampullæ, numbering from five to eleven in each sinus. In life they form very interesting objects. They project, or hang from the walls of the pallial membrane, like teats. Their walls are perfectly transparent, and the circulating fluid can be seen rapidly coursing into, and out of each one in turn.

Fig. 19.



The following figure (Fig. 19) shows a row of five ampullæ drawn from life, within which the blood corpuscles can be seen circulating.

Claparède says that in the normal branchia of an Annelid there cannot be any mixture of arterial and venous blood. The artery travelling as far as the end of the branchia, where it returns as a

[1] Hancock, Trans. Royal Soc. Vol. CXLVIII, p. 852.

vein. He says, "Veine et artère sont exactement parallèles l'une à l'autre. Dans toute la longueur de la branchie, ces deux vaisseaux sont mis en communicateur par une double série d'anses vasculaires qui passent dans la couche sous-cuticulaire et qui subissent avec la plus grande facilité l'action de l'eau chargée d'oxygène à travers la cuticule tres-amincie.'[1]

He denies, however, the independent contraction of the ampullæ, but says there is a rhythmical contraction of the whole branchia, Quatrefages, to the contrary, notwithstanding.

In the family Serpulæ, Claparède finds features remotely resembling the description of Quatrefages, where in these Annelids "l'artère se continue directement dans la veine à la base des branchies, et de leur point de réunion part un vaisseau unique qui pénètre dans chaque rameau branchie." In Discina I have not been able to discover the slightest trace of these ampullæ, though the pallial sinuses are very prominent; and the central partial partition of ciliated epithelium which induces the flow of the circulating fluid in these parts, are as distinctly marked in Discina as in Lingula. In the other Brachiopods the prominence of the pallial sinuses, with their diaphanous walls, must be regarded as a respiratory organ. In all the Brachiopoda the cirri of the arms must also share with the pallial membranes in this function.

Genital Organs.

Under this head we study the ovaries, oviducts, or segmental organs, and spermaries. In the Annelida, according to Claparède, the sexual elements, in course of growth, form ruffs all around the vascular axes.

In all cases the ova, when arrived at maturity, detach themselves from the ovary to float freely in the perivisceral cavity, where they are afterwards gathered up by the ciliated mouths of the segmental organs, and discharged by them.

This is precisely the case in the Brachiopoda. In Discina the borders of the delicate vascular membranes are thrown into conspicuous ruffs by the development of the ova. In Lingula the ovaries are intimately bound to the same membranes. In Terebratulina and Rhynchonella they not only gather about the large vascular sinuses in the pallial membranes, but hang in clusters from the genital bands

[1] Soc. de Phy. et d'Hist. Nat. de Genève. Tome XIX, 2d part, p. 331.

in the perivisceral cavity. In all these cases the eggs are discharged freely into this cavity, and there float in the perivisceral fluid until they are discharged from the body.

If we now consider the ducts by which these products in the Brachiopoda find egress from the body, we shall find a startling identity of structure with similar parts in the Annelida.

In all worms, with few exceptions, these ducts assume the shape of tubes, bilaterally disposed, suspended in the perivisceral cavity by delicate membranes, and communicating with this cavity by flaring orifices, which are strongly ciliated, as well as the tubes themselves, to their external orifices; the ciliary action always directing the currents out of the body. These are the segmental organs, or oviducts.

According to Claparède, the segmental organs in the Annelida present only very simple modifications of a *very constant type.* In a large number of worms, these segmental organs are repeated many times, a few of them only modified as oviducts. In other worms they are reduced in number; in Branchiobdella, according to Dorner, to two pair; in *Terebella parvula* to three pair, as Dr. Williams states. In Protula,[1] Spirorbis, Sabella, and allied forms, a single pair of segmental organs, modified as tubiparous glands are found in the anterior part of the thorax.

In Phoronis the ovarian openings are reduced to a single pair, and these open at the extreme anterior surface of the body between the arms, from which the eggs escape after having been discharged from the ovary into the perivisceral cavity. In the Brachiopoda the ducts, by which the generative products find egress from the body must be described in precisely the same terms as those used in describing the segmental organs of the Annelids. The ducts assuming the shape of tubes, bilaterally disposed, suspended freely in the perivisceral cavity by delicate membranes, and communicating with this cavity by flar-

[1] The tubiparous glands, according to Claparède, represent modified segmental organs. In *Protula* (*Salmacina*) *ædificatrix*, Claparède represents the tubiparous glands as opening by a common pore, as in Spirorbis. A careful study made by me of a species of Protula (probably *P. Dysteri* Huxley) at Eastport, Me., showed the wide separation of these glands, and the fact that they opened by two distinct pores, thus bringing them nearer the Sabellarians.

The minute structure of these glands, revealed a sinuous line rapidly undulating, following the inner outline of the gland. This appearance appeared due to ciliary action. Other features were presented by these curious organs, which led me to believe that other functions were performed by them beside that of secreting the tube. Their relations to the segmental organs were unquestionable, however.

ing orifices, which are strongly ciliated, as well as the tubes themselves, even to their external orifices, the ciliary action always directing the currents out of the body.

The concentrated character of the Brachiopods, and the limited perivisceral cavity, reduce the segmental organs, or oviducts, to the lowest number, and consequently we find in most of them but a single pair, as in Lingula, Discina, and Terebratulina, while in Rhynchonella two pair of oviducts are present. It is significant to note that in the last named genus both pair of oviducts have their inner mouths turned toward the back.

In a special memoir on the oviducts of Brachiopoda, now in preparation, I shall demonstrate the unquestionable character of these organs.

Having studied them in living Lingula, Rhynchonella and Terebratulina, and in alcoholic Discina, I find them presenting only simple modifications of a constant type.[1]

In Terebratulina the eggs were watched through the transparent anterior walls, after their separation from the pallial sinuses. While floating in the perivisceral cavity, they were seen gathered up by the flaring ciliated mouths of the oviducts, and were followed, as they slowly passed through the tubes, and caught as they escaped from the external orifices.

In Lingula, Discina and Rhynchonella, the external orifices of the oviducts are simple slits, while in Terebratulina they project from the anterior parietal walls, like tubercles, as figured by Claparède in the Annelid *Lepidonotus* (*Hermadion*) *fragile.* The glandular nature of the oviducts, and their striking resemblance in this respect, to similar parts in the worms has been alluded to under *Renal Organs.*

The following figures of the oviducts of Brachiopods, from my own studies, and the oviducts of certain worms, as figured by Claparède and Lancaster, are here given for comparison.

Having considered that portion of the genital system referring to the ovaries and oviducts, and shown their entire vermian character, we come to study the male organs of generation, and in this line of investigation we have to push into an almost untrodden field.

The Brachiopoda have been regarded by some authors as diœcious, the vascular sinuses presenting ovaries or testes, according to the sex

[1] Morse on the Embryology and Oviducts of Terebratulina. Am. Jour. Sci. and Arts. Vol. IV, p. 262.

Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

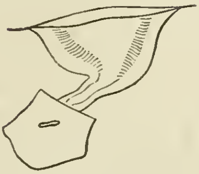
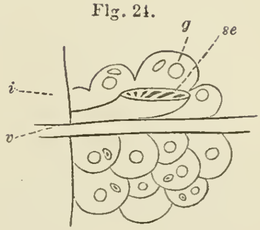


Fig. 24.



Segmental organs of Worms

Fig. 20. Lumbricus. Fig. 21. Pectinaria. Fig. 22. Eunice. Fig. 23. Stylodrilus. Fig. 24. Nereis. *se.* segmental organ. *g.* genitalia. *v.* vascular channel. *i.* intestine. Fig. 20 is from Lankester, the rest from Claparède.

Fig. 25.

Fig. 26.

Fig. 27.

Fig. 28.

Segmental organs of Brachiopods.

Fig. 25. Discina. Fig. 26. Lingula. Fig. 27. Rhynchonella. Fig. 28. Terebratulina. These figures are from my own studies.

of the individual. Hancock[1] however was inclined to believe the sexes united in all the forms coming under his observation. Oscar Schmidt[2] also says that in Terebratula the testicles and egg stocks are united in the same individual.

After patient study of these parts, I believe that in all the Brachiopoda the sexes will be found to be separate. In Lingula the spermaries occur in the perivisceral cavity, in masses like the ovaries. Having studied them alive it was found that while in some individuals the ovarian masses nearly filled the perivisceral cavity, in others spermaries occupied similar positions.

As Discina presents precisely the same characters in the ovaries springing from the vascular membranes, and filling the perivisceral cavity, it is reasonable to suppose that the spermaries correspond in position with those of Lingula.

A careful study of Terebratulina, lately made during its breeding season, shows also that in this form the sexes are distinct. While some specimens revealed the vascular sinuses filled with eggs, and even where the eggs had escaped by dehiscence the scars could be seen, in others the sinuses showed no traces of eggs, but on the contrary were filled with a creamy mass, slightly granulated, the borders of these masses being highly ciliated, and when crushed or separated under the compressor, bunches of spermotozoa and single ones were revealed. This probably represents the ovigerous mass of Hancock.

In several females examined, the eggs were attached in clusters to the genital band, even to the very edge of the mouths of the segmental organs. And in several males the spermaries were likewise attached in clusters to the genital band, and in such masses and so close to the segmental organ that the accessory vesicle of Huxley was obscured by them.

The masses of spermaries adhering to the genital band, and floating free in the pervisceral cavity, presented some curious features. They assumed the shape of long filiform appendages, attached by common centres to the genital band, and surrounded by an almost imperceptible cellular mass. The threads widened gradually to their distal extremities where they ended bluntly, and were capped with a few large brownish cells. The spermatozoa were thickly clustered in blunt fusiform masses at the extremities of the threads, forming a sort of brush. The same brownish granules appeared in the sinuses,

[1] Hancock, ibid., p. 824.

[2] Zeitschrift für ges. Naturwissenschaften, 1854, p. 325.

and likewise tipped the clusters therein contained, only these clusters were not supported on long threads, as in those which sprang from the genital band in the perivisceral cavity. The glandular portion of the segmental organ in the male appeared much darker than in the female. As Rhynchonella presents similar features in the ovaries contained in the pallial sinuses, we believe that the spermaries will be found in like positions.

In this connection we must also consider the accessory vescicles of Huxley (accessory hearts of Hancock). After careful study of these minute organs from a large number of living specimens, I am convinced that they do not bear Hancock's interpretation, and that they properly belong to the genital system and not to the circulatory system as stated by him. Hancock describes the walls of the "accessory hearts" as more delicate than the walls of what he regards as the central dorsal heart. This is certainly not so in regard to Terebratulina. In *T. septentrionalis*, the organ presents all the appearance of a gland. The walls are thick and glandular, in fact, no sure evidence of a cavity within has yet been met with. It is irregularly pyriform in shape, slightly flattened, and in some is attached by a very constricted neck to the genital band just beneath the flaring margin of the mouth of the segmental organ.

The exterior wall is made up of prominent transparent cells; at the base of the gland, and also on its walls, masses of yellowish granules in patches appear. On the genital band also I have seen irregular masses of cells, presenting all the appearances of the accessory vescicle. Repeated observations failed to detect any vascular communication with the band to which it is attached, not the slightest trace of circulation within its walls has been observed, nor the slightest evidences of dilatation or contraction, nor evidence of muscular fibre. I have repeatedly crushed it beneath the compressor, yet no signs of forcing out contents has been observed. Moreover the organ differed in appearance in different specimens, and even differed in appearance in the same individual upon the right and left sides of the body. With the idea at first that the sexes were united in Terebratulina, I was inclined to regard them as the testes, since they always occur in the immediate vicinity of the segmental organs.

Where a single pair of segmental organs occur, as in Terebratulina, two accessory vescicles occur, one to each segmental organ. Where two pair occur as in Rhynchonella four accessory vescicles are found likewise; one accompanying each segmental organ. In Lingula, and Discina, though the segmental organs are large and conspicuous, and their study rendered comparatively easy, yet in no case has the accessory vescicle been met with. So far as we know then, the accessory vescicle occurs in Rhynchonellidæ and Terebratulidæ, or in those groups with the dorsal and ventral plates interlocking. which have no anus, and in which the ovaries are contained in the vascular sinuses of the pallial membrane. The accessory vescicles do not occur in Lingulidæ or Discinidæ, or in those groups having the dorsal and ventral plates free, possessing an anal outlet, and which have the ovaries entirely free in the perivisceral cavity. That they have nothing to do with the circulation is evident from the fact that a portion of the pallial membrane separated from the animal, shows the circulation going on as usual. The vascular bands are also strongly ciliated, and in Terebratulina, as in Lingula, the perivisceral circulation is probably induced by ciliary action.

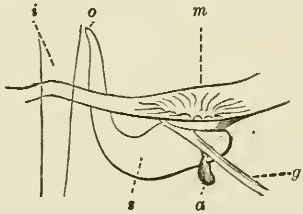
That the accessory vescicles, then, belong to the reproductive system, and not to the circulatory system, there can be no doubt, but just what their function may be, has yet to be discovered.

I copy from that inexhaustible work of Claparède, the Annelids of the Gulf of Naples, a figure of the segmental organ of *Alciope Cantrainii*, and accompany it with a figure of the segmental organ of *Terebratulina septentrionalis* with its accessory vescicle attached in the same position. There is at least something suggestive in the relations of the two figures, though by this suggestion I would not throw doubt on Claparède's determinations. With the impression that the sexes were united in Terebratulina, I was inclined to regard

Fig. 29.

Segmental organ of *Alciope Cantrainii*. *m*. inner mouth of segmental organ. *o*. external orifice of ditto. *t*. testes.

Fig. 30.



Segmental organ of Terebratulina. *s*. segmental organ. *m*. inner mouth of ditto. *o*. external orifice of ditto. *g*. genital band. *a*. accessory vescicle. *i*. intestine.

the external parietal glands discovered by me as representing the testes. With the identification of the spermaries as above described, and the consequent separation of the sexes, we must seek for another interpretation of the glands. As they are extremely mucous, and intimately surround the external tubular orifices of the segmental organs, the egg cannot possibly escape without first coming in contact with whatever substance these glands may secrete, and it is highly probable that they are instrumental in investing the egg with some external coat. The glands are very white in color, and are filled with minute granules which I at first mistook for spermatozoa. It is interesting to observe that they are present in both sexes, but what service they do in the male it is impossible to conjecture.

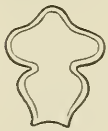
In connection with the external parietal glands, it is interesting to recall the capsulo-genous glands as described by Dr. Lankester[1] in the common earth worm. He says "Besides the regular glands developed on the parietes of the body, the earthworm exhibits numerous glands destined to form the egg capsule, in which both zoösperms from the spermatic reservoirs, and ova are deposited, These glands were first detected by D'Udekem. . . . The white color, and thick fleshy look which is sometimes observed about the exterior of these segments, is due to the developement of the capsulo-genous glands. Whether the capsulo-genous glands have everything or anything to do with the formation of the egg capsule is very difficult to determine; but the supposition of M. D'Udekem is so plausible, and comes from so good an authority, that it cannot but be received until absolutely disproved."

Embryology.

It seems a little remarkable that of the class of Brachiopods, upon which so many admirable memoirs have been written, so little should still be known about the embryology, or early stages of any of its forms. Yet all that has been done, thus far, to shed any light on this portion of their history, points to the unquestionable vermian characters of the class.

The earliest paper on which we find any reference to the embryonic form of the Brachiopod is by Oscar Schmidt, contained in the "Zeitschrift für ges. Naturwissenschaften," 1854 p. 325. He gives the following figure of the larval form of a species of Terebratula. (Fig. 31.)

Fig. 31.



Embryo of a Brachiopod.

In this figure the body shows a deep constriction in the centre, the lower end is abrupted truncate, as if that were to be the point of attachment. If that is the case it would correspond to certain Rotifers which also attach themselves by the posterior segment of the body.

(See Fig. 5 of Rotifer, on page 11, *Melicerta ringens* by Huxley, showing its first attachment by the posterior end, the animal at the same time surrounding itself with a sand case.)

Lacaze-Duthiers was the first naturalist to make known several stages of the embryology of a Brachiopod. In a memoir on Thecidium[2] this author gives several figures of the embryos of this Brachiopod. The body is composed of four deeply constricted seg-

[1] Journal Microscopical Science. Vol. V, 1865, p. 14.

[2] Annales des Sciences Naturelles, 4th Série, Vol. xv.

ments, the anterior one small and running back on the second segment. On one embryo he found two red eye-spots on the first segment, while on another embryo he found four red eye-spots. In the same number of rings, the peculiar form of the cephalic ring, and if Oscar Schmidt is right, the attachment of the embryo by the caudal segment, we observe the closest similarity between the embryo of this Brachiopod and that of *Melicerta ringens*, figured by Huxley.[1]

It will be seen by the accompanying figures of the embryo of Thecidium, copied from Lacaze-Duthiers, and the embryo of *Melicerta ringens*, that in the Rotifer embryo the body is drawn out, while in Thecidium it is condensed.

For several years I have endeavoured to secure some data regarding the embryology of Terebratulina, and in the early summer of 1872, I had the good fortune to find Terebratulina spawning.[2] The eggs were round and ciliated, and had the peculiar pencil of long cilia so peculiar to the embryos of many worms. The body was gradually cut up into three deeply constricted segments, and these at a later stage had the characteristic vermian contraction, the rings shortening upon themselves and then gradually expanding. Though I made several hundred drawings from fifty different embryos, yet

[1] Jour. Mic. Soc., Vol. I.

[2] Since this paper was in type, I have again visited Eastport, Maine, and have had an opportunity of studying the embryology of Terebratulina under more favorable circumstances. I have only room here to state that after swimming actively for a while the segmented embryo becomes attached by the caudal segment which is to be the peduncle, the middle or thoracic segment increases in diameter, one portion becoming more prominent; the first or cephalic segment continues to move and bend on the thoracic segment. Meanwhile the thoracic segment grows rapidly at opposite points, and finally engulfs the first segment by lobes above and below, these lobes being the dorsal and ventral valves. The mouth becomes apparent, and at the same time two groups of setæ make their appearance on the sides and front of the lobes, these are delicately barbed and *deciduous*.

The relations pointed out on pages 29 and 30 regarding the cephalic collar of the Annelids and the pallial membranes of the Brachiopods receives confirmation in this unlooked for simple developement of Terebratulina, and so far as these forms are concerned, we can for the first time state positively that the mouth and arms represent the first segment, the pallial membranes with the shells, the second or thoracic segment, while the peduncle represents the caudal segment.

The first three tubules in the shell are bordered by long delicate hairs, indicating that these are sense organs as in the tubules of certain crustacea, surrounded also by hairs as described by De Morgan, see p. 16. Regarding barbed setæ, see page 21.

These results were communicated to the Boston Soc. Nat. Hist., June 18th, 1873, and will soon be published in their Memoirs.

Fig. 32.

Fig. 33.

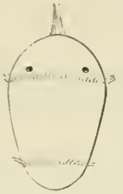
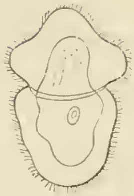


Fig. 34.

Fig. 35.

Fig. 36.



Embryos of Worms.

Fig. 32. Serpula. Fig. 33. Spio. Fig. 34. Melicerta (Rotifer). Fig. 35. Pileolaria. Fig. 36. Phoronis. (Fig. 32 original. Figs. 33 and 35 from Claparède. Fig. 34 from Huxley. Fig. 36 from Dyster.)

Fig. 37.

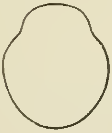


Fig. 38.

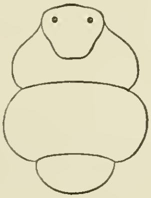


Fig. 39.

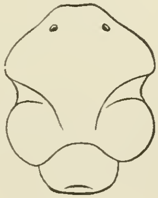


Fig. 40.

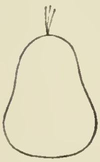


Fig. 41.

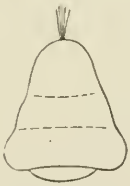
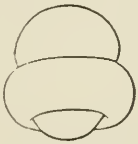


Fig. 42.



Embryos of Brachiopods.

Figs. 37, 38, 39. Thecidium (from Lacaze Duthiers).

Figs. 40, 41, 42. Terebratulina (original).

owing to the difficulty at that time of keeping the water at the frigid temperature they were accustomed to, the embryos all died. I saw enough, however, to lead me to believe that they eventually become attached by their caudal segment.

Thus the three series of observations by Schmidt, Lacaze-Duthiers and myself, on entirely different forms of Brachiopods, show the most perfect vermian development.

In regard to the early stages of Brachiopoda, Fritz Müller[1] has published some interesting observations on the early stages of Discina, which he studied at Santa Catharina, Brazil. The larva is described as having a perfectly orbicular dorsal and ventral plate, the pallial membrane gaping all round, and the dorsal plate freely moving, or sliding back and forth. Five pair of very stiff setæ project from the periphery, two pair forward and three pair backward, one pair much larger and stronger than the rest, and these were coarsely barbed. The posterior half is occupied by the alimentary canal, two auditory vescicles, and two eyes. The anterior half is occupied by four pair of cylindrical tentacles or cirri, strongly ciliated, between which a rounded knob is situated. (Possibly related to the rounded knob in Spirorbis and allied forms.)

The arms or cirri are supported upon a *long retractile neck* or œsophagus, at the forward extremity of which the mouth is situated. The larva not only swims by means of the cilia lining the cirri, but crawls by means of the ventral scale, and pushing itself along by the larger pair of bristles which have a vigorous motion, often crossing behind.

These barbed bristles of Discina, Müller finds, are deciduous, and it is interesting to remember in these comparisons that the larval worm has also coarsely barbed bristles which are likewise deciduous. What could be more annelidan than the description of this larva. It is true there are no larval worms possessing the dorsal and ventral plates, though in that degraded worm Sternaspis there is a pair of ventral plates or scuta, from the edges of which setæ project, and by means of which the worm shoves itself along. (The lines of growth are prominent on these scuta, as in Discina.)

Since then I have received, through the kindness of Dr. Hagen, a letter from Herr Müller, accompanied with a sketch of another larval form of Discina, in which he describes features similar to those

[1] Reichert und Du Bois-Reymond's Archiv., 1860, p. 72. Wiegmann's Archiv. 1861, p. 53.

above mentioned, and states that the species has been defined by Prof. Dunker as *D. radiata*.

The Brachiopods possess other affinities to Rotifera, beside the resemblances between the embryos pointed out above. We give here a definition of the Rotifera condensed from Rolleston's Forms of Animal Life, p. cxxxviii, Class Rotifera, inserting in italics those portions in which some agreement may be claimed.

"Vermes with a *retractile ciliated disk at the anterior extremity of their bodies.* (To be compared to retractile cirri in young Discina.) Usually plainly annulated externally, *never divided internally by transverse septa.* (Except Lingula.) In most Rotifera *entire body divisible into a 'body' proper, and a tail, anterior to which the digestive and reproductive viscera with their ducts are situated.* The body can often be seen when chitinization has not advanced so far as to form a carapace, not only to be distinctly annulated, *but to possess circular and longitudinal muscles in its walls. Cilia are never found on the external surface of the body, except upon the cephalic organ.*

The chitinous surface of the integument may develope setiform outgrowths of various shapes, or the animals may secrete or agglutinate a tube for the lodgement of their bodies. The tail is usually annulated when its integument is soft, (quite marked in *Lingula pyramidata*) or segmented when it is indurated.

(The paired claw-like processes is unlike anything found in Brachiopods. The anus is on the back and not on the side as in Brachiopods. The differences between the sexes is unlike the Brachiopods, though the cœcal stomach as in Ascomorpha, Notommata and Asplanchnia finds a parallel in the cœcal stomach of many Brachiopods. The jaws and gizzard are again different from what has yet been observed in Brachiopods.) *Two or more cœcal appendages are affixed to the commencement of the stomach, which, as also the intestine, is clothed with cilia.* (See Morse, "Early Stages of Terebratulina," and since observed in young Rhynchonella and Discina). The Rotifera have no heart. *The periviseral cavity contains a corpusculated fluid. No specialized breathing organs.* (save the curious ampullæ on the pallial membrane of Lingula.) The water vascular system has five ciliated infundibuliform orifices, (to be compared with the segmental organs in Worms and Brachiopods). The reproduction in Rotifera by means of winter eggs possibly finds a parallel in the statoblasts of Polyzoa."

Features of dissolution.

Believing the Brachiopods to be true worms, every feature of relation, no matter how trivial, becomes important in these comparisons. The mere fact of Lingula pyramidata agglutinating a sand tube is of small moment in itself, since such a feature might of course be a matter of secondary acquisition. The unquestionable fact however, that many groups of worms are notable tube builders, and this peculiarity is almost entirely confined to the worms, the feature of tube building in Lingula becomes a matter of importance in these comparisons. Therefore the points to follow, trivial in themselves, cannot, with justice, be overlooked in these comparisons.

Dr. Williams, in his elaborate work on the British Annelida,[1] in describing the dissolution of Arenicola and Nais, says in regard to the former, that the division occurs somewhere within the middle third of the body, though sometimes the head is detached, and sometimes the tail. This process, both in the Nais and Arenicola, occurs in July or August. The cephalic and caudal portions continue for some time to writhe in the sand. Towards September the fragments disappear by decomposition, the parts turning black. He further says that the sand of the sea-shore, and the water of the fresh water pools are thickly strewn with the mutilated bodies of these worms. "It is a catastrophe which every fall involves the whole community." He believes therefore that these Annelids are annuals. "They are born during the latter months of one summer, and survive the winter, attain the maturity of growth, reproduce the species, and die by the spontaneous subdivision of their body into fragments."

In studying *Lingula pyramidata*, I had come to the conclusion that with this Brachiopod at least, their duration of life did not probably exceed one year. Of over one hundred specimens of Lingula collected by myself in June, and as many more collected by Dr. Elliott Coues in July, I had remarked as a noteworthy fact, that specimens varied but little in size. I did not meet with a single young specimen, or, rather, a single small specimen. Furthermore the shells in all cases presented the same features of newness. There were no erosive or parasitic growths upon them (though late in the fall there is no reason why hydroid growth might not occur on that portion of the shell exposed). This fact, coupled with the absence of even a small specimen, for which I particularly searched, led me long ago to believe that they were all of the same age, and that their life did not exceed one year.

I brought several specimens home with me to Salem, Mass., and kept them alive during the summer months; imitating as far as possible the conditions in which I found them, keeping them in the same sand in which they were collected. They all died within a few days, during the last of September, and in their death they repeated almost precisely the features described by Dr. Williams in Arenicola and Nais. Spontaneous division occurred between the thorax and peduncle. The thorax was thrown out on the surface of

[1] Report of the Brit. Asso. for Ad. of Sci. 1851, p. 248.

the sand, while the peduncle lay embedded in the sand. The thorax lived for a few days in a weak condition, the setæ moving feebly, and the dorsal plate slightly oscillating. This portion finally turned black, and as one after the other perished in this way, I removed them from the vessel, in order that their decomposition might not vitiate the water, and thus imperil the lives of the survivors.

Several days after they had all been removed in this way, curiosity led me to turn up the sand, to find the condition of the peduncles, and judge of my astonishment at finding the perivisceral fluid contained in the peduncular cavity still rapidly circulating in several, though the region at which the separation had occurred was blackened by decomposition. In a few days more this circulation ceased, and decomposition envolved all parts. Here we have the most complete relation between the dissolution of this Brachiopod and that of the Annelid described by Dr. Williams.

Opinions of Authors concerning the Relations of the Brachiopoda.

Naturalists are sufficiently well acquainted with the relations repeatedly pointed out, as existing between the Brachiopoda and Polyzoa,[1] and there is no need of again repeating them here.

It is also a matter of history that the Polyzoa were placed with the Mollusca solely on the relations which were supposed to exist between them and the Tunicates, and afterwards the relations recognized between the Polyzoa and the Brachiopoda.

Again, there can be no question that at the outset the association of the Tunicata with the Mollusca arose from the relations supposed to exist between the external sac or tunic, with the two apertures of the one, and the shells and syphons of the other. Aristotle[2] dwells on this resemblance where he says, in speaking of them as Mollusca, "They are the only kind whose whole body is enclosed in the shell, and that shell of a substance between true shell and leather. They are attached to the rocks by their shell. They have two separate

[1] In the affinities of the Polyzoa with the Vermes, the curious genus Phoronis offers an important link. Claparède thinks the affinities of Phoronis are with the Gephyreans on the one hand, and the Polyzoa on the other. Kowalevesky has discovered that the larva of Phoronis is an Actinotrocha, and possibly the young Sipunculoids that Schneider saw resulting from a transformation of Actinotrocha, are early stages of Phoronis. Certainly no one studying the characters of Phoronis and Crepina can fail to see many very intimate relations between these forms and the hippocrepian Polyzoa.

[2] Fourth book of "History of Animals."

openings, which are very small and difficult to notice; the one to take in, the other to eject the water," etc.

The branchial sac was also believed to be the homologue of the gills of the Lamellibranchiate Mollusk, though Hancock[1] has shown that the branchial sac of the Ascidian is not the anatomical equivalent of the gills of the Lamellibranch, but is a portion of the alimentary canal.

Milne Edwards, in his splendid memoir on the composite Ascidians,[2] in speaking of their molluscan affinities, said that these relations were far less intimate than was usually believed, and that they departed from the Mollusca in their mode of circulation, in the metamorphosis which their fry passed through, and more particularly in the singular feature that most of them possessed in multiplying by gemmation.

Now since the Polyzoa are placed with the Vermes by Gegenbaur and others, and indeed were long ago placed there by Leuckart, while the Tunicates have been assigned to the Vermes by many of the most eminent German investigators, while others still would place them at the foot of the Vertebrate series, it is unnecessary for me to consider the affinities of the Brachiopods through their relations with these groups.

Kowalevsky, Kupffer, Schultze and others, assign the Tunicates a position at the base of the Vertebrate series, through the unquestionable affinities of certain of their forms to Amphioxus, as well as their singular embryological relations with the Vertebrates.[3] In this connection it is instructive to note that Gegenbaur sees a relation between the branchial sac of Balanoglossus, and the branchial sac of an Ascidian.

In the year 1848, the far seeing Leuckart was inclined to believe that the Tunicates formed an *intermediate class between the Echinodermata and the Vermes*, while others traced a resemblance between certain Nemertean larva and the early stages of the Echinoderms, causing Huxley to unite the Echinodermata with the Articulates. And lastly, a Tornaria described by Müller, Krohn and Alex. Agassiz, was taken to be an unquestionable Echinoderm larva. Now thanks to the brilliant investigations of Mr. Agassiz,[4] this Tornaria turns out to be the young of that odd worm Balanoglossus; though Mr. Agassiz finds a wide gap between the Tornaria of Balanoglossus and the Echinoderm young, yet he admits the striking resemblance between the two. He says, "This remarkable type recalls the Tunicates, from the nature of its gills and mode of

[1] Annals Nat. Hist. 4th Series, Vol. v., p. 196.

[2] Memoires de l'Acad. des Sciences. T. XVIII, 1842.

[3] Early Stages of an Ascidian. Proc. Bos. Soc. Nat. Hist., Vol. XIV., p. 351.

[4] The History of Balænoglossus and Tornaria. Mem. Amer. Acad., Vol. IX., p. 434.

formation. It has, like Echinoderms, a ring canal; its larva is eminently Echinodermoid, allied to Star-fish larvæ, which in their turn are more closely allied to the larvæ of Holothurians and Crinoids, than to those of Echinoids and Ophiurians."

Aside from the roundabout way in which the Brachiopods have been entangled with the Mollusca (their preposterous comparisons with Anomia will be considered presently), it is interesting to observe how often certain features of the Brachiopods have been compared to the lower Articulata by those who have made special researches upon them. Thus Dr. Gratiolet,[1] who studied *Lingula anatina*, says the organization of the arms resembles the branchia of certain Crustacea. He also expresses the opinion that the Brachiopoda are allied to the Crustacea in respect to their vascular system, and not to the Mollusca; least of all to the Tunicata. Again, after recounting the peculiar character of Lingula in the annulated hairs, developed from veritable glands, the structure and arrangement of their muscles, their arms and other features, Gratiolet says, the Brachiopods are very far removed from the Lamellibranchs, and have no kind of relation to the Tunicates.

Lacaze-Duthiers,[2] in speaking of the oviducts of the Brachiopods, recalls the fact that in Bonellia (of which he made an elaborate study) there are similar openings, which are the genital openings, through which the visceral fluid can escape. He also queries whether there are not two kinds of circulation in the Brachiopods, as in Bonellia. On the development of the young, studied by himself in Thecidium, he observes points entirely unlike anything existing in the Lamellibranchiates.

Burmeister compared the gills of Lingula to the gills of Lepadæ.

Gegenbaur, in his "Outlines of Comparative Anatomy," points to certain worm-like features in the Brachiopoda, and repeatedly calls attention to their worm-like genitals.

Dr. Williams,[3] in his elaborate work on the British Annelids, calls attention to the outlying affinities of the Vermes, recalling Dentalium, Chiton, Amphioxus, but no where alluding to any approach of the Annelids to the Brachiopods. None of the above authors, however, had ever suggested the removal of the Brachiopoda from the Mollusca, nor had they, or Owen, Vogt, Huxley or Hancock, ever made the slight-

[1] Jour. de Conch. 2d Series. Tome II, pp. 237, 252, 257.

[2] Annales des Science Naturelles. 4th Series. Tome XV.

[3] Report of the Brit. Asso. for A. of S. 1851. p. 164.

est allusion to Prof. Steenstrup's views on the subject, and until quite recently I had thought that to myself belonged the entire credit of the views advanced in this paper, until I was made acquainted with the fact that twenty-five years ago Steenstrup had not only considered the Brachiopods as worms, but had placed them near the tubicolous Annelids. Before presenting the views of this distinguished naturalist, it is proper to go back to the relations that many naturalists, as Agassiz, Deshayes, Owen and others, believed to exist between Terebratula and Anomia.

In the light of our present knowledge of the subject, it seems as incomprehensible that such views were held, as that the Cirrepeds were ever included with the Mollusca, and it is still more a matter of astonishment that to this day there are a few naturalists who have a vague idea that Anomia forms a sort of connecting link between the Brachiopods and the Lamellibranchiates.[1]

In the year 1853, Forbes[2] wrote as follows: "Linnæus included in his genus Anomia the species of Terebratula. Mislead by a false analogy, he considered these very different Mollusks to be organized on the same plan, and the perforation of one of the valves in each, to be of similar origin.

"Lamarck, in like manner, fancied that in Anomia he saw a passage into Terebratula and the Brachiopods; and some anatomists even believed that they had discovered transitional characters. A close examination shows that there is no relationship of affinity between them, but only a resemblance through formal analogy.

"The parts which seem, at first glance, in each to be identical, prove not to be homologous upon investigation. Anomia has really very close relations with Pecten, and is connected to the latter by the curious genus Hemipecten of Reeve. The perforations in one of the valves of Anomia is chiefly a greater extension of the auricular sinus in Pecten; and when the very young fry of this genus shall have been carefully observed, we believe they will be found spinning a byssus, which passing through this in the first instance, before a portion of it becomes attached, eventually becomes detached with a part of the adductor muscle, and forms the opercular process."

Lacaze-Duthiers,[3] in an elaborate memoir on Anomia, refers to

[1] At one time Vogt and Agassiz believed the dorsal and ventral plates of the Brachiopoda to be right and left, like the bivalved shell of the Lamellibranch!

[2] British Mollusca. Vol. II., p. 322.

[3] Annales des Sciences Naturelles, 1854. 2d Series, V., p. 35.

these statements of Forbes and Hanley, and expresses his belief in their correctness. In speaking of their peculiar asymmetry induced by this byssal modification, he aptly calls them the Pleuronectes among Mollusks.

In the year 1847, Steenstrup presented similar views before the Royal Danish Academy.[1] And in the same year, during the meeting of the Scandinavian Naturalists in Copenhagen, he made a similar communication, which was published in their Report for that year. On both occasions he militated against the suggestions of Owen, Agassiz, Deshayes, and other naturalists, who considered Anomia as a connecting link between the Lamellibranchiates and the Brachiopods. He showed that Anomia was not so abnormal as was generally supposed, and that the foramen in Anomia had no correspondence to the opening of the valve in Terebratula, but, on the contrary, was homologous to the notch in Pedum, Pecten, and certain other bivalve Mollusks, and that the plug in Anomia was simply a calcified byssus, and that it passed through this notch and held the shell fixed to some object. He showed also that the muscle attached to this plug was a foot muscle, corresponding to the muscle which goes to the sheath of the byssus in certain other Lamellibranchs; and concluding with the statement that the Terebratula and all the Brachiopods might necessarily be considered as not only widely removed from the Lamellibranchiates, *but as having no sort of relation to the Mollusca at all.*

Last year, in a brief examination of the early stages of Anomia, I had the pleasure of amply confirming the predictions of Forbes and Steenstrup, namely, that the plug in Anomia represented simply a modified byssus.

The following extract is taken from my short paper on the Relations of Anomia.[2] "The smallest specimens examined are quite orbicular, the upper or left valve is very tumid near the nucleus, the lower, or right valve is flat, and somewhat smaller than the upper valve. The foramen, or sinus, is not closed, but opens on the anterior border of the shell. The chief point of interest, however, is seen in the nucleus, or that portion of the shell first formed, when the animal was free and roving. This early condition of the shell is distinctly marked at the beak in both valves. It is yellowish in color, and marked with numerous, very regular concentric lines of growth, while the remaining portion of the shell is colorless, or white, with

[1] See the Proceedings for that year, pp. 74, 75.

[2] Proc. Boston Soc. Nat. Hist. Vol. xiv., p. 152.

irregular lines of increment. The nucleus is oblong oval. The umbones are nearly central, though nearer the anterior margin, and the shell is more globose behind. Both valves of the nucleus appear equally convex, and no sign of a sinus or perforation is visible in either valve. On the free edge of the right valve, directly under the umbo, a distinct notch is seen, the lines of growth indicating it, and showing that the edge of the shell is not absorbed to form this notch. It will be noticed that this marginal notch appears in that valve which is below, and which afterwards presents the opening for the passage of the byssal plug.

"The condition of the shell at this time clearly indicates that the animal is not only already attached, but has fallen to one side, and while in this position has added a few more lines of increment to its larval shell, as no sign of this notch is seen on the left or free valve. Soon, however, the peculiar and rapid secretion of a different shell growth takes place; the lines of increment are no longer regular, nor so con-

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

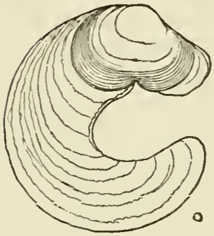


Fig. 5.

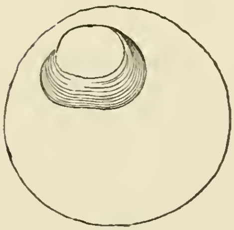


Fig. 6.

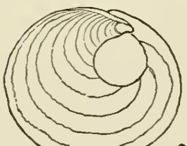


Fig. 1. Right or lower valve of Anomia, showing notch in ventral pallial margin, caused by byssus. Diameter one sixty-fourth inch.

Fig. 2. Left, or upper valve of Fig. 1.

Fig. 3. Foramen commencing to form. The black portion shows proportions of left valve.

Fig. 4. A more advanced stage of right valve with foramen almost completed.

Fig. 5. Left, or upper valve of Fig. 4. Diam. one thirty-second inch.

Fig. 6. Showing still later stage, with foramen completed, and nucleus still visible.

spicuous, and the shelly matter is white. The left valve adds concentric layers around its entire margin, not excepting the hinge margin. The lower valve appears to grow from its posterior and lower half, the successive accretions being produced around the byssus. This growth for a while seems to take place exclusively from the posterior half of the shell, limited in front by the byssus, and even after this growth has increased to twice the diameter of the embryo shell, only a slight increase is noticed on its anterior margin, this latter addition being slightly reflected. The left or upper valve grows more rapidly, so that its margin overlaps the right valve at all points. As the animal increases in size, the foramen increases also, and its earlier boundaries are consequently absorbed.

"It will be seen by reference to the figures, that the growth of the perforated valve is first posterior and downward, from the posterior half of the shell; it then grows forward, avoiding the byssal plug, and by successive additions surrounds the byssal plug, and ultimately reaches the umbones of the larval shell, and even beyond and behind this region.

"From these facts it is obvious that at an early stage the animal is free, and for a time locomotive; that it has an elongate, oval, bivalve shell, with close and regular lines of accretion, and that during the latter stage of this growth it becomes attached by a byssus passing from between the valves of the shell, as in Mytilus; that before the growth of the larval shell is completed it drops over to one side, since one valve only shows the notch upon its margin, and that so soon as this growth ceases, a new growth takes place, looser in texture, and white in color, as above described."

The figures are here given which accompanied the paper from which this extract is taken. At another time I hope to meet with living examples of Anomia in this early stage. The specimens from which the above studies were made, I found upon dried sea weed, but the shells told the story plainly enough, as will be seen by the figures.

Let us again revert to Steenstrup's views regarding the affinities of the Brachiopods. In the Proceedings of the Royal Danish Academy for the year 1848, pp. 88, 89, Prof. Steenstrup again refers to the supposed deviations of Anomia from the Lamellibranch, and showed that they were not only closely related to the other Monomyarians, but had no sort of approximation to Terebratula, or the other Brachiopods. In that meeting he indicated what he considered the true place to which the Brachiopods should be assigned.

Having shown that they were isolated from the Lamellibranchs, he there said if the Brachiopods were rightly looked upon, they would, according to his opinion, not find their place in the Molluscan series at all, but in the series of annulated animals, and just in the class of Annelids. In this class, however, he might not range them as a particular order, but as a link, or row of particular families, which one after the other came near to the now living Serpulæ, going slowly, without any abruptness, over to them. Steenstrup believed that if the relationship existing between the shells of Serpulæ and the tests of Thecidia, Crania, etc., was a natural one, then the type of the animal of Serpula might be recognized in the Brachiopoda.

At that time, Steenstrup believed that the Hippurites were Annelids too. This view he informs me he has since abandoned, though he regards them as a very alienated type from the Lamellibranchs. It seems strange, that in all the elaborate memoirs on the Brachiopods, no allusion has been made to Steenstrup's views on the subject. These allusions to the affinities of the Brachiopods in a language of which I was entirely ignorant, never came to my knowledge until nearly two years after my first views of the Annelidan affinities of the Brachiopods were published in "Silliman's Journal." These views he presents every year to the students at the University at Copenhagen, for which he tells me he has been highly blamed, but to which he still adheres.

In a letter to me he writes: — "You remember that Seneca says, we ought always to go 'Non pecorum modo, quo itur, sed quo eundum est.' As to the last half of this sentence I must be quite silent, but as to the first half I shall add that I have been highly blamed, that I did not follow the common 'quo itur' path."

Conclusion and Recapitulation.

The Mollusca have always proved a stubborn group to define, and simply because certain forms were placed with them, by general consent, which did not belong there. Milne Edwards first broke the spell by rendering the affinities of the lower classes less antagonistic by separating the Mollusca into two great divisions, the Mollusca and Molluscoidea. This act was promptly adopted by Prof. Dana as before alluded to in the first part of this paper.

However vague and ill-defined the Vermes may be, there seems to be no wider gap between their extreme forms than between Amphioxus and Man, or the Lerneans and Hymenoptera, or between Aspergillum and Loligo. Were it not that Protula and Autolytus increased by transverse division, one might look at low worms with these anomalous features of reproduction, as remotely separated from the Chætopodous groups.

In considering the assemblage of remarkable characters in the Brachiopods, we must recognize in them a truly ancient type, and consequently a synthetic, or comprehensive type. Thus while we do not find them in all their characters resembling any one group of worms, I have endeavored to show that all their features, to a greater or less degree, are shared by one or the other of the various groups of the Vermes, with one or two features shared by the Arthropods.

It is important to remark in this connection that most of the ancient groups differ from present groups with which they are associated. Thus the Trilobites are widely unlike modern Crustaceans, Milne Edwards and Van Beneden suggesting their affinities with the Arachnids. Tetrabranchiate Cephalopods are widely separated from the Dibranchiate Cephalopods. Crinoids are widely unlike modern Echinoderms. In other words, among the Mollusks, Echinoderms and Crustaceans are ancient types widely different from the modern types with which they are correlated.

So in worms we should expect to see ancient types, while presenting a high organization, yet differing from present groups to which they are unquestionably related. And from the high complication of structure of the Brachiopods, Tetrabranchiates, and other ancient types, it would seem that in their culmination in ancient times they had the same relation to animals living then as the higher groups of present times bear to their associates. As to the more ancient forms of Brachiopods, it is probable with them, as with other groups, that their lower members were soft bodied, and the argument that has been urged, as militating against Darwin, that animals of high complication of structure occur in the older groups, becomes valueless, when we consider that the lower forms of their respective groups are more often soft bodied, and that complicated forms of earlier times, were also culminating forms of pre-existing groups. In the light thrown upon the history of man by the wonderful discoveries in Archæology, where we meet with traces of an ancient civilization, with complicated language and manners, we can surely believe in savage hordes pre-existing, from which this ancient civilization has been evolved.

The Tunicates, Amphioxus, and many important groups, which have taught us so much regarding the affinities of classes supposed to be widely separated, had no hard parts to preserve, and nothing by which we could make out their structure. Even the worms, with the exception of the Chætopods, have left us nothing, and the last named group are known to us only by their tracks, spines, and tubes left in the rocks. Even the hard leathery peduncle of the fixed Brachiopods has, in one or two instances only, been preserved.[1]

The earliest forms of Brachiopods thus far met with, are those with thin, diaphanous shells (as in the Lower Lingula Flags), and even before these forms existed we can legitimately conceive the primary existence of certain Brachiopods, with the peduncle endowed with high functional importance, and the anus terminating posteriorly, as in those Annelids, like Lysilla, where the caudal portion is apodous, scarcely annulated, and devoid of setæ. Later appeared Brachiopods with an anterior termination of the intestine, as in Phoronis and certain sipunculoid worms, and finally the peduncle became attached, and the anus obliterated.

In regarding the relations of the Brachiopoda, let us suppose that nothing was known of such a form as Lingula, and that the only forms of which we had any knowledge, were the short and wide forms, like Chonetes. It would certainly be considered a wild supposition to suggest the possible existence of a Brachiopod, in which the shell should be translucent and elastic, four times as long as wide. A peduncle partially annulated, nine times as long as the body, capable of sharp vermian contortions, having a rapid circulation within, incased in a sand tube, with the animal living free in the sand, and having a limited power of locomotion. Surely it would tax the powers of the imagination more to conceive this form than to simply endow a sedentary Annelid, like Protula, with the cephalic collar extending beyond the arms instead of surrounding the base, and secreting a dorsal and ventral plate, with the anus terminating at the side instead of behind.

The presence of prominent dorsal and ventral plates enclosing the arms from which the arms in some cases are protruded and the consequent developement of special muscles to move these plates, form the only marked differences between the Brachiopods and the Worms. In the Gephyreans as in the common Sipunculus, for example, where the anterior portion is highly contratile, ponderous retractor muscles are developed with widely expanded bases, as in the Polyzoa and in many Brachiopods.

[1] In the Museum of the Geological Survey of Canada is a specimen of *Eichwaldia subtrigonalis* Billings, from the Black River Limestone, Lower Sil., showing the silicified peduncle nearly as long as the shell, photographs of which Mr. Billings sent me.

In most cases the Brachiopods are fixed, and it is well known that with the radical change in the habits or conditions of any group, a corresponding change is noticed in their structure. Thus among the Crustaceans the feature of attachment is accompanied with many changes in the structure of the animal which mask their proper affinities, as in the Cirripeds, and notably in the Lerneans. Similarly in certain low worms, internal parisitism is generally accompanied with a loss of gills, setæ and cilia.[1]

On the same grounds, we should naturally expect to see great and striking differences in those worms which are attached. Consequently those Annelids which are fixed, while in most respects resembling the free Annelid, yet differ from them in being edentulous, the mouth or head, in some cases, supporting a crown of cirri, oftentimes springing from two cephalic lobes, which may be developed into a closely twisted spiral. There is also a marked degree of cephalization, the anterior rings forming a thorax, and supporting branchiæ, while the caudal region is often apodous, and without setæ, and in some cases not even annulated, and often separated from the thorax by a deep constriction.

So in the Brachiopods, while in every feature of their internal structure betraying their annelidan affinities, and while the errantian forms with their long vermiform and annulated peduncle, their locomotion by means of setæ, and their power of fabricating a sand tube, unite them clearly with the fixed and highly cephalized Chætopods; yet in those groups that are attached, a remarkable concentration is seen, and many features are presented which have heretofore obscured the affinities of the group.

To sum up the whole then. — Ancient Chætopod worms culminated in two parallel lines, on the one hand, in the Brachiopods, and on the other, in the fixed and highly cephalized Chætopods. The divergence of the Brachiopods, having been attained in more ancient times, a few degraded features are yet retained, whose relationships we find in the lower Vermes; while from their later divergence the fixed and cephalized Annelids are more closely allied to present free Chætopods.

And so we must regard the Brachiopods as *ancient cephalized Chœtopods*, while Serpula, Amphitrite, Sabella, Protula and others, may be regarded as *modern* (later) *cephalized Chœtopods.*

[1] Rolleston. Forms of Animal Life.

The following characters of the Vermes, mainly compiled from Rolleston's "Forms of Animal Life," are here given, with the characters of the Brachiopods in parallel columns.

Vermes.	*Brachiopoda.*
Bilaterally symmetrical, depressed or flattened, or circular, never flattened laterally.	Bilaterally symmetrical, depressed or flattened, or circular, never flattened laterally.
In many cases, above and below similar, or these regions distinguished with difficulty.	In many cases, above and below similar, or these regions distinguished with difficulty.
Most free, some attached.	Some free, most attached.
Locomotor muscles closely connected with integumentary system, not only on ventral, but on dorsal and lateral aspects of body wall.	Locomotor muscles closely connected with integumentary system not only on ventral, but on dorsal and lateral aspects of body wall.
In some (Annulata) annulated externally, and divided internally by dissepiments, in others not divided.	Never annulated externally, except the peduncle. A single dissepiment in Lingula.
Two layers of muscles in body walls.	Two layers of muscles in body walls.
Digestive canal straight, or seldom convoluted.	Digestive canal straight, or seldom convoluted.
Suspended in perivisceral cavity by partial dissepiments consisting of delicate tissue.	Suspended in perivisceral cavity by bands consisting of delicate tissue.
Peculiar depuratory apparatus, characteristic of the entire sub-kingdom. This apparatus in the Annulata taking the shape of bilaterally symmetrical tubes, opening externally, and communicating with the perivisceral cavity by ciliated infundibuliform orifices.	Peculiar depuratory apparatus, characteristic of the entire class. This apparatus taking the shape of bilaterally symmetrical tubes, opening externally, and communicating with the perivisceral cavity by ciliated infundibuliform orifices.
Nervous system consisting at most of simple œsophageal collar, to which a few accessory ganglia, or chain of ganglia, may be appended.	Nervous system consisting at most of a single œsophageal collar.
In some the bilateral elements of the nerve chain widely diverging.	The bilateral elements of the nervous system widely diverging.
Generative products in most, set free in perivisceral cavity.	Generative products set free in perivisceral cavity.

Possessing chitinous outgrowths, either as scales or plates, hairs or spines, the latter being secreted by setigerous follicles.	Possessing chitinous and calcareous outgrowths, as scales or plates, and chitinous outgrowths, as hairs or spines, the latter being secreted by setigerous follicles.
Cuticle perforated by minute pores.	Cuticle perforated by minute pores.
Perivisceral cavity lined in some cases by delicate ciliated membranes.	Perivisceral cavity lined by delicate ciliated membranes.
An extensive vascular system, containing a colored fluid representing the pseudo-hæmal system. The corpuscular nutritive true blood is contained usually in the perivisceral cavity alone, and in a few instances is found penetrating the pseudo-hæmal system.	An extensive vascular system, which may represent the pseudo-hæmal system. The corpuscular nutritive true blood is contained in the perivisceral cavity alone.
Embryos distinctly transversely segmented. In some cases attached by caudal portion at a later stage.	Embryos distinctly transversely segmented. In most cases attached by caudal portion at a later stage.
In some groups intestine having no anal outlet.	In some groups intestine having no anal outlet.
Sedentary Annelids.	
Usually having body divided into regions, the thoracic and caudal.	Having body divided into two regions, the thoracic and caudal.
Springing from the head, in many, two arms, often twisted into a closely wound spiral, and sustaining ciliated cirri.	Springing from the head two arms, often twisted into a closely wound spiral, and sustaining ciliated cirri.
Encircling the head, or base of arms, a flaring membrane split upon the sides, and notched, in the dorsal and ventral median line.	Encircling the head and arms, a flaring membrane split upon the sides, and often notched in the dorsal and ventral median line.
Mouth unarmed.	Mouth unarmed.
Mostly fabricators of sand tubes which invests the body.	One, *Lingula pyramidata*, fabricates a sand tube, which invests the body.
Gephryreans.	
Never definitely segmented. Anus opening anteriorly in many.	Never definitely segmented. Anus, when present, opening anteriorly.

I desire to express here my deep gratitude to John E. Gavit, Esq., who has constantly aided me in getting material together in our Eastport dredgings, who has freely placed at my disposal his extensive microscopical apparatus, and who has, by timely suggestions, aided me in many ways.

My thanks are also due to Dr. J. R. Nichols for the constant use of a Smith & Beck Binocular; to Dr. Elliott Coues, U. S. A., through whose attention and kindness I was enabled to study living Lingula on the coast of North Carolina; and to Prof. J. W. Dawson, for specimens of Rhynchonella, and for the loan of a stout dredge; and to Dr. P. P. Carpenter for accompanying me to the mouth of the St. Lawrence, and for aiding me in dredging for Rhynchonella. I am also under obligations to Prof. A. E. Verrill, Prof. A. Hyatt, Thomas Bland, Esq., and Edward Burgess, Esq., for many favors.

To the Editors of "Old and New" I am indebted for the use of the engraving which adorns the title page; and to Mr. C. A. Walker for the pains taken in engraving my hasty drawings.

EXPLANATION OF PLATE I.

Figures 1 to 7, inclusive. *Lingula pyramidata* Stimpson, natural size, from life.

Figure 1. Representing two specimens as they appear partially protruding from the sand, showing the sand disturbed by them about their burrows.

Figures 2, 3, 4, 5 and 6, different specimens in various positions after having been removed from the sand in which they were found; Figure 3 showing the animal while in the act of occillating the dorsal plate; Figure 4, with peduncle straightened.

Figure 7. Representing bottom of earthen bowl, in which eight specimens had been kept alive in sand; the sand covering the bottom of the bowl an inch and a half in depth, above which the Lingulas protruded, and below which they would partially disappear with a quick jerk when alarmed. On removing the sand they presented the appearance as here given. Sand tubes had been made by them, adhering to the bottom of the bowl, quite unlike those made by them when free in the sand. Into these tubes the Lingulas had partially receded, as represented by the figure; *a.* represents a deserted sand tube.

Figure 8. *Protula media* Stimpson, natural size, reduced from a drawing made by Mr. Emerton, kindly loaned by Prof. Verrill.

Figure 9. Showing thorax and left arm enlarged from same drawing; the pectinated character of cirri are not fully shown. This drawing is inaccurate in not showing the calyx or membrane encircling the base of cirri, and in not properly showing the pectinated character of the cirri. The correct and beautiful drawing of Mr. Emerton's will be published by Prof. Verrill in the Proceedings of the Connecticut Academy of Sciences.

Figure 10. *Serpula crater*, from Claparède.

The last three figures are given to show the distinct separation of thorax and caudal portion.

The President announced the death of Prof. Wm. C. Cleveland, of Cornell University, a Corresponding Member of the Society.

Mr. W. H. Niles said that Prof. Cleveland was well known to several prominent members of the Society, who were not present this evening. Prof. Cleveland was best known as a civil engineer, and it was in this profession and its associated studies that the merits of his scholarship and work became most prominent. But he also had a genuine love of nature and truth, which he never failed to cherish. He made fine collections of minerals, plants, mollusca and fossils; and these were to him more than curiosities, for he studied their nature and affinities as a professional naturalist would have done. He often surprised his friends by his familiarity with the natural history of the region where he resided, and a number of the professors at Ithaca were astonished at the readiness and proficiency with which he instructed the classes in palæontology and geology, during an absence of Prof. Hartt. Mr. Niles had often sought his company for geological rambles, and had frequently derived valuable aid from him while considering certain difficult geological questions. Whoever knew him well, found him thorough in his investigations, accurate in his information, and clear in his reasoning.

Section of Entomology. March 26, 1873.

Mr. J. H. Emerton in the chair. Eleven persons present.

The following papers were read:—

Notes on Mr. S. H. Scudder's "Odonata of the Isle of Pines." By H. A. Hagen.

I have already published some notes on the Odonata described by Mr. Scudder (Proc. Bost. Soc. Nat. Hist., x., p. 187, and xi., p. 298) in the Stettin Entomologische Zeitung, for 1867, pp. 96 and

215, and for 1868, p. 274; also in the Proceedings of this Society, xv., p. 289. Having now an opportunity, thanks to the Society, for an actual comparison of Mr. Scudder's types with those in my collection, the following notes will, I hope, have an increased value, my previous paper being based on Mr. Scudder's descriptions only, although these are indeed excellent.

1. **Agrion Maria** Scudder. The type is a male, and identical with my *Neoneura palustris* from Cuba; *Neoneura carmatica* is perhaps only a variety of it. Mr. Scudder's name has the priority.

2. ? **Agrion** (Ischnura) **coecum.** The types are two males and one female, all having the labels in Mr. Scudder's handwriting on the pins, as throughout the Odonata described by him. The males are *Agrion coecum*, and belong to the variety *A. cardenium.* The female is *Agrion* (Leptobasis) *aduncum* Hag. Syn., 79, 9. The doubts of Mr. Scudder of the identity with my *A. coecum* are thus explained, the female not belonging to this species.

3. **Aeschna virens.** I have not seen the type.

4. **Macromia cubensis.** The type is a female. This species is *Erythemis longipes* Hag. Syn., 109, 3. Later I found the Brazilian species different, and named the Cuban species to Mr. Poey *Erythemis specularis.* As I would preserve my name for the Brazilian species, after which the description was principally made, the Cuban species should therefore be named *Er. Cubensis.*

5. **Tramea insularis.** I have seen one of the four male types and the female type described by Mr. Scudder. As I stated, Stett. Ent. Zeit., p. 223 and p. 226, the male belongs to *Tramea insularis*, the female to *Tr. abdominalis.* As I am assured by Mr. Poey and Mr. Gundlach both species fly at the same time and localities, the mistake in joining the species is not remarkable, indeed, I even received specimens from those gentlemen wrongly paired.

6. **Libellula auripennis.** Types male and female, the species of Burmeister, Hag. Syn., 155, 11.

7. **Libellula angustipennis** Rbr. The type is a teneral male, and not a female, as stated in the paper. As Mr. Scudder states that he took only one, and the specimen is labelled by him, it is doubtless the type. It is the smallest specimen I ever saw (length about 35 mill., the tip of the abdomen wanting; exp. al. 60 mill.), but it does not differs from the other Cuban specimens.

8. **Libellula vinosa.** Type, male and female. This is *Dythemis rufinervis* Burm. Hag. Syn., 162, 1.

9. Dythemis frontalis. Type, male and female, is the same species of Burm., Hag. Syn., 165, 6. At the time I published the Synopsis I had seen only the type of Burmeister. Later I received the species from Poey and Gundlach.

10. Dythemis pleurosticta. Type, male and female. Mr. Scudder's doubts about the identity of his species with *D. pleurosticta* Burm. are well founded. I received later numerous specimens, and described them, Stett. Ent. Zeit., 1868, p. 281. Mr. Scudder's species is identical with *Macrothemis celeno* Selys Longchamps, in de Sagra's Insects of Cuba, p. 454.

11. Mesothemis Poeyi. The type is a male of *Dythemis dicrota* Hag. Syn., 166, 9.

12. Mesothemis Gundlachii. The type is a young male of *Mesothemis simplicicollis* Say.

13. Diplax ochracea. Types two females, one teneral; the type of *Diplax abjecta* Scudder belongs to it as male. Having before me the type of *D. ochracea* Burm., I am sure that it is a different species. Mr. Scudder is right in supposing that *L. Justina* Selys should have been given as a synonym of this species in my Synopsis, instead of *L. Justiniana.* In my Synopsis *L. abjecta* from Cuba is described after a male identical with the type of Rambur. But there exists in Cuba a nearly related species, by Poey and Gundlach nearly always confounded with *L. abjecta.* To this, as I believe a different species, belong *D. abjecta* male, and *D. ochracea* female, of Mr. Scudder. I think the species is not described, and I propose the name of *Diplax fraterna.* An undescribed species, *L. Juliana* Selys, is very similar, but not possessing the female, I believe it to be more prudent to separate this Brazilian species from the Cuban one.

14. Diplax Justiniana. Type male and female. This is the *D. Justiniana* of my Synopsis. Later I believed them different from Selys' species, and separated them as *D. ambusta.* There are two nearly related species in Cuba, but to which of them *D. Justiniana* Selys belongs, I can not state now with surety. Perhaps Mr. Scudder's determination is the right one.

15. Perithemis Domitia. Type male is the variety *P. Metella* Selys.

Report on Mr. S. H. Scudder's Odonata from the White Mountains, after an Examination of the Types. By H. A. Hagen.

1. **Cordulegaster lateralis.** Type male. Is identical with *Ae. obiqua* Say, var. *a*, the type in the Harris collection, and with a male from Massachusetts in my collection, received long ago from Mr. Uhler. I believe the species to be *C. Sayi* Selys.

2. **Aeschna constricta** Say. Two specimens from the White Mountains, labelled by Mr. Scudder. in the collection of the Cambridge Museum are the species of Mr. Say.

3. **Aeschna eremita** Scudder. Type, male and female; several specimens labelled by Mr. Scudder in the Cambridge Museum from the White Mounlains, also a number from Fort Resolution, Slave Lake, by R. Kennicott, in my collection. A very interesting species very near to *Ae. juncea* Linné, and I believed it to be a variety possessing a male from the Isle Kenai and Norton Sound in Behring's Strait, which I am not able to separate from *Ae. juncea*. Nevertheless the denticulated carina mentioned for the upper appendages of the male by Mr. Scudder, is always very marked in the American specimens, and so far as I know never in the European. Only the male from Kenai agrees with the European ones. I believe it right to separate Mr. Scudder's species particularly as two very similar ones, *Aeschna crenata* from Irkutzk, and *Aeschna serrata* from the Kirghiz Steppe are more related to *Ae. crenata* by a denticulated carina.

4. **Aeschna propinqua.** I have not seen the type, but judging from specimens from Labrador and Fort Resolution agreeing with Mr. Scudder's descriptions, this is a good species.

5. **Cordulia eremita.** Type, male and female. De Selys Longchamps and myself compared them with the types of *Cordulia albicincta* Burm. There is no doubt about the identity; *Epitheca albicincta* in De Selys' monograph.

6. **Cordulia forcipata.** Type male. I possess both sexes from Fort Resolution. The type (as all belonging to Cordulia having been in the hands of the latest monographer, Baron De Selys Longchamps, by courtesy of this Society) is a good new species. *Epitheca forcipata* in De Selys' monograph; *C. chalybea* Syn., 138, 7 (not described).

7. **Cordulia Shurtleffii.** Type male is identical with *C. bifurcata* Hag. Syn., 127, 4 (not described).

8. **Cordulia Walshii.** Type male; *Epitheca Walshii* in De Selys' monograph. A very interesting new species; the female still unknown.

9. **Cordulia elongata.** Type male and female. *Epitheca elongata* of De Selys is identical with *C. saturata* Hag. Syn., 138, 12 (not described).

10. **Diplax rubicundula.** My specimens agree entirely with Mr. Scudder's elaborate description of this species. I did not see the types from the White Mountains.

Perhaps the synonymy of the species of Cordulia mentioned only by name in my Synopsis, p. 137, 148, may not be out of place here, as the species are now fully described.

C. bifurcata is *C. Shurtleffii* De Selys Syn., p. 31.
C. libera is *C. libera* De Selys, p. 29.
C. procera is *Epitheca procera* De Selys, p. 29.
C. chalybea is *Epitheca forcipata* De Selys, p. 61.
C. Franklini is *Epitheca septentrionalis* of my Synopsis and of De Selys p. 64.
C. Richardsoni belongs to the foregoing species.
C. cingulata is *Epitheca cingulata* De Selys, p. 68.
C. tenebrica is *Epitheca tenebrosa* Say, De Selys, p. 55.
C. saturata is *Epitheca elongata* of De Selys, p. 58.

Mr. Emerton exhibited under the microscope the young larvæ of a water beetle, *Cnemidotus muticus.* The eggs were laid in confinement on the roots of duck-weed. He also showed a species of Tortricid (*Penthina?*) which he had raised from a larva found in Brookline, Mass., on pines. The larva inhabits a case made of eight or ten needles joined together parallel to each other and forming a tube.

Dr. Hagen said that Dr. Packard had pointed out to him that the crustaceous genus Prosopistoma was founded by Latreille on the larva of a Bætisca, first described by Geoffroy in his Histoire Naturelle des Insects, and on similar larvæ from Madagascar. Walsh (Proc. Entom. Soc., Philadelphia, III., 200) has described the pupa of a Bætisca and succeeded in raising the imago, but no imago of this genus has been found in Europe. Westwood possesses specimens of Prosopistoma received from Latreille.

April 2, 1873.

The President in the chair. Fifteen members present.

Charles Darwin and Carl Ernst von Baer were elected Honorary Members.

Messrs. A. G. Whitman, J. W. Keene, Chas. H. Andrews, Chas. Foster, S. T. Crosby, Horace B. Plumer, F. C. Bowditch, L. M. Willis, M. D., and S. F. Whitney, were elected Resident Members.

The following paper was read: —

Some Remarks upon the Agency of Glaciers in the Excavation of Valleys and Lake-Basins. By Prof. W. H. Niles.

Last summer, while spending most of the season among the Alps, the point of greatest scientific interest to me was the origin of the topographical features of both mountains and valleys. The respective geological parts now performed by the meteoric agents, water, frost, snow and ice, formed the principal subjects of my study. I went there anticipating the pleasure of seeing the glaciers in the process of deepening the valleys and possibly of forming rock-basins. As to the extent and character of this work I was somewhat disappointed, and have returned quite a skeptic upon the theories of the excavating agency of glaciers.

Prof. Ramsay, in his theory of the formation of lake-basins, took the ground that much of the grinding power of glaciers was at or near their terminations. He maintained that there the ice would tend to heap up and attain an unusual thickness, and that the motion was not so much by virtue of gravity as by being pushed along by the ice descending from the middle, and upper portions. Such conditions he considered would give the lower ends of glaciers an extra erosive power, by which they would, particularly in soft places, excavate or hollow out the rock into basins, which being filled with water on the retreat of the glaciers, would form lakes. Prof. Tyndall had objected to this, because at such places glaciers are almost stationary.

I have seen no glacier which appeared to me to be excavating the rock at its termination in the manner required to form lake-basins. On the contrary the lower ends of most glaciers do not even extend into basin-like depressions. Many glaciers terminate on the steep slopes of mountains, and some at the edges of precipices. Certainly a glacier cannot be deepening a basin so long as it reaches only to its outer edge. In many instances the rock under the ice at the lower ends is convex rather than concave, and sometimes a mass of rock divides the glacier into two parts, as is the case with the Bies Glacier.

In studying the manner in which glaciers now grind the rock beneath them, we see what Prof. Agassiz has taught, that the greatest erosive force is exerted upon the convex or prominent portions of the surface. The Gorner Glacier furnishes superior opportunities for getting at its under surface in places, and of observing the contact of the moving ice and the rock. At such places the ice rests principally on the eminences, and bridges the hollows between them, as so well described and illustrated by Mr. Edward Whymper. Under such conditions the prominent portions must receive the full erosive power, and it becomes evident that the valley cannot be much deepened by present processes till these elevated places are leveled. But suppose the action to go on till all such prominences are removed, the glacier would then move over such a smooth and even surface with less resistance, and the grinding process would go on still more slowly than on the eminences. But the elevations still remain underneath the larger glaciers, which have flowed over them for ages, and their existence shows that these valleys can have been deepened only to a limited extent by the erosion of these glaciers.

Furthermore, such *roches moutonnées* are well known to be among the most common proofs of ancient glaciers, and they are found in larger as well as in smaller valleys. Sometimes still larger elevations standing in the valleys show how incompetent the glaciers have been to remove exposed masses of rock. A striking example of this is seen in the masses upon which the castles of Sion now stand, in the valley of the Rhone. As has been observed and stated by many others, it is at least difficult to understand how glaciers could have formed the Alpine valleys by excavation, when we consider that these prominences now exist in them, on the eroded sides of which the finer glacial striæ are well preserved, while on the lee sides there are often angular rocks, which show no traces of glacial action.

The recent and rapid recession of many glaciers has given some fine opportunities for studying the surface features of the rocks of their beds, before they become much obscured by débris and vegetation. The ascent of the Mettelhorn from Zermatt affords an example. After crossing the ranges of the Blatterhörner, the course leads through a small elevated valley, which at no remote time was occupied by a glacier. Last summer the snow remained on the steep sides of the amphitheatre from which it formerly descended to form the *nevé*, but the bottom was mostly bare. Here was an opportunity of seeing the rock surface nearly as the glacier left it. But excepting the barrenness, the features were of the same general character as in other valleys. There were no ponds nor basin-like depressions, but there were *roches montounées*, and ordinary forms of glaciated surfaces.

From all I have observed, I am led to the belief that if we establish our convictions concerning the agency of ancient glaciers upon what we can observe of the work of existing ones, then we must conclude that glaciers were not the principal agents in the excavation of valleys.

I believe the geological agency of glaciers is chiefly the transportation and reduction of the rocks and stones broken from the mountains, mostly by frost and avalanches, and hurled down upon them or into their crevasses. The amount of this geological work performed by any glacier depends not upon its size, but upon the precipitous character of the sides of its valley. It often happens that small glaciers transport more than large ones. Standing on the Hörnli, a spur from the Matterhorn, on one hand is the Zmutt Glacier, whose tributaries come from the bases of the gigantic precipices of the Matterhorn, the *Dent d'Heréns*, and the *Dent Blanche*, and its surface is literally covered with moraine matter. On the other hand is the great Gorner Glacier, whose branches come from a region of extensive snow-fields, with but comparatively few bare rocks, and the materials which it transports would be but a mere fraction of the amount carried by the much smaller Zmutt Glacier. The vast fields of snow seem to act like a blanket for the protection of the rocks, rather than as a destructive agent. Some have supposed that the great ice sheet of the glacial period acquired an immense power from the fact that it covered nearly all elevations. But the Alpine glaciers now obtain most of their freight from the extensive and precipitous bare, or half clad slopes, where frost and avalanches, not glaciers, carve out the rock and shape the peaks.

If, therefore, the valleys were not formed by glaciers, how were they produced? I am not a believer in the old fracture-theory, but in all the steep lateral valleys of the Alps the observer may see torrents of water cutting deep gorges in the rock; the frost breaks up the rocks at the sides, and the process of deepening and widening, or of valley excavation, may there be seen and studied. I believe it was so in the past, and that the valleys, in which the glaciers now are, were not formed by them, but rather that they received their courses and limits from the valleys.

April 16, 1873.

The President in the chair. Twenty-four persons present.

Mr. Wm. T. Brigham exhibited a fine collection of photographs, taken by Prof. Hayden's surveying party, of the Yellowstone Park country, and described the scenes thus illustrated.

Mr. Bouvé exhibited a fine Japanese crystal ball presented by Thomas Gaffield, Esq., to the Society.

Section of Entomology. April 23, 1873.

Mr. E. P. Austin in the chair.

The following paper was read: —

Anisopteryx vernata distinguished from A. pometaria. By B. Pickman Mann.

The question of the difference between *Anisopteryx vernata* and *Anisopteryx pometaria* having been raised, I have looked over my notes, and made some new observations, with the results contained in this paper.

In the following descriptions I have drawn as much as possible from Harris' Treatise on Some of the Insects Injurious to Vegetation, and have indicated by italics the portions so adopted.

First, I give the characters which, as far as I know at present, are common to both species.

The antennæ of the male have a very narrow and almost downy edging, on each side, hardly to be seen with the naked eye. The feelers are minute and do not extend beyond the mouth. The tongue is not visible. The wings are large, very thin, and silky; and, when the insect is at rest, the fore wings are turned back, entirely cover the hind wings, and overlap on their inner edges. The female is wingless, and its antennæ are short, being about half the length of the body, filiform, and *slender. Its body approaches to an oval form,* Harris adds, *but tapers and is turned up behind.* I am not able to say whether this character is common to both species or not.

I find the following differences between the species:—

Anisopteryx vernata.	*Anisopteryx pometaria.*
The first seven rings of the abdomen of both sexes with no spines upon the back.	The first seven rings of the abdomen of both sexes bear each upon the back two transverse rows of stiff red spines pointing towards the end of the body.
Fore wings of male ash-colored, with	*Fore wings of male ash-colored* or brownish-gray;
a distinct whitish spot on the front edge, near the tip;	the *whitish spot* found on the fore wings of *A. vernata* is *wanting.*
[*fore wings*] *crossed by two jagged, whitish bands; the outermost band has an angle near the front edge. The white bands are often entirely wanting, in which case only the whitish spot near the tip remains.*	*The whitish bands* found on the fore wings of *A. vernata* are *wanting,* but there is a jagged, submarginal white band on the upper side of the fore wings in most specimens.
Along the sides of the whitish bands *there are several blackish dots,* each on a nervure, and all generally connected together by a dusky band which includes them, and runs on that side of each whitish band which is towards the other. These bands remain visible when the whitish bands are wanting.	*There are three interrupted, dusky lines across the fore wings,* instead of two lines, as in *A. vernata.* Sometimes these lines are only indicated by dark spots on the front edge of the wing, and by blackish dashes at the crossing of median nervure; rarely are they very distinct throughout their whole extent.

Within the angle of the outermost whitish band, near the front edge, *there is a short, faint, blackish line*, following a nervure; *and there is a row of black dots along the outer margin, close to the fringe.*

There is *an oblique, blackish dash near the tip* of the fore wings, crossing a nervure; and there is a distinctly interrupted or nearly uniform continuous line of blackish along the outer margin, close to the fringe.

The hind wings are pale ash-colored, or light gray, with a faint blackish dot near the middle.

The hind wings are pale ash-colored, or very light gray, with a faint blackish dot near the middle.

In most specimens a curved white band is plainly visible on the hind wings, about half way between the middle and the end.

The white band found on the hind wings of *A. vernata* is wanting.

The outermost white band of the fore wings, with its angulation, and the band of the hind wings, are also visible on the under side of the wings. Within the angulation is a brown or blackish spot on the costa.

On the costa, opposite the beginning of the outermost dark band of the upper surface, and on the edge of the disk, are dark spots on the lower surface of the wings. Along the median nervure beneath is a dark line. These marks are sometimes indistinct.

The wings expand about one inch and a quarter (32 millimeters), varying between 26 and 34 millimeters, and predominating at 30 millimeters.

Of a rather smaller size than *A. vernata*, varying between 22 and 33 millimeters,[1] and predominating at 29 millimeters.

Antennæ of the female naked.

Antennæ of the female pubescent.

Abdomen not terminating in an ovipositor, rather bluntly tapering behind.

Abdomen terminating in a retractile ovipositor, rather acutely tapering behind.

Whole body and legs of the female smooth, clothed with glistening brown and white truncate scales intermixed, giving it an appearance of uniform shiny dark ash-color above and gray beneath.

Whole body and legs of the female pubescent, clothed with whitish and brown or black dentate scales or hairs; general coloration not uniform. A black band along the middle of the back of the abdomen, often interrupted on the second to seventh rings; with a whitish patch each side of its front end: the spines frequently giving a reddish appearance to the part they occupy.

Crest of prothorax and mesothorax black.

[1] One specimen in my collection with all the other characters except size, measures 38 millimeters.

Length of the female 6–10 mm.

Of 16 dated specimens of the male in my collection, 12 were taken in October or November, and 4 in March or April. The two spring specimens in my collection now are among the most strongly characterized I have.

Of several hundred females in my collection, four were taken in April and the rest in November.

Length of the female 5–8 mm.

Of 16 dated specimens of the male in my collection, 1 was taken in March and 15 in April.

Of nine females in my collection, all were taken in April. Among several hundred females of *A. vernata* taken in November I do not find one female of this species, wherefore I think it probable that this species is found only in spring.

I must acknowledge myself indebted to Mr. H. K. Morrison for the suggestion that I should find *A. vernata* a fall species and *A. pometaria* a spring species. It seems as if the occurrence of *A. vernata* in spring might be explained by considering the spring specimens as belated. The necessity of applying the name *vernata* to a fall species illustrates the danger of attempting to give names characteristic of season or locality.

I hope observers will take note next spring whether the eggs of *A. pometaria* do not want the jug-like shape and lid-like upper end which are seen in the eggs of *A. vernata*, also whether the eggs are not laid separately in chinks of bark, and whether their number is not about sixty, instead of over two hundred, as in *A. vernata*. I have only seen apparently immature eggs in the female.[1]

Dr. Hagen exhibited a book from a library at Beaufort, N. C., which was ruined by white ants (*Termes flavipes*).

Dr. Hagen also stated that he was engaged on a revision of the North American Phryganidæ, and gave the following list of species to illustrate the northern distribution of the sub-family.

Sub-family PHRYGANIDÆ.

Neuronia.

1. *dossuaria* Say (*Limnophilus dossuarius* Hag. Syn.). N. England.
2. *concatenata* Walk. (*irrorata* Hag. Syn.). New England.

[1] A few days after the presentation of the above communication Mr. Morrison informed me that he had lately seen a female *A. pometaria* thrust her ovipositor in between the chinks of bark of the apple-tree, and lay an egg there. He pulled off the bark and found eggs beneath. He had also seen the female thrust her ovipositor into the crack of a board fence, and lay an egg there. He did not observe the shape of the egg.

CORRIGENDA. to be explained in a subsequent communication : —

p. 384, lines 16–18. Omit the whole sentence from "The necessity" to "locality," inclusive.

pp. 382–384. Instead of *vernata* read *pometaria*, and instead of *pometaria* read *vernata*.

3. *stygipes* Harr. New England.
4. *ocelligera* Walk. Nova Scotia (perhaps *N. stygipes*).
5. *Pardalis* Walk. White Mountains.
6. *semifasciata* Say. U. S., northern part.
7. *postica* Walk. U. S., middle parts.
8. *ocellifera* Walk. U. S., middle and southern parts.
9. *angustipennis* Hag. N. England (perhaps *N. fuscula* Walk., *Rhyac ophila fusc.* Hag. Syn.

Phryganea.

1. *cinerea* Walk. N. England.
2. *interrupta* Say. (*Limnophilus interruptus* Hag. Syn.) New England.
3. *improba* Hag. Saskatchawan, N. England.
4. *vestita* Walk. (the male is *P. commixta* Hag. Syn.). N. Eng.

Agrypnia.

1. *colorata* Hag. Saskatchawan.
2. *straminea* Hag. Saskatchawan.
3. *glacialis* Hag. Saskatchawan.

Neuronia signata and *N. notata* Hag. Syn. do not belong here, so that the 11 species of the Synopsis are reduced to 8. Now the number is doubled; six are described for the first time : *N. stygipes*, *N. angustipennis*, *P. improba*, and the three species of Agrypnia.

ERRATA.

Page 22, line 2, *for* aurœcincta, *read* aureocincta.
Page 24, line 11, *for* Carithidea *read* Cerithidea.
Page 210, 4th line from bottom, *for Erismatura dominica read E. rubida.*
Page 222, line 28, *for* novaboracensis *read* noveboracensis.
Page 235, line 10, *for* cærula *read* cœrulea.
Page 187, the Bruchus mentioned as *B. granarius* has *not* been identified with that species by Mr. Mann.

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