PROCEEDINGS

OF THE

Boston Society of Natural History.

VOL. XXII.

1882–1883.

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CONTENTS OF VOLUME XXII.

LIST OF PLATES.

PROCEEDINGS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY.

TAKEN FROM THE SOCIETY'S RECORDS.

ANNUAL MEETING. MAY 3, 1882.

The President, Mr. S. H. SCUDDER, in the chair. Thirty persons present.

The following reports were presented: —

REPORT OF A. HYATT, CURATOR.

The experience of the past ten years has demonstrated the futility of any attempt to impress the community with an adequate sense of the public importance of the Museum without the aid of illustrations sufficiently perfect in themselves to show exactly what we intend to do. These must not only exhibit the general interest of the information, which is to be made available; but also prove, that a Museum is capable of becoming an instrument of public culture unequalled in the power of awakening intelligent appreciation of the usefulness of its work in the minds of those visiting its collections.

It is possible to so arrange, and subsequently conduct a Museum, that it will be as much more effectual in this way than any art gallery, or library, as nature herself is greater and more instructive than any imperfect imitations of her ever set in frames, or between the covers of books.

To sustain this claim it is necessary to display in our rooms a visual history of the world worked out with the indisputable characters of its own products. These, while they serve to explain their own rise and origin will, at the same time, and as the original source of knowledge, confirm or correct all the printed attempts to translate their meaning.

Acting upon these views the Council determined to complete the two collections of Mineralogy and Geology, which were the most suitable for this purpose, although the contemplated expenditure was far greater than would have been considered justifiable under other circumstances.

After these collections have been finished, and their capacity to do what is claimed tested, our hopes of bringing up the whole Museum to the same efficient condition must rest upon the generosity of the citizens of Boston, the existing funds of the Society being wholly inadequate for that purpose.

Microscopy.

This department has been enriched by the acquisition of a valuable collection of mounted Diatoms presented by a friend of the Society, Mr. Frederick Habirshaw. It contains nearly all of the common species of this group both fresh water and marine and many of the rarer species.

Most of the slides have been prepared by Prof. Hamilton L. Smith, Christian Febiger, Mr. Eulenstein and Messrs. Clere and Müller, and all verified and indentified by Mr. Habirshaw himself or by Mr. Samuel Wells. The collection contains 1577 slides, 188 genera and 1678 species and varieties. The excellent condition of the whole is due to the labors of Mr. Samuel Wells, who has revised, rearranged, and catalogued the slides.

Mineralogy.

A large amount of work has been done upon this collection by Mr. Crosby assisted by Miss Carter. Mr. Bouvé has also assisted the Society, as much as his health would permit, in the manipulation of the collections, as well as by his advice and experience in other respects.

The specimens in the wall cases on the floor of room **A** have been catalogued, labelled, and mounted on tablets, and those in the gallery of the same room, catalogued, and partly labelled and mounted. Other facts might be given, but in the absence of Mr. Crosby, who is now on a geological trip in Cuba, it has been thought best to defer a more detailed account until the collections are finished and finally reported on at the next annual meeting.

Geology.

This department remains in very nearly the same condition as when last reported upon, but two large floor cases have been built in room **B**, and other preparations made to complete the collections so that they will also be reported upon as finished next year.

Botany.

This department has not made as much progress as usual this year, on account of the almost constant occupation of Miss Carter in other work.

The relabelling of the general collections begun last year has been finished by Miss Carter through the Compositae. The additions have consisted of a few choice New England species from Mr. Sprague, some Alpine plants from Dr. Green's collection, presented by Dr. Quincy, about fifty species of plants collected by Mr. Henshaw while on the expedition made in the Arethusa. Mr. Cummings still has charge of this department, and we are indebted to his generosity for our ability to continue work here as well as the marking and labelling in the Mineralogical and Geological collections.

Synoptical Collection.

This department has received additions in the shape of several glass models, and a few preparations made and given by Miss Boardman. The great difficulty of presenting any adequate illustration of the most embarassing group of Mammalia, the Proboscidea, has been solved by the purchase of a baby elephant from India prepared and mounted by Professor Ward. This is old enough to show a pair of tusks and yet small enough to be placed on exhibition inside of one of the wall cases.

Special Anatomical Collection.

The alcoholic preparations have been arranged by Mr. B. H. Van Vleck in room **F**.

Paleontology.

No change has taken place in this department beyond the accession by purchase of a collection of fossils made by the Curator in 1867 from the Cambrian, Silurian, and Devonian formations in New York State, and formerly in the possession of the Peabody Academy of Salem. This is accompanied by a catalogue of 1333 entries and is partly named and labelled. The expedition on the Arethusa collected about 1000 specimens, many of them of great value on account of the rarity of the specimens and the locality from which they come.

Sponges.

The withdrawal of Miss Putnam last summer put a stop to any advance in this collection. This is much to be regretted as it would probably in her hands have speedily become the equal of any other in the Museum. The loss of this young lady's assistance was due to the same inability to meet the requirements of those who have to earn a living, which has repeatedly caused similar accidents in former years.

Corals and Echinoderms.

These collections remain as when last reported. A fine specimen of Madrepora has been received from Mr. W. B. Potter.

Mollusks.

Several hundreds of labels have been printed for Mr. Van Vleck, completing the collections in this respect. About one hundred more of the Blaschka glass models have been received, mounted and placed on exhibition. Two wooden cases, containing about one hunded and sixty trays, have been constructed in the work-room and the duplicate shells arranged therein. They have been arranged by Mr. Van Vleck according to Adams's classification so that they will hereafter be more accessible, and a catalogue made of the contents of each tray.

Crustaceans.

Mr. Kingsley before his departure to take the post of Curator of the Natural History Society in Worcester, very kindly assisted us by identifying the group of the Maioid crabs. Mr. Henshaw has worked out the New England species of the Pycnogonidae and the Isopods. Gifts have been received from Messrs. Edward Burgess, T. W. B. Clark, and J. S. Kingsley.

Insects.

Mr. Henshaw has worked over the Lepidoptera Heterocera and picked out the generic forms for exhibition.

The New England collections on exhibition have not been revised since 1878, and but very little of the new material received since that date is now incorporated with them; this revision has been begun by Mr. Henshaw. Donations, in addition to those to be mentioned from the Arethusa expedition, have been received from Dr. H. A. Hagen, Mr. E. P. Austin, Dr. F. C. Bowditch, Mr. C. B. Cory, and Dr. C. S. Minot.

Fishes.

The rearrangement of the New England collection has been nearly completed and a final report will probably be ready for presentation at the next annual meeting. Dr. H. E. Davidson has added to our former obligations by presenting the Society with some New England fishes prepared by himself, and a number of species from Bermuda. These exceedingly valuable additions to our collections now number forty species. There have been received very liberal exchanges from the Museum of Comparative Zoology of about one hundred and thirty specimens, selected especially for us by Mr. Garman, acting under the direction of Mr. Alexander Agassiz.

Birds.

Mr. William Brewster, who at my request most kindly assumed the charge of the Ornithological collections of the Society, has together with Mr. Henshaw completed the identification and arrangement of the New England collection, and will probably be able to make a final report before the next annual meeting.

The labelling of the collection of Humming Birds has been finished by Mr. Henshaw, and a revision of the Gulls and Terns begun by Mr. Brewster. Donations in addition to those to be noted further on from the Arethusa expedition, have been received from Messrs. Brewster, M. P. Barnard, A. J. Lewis, F. J. C. Swift, and Mrs. R. H. Gardner.

Mammals.

This collection has received some additions due to the bequest of Sydney Homer; six specimens in all, among which may be mentioned the rare Mustela Pennantii, male and female, a very fine Black Bear and an excellent specimen of the Beaver. To these must be added the young specimen of Elephas indicus already described in the remarks on the Synoptical collection. These additions will, with others yet to be added from the same source, make our New England collection presentable; but we still have no occasion for congratulating ourselves upon the prospects of this department, which is far below comparison with that of any other in the Museum.

Teachers' School of Science.

The last annual report contained an announcement that Mr. Augustus Lowell would take the larger public course given in this department under the protection of the Lowell fund. This promise has been carried out with characteristic thoroughness, and greater generosity than we had anticipated. He has granted the Society the privilege of making its engagements, and announcing its lessons in advance during the winter preceding their delivery, and also allowed the use of Huntington Hall in the Massachusetts Institute of Technology for the winter of 1882-1883. These privileges are of such value that they will doubtless greatly increase the public usefulness of this school, if the teachers of Boston continue to manifest the same intelligent and active interest as heretofore.

Eighteen lessons have been given this winter under the title of the "Lowell Free Lectures in the Teachers' School of Science." Eight of these were on Physics, by Professor Cross, of the Massachusetts Institute of Technology; five were on Geology, by Mr. W. O. Crosby, Assistant in our Museum; and five on Physiology, by Dr. H. P. Bowditch, of the Harvard Medical School; all were very successful and well attended by the teachers. The small size of the rooms at our disposal, though the physical lecture room of the Massachusetts Institute of Technology was kindly loaned for our use, obliged us to limit the issue of tickets to about four hundred.

These were distributed as follows.

35 to Masters of the Public Schools.
22 to Sub-Masters of the Public Schools,
21 to teachers who had attended 7 previous courses.
17 " " " " " 6 " "
17 " " " " " 5 " "
26 " " " " " 4 " "
50 " " " " " 3 " "
65 " " " " " 2 " "
51 " " " " " 1 " "
46 to new applicants, all teachers.
50 complimentary and scattering.

Only about five hundred circulars were issued, all to names appearing on previous applications, so that the forty-six new comers were gained without effort on our part.

The attendance in the series on Physics was about eighty per-cent. of the tickets specially reserved for the series, in Geology about seventy per cent., in Physiology ninety per cent. The general average was fifty per cent. Mr. E. P. Seaver, the Superintendent of Public Schools, attended the opening of the course and expressed his approval, adding the remark "that the teacher was ever improving his or her teaching capacity by coming to these lectures as a learner, and that the effects of the lessons given in the Teachers' School of Science had been plainly visible to him, both in the increased powers of the teachers themselves, and in their use of what they had learned in the instruction of their pupils in the Public Schools of Boston."

The Teachers' School of Science has also had another branch in active operation which has heretofore never appeared in this connection because the courses were paid for by the teachers themselves. Nevertheless the lessons given in our Winter Laboratory every Saturday since the commencement in the fall of 1877 properly belong in this part of the Curator's report. The Curator, assisted by Mr. Van Vleck, has had two classes in Zoology occupying four winters, and numbering in all fifty-nine teachers, Mr. B. H. Van Vleck a class in Physiology numbering fifteen teachers, and Mr. W. O. Crosby a special class in Geology.

These classes have demonstrated a demand for the kind of knowledge we can give so earnest that a good proportion of the teachers were willing to surrender their holidays to laboratory work and also to pay for the privilege. We can also state positively that there were a number more who would have attended but for the obstacle of the fee charged for tuition. We shall make no farther effort to continue these classes, now that the reality of this demand has been shown unless they can be placed on a more liberal basis, and one more consistent with the usual policy of the Society with regard to the needs of our public schools.

Winter Laboratory.

We shall hereafter give an account of what has been done in the laboratory attached to the Museum. This laboratory has been used by the following classes: one in Zoology from Boston University, one in Zoology and Paleontology from the Massachusetts Institute of Technology; both of these under charge of the Curator. One in Physiology from the Boston University, and one in Physiology composed of teachers of the public schools, both the last named under the charge of Mr. B. H. Van Vleck. An agreement has been arranged between our Council and the Boston University, which enables us to separate the work done in this department from all danger of future interference with that of other departments.

This is the second step in advance which the Winter Laboratory has made, the first having been the agreement with the Massachusetts Institute of Technology, and it now seems to give promise of becoming a permanent addition to our means of public usefulness.

Annisquam Laboratory.

The rise and progress of this new department was briefly given in last year's annual report under the general title of "Laboratory" p. 185, Report of 1881. The following extracts from our first circular will however explain more fully the history of this movement.

"NEW SEA-SIDE LABORATORY."

" The liberality and coöperation of the Woman's Education Association enable the Boston Society of Natural History to announce that a Sea-side Laboratory, under the direction of the Curator and capable of accomodating a limited number of students, will be open at Annisquam, Mass., from June 5th to Sept. 15th.

" Annisquam is situated on an inlet of Ipswich Bay, on the north side o Cape Ann, and is about three and a half miles by coach from the Eastern Railroad Company's station in Gloucester.

" The purpose of this Laboratory is to afford opportunities for the study and observation of the development, anatomy and habits of common types of marine animals under suitable direction and advice. There will therefore be no attempt, during the coming summer, to give any stated course of instruction or lectures.

"It is believed that such a Laboratory will meet the wants of a number of students, teachers and others *who have already made a beginning in the study of Natural History.* Those who have had some limited experience in a laboratory, or who have attended the practical lessons given by the Teachers' School of Science of the Boston Society of Natural History, are sufficiently qualified to make use of this opportunity.

" The work in the Laboratory will be under the immediate care of Mr. B. H. Van Vleck, Assistant in the Museum and Laboratory of the Boston Society of Natural History, a thoroughly competent instructor, and one who has also had long experience in collecting and observing at the sea-side."

When the summer opened we expected to have a dozen students, principally teachers in the public schools of Boston, whereas we had nearly double that number. Twenty-two persons, ten women and twelve men, availed themselves of the privileges offered; thirteen of these were teachers in the public schools of Boston, and various colleges and other institutions of learning were also represented, such as Princeton, N. J., Oswego Normal School, N. Y., Framingham Normal School in this State, and Smith College.

Four special students were in attendance and pursued advanced studies involving original work in embryology and anatomy. Four investigators honored the Laboratory with their presence, and pursued their labors in the more difficult fields of original research. There was but one student at large, that is in pursuit of information without decided views of using his acquisitions for some professional or practical purpose. The Laboratory was begun under the impression that such an institution would meet the wants of a number of students, teachers, and others, who had already made a beginning in the study of Natural History. This impression has received the fullest confirmation, though the expense of board and lodging in Annisquam prevented several persons from making application. It was also expected that the demand for such instruction as the Laboratory could give, would come largely from those who had been pupils in the Teachers' School of Science, and in the Laboratory of the Society of Natural History. This expectation was also fully realized; more than half of the whole number present had been under our instruction in Boston. The small sum charged for the use of the Laboratory per week to each person was none too small when it is considered that very few of those who studied there could have afforded any considerable sum in addition to their board and travelling expenses.

The success of the summer's work is due to the ability and energy of Mr. B. H. Van Vleck, who had the whole charge of the instruction and work done in the Laboratory, and it is also proper to remember that his labor was largely a donation for the purpose of trying this experiment. The great need of an institution for teaching field work cannot be properly estimated by the number of those who are attracted by the opening of such opportunities for study. The mental condition of those who attend, and what it has done for them, what it can do for others like them, and the sphere of influence which it reaches through them, are the only true standards by which its present and future usefulness can be properly measured. Nearly all the pupils were persons who could be termed "well educated"; nevertheless they were, with the exception of some who had already worked in the laboratory or field, entirely unable to obtain knowledge with their own eyes and hands, and had even acquired a notion that this was not possible for anybody except the trained scientist. Several of these teachers after their work was finished expressed their gratefulness for the new powers the course had developed in themselves, and the fascinating pleasures they had experienced in learning to use their own eyes and hands in the study of things hitherto unapproachable for their uncultivated senses, except through the deceptive meditation of books. When it is remembered that these teachers influence and mould the minds of thousands of young persons, it is at the same time proved, that what this laboratory has done and can do is not to be estimated by the number of its own pupils.

The sum contributed by the Woman's Education Association, four hundred dollars, by no means represents the whole of their work in this connection, since their committee assisted us in matters of a practical description, such as the distribution of circulars and providing suitable boarding places for students, the last difficulty being by far the greatest of those we have had to contend with in this new enterprise. We also owe our thanks to Mr. Geo. J. Marsh, of Gloucester, for the remission of the rent upon the building occupied by the Laboratory. It is gratifying, also, to be able to announce that the Woman's Education Association have been pleased with the result of their experiment, and propose to support the Laboratory for the coming summer. In fact the circulars announcing their intention and similar to the one above quoted, have already been issued. They have also gone a step farther and generously given us an important addition to the apparatus, a wind-mill for pumping sea water. This will enable us to offer additional opportunities for the study of living animals kept in aquaria, and also essentially facilitate the work of making a higher class of observations and original investigations.

Summer Work.

An expedition was made to the Island of Anticosti in the Gulf of St. Lawrence. The Curator was accompanied by Mr. Henshaw, Assistant in the Museum, Mr. William Brewster, Assistant in the Museum in charge of the Society's Ornithological Collections, Messrs. E. C. Gardiner, W. H. Kerr, and E. R. Warren of the Institute of Technology, and a crew of three men. We sailed on the morning of the seventeenth of June, arrived at Canso Light on the evening of the 20th though somewhat delayed by fog while off the coast of Nova Scotia. When in the Gulf we visited and collected at Port Hood, Cape Breton, then sailed to Entry Island, visiting also Amherst Island, Grand Entry Harbor, where we were storm-bound for several days, Bryon Island and Bird Rocks among the Magdalen Islands. From these Islands we ran to the west end of Anticosti through an easterly gale, and after remaining at Fox Harbor for several days, went across the Gulf to Gaspé on the coast of New Brunswick. The next stopping place was to have been Ellis Bay at the east end of Anticosti, but being prevented by unfavorable weather from entering the Bay, we anchored for the night at English Head and started next morning for the Mingan Islands on the coast of Labrador.

After a week spent among these islands we began our return trip, stopping at English Head and also visiting and collecting in Ellis Bay. The course from this locality carried us to Percé on the coast of New Brunswick, and from that beautiful though unsafe harbor we sailed direct for the Gut of Canso, arriving there July 31. The expedition left the Gut on the morning of Aug. 2, but was so delayed by fogs and bad weather, that we were unable to reach Annisquam again until the 15th of August.

The party made valuable additions to our Museum by its collection of fossils, insects, and birds and also by a series of photographs showing the terraces and other geological monuments, which are especially interesting in these localities for the remarkable display of the effects of elevation and the superficial denudation which has subsequently taken place. Mr. Brewster secured a number of interesting birds for our collection and also made notes of the occurrence of species which will appear in our Proceedings. Mr. Henshaw found insects abundant at Anticosti, and other localities, and brought home about five thousand specimens. He also collected and preserved fresh-water animals and plants.

Mr. Kerr collected many valuable fossils which were given to the Society. Mr. Gardiner acted as navigator and also performed other onerous duties, really acting as Assistant in charge of the yacht. To all of these gentlemen the Society owes its thanks for their voluntary contributions, since the expedition was made at no cost to the Society beyond the ordinary appropriations for summer work, and the collecting materials, alcohol, etc. Mr. Warren assisted Mr. Brewster in preparing his birds. The most valuable of the accessions is a fine and extensive series of specimens of the extraordinary fossil genus, Beatricea. This material will probably enable us to settle the true nature of this fossil, which has been at different times successively described as a plant, a coral, a cephalopod, and lately as a sponge.

In the summer of 1861, Prof. N. S. Shaler, Prof. A. E. Verrill, and the Curator, all three at that time students of Prof. Louis Agassiz, went over the same track, but spent more time at Anticosti, making large collections now stored in the Mus. Comp. Zool. at Cambridge. We found no specimens of the Unionidae in the fresh-water at that island, but this time we found Margaritana (Alasmodonta) arcuata living in Fox River.

The weather in the Gulf was exceptionally bad, even for that stormy region. The log book shows that there were but eighteen moderately fair days, some of these more or less interrupted by showers, during the sixty-two occupied in the trip. The ordinary temperature in the cabin was about 58° Fahr., rising rarely above 60°, and falling once to 37° and once to 34° Fahr. We did not attempt dredging since this would only have been successfully done by the sacrifice of opportunities for shore collecting of much greater value for the purposes of the expedition.

Report of Edward Burgess, Secretary.

The following report on the condition of the departments in charge of the Secretary is respectfully submitted.

Membership.

The roll of Corporate and Associate Members bears to-day four hundred and twenty-seven names, just thirty less than reported one year ago; but this loss is rather apparent than real, for the roll has been carefully revised, and names of many members have been erased for non-payment of fees, which strictly should not have been enumerated last year. Nineteen Associate Members have been elected. Owing to the failure of the last regular election, from lack of a quorum, there have been no elections in the higher classes of membership. We have lost by death six Corporate Members and four Patrons, among whom should here be especially mentioned Mr. John Amory Lowell, a member of the Council, to whom the Society was indebted for the Lowell Herbarium and other gifts, Dr. John Bacon, and Mr. James Davis, the latter of whom showed his interest in the Society by the generous bequest of five thousand dollars. Four Corresponding Members have died during the year, and one Honorary Member, Charles Darwin, whose death not two weeks since, the world now deplores.

A new list of members is about to be printed.

Meetings.

Sixteen general meetings have been held as usual, with an average attendance of thirty-three persons, the largest attendance being seventy-four, and the smallest, twenty. The average — thirty-three — is the same as reported last year. Forty-seven communications were made at these meetings.

The Section of Entomology held seven meetings, the average attendance being eight persons. Twenty communications were made.

Library.

The number of additions to the Society's Library make the largest total — 2346 — yet recorded for a single year. These additions are classified as follows.

	8°	4°	Fol.	Total.
Volumes	357	32	2	391
Parts	1217	241	138	1596
Pamphlets	189	22		211
Maps, Photographs, etc.				148
			Total :	2346

We are especially indebted to the Mûseo Pûblico of Buenos Ayres, to our President, Mr. Scudder, and to Prof. J. O. Westwood of England, for gifts to the Library.

The Librarian must make his usual lament over lack of funds for binding. In his opinion, there is no work before the Society so pressing as that required to put its Library in decent condition. A large proportion of our books are being injured for want of proper binding, and the value of the library would be immensely increased by filling the many gaps in important series of works.

We have just begun the transfer of our card catalogue to cards of the standard size, but the work with the present force must be very slow. Nine hundred and forty-four books have been borrowed from the library by one hundred and nineteen persons.

The Library Committee has also arranged to add to our shelf-room during the coming summer.

Publications.

The cost of the "Anniversary Memoirs" partly met during the present year, has somewhat crippled the Publishing Committee. We have, however, succeeded in bringing the issue of Proceedings nearer to date than for a long time past, and have published the last part of Vol. XX, two parts of Vol. XXI and four signatures towards a third part.

One number of the Memoirs containing an article by Prof. S. F. Clarke, "New Hydroid from Chesapeake Bay" (8 pp. and 3 plates) was published in January, and another number, containing Mr. S. H. Scudder's memoir on "Archipolypoda, a New Type of Carboniferous Centipedes," is nearly ready for publication.

It is much to be desired that the Society could afford to publish a general index to the twenty volumes of Proceedings now completed.

New exchanges have been arranged with the American Institute of Mining Engineers, the Second Geological Survey of Pennsylvania, the Torrey Botanical Club, and the editors of the Botanischer Centralblatt and the Naturalista Siciliano.

Walker Prizes.

The prize subject for the year "The occurrence, microscopic structure, and use of North American fibre plants, treating especially of the fibres employed by the native races," has brought forward no essay.

The subject already announced for 1883 is "Original unpublished investigations concerning the life-history of any animal."

The Treasurer, Mr. Charles W. Scudder, presented his annual report on receipts and expenditures, given upon the opposite page; and the auditing committee, Messrs. Richard C. Greenleaf and John Cummings, reported that they had examined the same and found them correct and with proper vouchers. They further reported that they had examined and verified the evidences of property belonging to the Society, held by the Treasurer and by the Trustees of the Walker Fund.

Boston Society of Natural History.

Annual Statement of Receipts and Expenditures, May 1, 1882.

1881, May 1, to May 1, 1882.

Admission Fees	$85.00
Annual Assessments	1155.00
Life Membership	50.00
Dividends and Income from General Fund	5136.98
Walker Fund Income	2015.00
Walker Prize Fund Income	252.00
Walker Grand Prize Fund Income	92.00
Bulfinch St. Estate Fund Income (Cash)	2403.61
Courtis Fund Income	395.00
S. P. Pratt Fund Income	665.14
Huntington Frothingham Wolcott Fund Inccme	381.68
Entomological Fund Income	25.00
Laboratory, Donations and Students' Fees	1545.23
Balance	509.22
	$14,710.86

1881, May 1, to May 1, 1882.

Museum or Cabinet		2538.09
Publication and Printing	3237.77	
Less Receipts on this account	2142.30	1095.47
Library		450.16
Salaries and Wages		6675.00
Repairs of Building		793.21
Fuel		347.50
Gas		101.60
General Expenses		971.70
Laboratory		1738.13
		$14,710.86

Excess of Expenditures, over Receipts	509.22

Teachers' School of Science, Donation from Augustus Lowell, Trustee	1500.00

Teachers' School of Science.

Expended to date for Lectures, etc	973.28
Unexpended balance on hand	526.72
	$1500.00

Boston, May 1, 1882.

CHAS. W. SCUDDER,
Treasurer.

The Society then proceeded to the election of officers for the year. Messrs. R. W. Greenleaf and J. H. Blake being requested to act as scrutineers reported that the following gentlemen, nominated at the previous meeting, were unanimously elected officers for 1882-83.

PRESIDENT,

SAMUEL H. SCUDDER.

VICE-PRESIDENTS,

JOHN CUMMINGS, F. W. PUTNAM.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

S. L. ABBOT, M.D.

SECRETARY.

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

J. A. Allen,
Henry P. Bowditch, M.D.,
Samuel Cabot, M.D.,
Thomas Dwight, M.D.,
W. G. Farlow, M.D.,
Samuel Garman,
Geo. L. Goodale, M.D.,
H. A. Hagen, M.D.,
B. Joy Jeffries, M.D.,
Augustus Lowell,
Theodore Lyman,
Edw. S. Morse,
Wm. H. Niles,
A. S. Packard, Jr., M.D.,
R. H. Richards,
N. S. Shaler,
Chas. J. Sprague,
M. E. Wadsworth,
Samuel Wells,
Wm. F. Whitney, M.D.

MEMBERS OF THE COUNCIL, EX OFFICIO,

Ex-President, Thomas T. Bouvé,
Ex-Vice-Presidents, Richard C. Greenleaf,
D. Humphreys Storer, M.D.

The following members were also elected: Corresponding Members, Professors Hermann Credner, Ferdinand Zirkel, Franz Leydig, R. P. Whitfield, Frithiof Holmgren; Corporate Members, Prof. H. W. Haynes, Mr. William Brewster; Associate Members, Joseph W. Warren, M.D., Messrs. James R. Osgood and Amory A. Lawrence, Miss Nina Moore, Messrs. Herbert Gleason, Charles E. Dotey, and F. L. Messenger.

It was voted to amend Section 9 of Article 3 of the By-laws to read: "Ten members shall form a quorum for business."

The following paper was read:

GLACIAL EROSION.

BY WILLIAM MORRIS DAVIS.

How much was the surface of glaciated countries changed during their occupation by ice? How far was the form of North-western Europe, Switzerland, and North-eastern America remodeled in the glacial period?

To answer such questions briefly, one should first ask the questioner what authority he prefers, for there is no admitted agreement on the subject among geologists. We may quote Rütimeyer, a Swiss geologist of high standing, to the effect that the glacial period was a time of rest in the formation of valleys; Ramsay, the late director of the Geological Survey of Great Britain, considers most of our northern lakes the result of localized glacial erosion; and Tyndall, whom some may take as an authority beyond the limit of his special studies, states his belief that without glacial action the Alps would have no valleys. Further opportunity for the choice of a ready-made opinion is given in the quotations and abstracts below from the writings of a number of geologists of different countries; it certainly does not lead to conviction, and the student must remain unsettled in his mind until he can go behind the authorities and come to observation and argument for himself.

How does it happen that there are so many contradictory answers to the question? We cannot lay all the disagreement to incorrect observation or imperfect conclusions, but must consider it to arise partly from the essential difference of glacial action in different regions. I believe that the following summary — an eclectic statement of the subject — may reconcile some of the divergent views and explain some apparently conflicting opinions. The observations and arguments on which this summary is based will be referred to below.

Glacial erosion was greatest near the centres of glacial dispersion, where the ice acted for the longest time, and where its thickness and velocity were greatest; here it succeeded in scraping away all of the rubbish of preglacial disintegration and rubbing down the solid rock below in some places for a moderate number of feet; here glaciers lowered the hills and deepened the valleys on which they moved. In their middle course, the extended ice-sheets were sufficiently occupied in carrying forward for a short distance the loose material that they found ready made, without attempting to wear away much of the rock below, except from projecting knobs; here they generally lessened the roughness of the country by rubbing down the ledges and filling the valleys. Near the broad margins, where melting equalled or overcame supply, where the ice was thin and slow-moving, and its under part was clogged with detritus, the ice-sheet acted more in the way of deposition than destruction, and as a rule failed to rub away the loose soils and gravels over which it advanced; here the principal effects are found in a concealment of previous lines of drainage by irregular accumulation of drift.

It should be noted also that glacial erosion was strongest during the early phases of its action, when it had loose surface detritus in large quantity to deal with; and that later, when the solid rock was reached, further change must have progressed with increasing slowness.

Before going farther, we may note the development of the idea that glaciers have a strong erosive effect on the surface over which they move.

Roches moutonnées and polished rock-surfaces, at first considered the result of floods, were shown by de Charpentier [1] in 1834 to be the product of glacial friction. In 1837, Agassiz [2] explained rock striations in the same way, and pointed out how they might be distinguished from slickensides and land-slide scratches ; they had been taken by de Saussure to be the effect of crystalline structure, like the parallel lines on the side of a quartz prism ; and by Hall [3] and Sefström [4] as the result of a flood. Glacial mud, the result of the production of striated and rounded rocks, was noticed by de Charpentier,[5] but first considered of much importance by Collomb [6].

In 1821, Venetz [7] suggested that the smaller Alpine lakes owed their preservation to having been cleaned out by glaciers ; an idea since carried farther by de Mortillet,[8] and extended by Ramsay [9] to the making of rock-basins. Esmark [10] first proposed that the Norwegian fjords had been shaped by glaciers ; Chambers [11] went farther in claiming that land ice had produced great general denudation. In 1858, Kämtz [12] suggested that the Swiss and Scandinavian glaciers had been self-destructive by wearing away their mountain supports ; Tyndall [13] repeated this in 1862, and at the same time stated his belief that without glaciers the Alps would have had no valleys. Finally, in 1874, Campbell [14] compared a glacial scratch and a Norwegian fjord as differing in size but not in kind. One cannot well imagine anything more excessive than these latter views.

With reference to subglacial streams, de Charpentier [15] referred the formation of *lapiaz* (*karrenfelder*) to their action; Agassiz [16] added pot-holes, and thought also that Alpine valleys of erosion had been cut out by streams

1 Annales des Mines, VIII, 1835, 231.
2 Soc. Helv. Actes, XXII, 1837, p. XII ; Etudes sur les Glaciers, 1840, 195.
3 Edinb. Trans. VII, 1815, 183.
4 Pogg. Ann. XXXVIII, 1836, 614.
5 Essai sur les Glaciers, 1841, 89.
6 Soc. Géol. Bull. VI, 1848-49, 492.
7 Soc. Helv. Denkschr, I, (2) 1833, 33.
8 Soc. Géol. Bull. XVI, 1859, 888.
9 Peaks, Passes, and Glaciers, 1859, 466 ; Geol. Soc. Journ., XVIII, 1862, 185.
10 Edin. New Phil. Journ., II, 1826-27, 118.
11 Id. LIV, 1853, 252.
12 Wien, Geogr. Ges. Abhandl. II, 1858, 241-243.
13 Phil. Mag., XXIV, 1862, 172.
14 Geol. Soc. Journ., XXX, 1874, 221.
15 Annales des Mines, VIII, 1835, 232.
16 Soc. Helv. Actes, XXII, 1837, p. XIII.

flowing along cracks made in the original ice-sheet by the uplift of the Alps.

Belt[1] compared lake-basins to pot-holes on a large scale ; Shaler[2] emphasized the action of subglacial water supplied by local excess of heat conducted from the earth's interior, and by pressure-melting.

A closer examination of the question leads us to divide the evidence *pro* and *contra*, into the following classes. Evidence derived from —

A. The action of glaciers in general;

B. The amount and distribution of glacial drift;

C. A comparison of the topography of glaciated and nonglaciated regions;

D. A supposed necessity for glacial erosion; that is from ignorance of any means except this action to produce certain observed effects.

A. 1. *Observations beneath Glaciers.* It was for a long time unnoticed or denied that glaciers eroded the surface beneath them; but observers have since then made their way a little distance under certain Swiss glaciers and have clearly shown that the ice wears and scratches the rocks below by rubbing sand and stones against them.

They generally report also open spaces between ice and rock except at certain projecting points of support, and infer from this that the glacier wears most on the convex parts of its base; that it does not fit closely down on its bed, and therefore does not materially deepen its valley; this work being left to the subglacial streams.

Agassiz describes his difficulty in convincing his friend, Studer, of the glacial origin of rock-striations until he showed them to him freshly made under the ice. (Études sur les Glaciers, 189.)

Desor, Soc. Helv. Actes, 1860, 133, and Gebirgsbau der Alpen, 1865, 116; Niles, these Proceedings, xv, 1873, 378-381 ; Bonney, Geol. Mag., III, 1876, 198, describe and reason thus from unoccupied hollows beneath the ice.

But direct observations of this kind cannot be carried far against the erosive power of the old glaciers, as the conditions in which one can now see the under surface of the ice must be very different from those that obtained when its mass was much

[1] Geol. Soc. Journ., xx, 1864, 464.

[2] These Proceedings, x, 1866, 359 ; XVIII, 1876, 126.

greater, and when outer air and observers were excluded. Erosion was certainly greatest on rocky knobs, but the old glaciers often fitted closely into the hollows of the ground, especially into hollows opening to the approach of the ice, and wore them smoother and deeper.

De Mortillet thus criticizes Desor. (Milano, Soc. Ital. Atti, v, 1863.)

Newberry describes scratches on the under surfaces of projecting ledges. (Geol. Ohio, II, 77.) Similar scratches may be seen at Catskill, N, Y.

A. 2. *Advance of Glaciers.* Glaciers have been observed to advance over a surface of loose material without causing great disturbance in it, certainly without ploughing it up, and hence it has been argued that there never could be great glacial erosion. This however goes to the conservative extreme and neglects the elements of time and weight. Surely the friction on the bottom gravels of the Valley of Chamounix, when the ice rose to the upper line of the scored rocks, would be effective in amount and duration to an extent not fairly indicated by the short-lived action of a small modern glacier.[1] Moreover, examples of an opposite, destructive effect have been seen as well and are also entitled to attention. It would seem therefore that glaciers in advancing over new ground sometimes do and sometimes do not tear and plough it up; a smooth gravel surface appears to be less liable to disturbance than a rough one or than loamy soil; but it may be noted that examples of slight erosion are entitled to especial attention, for they are not what one would expect.

J. de Charpentier (Essai sur les Glaciers, Lausanne, 1841, 41) records the advance of the Glacier du Tour eighty feet over a gravelly surface without destroying it, but the swampy soil of a field beyond was overturned ; also of the Glacier du Trient in 1818, when the ice insinuated itself between bed-rock and soil, overturning the latter and the trees growing in it. Further examples by Favre (Recherches Géol. I, 201) ; and Credner (Deutsch. Geol. Gesell. Zft., XXXII, 1880, 75, with figures.)

A. 3. *Retreat of Glaciers.* An emphasis that seems unwarranted has been laid on the occurrence of drift deposits sometimes disclosed by glacial retreat. The preservation of such detritus is claimed as evidence that the ice could not have worn it away, but this is not conclusive; it shows simply that the ice had not

[1] Ramsay, Phil. Mag. XXVIII, 1864, 304.

worn it away in the possibly short time it had been there. If it were found that a non-glaciated surface existed below this detritus, the observation would be decisive, but I am not aware that this has been done.

The rocky surface abandoned by the ice is by no means a smooth trough, but is of uneven, irregular form. If its irregularities were of broad curvature, they might be considered the remains of large masses of rock, now nearly destroyed; but they are not; the shapes rapidly change from hollow to mound, and such small unevenness can result only from the broad glacier having but little rubbed down a surface originally roughened by the more detailed action of atmospheric weathering. Here then where the ice has acted longest, it has failed to destroy all the smaller preglacial forms of the surface. (See C. 2, 5, 6.)

L. Agassiz gave a chapter to "l'action des glaciers sur leur fond" in his Études sur les Glaciers, Neuchâtel, 1840, and concluded that while they might be supposed to act powerfully on the rocks over which they move, the only effects noted were those of rounding and polishing; he considered the possibility of their deepening their channel and forming rock-basins for lakes, but rejected it because such basins are not found in the valleys from which glaciers have recently retreated.

E. Whymper gives good examples under this heading. (Scrambles in the Alps, 1871, 324.) He suggests that the final flat form of the *roche moutonnée* be called *nivelée*; such are rare in the Alps, but he found them in Greenland where the ice has presumably worked longer.

A. 4. *Transporters not Eroders.* What little drift occurs on these recently uncovered surfaces is very probably of modern arrival at the point where it is found, and may very possibly have largely come by crevasses from the top of the ice. For these surfaces are as a rule of nearly bare rock; the ice has been at work there so long that it has ages ago cleared away all the loose preglacial fragments, and since then has been working perseveringly, but with little avail as has just been shown, to rub down the solid rock. Hence it is probable that after its early activity in sweeping away what it found ready loosened, the ice did not supply itself with much more detritus, and its further erosion was slow.

Alex. Müller holds that glaciers, like rivers, carry away detritus provided for them by surface weathering; while the rock surface is snow-bound or ice-covered its waste will be slight. (Ueber Thalbildung durch Gletscher, Pogg. Ann. CLII, 1874, 476-482.)

Rütimeyer calls the period of glacial occupation, the pupa-stage of a valley's history, for the above reason. (Ueber Thal- und Seebildung, Basel, 1869, 24.) Kinahan says that glacial erosion is effective only where pre-glacial faulting, jointing, and weathering have loosened the bed-rock so that the ice has only to scrape away the prepared fragments: he notes the reduced rate of erosion after this has been accomplished and solid rock reached. (Valleys and their relation to Fissures, Fractures, and Faults; London, 1875, 120, 124.)

J. D. Whitney considers glaciers the carriers but not the originators of morainic material. (Climatic Changes, 1881, 7.)

A. 5. *Limit of Time.* All the preceding paragraphs show that a certain amount of erosion goes on beneath the ice, and this is confirmed by the milky appearance of the subglacial stream where it runs out at the end of the glacier, charged with rock flour; and quite unlike the limpid streams on the neighboring valley-sides, flowing from melted snow or from springs. But the comparison often made between the work of these two classes of streams, to the disadvantage of the latter, is hardly just. Brooks from springs are busy enough carrying down detritus just after a rain, although they have a rest from heavy work in fine weather: their action is intermittent, instead of almost continuous like that of the subglacial streams, but there has not yet been shown to be any great difference in the total results of the two; and certainly nonglacial streams have been active enough in all parts of the world, as is known by the results of their cutting.

But, in the face of the continual grinding that goes on beneath glaciers, to argue that they could never erode valleys, savors of the same conservatism that stood so long in the way of a proper understanding of the work of streams and rivers. These have done little in our short historic period, but have been admittedly very effective during their long persevering life. And almost equally effective would glaciers have been had they worked as long. We cannot deny their power, but we may say that the time through which they have acted has been insufficient to produce great results. (See below, C. 4).

A. 6. *Subglacial Streams.* A certain amount of rock erosion must be admitted and we may now inquire where this took place most rapidly. All that is due to subglacial streams will be closely limited to the lines of drainage of the subglacial surface, and these will as a rule correspond to the preglacial valleys. Undoubtedly their work has been effective in deepening old valleys, but it can hardly aid in the formation of basins. Granting that a small basin is begun, the standing water that must occupy all the passages in and below the ice will be inert of itself, and will act as a cushion to streams falling from above, and prevent their cutting to any great depth. Pot-holes or giant's cauldrons are the limit of this kind of action.

Charpentier showed that the fine mud of subglacial streams was an effect of glacial action, by noting that these streams became nearly clear in late winter when the motion and melting of the ice was decreased. (Essai sur les Glaciers, 1841, 89.)

Dollfus-Ausset (Matériaux pour l'étude des glaciers, 1864, I, 276) measured the fine sediment carried out by the stream from below the Unter-Aar glacier, finding 132 grammes in a cubic meter of water. This corresponds to a yearly rubbing off of about 0.6 millimeter of rock from under all parts of the glacier's basins; or an erosion of one meter in 1666 years; about two and a half times as much as water could do in the same period. It is not determined how much of the sediment came from sand washed under the ice by side streams, but it shows that the glacier does a considerable amount of work.

O. Heer describes the stream that runs out from the Rosenlaui glacier as having cut a channel deeper than the surface on which the ice rested. (Die Urwelt der Schweiz, 1865, 582.)

O. Fisher admits that glaciers may have cut out basins, but recognizes a limit of depth where decrease of motion will balance increase of pressure, and suggests that this limit will be the sooner reached on account of the buoyant action of subglacial water. (The Formation of Lake Basins; Reader, Apr. 9, 1864; Apr. 25, 1865.)

T. Belt suggested that the excavation of lake basins might be aided by the falling of streams through the ice. (Geol. Soc. Journ., xx, 1864, 464.) The idea is repeated by J. D. Kendall. (The Formation of Rock-basins, Geol. Soc. Proc., 1879, 105.)

Bonney has suggested that subglacial streams now carry more silt than formerly, when surface fragments had less easy access to the bottom of the ice. (Geol. Soc. Journ. xxvii, 1871, 322.)

Ch. Grad describes stream channels on these rocky surfaces, showing that the subglacial streams work faster than the ice. (Les Glaciers et l'origine des vallées. Club Alpin Franç. Ann., III, 1876, 474-479.)

W. H. Niles limits ice erosion to small results, but allows subglacial streams a considerable effect. (These Proceedings, XV, 1873, 378-381; XIX, 1878, 335.)

J. D. Dana states that much of the excavation of our valleys was done in the glacial period; partly by the direct action of the glacial, but vastly more by the action of subglacial streams laden with debris from the glacier. (Manual of Geology, 1880, 539; also Conn. Acad. Trans. II, 1871–73, 41–112.)

A. 7. *Pressure Melting* has been named as an important source of violent, cutting currents beneath the ice; but it involves two unknown quantities, the thickness and the temperature of the glacial sheet, and is of problematical occurrence; if proven, it would certainly account for a share of subglacial erosion, but how much we cannot reckon.

N. S. Shaler (Illustrations of the Earth's Surface; Glaciers. Boston, 1881, 146, 158; and these Proceedings, XVIII, 1876, 126.) He also suggests that the erosive action of subglacial streams may be increased by their being locally produced by the greater outward conduction of the earth's internal heat through some rocks than others. (On the formation of the excavated Lake-Basins of New England; these Proceedings, X, 1866, 358-364.)

A. 8. *Where is Ice Erosion most Effective?* The grinding power of the ice itself is generally considered greatest where it is thickest, so that at certain points local depressions will be formed, which in time will become rock-basins of great depth. To a certain extent this is undoubtedly true, but by no means to the extent claimed by the more advanced glacialists who refer to this origin lakes even two thousand feet deep. For as the basin deepens the motion of the ice at the bottom will be greatly retarded by having to advance up hill in its escape, and the decrease of motion will soon counterbalance the increase of pressure and so put a stop to further excavation. The velocity of the under parts of a valley-glacier is very small; in a lake basin it must be still farther reduced.

J. Ball, On the formation of Alpine valleys and Alpine lakes, Phil. Mag. XXV, 1863, 81; O. Fisher, as above; and Lyell, Antiquity of Man, 1873, 357; call attention to the retarded motion of the ice in depressions.

R. D. Oldham has shown that a glacier could not be forced *en masse* with uniform velocity out of a basin or up a slope by a force from behind; it would rather crush to fragments. He therefore concludes that no glacier ever did move through and out of a basin, overlooking the discrepancy between his supposition of uniform velocity and the known motion of glaciers. (On the Modulus of Cohesion of Ice, and its Bearing on the Theory of Glacial Erosion of Lake Basins; Phil. Mag. VII, 1879, 240-247.) The results are of no value, because the assumed conditions are not natural conditions, and in this the work unfortunately resembles many of the attempts to apply mathematics to geology.

A. 9. *Ice, more than Rock, is Eroded.* It must be granted that the ice itself will suffer most when pressed heavily on its bed, and in spite of its long action will fail to produce much erosive change.

W. H. Niles found by direct observation that the bottom ice moves faster than the stones below it, and that a groove is worn in the ice as it passes on. (These Proceedings, XIX, 1878, 332.)

K. Zoppritz looks on glaciers as very limited agents of erosion, and thinks that the ice rather than the rocks below will be eroded. (Der gegenwärtige Stand der Geophysik ; Wagner's Geogr. Jahrb. VIII, 1880, 74.) A. Gurlt comes to the same conclusion. (See under Fjords, C. 1.)

A. 10. *Preservation of Scratches.* A vigorous opponent of glacial erosion brings forward the frequently observed double set of scratches on a single rock surface to show that, far from being able to cut valleys and fjords, a glacier cannot even rub out its own marks.

Th. Kjerulf, in an excellent article, entitled Die Eiszeit, (Virchow u. Holtzendorff, Samml. wiss. Vorträge, Berlin, XIII, 1878, 74 ; also, Geol. Norwegen, Bonn. 1880, 39), considers this the strongest argument against glacial erosion.

If it could be fully proven that the divergent scratches were made at widely separated times, and that the rock surface was through all the interval subjected to glacial rubbing without protection from the onward travelling ground-moraine, this conclusion would be well based; but this is not proven, and the argument turns better in the other direction. Just because the older scratches survive, they cannot be very much older than the newer ones, and are therefore useless in giving a clue to any very early direction of ice motion, unless we suppose they have been sheltered by a temporary covering of boulder-clay. It is more probable that nearly all the scratches now seen were made in a late phase of the glacial epoch, near the margin of the retreating ice.

A. 11. *Self-limitation of Erosion.* It has been claimed that glacial erosion is self-limiting; that as time goes on, the trough is rubbed into a form of least resistance to ice motion, and then further erosion is pratically stopped. But the attainment of this form of least resistance may require great change in the valley form, and even after its attainment it would be difficult to deny that glacial action, if continued long enough, would produce great results. The question then becomes, have the old glaciers of the Alps, for example, had time enough to bring about the results claimed for them. It will be shown farther on by evidence based upon the form of glaciated valleys (C. 4), that they decidedly have not.

A. Favre says that however long glaciers act, they cannot cut out lake-basins, any more than sand-dunes can grow to equal the Himalaya, or than mud-volcanoes can approach Chimborazo. (On the Origin of the Alpine lakes and valleys; Phil. Mag., XXIX, 1865, 207; Recherches Géol. 1867, I, 202.)

Ramsay says great depth of basin does not militate against his theory, for depth is a "mere indicator of time and vertical pressure in a narrow space." "Given sufficient time," the Great Lakes of North America might thus be formed. (Geol. Soc. Journ. XVIII, 1862, 199, 202.) He sets no limit to glacial time, but compares it to "eternity" (Phil. Mag. XXVIII 1864, 303), although he had before stated that Alpine valleys must be essentially of preglacial formation, because in the quaternary period there has not been time enough for much change. (Phil. Mag. XXIV, 1862, 378.)

J. Ball and E. Whymper, ll. c., consider the glacial period an insufficient time for great results.

A. 12. *Several Glacial Periods.* Now that Croll's writings have popularized what had been before suggested — the recurrence of glacial periods — those who accept astronomical causes as sufficient to explain our glacial invasions, look upon them as rather frequent, geologically, and if lake-basins cannot have been produced by the last one, they throw the burden of the work upon the ice of earlier epochs. But this is going very far into unproven hypotheses.

N. S. Shaler admits that the last ice period found the surface of our country pretty much as it now is, and refers the more important changes of form to earlier invasions, which took place "again and again." (These Proceedings, X, 1866, 363; XVIII, 1876, 126.)

B. Concerning the amount and distribution of glacial drift.

B. 1. *Preglacial Conditions.* The argument from the amount of glacial drift[1] is the strongest that can be made in favor of gla-

[1] The drift must include all the boulder-clay or till, all the kames, and the greatest part of the stratified sands and clays of glaciated regions; for the small amount of postglacial rock-weathering shows that very nearly all this detritus has been in the power of the ice and its accompanying streams. Allowance should be made, if it were possible, for the fine rock-flour lost by washing into the sea.

cial erosion, just as the occurrence of stratified fragmental rocks in great volume gives the best demonstration of the strong erosive power of water. But the argument is of difficult and uncertain application from our ignorance of the origin, amount, and distribution of the drift, and of the condition of the country before glaciation. To obtain an idea of the latter point, we may compare nonglaciated and glaciated regions of similar age, as the Black Mountains of North Carolina with the White Mountains of New Hampshire, or the Andes of Central Chili with the Alps. It may be fairly inferred that the latter members of the contrasted pairs were, before the glacial period, as the former still are, covered with a great amount of loose rock and soil lying where it weathered or in the valleys near by, the result of secular disintegration. The passage of ice has rather rapidly scraped such material away from the mountainous or hilly countries, leaving the characteristic, firm, rounded tors,[1] and carrying the detritus off to lower ground; there it is generally deposited on a smaller area than that from which it came, and so is increased in depth; the facts that in hilly regions the drift is found mostly in valleys and that valleys are the ordinary lines of travel, serve still farther to exaggerate the impression of its average thickness.

If New England had as heavy a soil as the Carolinas, there need have been comparatively little erosion of solid rock below the soil to supply the observed amount of drift, but that some solid rock was successfully attached is shown by the unweathered character of many boulders; these, however, probably came from projecting knobs and ledges, and not from valley bottoms.

B. 2. *Amount of Drift.* A number of quantitative estimates of the drift have been attempted, but they are necessarily crude and may be exaggerated; but even admitting their truth they do not require anything like the amount of erosion claimed by the more advanced glacialists.

A. Helland (Ueber die glacialen Bildungen der nordeuropaischen Ebene, Deutsch. Geol. Gesell. Zft. XXXI, 1879, 97) finds Lake Wenern in Sweden and the Island of Seeland in the Baltic to be about the same area, but that the amount of drift on the latter is nearly double

[1] This is suggested by J. F. Campbell as a concise substitute for the unwieldy *roches moutonnées.* (Frost and Fire, Phila., 1865, II, 6.) It should certainly have a place along with till, kame, and drumlin.

(one and eight-tenths) the material supposed to be excavated in making the former; this excess is considered due to addition of fragments distinctly referable to the region south of Lake Wenern. But it should be noted that the hilly surface of Seeland [1] points to its being precisely one of the regions of concentrated deposit — an old halting place of the ice — and consequently it should not be directly compared with an equal area farther north. Helland farther estimates that the area of the Scandinavian Peninsula from which the drift came, is to the area of North Germany and North Western Russia on which it was deposited, as two is to five; and that the average depth of drift on the latter, estimated in conference with several geologists familiar with the region, is one hundred and fifty German feet: allowing one third of this to be of local derivation, the proportion of areas requires the average thickness of the drift carried from Scandinavia to be two hundred and fifty feet. This is certainly an impressive showing. I should like to find a confirmation or criticism of it by one less pronounced than its author in favor of great glacial erosion. It may be noted that even two hundred and fifty feet of detritus might be largely supplied by preglacial disintegration from so old a land surface as Scandinavia and also that even this thickness would still negative the idea that the valleys and fjords were of glacial origin.

A. Penck gives twenty meters for the average thickness of the ground moraine of the old Isar glacier in Southern Bavaria, and this corresponds to an erosion of thirteen meters in the mountains from which the ice moved. Including all the glaciers that advanced from North Tyrol on to the high southern plain of Bavaria, and taking the waterworn pebbles and sands that were carried by glacial streams with the ground moraine, the average total thickness is sixty meters, and this restored to its origin would raise the general mountain surface by thirty-six meters. (Vergletscherung der deutschen Alpen, Leipzig, 1882, 201, 330, 387).

N. S. Shaler (Illustrations of the Earth's Surface; Glaciers, 58), estimates the total amount of drift on New England and in its neighboring terminal moraines at 750 cubic miles, or more than the mass of the White Mountains. Supposing this to be derived from an area of sixty thousand square miles, it would have had an average thickness, if evenly distributed, of about sixty-five feet. This is not far from the possibilities of preglacial soils and valley alluvium; and although the total mass of the drift is very great, the fact that it was derived from a broad area shows that no excessive local erosion took place.

A careful measure of the drift in three of the Northern Central States [2] has lately been made by E. W. Claypole. (Evidence from the Drift of Ohio,

[1] Forchhammer, Pogg. Ann. LVIII, 1843, 628.

[2] According to the divisions proposed by Gannett, which should certainly be adopted in our new Geographies. See Census Bulletin, No. 277, 1881.

Indiana and Illinois, in support of the Preglacial Origin of the Basins of Lakes Erie and Ontario. Amer. Assoc. Proc., xxx, 1881, 23–35.) He averages the estimates made independently in different counties by the geologists of the several local surveys ; the result gives sixty-two feet for the three States, or for Ohio alone, fifty-six feet. A considerable part of this is local, and it is all, as will be shown later, within the region where the ice acted more as a depositing than as an eroding agent : it moreover contains the terminal moraines of the ice-sheet, and therefore gives an exaggerated measure of the thickness of detritus eroded from the country to the north. The fine rock-flour, carried far down the Mississippi valley, and not here included, must have been very considerable in total amount, but cannot have been a large fraction of what remains.

W. Upham estimates the mantle of drift that so generally conceals the rock-outcrops in Minnesota as from one to two hundred feet thick; it contains a large part of pebbles from rocks near by. (Minn. Geol. Rept. 1879, 5, 44.)

G. H. Stone estimates the average thickness of the drift in Maine at thirty to fifty feet, and thinks that glacial erosion "reached only a few feet below the limit of preglacial weathering." (Glacial Erosion in Maine, Portland Nat. Hist. Soc. Proc., 1881, 6, 11).

Torell, Ramsay and Bauermann, a committee appointed by the British Association to consider "Ice as an Agent of Geologic Change," reported a method of gauging the work of existing glaciers, but expressed no opinion as to past effects. Their suggestion requires long, laborious observation. (Brit. Assoc. Rep. 1869, 1°, 171–174.)

Dollfus–Ausset wrote " A la boue du glacier! à la terre végétale dans la civilization ! Sans glacier, pas de boue glaciaire, la roche a nu partout, et si le glacier ne l'a pas déposée directement, c'est lui qui est l'auteur, le fabricant de cette terre que nous cultivons. (Matériaux pour l' étude des glaciers, v, 351 ; also, 417.)

B. 3. *Great Boulders.* The large boulders of granite found on the Jura mountains, and derived from the Central Alps, imply a great transporting power in the glacier which carried them, but not necessarily an eroding power, as they probably rolled from a mountain slope on to the ice below. But it is otherwise with the enormous slabs of rock found in the drift of North Germany and England, for these were displaced, broken, and bent by the advance of the ice against them. The preglacial surface of these regions was probably one in which valleys of a moderate depth were sunk in generally horizontal rocks ; low abrupt cliffs and outliers must have been common, as they are now in the Bad

Lands of our Western Plains. The ice-sheet advancing over these sometimes shoved off layers of very considerable size, but the action seems to have been rather pushing than excavating. Boulder clay was often forced into crevices thus formed. The slabs do not seem to have been carried any great distance.

This piece of evidence taken alone would imply great erosive ability on the part of the ice, but its examples are exceptional and when found occur close by others where no important erosion has taken place, as is shown in the next argument.

The Island of Moen in the Baltic, east of Denmark, offers the earliest recognized examples of the kind; it has often been described; Forchhammer considered the accompanying boulder clay eruptive, so closely does it fill all the crevices in the broken chalk strata (Pogg. Ann., LVIII, 1843, 614, 625); Puggaard attributed the contortions of the chalk to postglacial plutonic forces (Geologie der Insel Moen, Leipzig, 1852, 61); this view is accepted by Lyell (Antiquity of Man, 387), who copies some of Puggaard's figures. Johnstrup first ascribed the dislocations to the pressure of an advancing ice-sheet (Deutsch. Geol. Ges. Zft. XXVI, 1874, 533-585): this is adopted by Helland, and Penck (id., 1879, 71, 176.) The dislocated strata are seen, greatly bent and arched, in the face of a cliff one to four hundred feet high: although severely disturbed, it is not known that they were carried forward.

Remelé describes a slab of chalk-strata in North Germany, one-quarter of a (German) mile long (about 2000 metres), and 25 metres thick; breadth not visible. (Deutsch. Geol. Ges. Zft. XX, 1868, 650-652.)

Penck refers to several accounts of these slabs, and states that whole quarries have been worked in them, and lime-kilns supplied from them for many years. (loc. cit. 120.)

J. Geikie refers to a boulder in Norfolk measuring 480 by 44 yards, and to another in Lincolnshire, 430 by 30 feet. (Prehistoric Europe, 1881, 194.)

B 4. *Central and Marginal Areas of Glaciation.* In examining next the arrangement and distribution of the drift, we must divide the several glaciated regions into central and marginal areas; the first, mountainous or rugged; the second, of much smoother and lower surface. It will then be seen that in the central areas the amount of drift is relatively small, as it is concentrated in the valleys, and does not cover the whole surface; and that it rests upon firm, striated rock from which all preglacial soil has been swept away. On the other hand, in the marginal area, the ground moraine forms an almost continuous sheet; it rests as a rule upon preglacial soil which was not rubbed away by the ice, and its upper and lower members are often separated by layers of gravel and other deposits, which have given rise to the theory of two or more periods of glacial extension in quaternary time. Further, on an apparently intermediate area, which I am not yet able to define, the ground moraine has frequently resisted the efforts of the ice to rub it along to the margin, and has accumulated in masses of considerable size, which took a form of least resistance as they grew beneath the glacier: these are known as drums, drumlins, whalebacks or lenticular hills (see B 10).

J. Geikie says "wherever the flow of the ice-sheet slackened there would necessarily be less erosive action, and therefore a greater chance of preglaial and interglacial land-surfaces being preserved. For the same reason we ought to find, as we approach the limits reached by the old confluent glaciers, that preglacial and interglacial deposits have suffered less erosion." "In exposed positions, such as hilltops and hill slopes, the till never contains intercalated beds." (Great Ice Age, 1877, 137, 133.)

Later he compares the old ice-streams to rivers, inasmuch as they erode in their upper valleys, and deposit on the more open flood-plains. In the central regions, where the erosive action was great, little or no boulder clay was allowed to gather, and hollows of smaller or larger dimensions were scooped out, when the nature of the ground was favorable to that end. Farther on, where the grinding power exerted by the ice was less, thick boulder clay frequently accumulated, and subglacial and interglacial beds were often preserved. In hilly regions there will be *roches moutonnées* and lakes, but little till; cliffs and escarpments will yield large fragments; on open lowlands, where the ice has thinned by spreading and its motion has slackened, much till will be deposited, and near its margin it will produce very little disturbance. (Prehistoric Europe, 1881, 288, 289.)

Helland writes (freely translated and condensed): The glaciated area consists of two parts; the region of erosion, and the region of deposition of the great ice-streams. The first includes Norway, Sweden and Finland, where bare glaciated rocks and rock-basins occupy much of the surface; the second is the North European plain, where the rocks, seldom striated, are generally hidden by glacial deposits. (Deutsch. Geol. Ges. Zft. XXXI, 1879, 99).

A. Penck adopts these views and says that land-ice accumulates under its peripheral parts, the material eroded from near its source. (Vergletscherung der Deutschen Alpen, Leipzig, 1882, 199, 98.)

The following examples will illustrate these general statements.

B. 5. *The Alps.* In the upper valleys of Switzerland, I find no account of old gravels, nor is there in these elevated districts, near the centre of glacial dispersion, any broadly continuous glacial deposit; local terminal moraines dropped as the ice finally disappeared are plentiful though scattered; but glaciated rocks are always abundant below the upper level of glaciation. On the surrounding lower country there is a complete contrast to this. The bed-rock is generally not glaciated unless it rises in projecting ridges; it is covered by old water-worn, stratified gravels, and on these are laid the boulder-clay, unstratified and with scratched stones direct from the ice. Many sections are known where "interglacial" deposits are preserved undisturbed between a lower and an upper till.

Necker noticed the occurrence of old gravels (alluvion ancienne) beneath the till (diluvium) near Geneva. (Etudes géol. dans les Alpes, Paris, 1841, 232.)

A. Favre gives further description of the same deposits; he considers the old gravels washed ahead from the glacier as it advanced. (Recherches Géol. I, 208; Phil. Mag. XXIX, 1865, 209; at the bottom of this page, *but* should be inserted before *from the Valais*; later he questions this origin, Soc. Géol. Bull. III, 1875, 658.)

Falsan and Chantre recognize the general occurrence of gravel under the till of the Rhone glacier below Geneva; they explain it as above, and deny erosive power to the ice that moved over it. (Monographie géol. des anciens glaciers du bassin du Rhone. Lyon, 1879-80, II, 65.)

B. Studer describes the old gravels under the till below several of the Swiss lakes, and decides that the lakes could not have been eroded by glaciers that failed to rub away the gravels. (De l'origine des lacs suisses, Bibl. Univ. Arch. XIX, 1864, 89.)

Fr. Kinkelin finds the same old gravels between the Tertiary strata and the till east of Lake Constance where the Glacier of the Rhine had a broad extension. (Ueber die Eiszeit, Senckenberg. Ges. Bericht, 1875, 91.)

Zittel describes the glacial deposits of the plain south of Munich as resting in great part on loose gravels and seldom reaching to solid rock. (Ueber Gletscher-Erscheinungen in der bayerischen Hochebene, München, Akad. Sitzungsb, IV, 1874, 264.)

Penck gives full details for the same region. (Vergletsch. Nord. Alpen.)

E. Desor calls attention to the necessary contradiction between the theories of glacial erosion and interglacial epochs; the evidence for the latter depends on the fact that the ice did not strongly erode the surface over which it advanced. (Paysage Morainique, Paris, 1875, 79 —.)

The so-called interglacial beds of the northern slope of the Alps are described as follows:—

Morlot called attention to stratified gravels between two masses of boulder clay at the entrance to the valley of the Dranse, south of Lake Geneva, and based his theory of a double glacial period upon this and similar observations elsewhere. (Lausanne, Soc. Vaud. Bull. 1855.)

Heer describes the subglacial and interglacial gravels and lignites, and decides that there must have been two ice-invasions of the lower ground of Switzerland; he does not admit any great glacial erosion. (Die Urwelt der Schweiz, 1865, 532, etc.)

Lyell gives a general account of these beds in his Antiquity of Man, 1873, 365—, 352.

On the Italian side of the Alps all the outer moraines are found on loose, stratified deposits; sections showing this superposition are given by—

Martins et Gastaldi (Sur les terrains superficiels de la vallée du Po, Soc. Géol. Bull. VII, 1849, 554), near Turin.

B. Gastaldi (Riescavazione dei Bacini lacustri, Milano, Soc. Ital. Mem. I, 1865), on the Dora Riparia.

G. de Mortillet, at foot of Lago d'Iseo. (Soc. Géol. Bull. XVI, 1859, 888. Sur l'affouillement des anciens glaciers, Milano, Soc. Ital. Atti, V, 1863.) In a comparison between the northern and southern flanks of the Alps, he states that the general order of drift deposits, as seen at many points, is "alluvion ancienne, dépôts glaciaires, alluvions recentes." (Soc. Géol. Bull. XIX, 1862, 849.) Mortillet and Gastaldi believe that the old gravels once filled the lake basins, and have been swept out by glacial erosion; for recognizing that part of the gravel is derived from the central Alps, and refusing to admit that it might have been washed from glaciers occupying the basins, they are driven to this conclusion. (See these Proceedings, XXI, p. 336, where the question is further discussed and fuller references given.) Gastaldi later admits that glaciers may have cut out cirques and rock-basins. (On the Effects of Glacial Erosion in Alpine Valleys, Geol. Soc. Journ. XXIX, 1873, 396-401.)

G. Omboni considers the old gravels washed from the glaciers; the lakes exist because occupied by ice to the exclusion of sediment. (I ghiacciai antichi e il terreno erratico di Lombardia, Milano, Soc. Ital. Atti, III, 1861; and Halle, Zft. Gesammt. Naturw. XXIV, 1864, 548.)

B. 6. *The Vosges.* The same frequent superposition of moraines upon water-worn detritus has long been known in the Vosges.

E. Collomb. (Quelques observations sur le terrain quarternaire du bassin du Rhin, et des relations d'âge qui existent entre le terrain de la plaine et celui de la montagne. Soc. Géol. Bull. VI, 1848-49, 479-499.) It is in this paper that attention was first called to the importance of glacial mud as a source of fine deposits.

B. 7. *Scandinavia and North Germany.* In Northern Europe we find Norway and the higher parts of Sweden showing great areas of glaciated rock, with plentiful boulder-clay resting directly on its polished surface; the only exceptions to this are in south-eastern Sweden, farther from the centre of glacial motion, where there seems to be a nonglacial deposit beneath the till at some points.

Th. Kjerulf describes the striated rocks and erratics in detail, but does not mention any loose subglacial detritus. (Geologie des südlichen Norwegens (trans. by Gurlt); Bonn, 1880.)

Erdmann speaks of a glacial erosion in Sweden sufficient to destroy or greatly to decrease certain areas of stratified rocks now known only by their fragments in the drift or limited to small spaces; he describes the till (krossten grus, gravier anguleux) as occurring everywhere without deposits between it and the striated and polished rocks below, excepting in some low grounds near the coast, where an intermediate "argile" has been found. (Formations quaternaires de la Suède, Stockholm, 1868, 24, 25.)

O. Torell states that as a rule in Scandinavia one finds scratched rock surfaces immediately below the till (ground moraine), but east and south of the Baltic, loose, stratified deposits occur between the till and the preglacial strata. He considers these stratified deposits to have been washed off from the advancing ice, as Favre explained the "alluvion ancienne" of Switzerland, and he implies that the rocks below are not striated. (On the causes of the Glacial Phenomena in the N. E. portion of North America, Stockholm, Akad. Handl. Bihang. v, 1877, and Amer. Journ. Sci. XIII, 1877, 76.)

Crossing the Baltic there is a complete change. The quaternary plain of North Germany seldom shows any bed-rock, but consists of a complicated set of unstratified and stratified drifts, the effect of land-ice and running water repeated in several alternations, and as a rule showing more the effect of deposition than of local erosion. There are however certain examples, especially in the lower beds of till, showing very considerable disturbance in the Cretaceous and Tertiary rocks, such as might be produced by the long continued pressure against rock escarpments (B. 3.); but the same sheet of lower till, if rightly identified, is often found resting on loose, stratified preglacial gravels; similar interglacial beds occur between the several deposits of boulder-clay, with their bedding as a rule but little disturbed.

A. Penck supposes three successive advances of a Scandinavian ice-sheet over North Germany, each advance adding a deposit of till, and burying but not destroying the sands and gravels below. He describes the lower till as containing the largest boulders; the later ice-advances passed over a smoother, drift-covered surface and found less opportunity to break off opposing rock-ledges. (Geschiebeformation Norddeutschlands, Deutsch. Geol. Ges. Zft., XXXI, 1879, 195, 198.)

Berendt explains the lower till as the ground moraine of a sheet of land ice; the interglacial gravels formed during a depression of the land when the ice floated across from Scandinavia; the second till made as a second ground-moraine when the ice settled down as the land rose again. (Gletschertheorie oder Drifttheorie in Norddeutschland. Deutsch. Geol. Gesell. Zft. XXXI, 1879, 1–20.) We need not accept in full either of these theories as to the motions of the ice-sheet, except so far as they show that it frequently moved over loose sands and gravels without destroying them.

A. Helland gives good evidence to show that Scandinavian ice actually crossed over to North Germany, and that while it had eroded a great amount of rock near its source, its action had generally changed after passing the Baltic. Admitting that the so-called interglacial deposits may be sometimes local or subglacial, he thinks it probable that there were two glacial invasions, and explains that the second failed to destroy the interglacial deposits because, while the Scandinavian Peninsula was an area of glacial erosion, the North German Plain was an area of deposition, thus adding a new point of similarity between glacial and river action. (Deutsch. Geol. Ges. Zft. XXXI, 1879, 63—.)

H. Credner calls attention to the preservation of preglacial river gravels under the glacial drift near Leipzig, and to the general occurrence of stratified drift below the till in Saxony. (Ueber die altdiluvialen Flussschotter und die Diluvialhügel der Gegend von Leipzig, Deutsch. Geol. Ges. Zft. XXXII, 1880, 588.)

It would seem therefore that the first advance of Scandinavian ice across the eroded land-surface of Tertiary strata in North Germany in some places deposited a ground-moraine upon a bed of gravel washed from the ice itself or of preglacial date; and in other places, where the form of the surface offered more resistance to the passage of the ice, the rock was broken off from the projecting ledges, and shoved along a certain distance under the ice. By this rubbing down and filling up of inequalities, the old land surface was left smoother than before; it was further levelled by deposition of gravels from glacial streams during any local retreat of the ice; then the later advances of the oscillating front found a more even surface for their motion, and hence the later boulder-clays were laid down with less disturbance on the loose detritus beneath.

The frequent recurrence of glacial till on stratified gravel shows how weak a destructive force the ice-sheet generally had in this marginal region.

B. 8. *Great Britain.* The glacial centres of Great Britain, in which no extended preglacial gravels remain, occupy all the mountainous areas of Scotland, North-western England, and Wales; in these districts, especially on their greater elevations, much glaciated rock and comparatively little drift is found; what remains there is probably connected with the retreat of the ice rather than with its advance. The lowlands and shores of Scotland, with the eastern and central parts of England, are about all of the marginal area now above sea-level; it is in these regions that we find examples of preglacial soils, striated pavements and drumlins.

A. Geikie described a number of stratified beds under the drift at Clackmannan, near Sterling, Aberdeen and Edinburgh and in the Clyde basin; as well as several striated pavements near Edinburgh, on the Firth of Forth between Leith and Fisherrow, and farther east by Dunbar, at Gareloch and on the Solway by Carsethorn. (On the Glacial Drift of Scotland, Glasgow Geol. Soc. Trans., I, 1862, 2°, 59, 66.)

J. Geikie devotes several chapters to the pre- and interglacial beds of Scotland and elsewhere, and remarks on their common occurrence in the marginal areas of the Lowlands and near the coasts. (Great Ice Age, 1877; Geol. Mag., V, 1878, 73-79; Prehistoric Europe, 1881. The latter volume gives the best résumé of the history and present condition of glacial research in Europe that has yet appeared.)

Lyell described the Forest-bed of Cromer, on the Norfolk coast of England, as overlaid by pebbly sands and clays with lignite, and above these, twenty to eighty feet of boulder clay, containing erratics, some of which have been identified as Scandinavian. (Antiquity of Man, 1873, 254.)

T. M. Reade contends that floating ice, not land ice, has been at work here. (On the Chalk Masses or Boulders included in the Contorted Drift of Cromer. Geol. Soc. Journ. XXXVIII, 1882, 222-238.)

S. V. Wood, Jr., finds a series of boulder clays and sands interbedded in the same region. (Geol. Mag., VII, 1870, 18, 19.)

Hull, Harkness, Mackintosh, Rance and others, have written of the subglacial and interglacial beds of England and Ireland; I do not pursue the subject here because it is complicated with possibilities of iceberg as well as of land-ice action; so far as the results show true glacial action, they bear out the small erosive power of the marginal parts of the ice.

B. 9. *North-eastern America.* The Atlantic Border of North America shows few examples of preglacial or interglacial gravels, but farther inland and in the upper Mississippi region they are of wide-spread occurrence. In the East, the old surface of the crystalline rocks was generally too rough to allow an equable, non-erosive motion of the ice-sheet; but in the west, the broad, comparatively level country across which the ice advanced, permitted it to pass over loose deposits without seriously disturbing them.

J. G. Hinde gives a section at Scarboro', on the north shore of Lake Ontario, made up of one hundred and forty feet of sand and clay, seventy of till, ninety of sand and clay, thirty of till, and fifty of sand and clay at the surface; he describes a striated pavement in the same neighborhood. (Canad. Journ. xv, 1877, 388-413.)

E. Andrews writes, "throughout central Illinois and probably in the corresponding latitude of the adjacent States, the ancient Pliocene soil still lies undisturbed beneath the boulder drift." "A breadth of some two hundred miles along its (the drifts') southern border rests on Pliocene soil, small patches of which are also found a hundred miles north of Chicago." He quotes J. W. Dawson, Hurlburt and Kennicott to show that drift is generally absent on the Laurentian highlands to the north, but considers floods and icebergs as the agents of transportation. (On the Western Boulder Drift, Amer. Journ. Sci., XLVIII, 1869, 172–179.)

N. H. Winchell, in summarizing the Drift Deposits of the Northwest, describes a gravelly deposit below the "hard-pan" or till; it is not always present, but is common enough to supply water to a wonderful series of Artesian wells in northwestern Ohio; when it occurs the bed-rock does not show so plainly the marks of glaciation, but when absent the rock is nearly always scratched. (Pop. Sci. Monthly, III, 1873, 209.)

W. J. McGee finds in north-eastern Iowa a boulder clay, averaging twenty-five feet thick, generally resting on stratified blue clay or pebbly clay and sand; there are no striae, and few good *roches moutonnées* and the direction of glacial motion has to be estimated from the position of the "elliptical kames" (drumlins?). (On the Complete Series of Superficial Formations in North-eastern Iowa, Amer. Assoc. Proc., XXVII, 1878, 198–231. See also Amer. Journ. Sci., XVIII, 1879, 301.)

W. Upham describes the occurrence of decomposed gneiss and granite and many beds of gravel under the drift in Minnesota. (Minn. Geol. Surv. Rept. 1879, 35, 42, 48.)

B. 10. *Drumlins.* The intermediate region between the centre and the margin of the glaciated area is sometimes marked by the occurrence of drumlins, or long, arched hills of compact boulder-clay, with their axes parallel to the direction of glacial motion; their length may be a mile, and their height one to three hundred feet. We may suppose in a general way that these were formed where the supply of ground moraine was more than could be carried forward by the ice; a ledge of rock is sometimes found below them, but not always, and does not seem essential; just why they are placed where they are found does not yet appear. They must have grown by gradual addition of material, preserving a form of least resistance to the on-flowing ice as they grew. The rock-surface below them is, so far as I know, always glaciated, showing that their accumulation was preceded by erosion, but where the ice-sheet played such opposite rôles, its erosion cannot have been excessive. The thickness of the till in these drumlins is apparently due to their material having been gathered from a much larger area than their base.

L. Holmstrom supposes that the ground moraine moves slower than the ice above it and thus serves as a protection to the rock below. (Neues Jahrb. 1882, 58.)

The drumlins of Ireland are described by M. H. Close, who suggested the application of this name to boulder-clay ridges; he notes that they are parallel to one another, and to the neighboring striae, although varying greatly in direction in different districts, and thinks they "are the *moraines du fond* belonging to the ice flows that once covered the country." (Notes on the General Glaciation of Ireland, Ireland Geol. Soc. Journ., I, 1866, 207–236. The map accompanying this paper is given also in Geol. Mag. IV, 1877, 235.) Close adds later, "It is perfectly certain that it must have been the rock-scoring agent which produced the boulder clay ridges." (The Phys. Geol. of the Neighborhood of Dublin, Ireland Geol. Soc. Journ., V, 1877–78, 49.

Kinahan and Close give an excellent map of the drumlins of a district of Western Ireland, showing their remarkable parallelism to the glacial striae in spite of their variable directions in different parts of the field; they are from half a mile to two miles long, and some are as much as 180 feet in height. (General Glaciation of Iar–Connaught, Dublin, 1872.)

Sir J. Hall called attention to the diluvial ridges in the neighborhood of Edinboro' in his esssay on the Revolutions of the Earth's Surface. (Edinb. Roy. Soc. Trans., VII, 1815, 175, etc.)

J. Geikie mentions their occurrence in the Lowlands, as preserving with small change the form given by the ice. (On Denudation in Scotland since Glacial Times, Glasgow Geol. Soc. Trans., III, 1867, 59, 61, 68; and on the Island of Lewis, Geol. Soc. Journ., XXIX, 1873, 542.) He says later that these long ridges, sowbacks or drums are parallel to one another, to the valleys or straths in which they lie, and to the motion of the ice-sheet under which they were moulded. (Great Ice Age, 1877, 13, 76.)

Drumlins do not seem to be of common occurrence in Scandinavia or North Germany. In America they have a wide distribution, but as yet they have been incompletely studied and very seldom mapped.

G. F. Matthew describes a form of drift hills, known as whale-backs, in New Brunswick that apparently belongs under this class. (Report on the Superficial Geology of New Brunswick, Canad. Geol. Surv. 1877–78, 12 EE.)

N. S. Shaler first called attention to them near Boston, but considered their form the result of postglacial marine and subaërial erosion. (On the Parallel Ridges of Glacial Drift in Eastern Massachusetts, Boston Soc. Nat. Hist. Proc., XIII, 1869–71, 196.)

W. Upham described them for the same region (Glacial Drift of Boston and Vicinity, Id, XX, 1879–80, 220); he had previously observed and mapped them for New Hampshire, under the name of "lenticular hills," claiming that they were formed under the ice, because of their shape, firmness, and parallelism to glacial striae. (Geol. New Hampshire, III, 1878, and Atlas.)

C. H. Hitchcock gives the same view of their origin. (Lenticular Hills of Glacial Drift, Boston Nat. Hist. Soc. Proc. XIX, 1876–78, 63–67.) They are also common in Central Massachusetts, stretching into Connecticut; in New York from Syracuse to Rochester (J. Hall, Geol. N. Y. 4th Distr. 1843, 319, 414, etc; L. Johnson, The Parallel Drift-Hills of Western New York, N. Y. Acad. Sci. Trans. I, 1882, 77–80), and in Wisconsin (T. C. Chamberlain, Geol. Wisc. II, 212, in the Kettle Range). They will doubtless be found in many other parts of the country.

C. Arguments from the Topography of Glaciated Regions.

C. 1. *Fjords.* Prominent among the evidence of great glacial erosion from a peculiar topography of glaciated regions is the occurrence of fjords. It is claimed that as they are, when in well developed form, limited to countries once covered with ice, they must be the direct and peculiar result of its action. Indeed fjords are taken by some as good evidence of the former presence of glaciers, without further proof.

Esmark was among the first to suggest the possible greater extension of ice in past times; he based his supposition on finding in Western Norway, erratics of varied composition and with unworn edges; a mixed deposit of sand and boulders that a flood could not have left, but which might have been dropped from melting ice; and dikes or ramparts like those formed at the ends of existing glaciers. These can be explained only by the aid of masses of ice "which must have filled up the whole valley, and, by their spreading and pressure, have hollowed out its bottom." The former action of ice shows "why the Norwegian mountains in general are so steep, I may say perpendicular, on the sides which hang over the valleys, not only in the valleys which are high above the level of the sea, but in those from the bottoms of which the waters run into the Norwegian Fjords. Ice or glaciers, by their immense expanding powers, must beyond doubt have produced this change in their original form, from this circumstance, that they were continually sliding downwards from the higher mountains to the lower districts, and by this progressive motion carried with them the masses of stone which they had torn from the mountains." (On the Geological History of the Earth, Edinb. New Phil. Mag., II, 1826–27, 107–121. I have not seen the original article of which this is a translation.)

R. Brown ranks glaciers as of much importance in forming fjords in valleys previously begun by dislocation or water erosion. (Geogr. Soc. Journ. XXXIX, 1869, 121–131 and XLI, 1871, 348–360.)

A. Helland considers cirques and fjords largely the effect of glacial erosion, but his argument is chiefly that these forms are found only in glaciated regions, and that they cannot be produced by ordinary erosive agents. (Die glacial Bildung der Fjorde und Alpenseen in Norwegen, Pogg. Ann. CXLVI, 1872, 538–562; On the Ice-Fjords of North Greenland and on the Formation of Fjords, Lakes and Cirques in Norway and Greenland, Geol. Soc. Journ. XXXIII, 1877, 142–146.) He accepts the idea suggested by Haast (Geol. Soc. Journ., XXI, 1865, 130) that glacial action is strongest near the end, where reaction from the terminal moraine causes greater pressure on the valley bottom; an idea that lacks confirmation.

A. Penck follows Helland in this question; he neatly compares the Norwegian fjords, once cut by ice, to the Wadies of the Sahara, once cut by water, for in both regions the cutting agent has disappeared by climatic change. (Norwegens Oberfläche: Glaciale Bodengestaltung; Ausland 1882, 190-194, 348-352, 369-373).

J. F. Campbell (Frost and Fire, Philadelphia, 1865) attributed most glacial action to floating bergs, at a time of submergence; in the same work he suggested a peculiar alphabet of signs to represent various effects of erosion. Later, writing of glacial scratches, he said that these "hair lines, Irish glens and Norwegian fjords are all grooves of one pattern, though upon different scales. If ice made one set of grooves, bigger ice might make the biggest." He believed then that a crust of ice extended from the North Pole southward to the latitude of "Washington in America, and as far as Greece on this side of the Atlantic, and probably united East and West round the world," and "reached nearly to the Equator." (On the Glaciation of Ireland, Geol. Soc. Journ., XXIX, 1873, 221.) Finally after a trip round the world, he concludes that there was no polar ice-cap; "that vast sheets of polar ice did not climb over the Alps, the Caucasus, the Himalayas and the Rocky Mountains, . . . polar glaciation and the records of it belong to the Atlantic Basin." "I am prepared to maintain that . . .

the Dead Sea and the neighboring lakes, the Caspian and the Black Sea, are not 'lakes of glacial erosion,' but hollows otherwise formed, probably by great movements and bending in the earth's crust." (On Glacial Periods, Geol. Soc. Journ., XXXV, 1879, 136, 137.)

Fr. Ratzel concludes that as water cannot form fjords, and as there is no other sufficient agent except flowing ice, the making of fjords must be ascribed to the glaciers of the ice period. (Ueber Fjordbildungen an Binnenseen, Peterm. Geogr. Mitth. 1880, 393.)

It may be objected to this that fjord coasts are old and have had a longer preglacial existence as dry land than their glacial and post-glacial ages combined; that dislocation and ordinary surface erosion through a period long enough to produce deep valleys, and followed by submergence, will account for all the larger forms of fjords; that the coincidence of the more important fjord coasts with regions of former glaciation is the result of a cause that governs both, namely the heavy precipitation found wherever moist winds strike a mountainous shore; that the decrease of glaciers and the appearance of fjords may both be the result — one partly, the other wholly — of the subsidence of a once elevated mountain land; and that the larger details of form in fjords, as in other old mountain regions, are more dependent on the structure and kind of rock in which they are cut than on the agent which cut them. Moreover the bays and islands on the irregular shores of the Adriatic and in the Grecian and Malayan Archipelago, where no one claims that glaciers have acted but where all will admit subsidence following erosion, are similar to the features of fjord coasts, and differ rather in characters of quantity than quality, presumably because of a less elevation and erosion during the first period and a less subsidence since.

Dana first explained fjords as resulting from denudation followed by submergence; whether the erosion was done by "running water alone, or more or less by glaciers" must be determined by further examination. (Geol. U. S. Expl. Exped., Phila. 1849, 676.)

Murchison considered fjords most largely the effect of dislocation. (Geogr. Soc. Journ., XL, 1870, p. CLXXII. See also Id., Address, XXXIV, 1864.)

Kjerulf states that many of the islands and shores of the Norwegian fjords show rocks that do not belong at such a depth, but rather on a level with the surrounding high country; he therefore concludes that these deep valleys must be largely the result of dislocation and down-faulting. (Geol. Norwegen, 1880, 332.)

A. Gurlt calculates that the weight of even 2000 feet of ice, or 825 pounds to the square inch, would not be enough to break rocks of moderate firmness; therefore glacial erosion must be limited to rubbing down and smoothing angular forms, and fjords must be primarily produced by dislocations. (Ueber die Entstehungsweise der Fjorde; Bonn, Niederrhein. Gesell. Sitzungsb. XXXI, 1874, 143–145.)

F. v. Hochstetter regards the erosive power of ice as small, and states that the coincidence of fjord and glaciated coasts depends on climatic and orographic conditions which determined both. (Hann, Hochstetter and Pokorny, Allgem. Erdkunde. Prag. 1881, 333, 335.)

O. Peschel's chapter on Die Fjordbildungen gives a résumé of this view of the subject. (Physische Erdkunde, Leipzig, 1881, I, 461-485.)

E. Reclus explains the absence of fjords in equatorial regions by their having there been filled with sediment; while toward the poles, the former occupation by ice has prevented this filling and preserved them in their early form. (La Terre, Paris, 1877, I, 165.) But it is improbable that this is the most important cause governing their distribution.

G. Hartung writes, "Fjords cannot be produced by glacial action, because they had almost their present form before the glacial period." (Beitrag zur Kenntniss von Thal- und Seebildungen; Berlin, Ges. f. Erdkunde, Zft. XIII, 1878, 295.)

The commonly increased depth of fjords above their mouth may be the result of dislocation of the bottom, or of obstruction of the outlet by moraines or sea-wave drift. This peculiarity of form does not require anything more than obstructive aid from ice, and certainly cannot be used as necessitating ice-erosion[1] more than the occurrence of lake-basins can.

C. 2. *Valleys.* The more pronounced glacialists include many valleys among the effects of ice-action.

R. Chambers wrote that the form of the hills in Scotland (and consequently of the valleys also) "can only be accounted for by our supposing that there was, *first*, a general sweeping of the surface of this district by a deep flow of mobile ice, one great cause, if not the principal, of that enormous denudation which has been described, but of which the spoils, from the universality and power of the agent, were in a great measure carried away"; *second*, a local and less powerful glaciation. Fractures were regarded as defining the place of the greater denudation. (On Glacial Phenomena in Scotland and Parts of England, Edinb., New Phil. Journ., LIV, 1853, 252, 281.)

[1] It is so used by Geikie and Helland.

In his remarkable essay "On the Conformation of the Alps" (Phil. Mag., XXIV, 1862, 169-173), Tyndall certainly makes "use of the imagination," but hardly a "scientific use." The groundless assumptions that characterize this paper stand in striking contrast with the care displayed in the author's experiments on radiant heat and spontaneous generation. The power of water to cut out valleys is denied because glacial scratches remain in the Alps after a "million years" exposure to the weather, and the form of the mountains is ascribed mainly to glacial action. Their known geological structure is altogether disregarded. Indeed the paper is beyond criticism. These extravagant views are somewhat reduced two years later. (Phil. Mag., XXVII, 1864, 255–271, and thus appear in Hours of Exercise in the Alps, 1871, 237–251).

J. Leconte says the fact that the Yosemite and other similar cañons in the Sierra Nevada "have been *occupied* by glaciers, makes it almost certain that they have all been *formed* by this agency." "I must believe that all these deep perpendicular *slots* have been sawn out by the action of the glaciers." (Ancient Glaciers of the Sierras, Amer. Journ. Sci., V, 1873, 339. See also his Elements of Geology, New York, 1878, 51, 534.)

O. Fisher considers glacial action important in modelling the forms of even Southern England. (On the probable Glacial Origin of Certain Phenomena of Denudation, Geol. Mag., III, 1866, 483–487. For his views on the glacial origin of lakes, see the Reader, Apr. 25, 1865.)

A middle class take the very popular ground that although the valley is not entirely due to ice-erosion, its cross-section profile will show whether it has been occupied by a glacier or not. A valley cut by water only is said to have a V-form; a glaciated valley is U-shaped. But the rule is not a safe one, for while it is probable that glaciers have in some cases made changes of a considerable and visible amount in the upper valleys, especially in Norway and Sweden where their work was of great strength, the conditions that control a valley's form are too complicated to admit of so simple a division.

This is after the manner of Campbell's alphabetical topography.

Ramsay's views go far enough, without being unfairly exaggerated to include the making of all lakes or cutting of valleys by ice. In an article that appeared two months after Tyndall's, above noted, he says "no true geologist is likely to assert that these valleys (in the Alps) have been mainly scooped out from end to end by ice, for the reason that, *since* the disappearance of the ice, running water in the formation of gorges, etc., has comparatively effected so little." "The large valleys were in their main features approximately as deep as now before they were filled with ice. The belief is as old as Charpentier." (On the Excavation of the Valleys of the Alps, Phil. Mag., XXIV, 1862, 377–380.)

J. Geikie — Ramsay's ablest advocate — writes that the erosion of the last glacial period, although absolutely great, was relatively inconsiderable, for " we have every reason to believe that all the fjord-valleys and glens of the Highlands had assumed very much their present appearance before the advent of the Ice Age." (Great Ice Age, 1877, 389.)

F. J. Kaufmann concludes, from an examination of glaciated and non-glaciated valleys in Northern Switzerland, that the round-bottom valleys owe their form to glacial erosion, and that this destructive force keeps pace with the other denuding agents (see C. 4). (Beitr. Geol. Karte der Schweiz, 11 Lief., 1872, 451, 453.)

C. King states a strong case of this kind: he finds the upper valleys of the Uinta Range have a distinctly U-shaped profile within the glaciated district, and a V-form below it, and decides that the difference must be due to glacial erosion. (U. S. Geol. Expl. 40th Par. 1878, I, 478–487.)

The following authors do not admit that glaciers have produced any significant change in valley-forms.

Gümbel shows from the direction of glacial scratches that the glaciers found the Swiss valleys much in their present form and depth. (Gletschererscheinungen, München Akad, Sitzungsb. II, 1872, 234.)

T. G. Bonney has devoted much time to observing Swiss valleys, cirques and lakes in search of critical evidence for or against the glacial erosion theories. He finds only evidence against them, and decides that these forms are all essentially preglacial. (On the Formation of " Cirques," and their bearing upon Theories attributing the Excavation of Alpine Valleys mainly to the Action of Glaciers, Geol. Soc. Journ. XXVII, 1871, 312–324; also XXX, 1874, 479–488.)

E. Whymper says, " Given eternity, glaciers might even grind out valleys of a peculiar kind. Such valleys would bear remarkably little resemblance to the valleys of the Alps. They might be interesting, but they would be miserably unpicturesque." (Scrambles in the Alps, 1871, 331.) He notes the increasing slowness of glacial erosion as the eroded surface is smoothed, and concludes that after polishing the rocks, glaciers are conservative rather than destructive (132–154); and adds a critical review of Ramsay's and Tyndall's writings on this subject (311–344).

Ch. Grad decides that neither valleys, lakes nor fjords owe their origin to ice action (see A 6). (Les Glaciers et l'origine des vallées, Club Alpin Franç. Ann. III, 1876, 479.)

J. P. Lesley calls attention to the agreement in the form of the Pennsylvania valleys within and without the glaciated area, and concludes that as a rule an ice-sheet is protective or only slightly destructive. (Amer. Phil. Soc. Proc., XX, 1882, 95-101. This paper is received while the present article is going through the press.)

C. 3. *Cirques.* The amphitheatres or *cirques* in which many valleys head are often considered the peculiar work of ice; but the arguments in favor of this view are only that glaciers have occupied the *cirques*, and that it is difficult to explain them in any other way(see D).

D. Mackintosh describes the "coums" of Wales, and thinks it possible that ice might have cut them out, if it had a rotary motion; but that the explanation of their origin will ultimately be found in some kind of action midway between glacial and marine. (The Scenery of England and Wales, 1869, 194–204.)

B. Gastaldi finally admitted the glacial origin of cirques, after at first going only as far as required by de Mortillet's theory of the origin of the Italian lakes. (On the Effects of Glacial Erosion in the Alpine Valleys, Geol. Soc. Journ. XXIX, 1873, 396–401.)

J. J. Goodchild is "led to regard nearly all the more prominent rock-features of these well glaciated parts (Yorkshire dales) as in one way or another the result of glacial erosion," because of the difficulty of explaining them in any other way. (Glacial Erosion, Geol. Mag. II, 1875, 362. See also Geol. Soc. Journ. XXXI, 1875, 98.) In attempting to explain small cirque-like hollows in Northern England, he says that the hypothesis that they "are due to the eddying of the ice must be accepted until it can be shown that this hypothesis is clearly disproved by any of the facts." He supposes the rotary motion given to the ice as it is given to a river, by a bend in its course or the entrance of a side stream. (On the Origin of Coums, Geol. Mag. II, 1875, 497.) But no evidence of any such rotary motion has been found for any of the well-studied existing or extinct glaciers of Switzerland, in spite of their many branches and crooked valleys. It would be interesting to inquire whether these peculiar valley forms (coums, scars, etc.) are limited to regions known to have been glaciated.

J. J. Stevenson attributes the form of trough-valleys and cirques to glacial action. (Explorations and Surv. W. of 100th Merid. Geology, Washington, 1875,426-453.)

J. F. Carll believes there may be different currents in the ice-sheet, one above the other, but not parallel; where two ice-currents met in the upper Genesee valley, "an ice-eddy resulted, which cut out a broad basin and deposited heavy masses of drift." "This action of the two currents is made manifest both by the shape of the basin and by the position of the eddy hills." He attributes some of the excavation of Lake Erie to the subglacial streams. (Second Geol. Surv. Penn., Oil Regions, I 3, 1880, 333, 389, etc.)

A peculiar comment on the above is made by S. A. Miller. (North American Mesozoic and Cænozoic Geol. and Pal., Cincinnati, 1881, 338.)

C. 4. *Slope of Valley Sides.* By far the strongest argument against the preceding suppositions is the well established fact that there is no marked change of slope on the sides of the Swiss valleys, in passing from the upper nonglaciated surface, down to the glaciated rocks. This does not show that the glaciers had no effect, but merely that their power of erosion was not, during the time they were in action, materially different from that of ordinary weathering. For in post-glacial times these valleys have not lost their glaciated surface; we see them as they were left by the melting ice. And if, during the glacial period, the valleys under the ice had increased in depth faster than before or after, there should be an increase in the angle of slope on the sides at the limit of glacial action; but there is no such increase.

F. J. Kaufman considers glacial erosion as effective as other destructive forces, and denies the preservative power of ice claimed by Rütimeyer and others (A 4), because the surfaces that were covered during the longer period of glacial occupation are now no higher than their surroundings (l. c. 453).

We may carry this a little farther, and show from it that the Swiss valleys have not greatly changed since preglacial times.

The valleys have scarcely deepened at all since the disappearance of the ice, although exposed to weathering of the kind that, during the glacial period, kept pace with the ice erosion. Now supposing post-glacial is equal to glacial time, and post-glacial weathering is equal to the weathering during the ice time, the valleys cannot have changed form during the glacial period any more than since that time. Probably neither of these suppositions is so far from the truth as to admit a very great change in the conclusion deduced from them; but admitting that former weathering was even ten times as rapid as that of the present time, and that the glacial period was as much as ten times longer than the postglacial; then the glacial change in the valleys should equal one hundred times that which their general surface has suffered since. But even this extreme change would not account for the excavation of the Swiss lakes.

F. Pfaff gives this argument. (Ueber die Bewegung und Wirkung der Gletscher, Pogg. Ann. CLI, 1874, 325–336.)

A. Heim writes "the slope of the valley sides (in the Alps) shows no essential change above and below the limit of glaciation." (Mech. der Gebirgsbildung, I, 252.)

J. D. Whitney says, "no change of form can be observed at the former line of ice. Aside from the morainic accumulations, there is nothing to prove the former existence of the glacier except the smoothed, polished or rounded surfaces of the rocks, which have no more to do with the general outline of the cross section of the valley than the marks of the cabinet-maker's sand-paper have to do with the shape and size of the article of furniture whose surface he has gone over with that material." (Climatic Changes of later Geological Times, 1880, 9.)

The occurrence of rocky knobs in valleys as weighing against their glacial origin, will be mentioned under C 5.

C. 5. *Lakes.* The glacial origin of lakes has already been discussed in the paper to which this is supplementary, and here a brief summary of the question will be sufficient.[1]

Ramsay first gave prominence to this theory in 1862. I believe that if the limit of erosion given in his earlier paper three years before had been retained, and no effort had been made to explain lakes larger than the llyns of Wales and tarns of Scotland, his theory would have met with universal acceptance; but while its extension to include the larger lakes of Switzerland, and even the Great Lakes of this country, met a warm welcome from many, it encountered also the opposition I have here quoted. It should be noted that Ramsay excluded valley-making from his theory, and was careful to state that many lakes might be and had been formed in other ways, but he referred the majority of lakes in the northern hemisphere to the excavating power of ice. His argument was essentially that of necessity (see D.); and he considered the erosive power of the old glaciers to be near their ends or where they were thickest. (On the Glacial Origin of Certain Lakes in Switzerland, etc., Geol. Soc. Journ., XVIII, 1862, 185-204.)

J. Geikie states that glacial erosion was greatest where the ice was thickest, as is shown by the increased depth of the Scotch lakes near their heads; where the slope of the glacier's bed decreased, as is shown by the occurrence of lakes along mountain borders; and where the ice-stream was turned aside, entirely or only in its lower layers, as is shown by his "deflection basins." (Great Ice Age, 1877, 278-289.)

Sir W. E. Logan describes the innumerable lakes of the Laurentian Highlands as generally following the softer strata (often crystalline limestone), and "it appears probable that one of the main erosive forces has been glacial action." The Great Lake basins "are depressions not of geological

[1] See the Classification of Lake Basins. These Proceedings, XXI, 1882, 336-344. In order that the two papers may be to a certain extent independent, some statements are given in both.

structure, but of denudation; and the grooves on the surfaces of the rocks which descend under their waters, appear to point to glacial action as one of the great causes which have produced these depressions." (Geol. of Canada, 1863, 889.)

T. Belt follows Ramsay. (On the Formation and Preservation of Lakes by Ice Action; Geol. Soc. Journ., XX, 1864, 463-465.)

The controversy between J. B. Jukes and H. Falconer in the Reader (1864, 173, 269, etc.,) was whether valleys and lakes are the result of erosion or dislocation; Falconer holding to the old idea that general erosion has played a small part and that glaciers have done nothing but occupy basins to the exclusion of sediment; Jukes claiming that more surface forms depend on erosion than on construction, and that in the formation of lakes glacial erosion is the "only mode of escape out of a great difficulty." He elsewhere says that lakes were always a puzzle till Ramsay suggested their true explanation. (Brit. Assoc. Rep., Address to Geol. Sect. 1862.)

J. M. Wilson observes that erosion depends on joints, and thinks that if the joint surfaces were concave, lake-basins would be formed as blocks of rock were pushed away. (On the forms of valleys and lake-basins in Norway, Geol. Mag., IX, 1872, 481-484.)

A. Helland points to the moraines partly enclosing many Norwegian lakes, and takes them as evidence that the basins were cut out by the terminal part of the old glaciers. He insists that many of these lakes are in true rock-basins and therefore must be due to glacial excavation. (Die glaciale Bildung der Fjorde und Alpenseen in Norwegen; Pogg. Ann., CXLVI, 1872, 538–562.)

J. S. Newberry describes the eastern Great Lakes as excavated from solid rock once continuous over the area now occupied by water; the agents of erosion were water and ice, "and of the two that which was by far the most potent and that which alone could excavate broad, boat-like basins, such as these, was *ice*." (Geol. Ohio, 1873, I, 49.) "There can be no doubt that the basin of each of the Great Lakes has been produced by a local glacier," either before or after or before and after their occupation by the continental glacier. (Geol. Ohio, II, 1874, 74. Professor Newberry's latest paper on this subject has just been published in Amer. Phil. Soc. Proc., XX, 1882, 91–95.)

G. J. Hinde writes, "when the path of the glacier can be thus traced, following the axis of the Lake (Ontario) from north-east to south-west, and masses of till which have been eroded from the rocks outcropping in the area of the lake are met with heaped up on the banks at its south-west end, the only conclusion which can be drawn is that the lake-basin is due to the powerful eroding influence of a glacier." (Canad. Journ., XV, 1877, 396.)

N. S. Shaler says, "the lakes of Switzerland, those of New York and New England, are good and familiar instances" of glacial erosion. "On a larger scale this work is indicated in the Great Lakes of the central part of the country (North America), and the numerous excavations that divide the northern part of the continent into a sea of islands." (Illustrations of the Earth's Surface, Glaciers, 1881, 52.)

A. Penck's latest work (Die Vergletscherung der Deutschen Alpen, Leipzig, 1882), referred to twice above, has been seen only since the writing of this paper. He strongly advocates the glacial origin of the Bavarian marginal lakes.

In 1821, Venetz wrote "How many little lakes are there in the mountains which would probably have been filled with earth and stones if the glaciers had not formerly cleaned them out." (Soc. Helv. Mém. I, 2°, 1833, 33.) This intermediate position was revived and extended by G. de Mortillet in 1859; he supposed that glacial action in forming lakes was limited to the cleaning out of preglacial detritus from valleys or basins. This was applied especially to the marginal lakes of the Alps, and found much acceptance among those who could not go to the lengths demanded by Ramsay, but who admitted some destructive power in glaciers. (Soc. Géol. Bull., XVI, 1859, 888.)

The action of glaciers in preserving lakes by excluding the deposition of sediment during the occupation of the basin by ice has in many cases been very important, but this does not imply any great erosive power.

Charpentier wrote, "As the glaciers in advancing swept off the soil down to solid rock, we can easily see why our lakes have not been filled by the immense quantity of blocks, gravel and sand which must have crossed them, or more exactly must have passed over them, and which would not have failed to fill the basins if they had been carried by water." (Annales des Mines, VIII, 1834, 228.)

Agassiz placed the formation of the Swiss lakes before the disappearance of the glaciers from the low ground, and explained their escape from filling up with drift by their occupation by ice. (Études sur les Glaciers, 1840, 283, 286, 314, 318, 325.)

This idea has since been adopted by E. Desor (Gebirgsbau der Alpen, 1865, 136), O. Peschel (Ueber den Ursprung der Jura-Seen, Ausland, 1868, 1005), and others. E. v. Mojsisovics considers the larger Alpine lakes preglacial; and holds that the "abenteuerliche Aushöhlungstheorie" is untenable on physical as well as geological grounds. (Bemerkungen über den alten Gletscher des Traunthales, Wien, Geol. Reichsanst. Jahrb., XVIII, 1868, 310.)

The objections to the glacial origin of the larger lakes may be thus summarized. The argument from necessity may be very often if not always met by denying it; for many lakes thought to be in rock-basins have been shown to be only in obstructed valleys, and others actually in rock-basins may have been formed by dislocation or warping of the valley bottom. The amount of erosion required to produce the larger lakes is greater than the glaciers had time to effect, and it is very doubtful whether erosion is as active at the bottom of a basin as on more prominent points (A. 8). The erosion required to produce a lake where none existed before is not measured by the depth of the lake alone, but by the excess of the erosion there over that on the neighboring surface; it is often impossible to account for this excess for it is not always referable to the greater thickness of the ice or softness of the rock. Many lakes claimed to result from glacial action are near or within the marginal area of faint erosion. Knobs of rock remain in the lakes and in the valleys above them; it is impossible to explain their preservation if the basins about them have been cut out by a broad eroding engine like a glacier.

The possibility of lake formation by warping or dislocation is advocated by Rütimeyer (Ueber Thal- und Seebildung, Basel, 1869, 72), Heim (Mechanismus der Gebirgsbildung, 1878, I, 316), Lyell (Antiquity of Man, 1873, 358), Bonney (Lakes of the North-eastern Alps, etc. Geol. Soc. Journ., XXIX, 1873, 382-395), Hector (Geol. Mag., II, 1865, 377-378), Duke of Argyll (Address, Geol. Soc. Journ., XXIX, 1873, p. LXX; also XXIV, 1868, 255-273), Kjerulf (Geol. Norwegen, Bonn, 1880, 330), Whitney (Climatic Changes of Later Geological Times, 1880, 16), and others. The common occurrence of lakes of the barrier type has been emphasized in my previous paper. When the examples that may be thus fairly explained are deducted from the list of the larger lakes, comparatively few remain, and the argument from necessity is greatly weakened.

O. Heer contends that the valleys and lakes of Northern Switzerland had much of their present form before the glacial period; they are cut in upturned Miocene rocks, and the old gravels, that were washed from the ice as it advanced, now unconformably overlie the eroded Miocene strata, following even insignificant irregularities of their surface. This could not be the case if the ice had cut the valleys. (Die Urwelt der Schweiz, 1865, 516, 532, 581.) The valley cutting would then be of Pliocene date, and this is confirmed by finding no Pliocene formations in Northern Switzerland.

No sufficient reason has been given to show why the glaciers on the Italian slope of the Alps should be suddenly endowed near their ends with erosive power sufficient to cut out lakes one to two thousand feet deep, while a little farther up stream their valleys were but slightly modified, as Ramsay himself claims. In Lago Maggiore, near its deeper parts, the Borromeo Islands rise to the surface. The glacier of the Rhone failed where it had great thickness to cut away the hills at Sion, and yet after it had lessened its thickness and slackened its motion by spreading out upon the plain, it is supposed to have cut out the basin of Lake Geneva; this lake is not in the line of the thickest part of the glacier, and it is deepest where its rocks are hardest. Lakes Neuchatel and Bienne are distinctly in the marginal area of the ice-sheet, where it had little erosive power; in the former, there is a rocky reef that rises to within a few feet of the surface, having in some remarkable way escaped destruction. To explain the glacial origin of Lake Constance, one must suppose that the glacier of the Rhine waited till it emerged from its narrow mountain valley before beginning its erosive work; and then while its eastern half moved quietly over the low grounds with but little destructive effect, its western half ploughed out the lake basin to a depth of nine hundred feet.

C. 6. *Detail of Glaciated Surfaces.* A close examination of glaciated regions will generally discover rock-forms that are difficult to explain on the supposition that glaciers have materially denuded the surface on which they moved. Angular surfaces of rock remain where it is impossible to suppose that they could be preserved if the general surface had been considerably eroded. Tors never require much erosion in their preparation, and often show that but little has been possible.

Tyndall claims that the rocky hills found in valleys and lakes are no evidence against glacial erosion, for they may have been worn down "thousands of feet." (Hours of Exercise in the Alps, 1871, 240). But this overlooks the observations presented in A. 3.

T. G. Bonney describes certain forms in the valleys above Lake Como that seem quite inconsistent with severe glacial erosion. (Notes on the Upper Engadine and the Italian Valleys of Monte Rosa, and their Relation to the Glacial Erosion Theory of Lake-Basins. Geol. Soc. Journ., XXX, 1874, 479-488.)

A. Heim says that the careful study of any (Swiss) valley will show that glaciers have only rounded off sharp forms, and that often only on the "stossseite," or here and there rubbed out shallow troughs, but never essentially altered the valley-form; whoever has examined these localities with his own eyes will find the hypothesis of glacial erosion as applied to the Alps and to Norway, a mischievous exaggeration (arge Uebertreibung). (Mechanismus der Gebirgsbildung, 1878, I, 251-2. See also Antheil der Gletscher bei Bildung der Thäler. Zürich, Vierteljschr., XX, 1875, 205-207.)

G. H. Stone describes a surface of preglacial weathering between neighboring glaciated rocks, implying a very small erosion below the old soils. (Portland Nat. Hist. Soc. Proc. 1881.)

C. 7. The Driftless Region of Wisconsin was described by Whitney in 1862 (Geol. Wisc. I, 99) and has been further studied by the present geological survey of that State (II, 1877, 608–611.) It is a district several hundred square miles in area, enclosed on all sides by drift-covered surfaces. These neighboring glaciated regions have lost the more delicate pinnacles of rock which still remain from preglacial times on the non-glaciated area; but this loss has not been sufficient to alter the general hill and valley form to any great extent, for the stream courses on the contrasted districts are closely of the same character. Within the isolated region not affected by ice they retain the meandering courses characteristic of stream erosion in horizontal strata, and evidently are the product of a long preglacial land existence. The occurrence of the same type of valley on the surrounding glaciated districts shows clearly that they also retain much of their preglacial form, and that the broad ice sheet was powerless to destroy the general features of the country. The changes that have occurred are most largely the effect of drift obstruction. Moreover, the Wisconsin River twice runs on and off of the driftless region, showing that there is no great change of level along the drift border. But the bordering drift country extends directly east to Lake Michigan, of which the trough is supposed to be cut out by the ice; how is it possible that the ice should have so greatly varied in its cutting power in the same latitude, or at essentially the same distance from its source? Of course a greater thickness of ice in Lake Michigan would have made some change in its action there, but this greater thickness must have resulted from a preglacial wearing down of the basin and if that be granted, there is no difficulty in accounting for the lake without any glacial aid except that of furnishing drift obstructions to old valleys.

D. *The Argument from Necessity.*—The last argument for glacial erosion is of small value. Carried to the extreme, it explains all the Alpine valleys by ice-action, water and weather erosion being insufficient; it ascribes the very disappearance of the Alpine glaciers to their having worn down the mountains on which they lay; it explains the (apparent) small proportion of high mountains in northern regions by their having been worn away by the great "polar ice-cap"; it proves the former existence of an enormous glacial sheet in North Carolina by the uniform height of many hill summits, the remnants of an old plain, for how could this have been produced save by glacial erosion.

W. C. Kerr explains the origin of some features in the Topography of North Carolina (Amer. Journn. Sci., XXI, 1881, 216-219) by referring them to an old glacial period. These features are the uniform heights to which the hills rise in the Piedmont region, indicating the existence at that level of an old plain since deeply cut by river action. Nothing could explain the origin of such a plain "except the presence of a great glacier, which in some ancient time had moved down the valley and left the surface nearly level." "The reasonableness of this hypothesis will appear if it is considered what would be the consequence of the movement of such a glacier over the present surface for a few thousand years." Mr. Kerr notes that this evidence of the "existence and action of glaciers is totally different from the commonly recognized marks and results of glacial action," in which we agree with him more fully than in the preceding quotations.

And yet great prominence has been given to this argument from necessity by the more pronounced glacialists. Ramsay says (Geol. Soc. Journ. XVIII, 1862, 193; see also J. Geikie, Great Ice Age, 277), "If the Lake of Geneva do not lie in a synclinal trough, in an area of subsidence, in a line of fracture, nor in an area of mere aqueous erosion, we have only one other great moulding agency left by which to modify the form of the ground, namely that of ice." Put into another form, this reads, if the phenomenon L cannot be explained by any one of four causes, it must be by a fifth. Now this assumes so exact a knowledge of L and of the four causes, that they can be excluded; it assumes the sufficiency of the fifth cause and the absence of any other alternatives. We may well ask whether all the so-called rock-basins to which this argument has been applied are really quite enclosed by solid rock; secondly, have the four causes been completely excluded from any share in the result; thirdly, are there not other causes besides the five named. Another inconclusive argument may be noticed here; it consists in carrying a cause to an extreme in order to disprove it; for example, if the Swiss lakes are the results of local downfolding or subsidence, how about the numerous small lakes of northern countries? Manifestly we cannot suppose as many subsidences as lakes, for they would be required by the thousand in North America; hence the Swiss lakes were not produced in this way[1] — a complete *non-sequitur.* It is a little surprising to find this argument elsewhere figuring against glacial action, thus: to admit that our Great Lakes were cut out by erosion, would require us to suppose that great enclosed seas, like Hudson's Bay and the Mediterranean, and even the ocean itself, were formed in the same way; but this is clearly impossible; hence the Great Lakes are not of erosive origin.[2]

We have already shown that there is much to favor the constructional origin of the Swiss Lakes, and that many of them depend as largely on barriers as on excavation: a similar explanation applies to our Great Lakes. The glacial origin of fjords and cirques is advocated chiefly on account of the difficulty of accounting for them in any other way, and not because it is directly shown that glaciers have a great erosive power, or because it is proved that orographic and ordinary erosive forces cannot produce them; they naturally are found in glaciated regions, because both belong in mountainous or rugged districts, and I cannot doubt that further study of the methods of general construction and denudation will show us how to account for them. Great glacial erosion thus appears as unnecessary as it is impossible, and the argument from necessity becomes inconclusive.

The author hoped to present in this article an abstract of the line of argument used by each observer quoted in attaining his conclusions; this has been done in certain cases, and implied in nearly all; but the full carrying out of the plan would have made the paper too long, and it has perforce been modified. The conclusions are of course in every case no more exact than the observations on which they rest; and as further study may modify the understanding of certain problems, the resulting conclusions

[1] See Ramsay, loc. cit. 191. [2] Whitney, Climatic Changes, 16.

will also change. The argument from the amount of drift is especially open to correction in this respect. But when all allowance is made for these chances of error, it is believed that the several lines of argument point with substantial agreement to the following results.

Summary. The amount of glacial erosion in the central districts has been very considerable, but not greatly in excess of preglacial soils and old talus and alluvial deposits. Most of the solid rock that was carried away came from ledges rather than from valleys; and glaciers had in general a smoothing rather than a roughening effect. In the outer areas on which the ice advanced it only rubbed down the projecting points; here it acted more frequently as a depositing than as an eroding agent.

No large lakes have been produced by glacial erosion: the number of true rock-basins of erosion has been greatly exaggerated. The most considerable topographic effect produced by glaciers is the heaping of various morainal deposits on an area smaller than their source, and in this way very often forming hills of considerable size. A similar indirect result of glacial erosion is seen in the very numerous lakes made by drift obstructions in preglacial valleys.

The following paper was also presented:

OLDER FOSSIL INSECTS WEST OF THE MISSISSIPPI.

BY SAMUEL H. SCUDDER.

Mr. R. D. Lacoe, to whom I am so largely indebted for material in studying carboniferous insects, has recently sent me from Kansas City, Missouri, a specimen (No. 2030) of an heteropterous Hemipteron found in beds claimed to be carboniferous, and which, according to the Missouri geological reports, have eight hundred feet of coal measures above them. It consists of an excellently preserved front wing, showing clearly the venation, with the division of the wing into distinct areas as well marked as in modern types. The corium is extensive, as in the modern genus Zaitha, and the membrane covered with faint arborescent veins which ultimately form at the edge a narrow fringe of approximated parallel veinlets. The wing is of considerable size, measuring about 16 mm. in length and 6 mm. in breadth. It will be fully described and figured on a future occasion under the name of Phthanocoris occidentalis. This is the first hemipterous insect discovered in this country in rocks older than the tertiaries.

Another discovery, just made by Prof. Arthur Lakes of the Colorado School of Mines, is of an important deposit near Fairplay, Colorado, which Mr. Lakes, in the first announcement to me of his good fortune, believed to be either upper carboniferous or permian; and Mr. Lesquereux, on examination of the plants found there by Mr. Lakes, thinks unquestionably permian or upper carboniferous. The insects so far found consist of the upper wings of three cockroaches and the hinder wing of one of them. Two of the cockroaches belong to the Palaeoblattariae as I have defined them, and both of these to the Blattinariae. One is an Etoblattina or allied genus about the size of E. affinis (Gold.), whose closer affinities have not yet been studied; the other is very interesting, belonging to a new type remarkable for its leaning toward mesozoic forms in two ways: its very small size, in which it agrees altogether with the general meagreness of liassic species; and in the basal union, throughout nearly half the wing, of the externomedian and scapular veins, showing a stronger affinity to modern types in this respect than any other Palaeoblattariae. The third cockroach is an even more remarkable form, if the beds are really paleozoic, as claimed; for it is of a distinct mesozoic type, of the same size as the last mentioned, and not only with no distinct externomedian vein, but with the anal veins parallel to the margin and apparently impinging on the anal furrow, instead of striking the inner margin, as in all Palaeoblattariae. It therefore does not belong to the Palaeoblattariae at all, and if the beds are paleozoic, it is the first instance known of any cockroach of the modern type in these ancient rocks, while over sixty Palaeoblattariae are known. Paleoblattariae do occur in small numbers in mesozoic rocks, though none are known above the lias, so that I have been inclined to look on these rocks as mesozoic; and should still do so were it not that if they are paleozoic the discovery here of this neoblattarian is more than paraleled by finding Phthanocoris in carboniferous rocks; for until now no member of the heteropterous division of Hemiptera has been discovered in paleozoic rocks. Yet should the beds prove to be paleozoic it introduces a strangely discordant element among American paleozoic cockroaches; for all of the more than twenty species known to me altogether agree in their general features with those from the old world; or where they do not, as in the family Mylacridae, they represent, as I have pointed out, a more primeval type. In explorations at the locality near Fairplay, the coming summer, I hope to do something toward solving the question of the real age of the deposit.

General Meeting. May 17, 1882.

The President, Mr. S. H. Scudder, in the chair. Sixty-five persons present.

Mr. T. T. Bouvé showed some sand from a beach on the outside of Marblehead Neck, containing grains of magnetite of iron mixed with small garnets. No rock from this locality is known to contain these minerals, but the sand points to the former existence of one which has been entirely worn away by the action of the sea. Mr. Bouvé also showed a rich collection of beautiful and valuable gems, and commented on the ignorance of jewellers regarding many species.

The following paper was read:

SOME NEW EVIDENCES OF CANNIBALISM AMONG THE INDIANS OF NEW ENGLAND FROM THE ISLAND OF MT. DESERT, ME.

BY HENRY W. HAYNES.

During the past three summers I have spent considerable time in the study of various Indian shell-heaps to be found in different parts of the island of Mt. Desert; more especially of the one at

Hull's Cove, of that upon Bar Island, and of the one upon the shore of the creek immediately opposite.

These large collections of shells on the shores of Frenchman's Bay were first mentioned by Williamson, who speaks of their great extent, and adduces in proof of their antiquity the circumstance that the first settlers found a heavy growth of trees upon them, whose stumps are still to be seen.[1]

Dr. Jeffries Wyman has published an account of his investigations in some of them, but in localities different from those which I have studied.[2] He states that implements made of stone were very rare in those examined by him, and that pottery was but poorly represented. My experience has been quite different. I have found half a dozen stone axes, one of which was fully nine inches long, and quite a number of other implements of considerable size. These axes were all of the "celt" pattern, including one of the so-called "shoe-shaped" type, and not "tomahawks," furnished with a groove around the middle. There were also as many as a hundred smaller objects, all remarkably well chipped, and mostly made out of a compact green felsite, speckled with quartz. There were at least two dozen large spear-heads, and as many knives; as many arrow-heads, and an equal number of skin-scrapers. Of the latter class one quite small specimen, made of a red felsite resembling the "Saugus jasper," is interesting as being precisely similar in size and shape, and probably in material, to one which I had found some years previously in the cave at Mentone, in the south of France, from which came the skeleton of the famous "Fossil Man," now preserved at the Jardin des Plantes" in Paris.

Fragments of pottery were not at all rare in any of the heaps I examined, and among them was a portion of a bowl of a pipe. Dr. Wyman found that implements made of bone were more common, and several of these he has figured in a couple of plates. Of most of these bone implements I also met with similar specimens, including two examples of the peculiar little object made out of the lower incisor tooth of a beaver, cut down to a thin edge.

[1] History of Maine, Vol. I, p. 80. [2] American Naturalist, Vol. I, p. 561.

The heaps themselves were mainly composed of the shells of the common clam, the whelk and the mussel, and in them occurred the bones of the following species of animals, which have been already determined: the Moose, Deer, Bear, Dog, Beaver, Otter, Seal, Dog-fish, Goose, and the Great Auk, now extinct. This list agrees substantially with that given by Dr. Wyman.

But what I wish especially to bring to the attention of this Society at the present time is the fragment of a human bone, which I dug out of the shell-heap at Hull's Cove in the summer of 1880. It is a portion, about three inches in length, of the left femur, between the lesser trochanter and the foramen, according to the determination of Mr. F. W. Putnam. It was found under precisely the same circumstances as the bones of animals obtained at the same time from the heap, all of which were broken into pieces such as would come from portions of flesh of a size suitable for cooking in the pots, whose fragments abounded there. Like these it appears to have been broken for a similar object, and thus it would seem to furnish substantial evidence of the prevalence of cannibalism among the people, whose kitchen refuse makes up these shell-heaps.

Although Mr. Francis Parkman, in his various historical writings, has given many narratives derived from early Jesuit sources, which show that this practice existed among the Iroquois, the Algonquins, and other north-eastern tribes, yet the practical proof of it hitherto brought to light in New England amounts to but very little. All the shell-heaps of this region that have thus far been investigated, so far as my information extends, have afforded only six instances in which fragments of the human skeleton have been found.

At Cotuit-port, in Barnstable, Mass., Dr. Wyman came upon a metatarsal bone of the great toe of the human foot.

Mr. J. Eliot Cabot dug out of a shell-heap at Ipswich, Mass., a portion of a lower human jaw and also the upper part of a humerus, which had been fashioned into an implement. This is now preserved in the Peabody Museum at Cambridge.[1]

A human skull was found by Mr. Caleb Cooke, under the

[1] Second Annual Report of the Peabody Museum, p. 16.

Pine-grove shell-heap, near Salem, Mass. This Mr. Putnam believes to be the oldest one ever discovered in New England.[1]

But most considerable of all is the discovery made in 1877 by Mr. Manley Hardy, at Great Deer Isle, in Penobscot Bay, of "a human femur, and near by some twenty or thirty more bones of legs and arms, a sternum and portions of a pelvis, but no vertebrae, or ribs. . . . . Many of them were broken, and they had no more apparent connection with each other than any heap of bones among kitchen refuse would have; and were mixed with bones of moose and beaver and with ashes and remains of fires." Subsequently two crania, with the lower jaws detached, were found underneath the whole mass. This Mr. Putnam regards as "the only evidence yet obtained of cannibalism among the shell-heap people of New England."[2]

But in this instance, as well as in that of the skeleton stated in the newspapers to have been found in a shell-heap in Georgetown, Me., and to have been deposited in the cabinet of Bowdoin College, the objection may be raised that possibly these are only examples of intrusive burial. This is undoubtedly the case of the skeleton found by Dr. Chapman in the enormous shell-heap at Damariscotta and Newcastle, Me.[3] Of that I have here two fragments for purposes of comparison, which show from their condition and the entire absence of organic matter in them that they are much older than the fragment of a femur from Hull's Cove.

To this the explanation of burial cannot apply; and it seems difficult to account for its presence among fragments of bones of animals that had evidently served for man's food upon any other theory than that of the prevalence of cannibalism among the race, whose relics we find so abundantly in the shell-heaps of Mt. Desert.

Mr. S. H. Scudder read a paper on a second new type of carboniferous myriapods, which he named Protosyngnatha. He also described a new form of Archipolypoda, remarkable for being hairy. The papers will appear in the Memoirs.

[1] Tenth Report of the Peabody Mus., p. 29.
[2] Eleventh do. p. 196.
[3] Proceed. of Sci. Assoc. of Urbana, Ohio, Vol. I, p. 76.

Mr. Samuel Garman remarked on the evidence of an annual dormant period among sharks.

Section of Entomology, May 24, 1882.

Mr. S. H. Scudder in the chair. Four persons present.

Mr. S. H. Scudder exhibited a specimen of Scolopendrella found near Boston by Mr. S. Henshaw, which seemed to belong to a species distinct from any described.

The crateriform openings considered by Ryder as stigmata could be readily seen (figs. 1 and 2) just in advance and within the bases of the legs, or at least of the abdominal pairs, circular in outline, and large enough to insert the tips of the legs. The collophore of Packard is situated midway between the crateriform openings at the base of the first abdominal legs and appears to consist of a circular opening closed by four triangular pointed teeth, which converge over its centre and are striated in the same sense. The ventral appendages at the base of the legs are excessively minute, not half so long as the claws, and the structure of the legs themselves is unusual. They are four-jointed (fig. 2, 3) besides a basal prominence on which the ventral appendages are situated; the joints are quadrate: the first scarcely longer than broad; the second three-fourths as broad and half as long as the first; the third about half as broad as the first and a little longer than the second; the last less than half as broad as the second, and four times as long as broad, or a little longer than the basal joint, equal, the tip rounded on the outer side and furnished with a minute saucer-shaped pad or flanging appendix, from which arise the exceedingly delicate, rather strongly curved, subequal claws, as long as the width of the apical joint. The inner third or half of the basal three joints appears to be compressed, and at the tip flexible, so that when the leg is bent (fig. 3.) the stiff base of a joint imbeds itself in the apex of the joint preceding it and makes it appear sharply and deeply angulate at the tip, within. On account of the robustness of the legs, the name of Scolopendrella latipes is proposed for the species.

Fig. 1.

Fig. 2.

Fig. 3.

The joints of the antennae in this specimen are sixteen in number, of which two of the basal ones are not shown in figure 5 and are of a very graceful champagne-glass shape, broader than long, broadest apically, the terminal joint hemispherical, the rounded portion apical. Excepting the last three or four, the joints are deeply imbricate, and each bears around the tip a series of distant, exceedingly minute, scarcely visible and very short hairs, about one fourth as long as the joint.

The head (fig. 4), drawn from the specimen after an accident had crushed it and spread abnormally the front part of the head, is rounded subquadrate with no superior stemmata. The median suture is broken in the middle, the broken ends enlarging as if for the passage of a canal, and on the opposite sides of the head there is a similar break in the contour of the outer surface, which I have taken as probable indications of stigmata. The mandibles, as in Muhr's figure of his S. microcolpa, are broad serrated plates, the serrations, as there, naturally falling into an equal anterior and posterior series. But the maxillae appear very different, being slightly curved, finely pointed falcations with no appendages. There is also exposed between the unnaturally expanded mandibles and maxillae the oral beak, as it might be called, the reniform mouth being protruded at the summit of a conical extension of this part of the head, mch as in Podura and recalling in a very modified manner the probable structure of the strange genus Lipocephalus from the Tertiary shales of Florissant, Colorado. On either side of the walls of this conical projection are a couple of triangular folds or plates, which may represent the labium but which are altogether different from Muhr's representation of S. microcolpa.

Fig. 4.

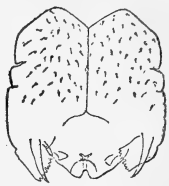


Fig. 5.

The body is stout, very delicately shagreened, the joints perfectly simple, without any imbrication or angular prolongation of the sides of the dorsal plates. There are seven abdominal joints each with a pair of legs, and the last bearing also a pair of stout conical anal appendages as large and as long as the legs before their apical joint. There are no hairs upon the body, but a few widely scattered minute papillae on the anal appendages, which look as if they were meant for hair-bases.

The supposed tracheal openings of the head, and the protrusion of the oral parts are additional marks of affinity which S olopendrella bears to Thysanura, where, following Dr. Packard, the speaker was inclined to place them.

The movements of the living Scolopendrella, notwithstanding the modifications one would look for in a polypodous creature, at once remind one of the Thysanura, and especially of the Cinura, in their spasmodic character; these creatures run a short distance, perhaps several times their length, stop for a moment or two, and then dart off at an angle to repeat the movement again and again.

The length of the specimen studied is 3 mm.

Mr. Scudder also exhibited specimens of the curious myriapod Polyxenus fascicularia Say, found with the preceding, and called attention to the structure and disposition of the tegumentary appendages.

In a memoir just printed by the Society,[1] it is stated that modern diplopod myriapoda are never supplied with any more striking dermal appendages than serrate laminae, roughened tubercles or simple papilla-mounted hairs. At that time Polyxenus was unknown to me in nature, and I had not chanced to meet with special reference to its clothing. In this striking exception to the above statement there are two classes of dermal appendages.

The first are those attached to the sides of the body-segments and border the incisures on the upper surface. The simplest border the incisures and are stout, more or less club-shaped spines (fig. 6, a.), often largest at the distal extremity, lying with their bases next the incisures, those behind the incisure being of uniform length and directed backward, those in front of it of variable length, generally alternating between short and long, and directed forward; they are all furnished with two or more longitudinal rows of flattened teeth, directed apically and outward. Toward the sides of the segments these spines generally assume the form of those belonging to the whorls on the lateral mammillae, where the appendages present a uniformily spreading hemisphere of points and consist of curved sabre-shaped spines (fig. 6, b.), deeply and sharply serrate on the convex edge and increasingly so toward the pointed tip; a few much less conspicuous serrations often appear on the concave side toward the tip. These spines are two or three times longer than the club-shaped spines of the upper surface, but not much longer than those of the head, which approach them also in structure, like those which are found near the sides of the dorsal surface of the body.

Fig. 6.

But besides these two kinds, which show more or less tendency to blend, there is another entirely distinct form, found only massed in a pair of dense cylindrical fascicles, which occupy the whole of the posterior portion of the dorsal surface of the terminal segment, and in life are directed straight backward. These give the minute myriapod a very close resemblance to the larva of Anthrenus, with which it agrees also in size. The individual spines (fig. 6, c.) are shaped like a very elongated fish-hook, being exceedingly slender, the shaft gently curved and the tip recurved and apically barbed;

[1] Archipolypoda, a subordinate type of spined myriapods from the Carboniferous formation. Mem. Bost. Soc. Nat. Hist., III, 143–182, pl. 10-13.

more or less alternating, slender, straight or sinuous, scarcely tapering, slightly divergent, delicate spinules border the shaft on the convex and concave sides, diminishing in length apically and dying out long before the summit is reached, particularly on the concave side; these spinules become altered on this latter side to very long, reversed (or, if the spine be placed vertically, pendent), spatulate appendages at the apical crook, where three of them, increasing in size away from the apex, are attached to the concave surface ; the tip itself is armed on the convex side with a barb or fluke, laterally compressed, and with the tooth or fluke sharply angulate. The whole spine is twice as long as those of the lateral papillae and very much slenderer, rather resembling a barbed hair. None of these appendages can be very fairly compared, as Packard has done (Guide, p. 678), to the hairs of Dermestes, at least as these are figured by Riley. I have had no opportunity to examine them.

Dr. Hagen read the following paper:

DESCRIPTION OF TWO INTERESTING HOUSES MADE BY NATIVE CADDIS-FLY LARVAE.

BY CORA H. CLARKE.

I have found in great abundance in streams near Boston, Massachusetts, some very interesting cases of trichopterous handiwork, together with the architects,— larvae belonging to the family Hydropsychidae, and the genus Hydropsyche. The typical form of the structure resembles a tunnel attached to the surface of a stone, having at its mouth a vertical framework with a net stretched across it (see fig. 1[1]). An open mouth or entrance to the case is always close to this net, on the side towards the current, so that without wholly leaving its house, the larva can remove from the net anything eatable which the current may have lodged there. The mode of building varies considerably.

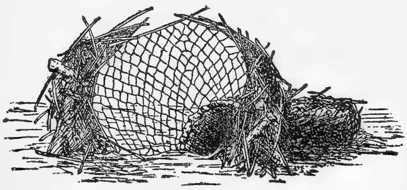


Fig. 1.

The case is usually about half an inch long, and a little curved,

[1] Fig. 1 is enlarged about four diameters, the remaining figures are of natural size.

loosely attached to the stone by its edges, and without any bottom. It may be composed entirely of sand, or of bits of plants, or both combined.

The supporting framework of the net is always formed of vegetable bits, and is sometimes a simple arch, sometimes a complete ring, and sometimes a short cylinder. It is occasionally stayed or held in position by silken cords stretching from it to suitable points on the stone. It is stiff enough to stand erect even when removed from the water. When it is in the shape of a cylinder or broad arch, the net is always stretched across that end of it which is down stream, and the entrance usually opens under the shelter of the arch.

The case of the pupa (fig. 2) is more strongly built than that of the larva. It is symmeti ical and oblong, over half an inch long, composed of coarse sand-grains or tiny stones, and firmly attached to the foundation stone by its edges. Across the bottom, resting on the stone, is a silken web. At each end, nearly concealed by the little stones, is a grating which insures a fresh current of water through the case.

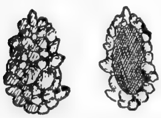


Fig. 2.

The larvae are strong little creatures, with the body grayish, and the head, thorax and short legs dark brown. The body is somewhat curved, and copious tufted gills hang from the under side. Dr. Hagen will give a detailed description of them at another opportunity.

In a stream in Brookline, Mass., are large communities of these larvae. The stones in the stream are covered with mud, leaves, sticks and rubbish. Looking down upon these stones, quantities of dark holes can be seen, facing the current, often a row of them side by side, stretching abliquely across the stone. Removing a mass of the rubbish with the hand, the delicate net can be seen across each hole, supported by its framework of vegetable bits. Sometimes a stick, which has fallen into the brook, has a row of cases and nets built upon it. Often a stone will have a row of them side by side along one edge, or there may be only a few of these structures scattered separately upon its surface.

I have always found them where the current is very swift, and if the stones with the cases and larvae are placed in standing water, the larvae nearly all die in the course of a few hours. Occasionally however, one, more hardy than the others, will live for several days, or even two or three weeks.

I have not looked for this species except in the neighborhood of Boston, but I have received a net and larva from Mt. Desert, Me.

A very peculiar case is also made by another larva belonging to the same family, Hydropsychidae, and the genus Plectrocnemia. Cases of this kind are quite abundant in Stony Brook, near Boston, close to the Forest Hills station. Looking down into the clear water, we see on the muddy bottom, dead leaves, sticks twigs, etc., covered with a thin film of mud. Among these are some objects which appear like nearly erect twigs or leaf petioles, but with a small hole in their apex. These are in reality tubes of mud constructed by the Plectrocnemia larvae, and by working the fingers about in the mud at the base of the tube, it can be taken out, together with the part that lies concealed beneath.

The typical form (fig. 3) is a tall, nearly cylindrical chimney, from one to two inches long and one eighth of an inch in diameter, about three-quarters of an inch projecting above the surface of the mud. At the base of this chimney are one or more lateral tubes, which for a quarter of an inch are of the same diameter as the vertical tube, but then swell out into an oblong chamber about half an inch long and a quarter of an inch or more in the greatest diameter. Usually there is a small hole at the end of this chamber, but sometimes the chamber extends into another short piece of cylindrical tube which contracts to a small aperture at its termination. Whether these holes serve merely as an exit for the respiratory current, or whether the larva uses them as doors I cannot determine. Neither can I decide in which part of the case the larva lives, whether in the vertical chimney or in the side chamber; but I have always found the pupa in a vertical position in the upright shaft, its place being usually indicated by an enlargement of the tube (fig. 4). These chambers have a smooth

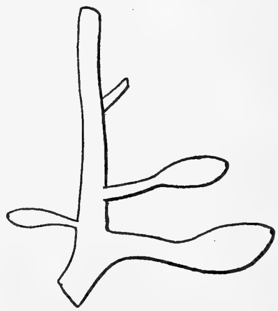


Fig. 3.

internal lining of silk, which at the lower end is separated from the side of the tube and seems to be slightly drawn together, so that it is difficult to push anything through from the outside, though a small stick can be easily thrust through from the inside. At the upper end of the case, just above the head of the pupa, is a perforated disk. I collected a number of tubes on May 13th, and found that nearly all the larvae had pupated.

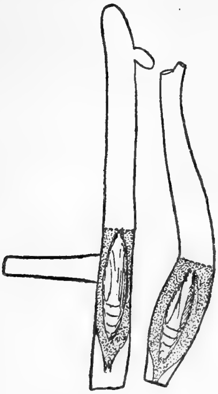


Fig. 4.

On June 28th, I found in the same place the cases of the young larva (fig. 5), shaped like those of the adult, with the same vertical chimney and lateral chambers. In these the height of the shaft varied from one-half to seven-eighths of an inch, and the length of the side pieces from one quarter to nearly one-half of an inch.

Larvae collected in November were almost seven-eighths of an inch long. The body of the larva is slender, and somewhat flattened, and ends in a pair of long anal crotchets. There are no external respiratory filaments. The small head is yellow, the thorax white, and the abdomen lavender-blue. The young larvae are white.

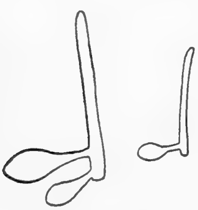


Fig. 5.

A microscope shows the long spinneret of the larva, and the little brushes of hairs on the mouth parts. The legs are very short, and the last joint of the first pair is flattened and edged with a thick brush of hairs. The hairs on the other legs are short and stiff.

The pupa is nearly half an inch long, with a light green abdomen and blackish-gray wings. The abdomen is kept in constant motion, and has three pairs of gills upon each side; the first and second pair are forked.

I have kept the larvae all winter in confinement, hoping to see them build, but they merely made a rough, horizontal tube, showing no disposition to construct a vertical chimney. The tubes were attached to the bottom of the vessel and left unfinished beneath.

Although the greater number of the tubes found in the brook were constructed of mud, and had a smooth external surface, I have sometimes found the exterior rough with coarse sand grains, or bristing with bits of straw and other refuse which had washed into the brook.

In a brook in the woods, in Canton, Mass., I found cases composed entirely of sand. They were quite small and contained no larvae. Fig. 6 is added to show a form of case sometimes seen, having two openings at the top of the chimney instead of one.

Fig. 6.

General Meeting, October 4, 1882.

The President, Mr. S. H. Scudder, in the chair. Thirty-seven persons present.

After the record of the previous meeting was read and approved, the President spoke in fitting words of the death, at the beginning of the summer vacation, of Professor William Barton Rogers, who was elected a Corresponding Member early in the Society's history, and became a Resident Member in 1857, having previously been elected an Honorary Member in 1842. It was voted that the chair appoint a committee to secure a memorial of Professor Rogers for the Proceedings. Messrs. F. W. Putnam, N. S. Shaler and T. T. Bouvé were accordingly appointed.

Mr. F. W. Putnam then gave an account of some shell-heap extions made during the summer in Muscongus and Damariscotta Bays, showing part of the collections made, including bone fishhooks, spears, awls, etc., broken pottery, together with stone hammers, celts and other implements.

The following papers were read

ON THE CLASSIFICATION AND ORIGIN OF JOINT-STRUCTURES.

BY W. O. CROSBY.

The attention of geologists has been recently attracted to the subject of this paper through the interesting articles by Mr. Gilbert and Professor Le Conte in the American Journal of Science for January, March and July of the current year. In his second paper, where the origin of joint-structure is more particularly discussed, Mr. Gilbert has made it pretty clear that, notwithstanding the remarkable efficiency of dessication in producing approximately vertical fractures in recently deposited sediments, as in the examples cited by Professor Le Conte, these cracks are essentially unlike the planes of division in the Post-tertiary clays of the Great Salt Lake Desert, and do not possess, as the latter unquestionably do, the characteristics of ordinary joints. And it seems, further, as if his arguments to show that the intersecting systems of continuous and parallel joints, so universally present in sedimentary formations, can not be due to either shrinkage or compression, must carry conviction to all minds. In short, Mr. Gilbert has conclusively demonstrated that parallel jointing must be quite distinct in its origin, as it usually is in its characteristics, from both shrinkage-cracks and slaty cleavage.

Having reached this point, Mr. Gilbert follows Professor Dana in so restricting the definition of joint-structure as to exclude all shrinkage-cracks, as well as slaty cleavage. This classification appears to the present writer of doubtful utility, chiefly because of its impracticability. A very large proportion of the planes of division in eruptive rocks are due to shrinkage, this cause being clearly recognized by all in the columnar structure of basalt; and it is in many cases simply impossible, at least with our present knowledge, to distinguish, in this class of rocks, the cracks due to shrinkage from those produced by other causes. Similarly, there can be no question that the dessication, consolidation and crystallization of sediments develop a tendency to contraction; and, as I have attempted to show, in the Geological Magazine for September, 1881, if not immediately, yet sooner or later, this contraction must take place. When it does occur, fractures are formed which, considering that all degrees of regularity exist among joints not due to shrinkage, must in many cases be extremely difficult to distinguish from the latter.

If all shrinkage-cracks in sediments were merely superficial sun-cracks, the problem would be comparatively simple; but, taking things as they exist, we shall be obliged, if we adopt the classification proposed by Professor Dana and Mr. Gilbert, to coin a new term, to be used, provisionally at least, in those very numerous cases where the origin of the planes of division cannot be determined. The distinction of ordinary joint-structure from stratification and cleavage is rarely difficult, but its distinction from shrinkage-cracks is often a very puzzling and difficult problem, especially in coarse-grained and crystalline rocks.

Although it is true, as Mr. Gilbert states, that the shrinkage-cracks and blocks tend to be circular; yet it is also true, as an examination of actual examples will show, that there are circles within circles, the centres of contraction being comparatively few and distant at the beginning of the shrinkage; and, when the process is complete, the primary cracks are, in their length and straightness, in striking contrast with those formed later. And it is important to observe that the size of the contracting circles or polygons must be, approximately at least, proportional to the thickness of the deposit, which is equivalent to saying that they must be large in most examples of geological importance.

It seems better, therefore, to class shrinkage-cracks as joints, and then to distinguish, where we can, between the joints having unlike origins. This plan obviates the necessity, which would otherwise exist, of adopting a new name for what geologists now almost universally call the prismatic *jointing* of basalt. Besides if fractures due to *shrinkage* are to be separated from the class of joints, then the concentric fractures parallel with the surface in granitic rocks, and which it is now generally agreed are the result of *expansion* caused by the sun's heat, should also be classed separately.

A joint is a plane of division, not often merely a theoretical or potential division, as in crystalline cleavage, but an actual physical break — not a plane where division may occur, but the division itself. In this respect joints agree with shrinkage-cracks, but differ widely from slaty cleavage and the planes of weakness coinciding with and arising from stratification. Joints and shrinkage-cracks agree, too, in their independence of the stratification, in running in more than one direction in the same mass of rock, and in being usually approximately vertical, at least in sedimentary rocks. They differ chiefly in this, that shrinkage-cracks are usually short, are not arranged in sets by their parallelism, and rarely cross each other.

Broadening the definition of joint-structure in the way here proposed, we are obliged, of course, to recognize several distinct classes of joints — distinct both in characteristics and origin. These are, first, the usually short, non-parallel, and non-intersecting joints dividing the rocks into polygonal blocks the sides of which are not, as a rule, continuous in the same straight line with the sides of adjacent blocks. The joints and blocks are usually extremely irregular, though the prismatic jointing of basalt is a notable exception. Geologists are generally agreed that the joints of this class are due to contraction, the contraction arising from the dessication and consolidation of sedimentary rocks, the cooling of eruptive rocks, and the crystallization of rocks of either class. Hence these may be properly called *contraction* or shrinkage joints. Next in order come the much less important fractures, observed chiefly in granitic rocks, which are parallel with the surface of the ground and appear to die out at a depth of one hundred to two hundred feet. These have been explained by Professor Shaler, probably to the satisfaction of most geologists, as due to the expansion of the surface under the influence of the sun's heat; and therefore, may be properly known as *expansion* joints. We see something analogous in the exfoliation of granite blocks when exposed to fire.

The third and most important class embraces the straight, parallel and intersecting joints, the joints properly so-called, according to Mr. Gilbert. Concerning the origin of these, several opinions have been entertained by geologists; but, as already stated, Mr. Gilbert has demonstrated that the two causes most commonly appealed to — shrinkage and compression — are entirely inadequate. Besides the hypotheses that the joints of this class are, in their origin, akin to shinkage-cracks or to slaty cleavage, Mr. Gilbert cites two others, both of which he likewise properly rejects: viz., (1) that which refers these fractures to the operation of magnetic forces, and (2) that which explains them as due to an unexplained shearing force. In other words, fatal objections beset every explanation heretofore proposed, and the problem presented by ordinary or parallel jointing would appear to be still unsolved. The recent discussion of this subject, however, has led me to examine with greater care than ever before an idea which has often been in my mind, viz., that *earthquakes* are the cause of parallel joint-structure; and I am persuaded that we have here an explanation which, if not the true one, is at least open to less obvious objections than any that have preceded it.

An earthquake, it is well known, is a series of spherical, elastic waves originating in a shock or jar at a considerable depth below the surface. The velocity of the earth-waves, when not very high, is determined solely by the elasticity of the medium; and the normal velocity in solid crystalline rocks, like granite, as shown by the progress of slight tremors and sound-waves, is 10,000 to 12,000 feet per second. But observation of many earthquakes, as well as Mallet's experiments, shows that the actual velocity of the spherical wave, in the case of severe earthquakes is often less than one-eighth and rarely exceeds one-fourth of the normal velocity, or 1200 to 1600 feet per second. The enormous difference is satisfactorily explained as due to a difference in wave-height. For, while the rocks, which are at best but very imperfectly elastic, carry successfully without rupture the low waves, they are *broken* at every step by the passage of the high waves of the important earthquake.

This explanation, which I have taken almost *verbatim* from Le Conte's Elements of Geology, appears to be generally accepted by geologists. Now all parts of the earth's crust are affected by earthquakes; and, during the course of geological time, the number, even of severe shocks, occurring in those areas most nearly free from seismic disturbance must be very considerable. But all important vibrations break the rocks which they traverse; and hence the conclusion follows irresistibly that all geological formations (except, perhaps, the most recent, which are precisely those freest from joint-structure) must be extensively broken as a consequence of the passage of the numerous earthquakes which they have experienced.

The question arises, then, where are these fractures? A positive answer must be found, because their existence cannot be denied. They are not the planes of division which we call slaty cleavage, because earthquakes are not limited to a particular class of rocks, and successive shocks do not run always in the same direction. They are not the planes of weakness coinciding with the stratification of stratified rocks, for the same and other reasons. So far as I can see, we have but one alternative, and that is to call them *joints*. They are plainly not contraction or expansion joints, and hence by a process of elimination we arrive at the conclusion that earthquakes are a principal cause, at least, of ordinary or parallel joints.

We have already noticed the more important characteristics of this class of joints; and I invite attention now to a consideration of the probable nature of earthquake-fractures, with a view to comparing them with parallel joints. During the passage of an earthquake, the rocks are subjected in rapid alternation to powerful compression and equally powerful rarefaction or tension, the latter, probably, being the chief cause of the fractures. The main point is that the fractures must be parallel to the wave-surface, *i. e.*, normal at every point to the radius of the sphere or the direction of the wave-movement. This is clearly observed in the case of fractured buildings, which are traversed by the wave in precisely the same manner as the rocks on which they stand; and nearly all determinations of the position of the seismic vertical and focus of earthquakes rest upon this assumption.

It follows from this that the fractures will be horizontal between the focus and epicentrum, and that they will dip away from the epicentrum in all directions as we recede from that point, the inclination to the horizon steadily increasing with the distance. And since the focus, according to our best determinations, is rarely more than ten, and often considerably less than five miles below the surface, the fractures must, as a rule, be approximately vertical at all points beyond a few miles from the epicentrum. Now joint-planes, although sometimes nearly or quite horizontal, are usually approximately vertical, showing a close agreement in this respect with earthquake fractures.

The point has been raised that the distance from the epicentrum at which earthquake fractures would become as nearly vertical as average joints is usually so great that the vibrations must lose their power to break the rocks before traversing it. This objection may, I think, be sufficiently answered by calling attention to the fact insisted upon by Mallet, that the earthquake focus is not a point, nor, normally, a space or cavity of equal extent in all directions, but it is a fissure. So far as I know, every determination of the form of the earthquake focus that has been made supports the conclusion that earthquakes usually originate in (*i. e* the original impulse is due to) the formation, suddenly, of a more or less extensive fissure. The enormous strains in the earth's crust, arising primarily from the contraction of the interior, increase until the limit of the resistance offered by the rocks is reached, when the latter are crushed or ruptured along a plane normal to the direction of the strain. The concussion or jar attending the yielding of the rocks spreads in all directions and constitutes the earthquake.

These great crust-strains, whether of the nature of tension or compression, are usually conceived as horizontal; and hence we must think of the resulting fissures as normally vertical, or, at least, as making a large angle with the horizon. Now it is reasonable to suppose, and the supposition agrees exactly with Mallet's conclusions based upon the Neapolitan earthquake of 1857, that the amplitude of the vibrations is greatest, and hence that they spread with destructive force farthest, in directions at right angles to the plane of rupture, the isoseismal curves being elongated ellipses having the fissure in which the shock originates for the minor axis. In other words, the shock or blow being delivered upon vertical surfaces, the resulting vibrations of greatest amplitude and breaking power run horizontally, and produce vertical fractures, from the beginning, the vertical fractures or joints, according to this view, commencing at the seismic vertical, and being parallel with the primordial fissure.

Where the chief part of the energy represented by an earthquake is delivered and propagated horizontally and at a considerable depth, the effect upon the surface, as regards the destruction of human life and property as well as the developement of joint-structure, must be comparatively slight; and we have, therefore, cause to be thankful that earthquakes do originate mainly in vertical fissures. There can be no doubt, however, that the primary or causative fissures often approach much nearer the surface than that in which the Neapolitan earthquake so carefully studied by Mallett originated; and it seems in the highest degree probable that the New Zealand earthquakes of 1848 and 1855 are a common type. These disastrous shocks were due to the sudden formation of gigantic fissures which reached the surface, being traced as open cracks —the first (in the south island) for a distance of sixty miles south-west from Cook's Strait, and the second (in the north island) for the almost incredible distance of ninety miles north-east of the same channel. The second fissure was accompanied throughout its entire length by a permanent dislocation of the rocks, the country on the north-west side being elevated nine feet, while the south-west side remained stationary.

Joints are, as a rule, most conspicuously vertical in horizontal strata. But in such formations, especially if there are partings or planes of weakness between the beds, the earthquake movement need not be horizontal in order to produce vertical fractures, for these are almost inevitable, even though the vibrations move obliquely upward at a considerable angle, on account of the natural tendency of the beds to break at right angles.

Earthquake fractures are necessarily parallel, and, although portions of curves, yet for the most part of curves so great as to appear sensibly straight in any single exposure, or even in a series of exposures extending many miles. Here again they are essencially identical with joints. Joints are not only parallel, but in the same district, the principal sets usually show considerable constancy in direction. Now earthquake foci, so geologists generally believe, are situated along certain definite lines in the earth's crust — sometimes lines of volcanic activity, but more commonly lines of upheaval, plication and faulting. In other words, earthquakes usually originate in the axes of mountain-ranges, or in zones parallel with these. And this is simply equivalent to saying that, as a rule, we may expect to observe considerable constancy in the directions of earthquake-movement and of earthquake-fractures in districts of limited extent.

It is a familiar fact that the faults, veins and dikes of a district are usually parallel with the principal sets of joints. But this relation is easily and naturally explained, if we accept earthquakes as the cause of jointing, since the joints are incidental to the formation of the fissures represented by veins, dikes and faults.

Again, joints are not only arranged in sets by their parallelism, but the sets cross each other at all angles without interference. The same is undoubtedly true of earthquake-fractures. An earthquake, of course, moves in all directions, but the area affected is usually so great that in any limited tract, not too near the epicentrum, it will seem to move in only one direction. A series of vibrations travelling from east to west would produce a set of parallel joints running north and south; and these will be no obstacle whatever to vibrations moving in a north-south direction, which would give rise to a set of east-west joints, crossing the first set at right angles and absolutely without interference. And, similarly, a shock coming from the north-east, or some other intermediate point of the compass, would determine a set of joints crossing both the preceding sets obliquely, and so on.

It has been suggested to me by Professor Hitchcock and several other persons, as an objection to the earthquake theory of jointing, that among the blocks produced by jointing it may be observed that certain forms are more characteristic of some rocks than of others, rhomboidal blocks, for instance, being especially common with slate and cubical blocks with sandstone and coal. Probably all geologists have observed something of this sort; but it is easy to exaggerate such distinctions, and I believe that they are largely fanciful and that in so far as they actually exist they may be satisfactorily explained without surrendering the theory here advocated. There is a vast difference in the smoothness and regularity of the blocks in different kinds of rocks. To appreciate this we only need to compare the compact sedimentary rocks like slate and limestone with the coarse-grained and crystalline rocks like granite, etc. But these differences, it is clear, are determined by differences in the texture and elasticity of the rocks, and are no argument whatever against the view that the fractures are due to vibratory movements of the rocks, for the same series of vibrations would inevitably produce smooth and regular fractures in slate and exceedingly rough and irregular fractures in granite. It is unquestionably true that approximately rectangular blocks are far more common in all kinds of rocks than blocks with very oblique angles. The proper explanation here, I think, is that, after the rocks have been broken by one set of joints, the layers or sheets thus formed possess a strong natural tendency to break at right angles; and, as previously stated, under such circumstances, oblique vibrations may give rise to rectangular fractures and blocks.

Granting, for the sake of the argument, that, as Professor Hitchcock and others claim and as I deny, aside from the varying degrees of smoothness and regularity of the joint-blocks, certain general forms, as rhombohedrons or cubes, are peculiar to particular kinds of rock, still it must be admitted that this correlation is as easily harmonized with the earthquake as with the shrinkage hypothesis, for it appears, in fact, to be explainable by no hypothesis, save the absolutely baseless one that jointing is a species of crystallization.

Prof. James Hall has called my attention to the fact that the Post-tertiary clays in the vicinity of Albany, N. Y., like those of the Great Salt Lake Desert, possess a well developed joint-structure, two sets of joints crossing at right angles. And he has expressed the belief that this is an example of parallel jointing which can not be due to earthquake action, because of the inelastic nature of the clay and the fact that it rests upon a bed of gravel, which, it is thought, protects it from all breaking shocks. But, if the stratum of gravel affords this measure of protection to the clay, it becomes difficult to understand how areas underlaid by gravel can ever be disastrously affected by earthquakes, as they undoubtedly have been. A large part of the earth's surface has essentially the same structure, consisting of alternating beds of gravel and clay. Besides, it is perhaps possible, that at Albany, the shocks, travelling horizontally, might pass "end on" into the clay without traversing the gravel. The inferior elasticity of the clay, so far from being an argument against the earthquake hypothesis, would seem to tell strongly in its favor, since the probability that vibrations will be attended by fractures, is *inversely* proportional to the elasticity of the medium. In other words, we might safely grant that only slight vibrations can enter the clay, because these would be sufficient to break a medium so inelastic. Professor Hall refers the jointing of the Albany clays to the shrinkage-hypothesis, although, as Mr. Gilbert has shown, it possesses almost none of the characteristics of true shrinkage-cracks, of cracks known to be due to shrinkage; while it is difficult to see wherein the earthquake hypothesis falls short of a perfect explanation of the phenomena.

Apparently, there is no important characteristic of parallel jointing, which is not satisfactorily explained by a reference to earthquakes as a cause. A moment's reflection, however, will show that we can not properly regard earthquakes as the sole cause, but simply as a principal cause, of this class of joints. The phenomena of elevation and plication must be accompanied by fractures; and these, it is easy to see, will have the normal features of ordinary or parallel joints, being parallel, and intersecting without interference when the strains are varied in direction. But we must not lose sight of the fact that earthquakes account for joints in rocks of all classes and conditions — in the unconsolidated and undisturbed post-Tertiary clays of the Great Salt Lake Desert, as well as in the ancient crystalline and contorted gneisses; while the normal accompaniment of compression and plication, on the other hand, is cleavage, and not jointing; although neither structure can be developed by these agencies without disturbing the stratification.

With shrinkage and compression, time is an important element. The strain is developed very gradually, and a well marked fracture, due to these causes, may be days or years in forming. The earthquake, on the other hand, is just the reverse. According to Mallett, the amplitude of the earth-waves varies from three or four inches to as many feet, and the velocity of vibration, or of shock, from ten or twelve feet to eighty feet per second, giving an average of about fifteen complete vibrations per second. In other words, the rocks, during the passage of the earthquake, are jerked violently through a distance of several inches or feet and back again fifteen times in a second, or at that rate. The energy displayed is immense, but its application is so nearly instantaneous that the element of time almost disappears. Compression and shrinkage mean a very gradual pressure or an equally gradual pull; but in the earthquake the push and pull are combined, the first being like a heavy sharp blow, while the latter is equivalent to a powerful and sudden jerk. No argument is required to prove that, other things being equal, a strain will produce a more regular fracture if quickly than if slowly developed.

My purpose now is to show that in certain rocks which, under ordinary circumstances, break very irregularly, and yet possess a joint-structure of remarkable straightness and regularity, earthquakes are a far more probable cause of the jointing than either shrinkage or compression. As a magnificent example of such a formation, I would refer to the conglomerate so extensively developed in the vicinity of Boston. Few rocks are more heterogeneous in texture and composition, and the artificial fracture is exceedingly uneven, rarely dividing the pebbles and almost never dividing them smoothly. But the joints, of which there are several well defined sets, are beautifully, almost mathematically, regular — true planes, passing through pebbles and cement alike, as by one clean, swift stroke. It is rare to find a case where the joint is deflected by a pebble; but very commonly the divided pebbles are slightly faulted, the two parts no longer corresponding in position. The dislocation varies from a small fraction of an inch, to a foot or more. The pebbles are chiefly quartzite, petrosilex and granite, and are distinctly stronger than the cement. Under the influence of shrinkage they would be dragged from the cement along the fractures, and neatly divided pebbles would be the rare exception, instead of the nearly universal rule. The conglomerate at Newport, R. I., affords another good example of wonderfully regular parallel joints in a rock, the coarseness and irregularity of which are rarely exceeded.

In my paper already referred to in the Geological Magazine, I have taken for granted (as geologists have heretofore been accustomed to do) that, although joints are sometimes due to movements of the rocks, contraction is the more general and efficient cause. And, proceeding upon this assumption, I have there endeavored to show that, as a rule, during the deposition of sediments and their subsequent burial beneath newer formations, the ordinary causes of contraction — consolidation and crystallization — will be neutralized by the increased temperature of the sediments; and that it is only when these are brought back to or toward the surface by erosion, that a net contraction can take place, and joint-structure be developed; the immediate cause of the contraction and jointing being, not consolidation or crystallization, but cooling.

Contraction in the vertical direction in sediments must always be inoperative, so far as the formation of fractures is concerned. And my father, F. W. Crosby, has recently suggested to me another reason why vertical shrinkage-cracks or joints cannot appear in deeply buried rocks, viz.: that the enormous pressure of the overlying strata would coöperate with the heat in causing lateral expansion and preventing contraction. The pressure at a depth of only one mile must be nearly one million pounds on every square foot, sufficient to cause all ordinary rocks to spread horizontally, and neutralize any conceivable contraction.

In support of the theory thus worked out, I have brought the testimony of the coarsely crystalline eruptive rocks. These masses, as most geologists agree, have been formed at considerable depths in the earth's crust, appearing on the surface only as the result of immense erosion; and yet their outlines are usually extremely irregular and ragged, showing that, at the time of their intrusion the enclosing rocks must have been essentially unjointed. My aim, in this connection, is to show that the argument for the superficial nature of joint structure is strengthened, rather than weakened, when we substitute earthquakes for shrinkage as the principal cause of jointing.

In the first place, earthquakes are comparatively superficial. This is one of the most important and firmly established propositions yet added to the theory of earthquake phenomena. Moreover, it seems pertinent to call attention here to a point which has, apparently, been neglected in determining the depth of earthquake foci, but which has, nevertheless, an important bearing upon that problem. Briefly stated, it is this: The rocks composing the earth's crust, it is universally conceded, are less thoroughly consolidated, less crystalline, and more broken by cleavage, faults, etc., in other words, are far less elastic, near the surface than at considerable depths. Consequently, while the vibratory movement which we call an earthquake moves downward and horizontally with comparative freedom, its progress upward will be greatly retarded by the inelastic nature of the rocks in that direction. But the main point is that, with the change in the character of the medium, the waves suffer refraction, being bent toward the seismic vertical. The effect of this refraction is to increase the angles of emergence and the steepness of the wave-paths; and the latter, extended backward, will consequently meet at some point below the focus. That is, in calculating the depth of earthquake foci, allowance should be made for the fact that the elasticity of the crust increases with depth; and if this point has not been considered, the depths now generally accepted are probably too great.[1]

It is more important for our present purpose, however, to observe that the number and extent of the fractures produced by an earthquake are inversely proportional to the elasticity of the rocks which it traverses; and that just as certainly as the elasticity increases downward, the fractures (joints) must increase upward. Therefore, if, as seems necessary, we regard earthquakes as the principal cause of jointing, the conclusion is inevitable that this structure has its best development near the surface and dies out at great depths. But, as we have already seen, shrinkage-joints, whether due to cooling, consolidation or crystallization are probably mainly superficial. And a moment's reflection will show that the fractures resulting directly from the compression and

[1] In the interest of science, I wish to direct attention to an error of a somewhat serious character in the masterly treatise on the Neapolitan earthquake of 1857, by the late Robert Mallet. On page 262, of the second volume, it is stated, in effect (and the accompanying diagram shows clearly the same thing), that earthquake-waves, on passing from the solid, unbroken and elastic underlying formations to the imperfectly consolidated, broken and inelastic overlying formations, *i. e.*, from rocks in which their velocity is greater to those in which it is less, suffer refraction in such a manner that they are bent *away* from the perpendicular. But every student of physics must see at a glance that the refraction is necessarily in the opposite direction, or *toward* the normal to the surface of the media; and it it very strange that so patent an error should have crept into the work of this eminent and painstaking investigator.

The amount and direction of the refraction of the earth-waves, are, of course, important elements in determining the depths of seismic foci. The wave-paths, on account of being bent upward, must, when followed backward, if no correction is made for refraction, seem to converge at some point *below* the focus, as already explained, and thus the depth is made too great. That Mallett has not applied, or at least has not properly applied, the correction for refraction is evident from the fact that he conceived the wave-paths to be depressed instead of elevated by refraction, and therefore as appearing to converge above, and not below, the focus. Hence his determinations of the depths of earthquake-foci are probably in excess of the truth.

folding of the rocks must observe the same law in their distribution in depth. For it is reasonable to suppose that crust-strains originating in the shrinking of the earth's interior will culminate in the more superficial portions of the crust.

Hence, in conclusion, we may safely say that every theory of the origin of joint-structure now entertained by geologists (and in a certain sense they are all true, some explaining one kind of jointing and some another) is consistent with the view that jointing is essentially a superficial feature of the earth's crust.

NOTES ON THE DEVELOPMENT OF RANA SYLVATICA LECONTE.

BY MARY H. HINCKLEY.

Of the species of Rana found in Milton, Massachusetts, R. sylvatica congregates at the water earliest in spring, for purposes of egg-laying. The time of appearance varies with the season, according as the mild weather is early or late. In 1880 they were seen Feb. 28, while in 1881 and 1882 they were not found till March 18, and 23. Their appearance in these years was preceded by three or more days in which the temperature of the air at mid-day ranged from 40° to 60°. The frogs apparently collect immediately on awakening from their torpor, in the shallow water, on the sunny side of small ponds, inundated swamps, and bogs. On sunny days the still shallow water near the shore will be found several degrees warmer than that which is deeper or in shadow. My notes give the lowest temperature of water in which I have seen the frogs moving, 45°; the lowest in which they were found spawning, 50°.[1] After collecting at the water they are evidently only affected by the temperature of the air indirectly as it affects the water. I have heard R. sylvatica in full voice in the evening when the air was 30°, but this occurred after a mild sunny day, and probably before the water had become chilled by the night air. In water at a temperature of 45° the frog lacks its usual agility and floats about like a dead leaf on the

[1] See notes on the Toads and Frogs about Cambridge, Mass., by Mr. F. W. Putnam, in these Proceedings, Vol. IX, p. 229. Also notes on Batrachians found in the vicinity of Springfield, Mass., by Mr. J. A. Allen, these Proceedings, Vol. XII, p. 196.

water's surface only occasionally giving a subdued croak or quack. At 52° they are active and clamorous.

When first seen in the spring, the coloring of this species is dull, owing to the condition of the outer skin, which is soon shed, leaving the frogs brilliant in tint. The females, at the time of egg-laying, I have found invariably lighter in color than the males. Both sexes, however, as is known, are subject to variableness of shade in the same individual. In making a drawing I have found the change so rapid and continual as to render it difficult to secure a correct representation of color. If the glass containing the frog was placed on white paper, in a full light, the skin would frequently change from the ordinary shade of brown, to light ashy fawn, in the course of fifteen minutes. On moving the jar away from the light to a dark surface of wood or woollen, the frog would as soon return to its original color.

The note of sylvatica peculiar to the mating season I have only seen or known to be given by the males, and only when in the water; it consists of a repeated croak or quack, and may be heard at any time of day or night when the temperature is favorable. The mouth remains closed and each time the sound is uttered the side of the body over each lung is distended into an oblong sac. This clamor has often been mistaken for ducks quacking, but when near enough one finds it more liquid in tone. In "Early Spring in Massachusetts," p. 228, Thoreau describes the note, "Wurrk wurrk wurr r k wurk." During the mating season the males will give voice in confinement, under favorable conditions of water and temperature. In addition to the notes already described, I have heard the young frogs reared in captivity give a single musical "chip," not unlike the call note of the song-sparrow. The note was uttered at intervals, in the excitement of capturing flies on which they were fed. Owing to the frog's extreme shyness I have never been able to detect the sound in the field.

The eggs are deposited near the shore where the frogs first congregate and the temperature of the water is most favorable. They are of a deep chocolate-brown color on the upper surface, and whitish beneath. When first laid they are held closely together by a gelatinous substance, which, after a few hours in the water, begins to increase in size, and gradually changes from a bluish to greenish tint. These masses of eggs are attached to grasses, weed stalks, or branches under water. It is not uncommon to find two or more bunches laid closely together, giving, as soon as the gelatinous portion enlarges, the appearance of one large bunch. This season I found in a swamp within a space of about ten by eighteen inches, sixteen bunches, evidently laid about the same time, attached to the reclining grasses of a submerged tussock. The masses of eggs vary little in size. On counting a bunch of average size the day after it was laid, which measured about four inches long by three wide, I found it numbered 1380 eggs, each of which was enclosed by two transparent, membranous shells. The time in which the eggs develop depends chiefly on the temperature of the water; those laid early in March are rarely hatched before the first week in April here, while those laid at the latter date, in an average season, hatch in from ten to fourteen days. This year, eggs laid March 23, and April 2, hatched at the same time, April 16. In this locality the period of egg-laying is usually over about the twentieth of April.

On March 8, 1880, there was a light fall of snow on the ground, but at noon the temperature of the air was 40°, and at a small, sheltered pond the frogs were seen. They were in the shallow water on the sunny side of the pond; its shaded side held a rim of thin ice. The water was clear as glass; nothing disturbed its surface but the wedge-shaped wakes made by the frogs in swimming about, with only their head and shoulders above water. As soon as they were aware of a spectator, the quacking, which they were giving with much animation, suddenly ceased, and the frogs dived out of sight, leaving a faint ripple to smooth out on the water's surface. After a while a frog arose cautiously, scarcely dimpling the surface of the water, and having floated about some time as if to assure himself that danger was past, gave four "quacks" in quick succession, apparently as a question to establish the whereabouts of the rest of the party. He so exactly matched the brown, water-soaked herbage in color, as to be unnoticed till he moved. A slight disturbance of the water soon followed as another frog arose less cautiously. He repeated the same sound in a different key, and propelled himself towards the first frog. Suddenly the surface of the water was in commotion with whirls and wakes. Heads appeared above dead weeds and grasses till I counted twenty-three frogs all giving voice. The presence of the females, who were largely outnumbered by the other sex, had evidently aroused a spirit of jealousy among them, and each frog was intent on driving the others from the place. This state of things lasted till, as if by common consent, all became silent, and disappeared among the dead herbage under water.

The reflection of the dark pine trees growing on the opposite shore, revealed clearly the bottom of the pond with its dead leaves and brown weeds. Attached to the twigs of a dead birch tree that had fallen in the water, were five bunches of frogs' eggs, each one of which looked like a small quantity of No. 9 shot held in a bluish jelly. The depth at which they were deposited varied, but most of them were near the surface. Two separate masses were laid, one above the other, on the same twig.

Ice an inch thick formed over these eggs the night following, and the next day no frogs were to be seen. Cold and snow continued several days, but as soon as the ice thawed and the water reached a temperature of about 52°, the quacking was resumed and nine more bunches of eggs were laid. All the eggs were within a space about a yard square. The 18th of the month the temperature fell to 20° at night, and the next day found the pond again partly frozen over. Flakes of ice were floating in the open space and eight frogs, including males and females, were lying dead in the water having perished evidently from cold and exhaustion. Five others were floating about helplessly in a perpendicular position, but revived on being brought into a warm room.

For the month of March the mean temperature was 36.25. The eggs appeared to undergo no change excepting that the albuminous portion increased in size. Not until the twelfth of April did the tadpoles make their escape from the outer membranous shell. At first they collected on the upper surface of the jelly, where they laid as if dead, excepting an occasional muscular contraction in which the tadpole doubled against itself for an instant.

All the eggs hatched at about the same time. Scattered through the jelly portion, in some of the bunches, where a few eggs evidently not fertilized. Only Branchipi and water-beetles were seen moving about in the water when the eggs were laid, but before they were hatched, leeches (Macrobdella decora) were undulating to and fro. Having attached themselves to a bunch of eggs the leeches would insinuate themselves through and through it till in one instance every egg was eaten.

My observations for the season of 1880, with additional notes of 1881 and 1882, continue thus:

April 12. Tadpoles hatched and collected on upper surface of jelly. They measure about eight millimetres in length, are soot-colored, with a lighter abdomen. Mouth and eyes undeveloped. There are two prominent holders, one on each side below and back of the cavity which marks the mouth, by means of which the tadpoles cling to whatever they touch. Two small projections, one on each side below the prominences which mark the eyes, are the external gills in process of development. The nostril pits are conspicuous, and near the extremity of the head.

April 13. Gills partially developed. Tadpoles increasing in length by development of the tail. Body shows the presence of food in the intestines.

April 14. External gills, which are fully developed, consist of two branches on each side the head, with from four to six processes in each. These gills are occasionally shaken. Throughout their length the blood corpuscles may be seen moving by throbs. A membrane has developed from before the gills and is gradually growing downwards over them. Eyes and mouth developing; the latter taking its place nearer the extremity of the head. Holders losing prominence. Tadpoles occasionally wriggle about, usually in a circle. The grasses and weed stalks immediately at hand are black with their clinging forms.

April 15. Noticed to-day a movement of the jaws of the mouth. A golden dotting is seen on the eye. Gills growing limp, and circulation decreasing as they are resorbed. Form of tadpoles more rounded.

April 16. Gills on right side resorbed. A few golden dots have appeared on the body and along the sides of the head from the mouth back under the eyes. A line of the same color is visible down the middle of the muzzle.

April 17. Gills on left side nearly resorbed. Golden dotting on body increasing. Mouth shows incipient papillae at edge of border. Eyes more fully developed.

April 18. Gills resorbed on left side, leaving a small, oblique, cone-shaped tunnel with a rounded opening at the top. Looking through this, the action of the gills which have developed within may be seen. Among tadpoles of this species and R. halecina, I have met with several having a like aperture on the right side also. Black fringe at edge of upper lip and of the three folds of under lip beginning to appear. Eyes developed, so as to serve their purpose apparently.

April 19. Golden dotting on head and body increasing. Length of tadpoles about 13 millim., gained chiefly by the development of the caudal portion of the body.

April 23. Holders entirely resorbed and tadpoles moving more widely. Head is more pointed than that of R. halecina, R. palustris, R. fontinalis, or R. catesbeiana. Length of head and body contained twice in the length of the tail. Black coloring spreading over under surfaces. Tadpoles look as if held in a transparent membrane.

April 25. Under lip shows three fringed folds, and beneath upper lip, one each side the upper jaw.

May 1. Tadpoles have abandoned their birth place and are found everywhere about the pond, generally occupied in seeking food.

May 2. Tadpoles collected about, and gnawing on strings of eggs of Bufo americanus brought to the pond last night.

May 3. A prismatic hue on abdomen, and a bluish sheen on upper surface of body. Golden dotting brilliant. Tadpoles appear dark olive-green under water.

May 6. Legs have appeared as small white buds in front of the base of the tail near the lower edge on each side. Fourth fringed fold on under lip and second fringed fold beneath upper lip each side the upper jaw, developing. Golden dotting has become confluent through the middle portion of the abdomen. The eye has a transverse suture in its lower semi-circle, which branches and appears to form or be connected with, the more or less defined ring within the iris.[1] The golden line immediately bounding the pupil fails to meet midway its lower half.

May 8. Observed to-day the glandulous lines,[2] like a hair line

[1] See Goette. Der Unke, p. 323.

[2] Cornalia. "Sull Pelobates fuscus et sulla Rana agilis trovati in Lombardia," Atti. Soc. Ital. Sc. Nat., Vol. XVI, p. 96, pl. 3, 1873.

Lessona. Studii sugli Anfibi anuri del Piemonte, in Reale Acc. dei Lincei, S. 3, Vol. I, p. 26, 1877.

M. Heron Royer. Le tetard de la grenouille agile, et note pour reconnaitre celui du pélodyte ponctué; Bull. Soc. Zool. de France, p. 132, 1878.

of gold on head and body. They begin at the end of the muzzle and enclose on each side the nostril-opening and eye by two lines, one above and one below these organs. At a point about midway between them the lines are compressed; behind the eye the lower lines continues upward and meets that above it. A short line starts from that below the eye and continues to a point behind it. Still a third line mingles itself with that directly below the eye. Behind the eye, on each side, the marking is difficult to follow, but soon two distinct lines are traceable, the upper continuing backward and sweeping upward to the upper surface of the tail and for a short distance on the side; the lower one continuing along the body and for about one-third the length of the tail midway its side. Besides these lines are others on the sides and back which are not constant in presence or form. A tadpole of R. sylvatica now before me has, in addition to the lines described above, a sinuous line on each side running down on the abdomen, and another which crosses the widest portion of the body, then doubles back part of its length to continue half way down the tail, forming in its passage two loops across the upper surface of that member. Glandulous lines occur in the tadpoles of all the Ranae found here. Mr. Fernand Lataste (Étude sur le Discoglossus pictus; Actes de la Soc. Linneenne de Bordeaux. 1879, Tom. XXXIII, (Quatrième série; T. III,) p. 309) describes these lines as "Organes cutanés, de nature glandulaire et nerveuse, sans doute des organes que les auteurs d'outre-Rhin decrivent comme des organes d'un sixieme sens, analogues des organes de la ligne laterale des poissons." In the paper cited, M. Lataste also speaks of these glandulous lines as "un caractère important de la famille Pelobatidae."

May 10. Golden dotting on tadpoles shows a reddish tinge like burnished copper. As many as can, are collected about and feeding on the larvae of R. palustris just escaped from the outer membranous shell. The gelatinous portion of the eggs soon loses its consistency with this species, and the tadpoles drop out by a slight pressure.

May 15. Observed to-day a network of minute black lines on the surface of the skin, dulling its brilliancy. Many tadpoles have the tail more or less mutilated, probably in escaping from the grasp of the larvae of the water beetles. One had lost almost the entire tail and was floating about in a helpless condition, his companions busily gnawing the flesh from his body, while yet alive.

May 20. Legs developed so that the feet and toes are well defined.

May 27. The pigment of gold color on the dorsal surface, including that of the glandulous lines, has gradually disappeared, leaving the latter a line of well defined pores. A band of deep brown extends across the head between the eyes, and spots of the same tint are seen on the back, also transverse bars on the legs, and more or less brown flecking on the tail. All the tadpoles examined have now developed the third, short, fringed fold under the upper lip each side the jaw. For description and figure of the mouth of this species, see Proceedings of this Society, Vol. xxi, p. 310, pl. 5, fig. 6. Microscopic examination shows each division or tooth of the black fringe at the edge of lip and folds of the mouth, to be composed of a series of cup-shaped forms rising one out of the other; the rim of each is dentate. The most fully developed teeth number four series beyond the tissues of the lip. Mr. Van Bambeke in the Bull. de l'Acad. royale de Belgique T. xvi, 2m série, p. 353, pl. i and ii, describes and figures these organs for the tadpoles of R. temporaria of Europe, and I find the description and figures answer for the same organs in R. sylvatica. Mr. Van Bambeke says, "Chez la Rana temporaria, l'extremité recourbee est terminée en palette, presentant des dentelures ou crenelures sur son pourtour, l'entonnoir est large." See also Mr. Fernand Lataste, "Etude sur le Discoglossus pictus, Actes de la Soc. Linneenne de Bordeaux, T. xxxiii, (Quatrième série; T. iii) pl. v. fig. 6, 1879.

May 29. A light-colored ridgy line has appeared connecting the nostril opening with the nearest corner of the eye. At this corner of each eye the nictitating membrane is developing. Tadpoles are resting much of the time in the sunlight above the green growth under water.

May 31. A narrow whitish stripe has come into sight on each side the head, beginning about half way between and about an equal distance below the nostril opening and eye, running downward and backward to a point which later takes its place above the corner of the young frog's mouth. The tadpoles have now reached the limit of their size and average about 58 millim. from the end of the muzzle to that of the tail.

June 2. Found some of the tadpoles in the shallow water near the shore with one arm thrown out, usually the right. The cutaneous folds extending from behind the eye to the posterior extremity of the body are visible, and within the spots of dark brown on head and back, granulations have appeared. The black net work is disappearing as the skin develops in texture and color to that of the perfect frog. Sections of the toothed edges of the horny jaws are beginning to flake off, and the fringe to separate.

June 3. Many tadpoles have both arms free. The nictitating membrane is partly developed for half the distance along the tissue bounding the lower semicircle of the eye. A whitish stripe has appeared above the mouth on each side near the middle of the muzzle continuing backward till it meets and forms an elbow with that described May 31. The soft parts of the mouth are beginning to be resorbed. Some of the tadpoles have shed both jaws and fringes. The order and rapidity of the loss of these organs varies in different individuals. The tail has become faded in color and the thin edges are fast becoming resorbed. No food appears to be taken now.

The tadpoles are at the edge of the shore partly out of water: they are extremly shy, and on being alarmed, hurry away to bury themselves in the mud at the bottom of the pond. The tail has apparently lost its muscular energy.

June 4. The nictitating membrane is fully developed in all the tadpoles examined. The tail is rapidly disappearing and legs increasing in size. The head is losing its bloated fullness and assuming the shape of that of the young frog. By this change, the whitish stripes, at first elbow-shaped, are gradually brought into line above the edge of the upper jaw. The soft parts of the mouth are nearly resorbed, leaving that feature a small aperture. The dark brown vitta each side the head including the lower half of the eye, has appeared. The skin is in process of shedding, by some entire, arms excepted, by others in fragments.

June 2. The gape of the mouth has widened and the jaws are slowly opened and closed as if the tadpole were gasping. A few frogs have already become wholly lung breathing. The eye is developed; the pupil has the power of dilatation and contraction.

June 7. Found many young frogs in the grass along the shore, having the mouth fully developed externally, and the tail reduced to a mere blackened stump.

June 9. Tail has wholly disappeared, and the tadpoles whose entire length was 58 millim. May 31, having steadily diminished in length and girth since the arms were thrown out, measure to-day as young frogs, only 18 millim. from the muzzle to the end of the body. Obscure spots of dark brown are seen on the throat and breast, which disappear as the young frogs reach maturity. But a small fraction of the gross number of tadpoles hatched, has escaped the numerous enemies and reached the stage of the young frog.

I have found some difference in the size reached by tadpoles of this species, and the same is true in regard to the rapidity of their development. At a pond distant only about twenty-five rods, tadpoles hatched at the same time began to leave the water a week earlier.[1] The pond is situated in an open pasture, exposed to the sunlight and protected from the north and east winds by rising ground. It is shallow, and evaporates wholly by mid-summer, and at all times responds quickly to the sun's heat, averaging a higher temperature than the deeper and more shaded pond in the woods. But I have observed for many seasons that the tadpoles grown in the deeper body of water average a larger size than those reared in the smaller, shallower pond. The same difference in a more marked degree may be seen between tadpoles of *R. catesbeiana* taken here in the Neponset River, and those grown in a small pond near it.

For a short time the little frogs were seen under the growth of herbage about the pond, but soon dispersed to the woods where they were at first numerous, but by the last of August, having distributed themselves more widely, were met with less frequently. Among frogs hatched from the same mass of eggs may be found, as is known, some latitude of variation; it exists not only in the

[1] In 1880 the mean temperature for May was 66.02°, the highest for 20 years here. In the colder seasons of 1881 and 1882 it was 59.01° and 51.34° and R. sylvatica was 10 and 11 weeks in passing through the larval stages in these localities.

adult but in the young and larval stages. An important instance of variation, in view of Mr. F. Lataste's recent classification of the larvae of the anourous batrachians under the head of Laevogyrinidae and Mediogyrinidae (Actes Soc. Linn. Bord., XXXIII, p. 338, 1879) is shown by the constant presence of one, and occasional presence of two spiraculums, in larvae of R. sylvatica and R. halecina. We agree with Mr. Allen in the careful notes cited, p. 197, that R. cantabrigensis Baird, Proc. Phil. Acad. Nat. Sci., Vol. VII, p. 62, differs in nothing from frequent specimens of R. sylvatica. In this connection we would also refer to the possible confusion arising from lack of observation on the differences the same species may present in the young and adult. We agree with Mr. Allen (see paper cited p. 190) in finding no differences between Hyla richardii Baird, and the green tree frog of Massachusetts, wrongly identified, we believe, as Hyla squirella Bosc. We fail to see wherein the frogs differ, in either case, from Hyla versicolor in the young stage.

General Meeting, October 18, 1882.

The President, Mr. S. H. Scudder, in the chair. Thirty-one persons present.

The Committee appointed to arrange for a memorial to Professor Rogers reported, that they had invited Major Jed. Hotchkiss of Virginia to write a memoir for the Proceedings.

Mr. Samuel Garman spoke of the part played by "medicine" among the Indians, relating some stories thereon, which he had learned from a Sioux. He also showed some "antelope-medicine" of the Ogalalla Indians, consisting of a faggot of small sticks each bearing a small bag of tobacco, which was set up on the ground by a party of huntsmen on leaving for a deer hunt, as an offering to the sun and moon for good luck in finding their game.

The following paper was read:

A RECENT FIND IN THE TRENTON GRAVELS.

BY C. C. ABBOTT, M.D.

That particular accumulation of sand, pebbles and boulders lying in the valley of the Delaware River, from the head of tide water, southward, almost to the sea — and known as the "Trenton gravel," has been so frequently discussed, both as to its geological and archaeological significance, that to refer to it again, even incidentally, is suggestive of twice-told tales; but if the literature of the subject be examined, it will be found that only the merest outlines of the archaeological significance of these gravels have been given, and many details are yet required, before a living picture of the ancient glaciated river and its fauna can be produced.

To present new facts, that will go a little way in thus completing the picture — or better, the prehistoric annals of this river — is the purpose of this brief paper.

On the evening of January 19th, 1881, I had the pleasure of presenting to this Society a statement of the progress in the investigations of these gravels that I had made, and offered what I maintained and still maintain was sufficient evidence for asserting, without qualification, that at the time these gravels were deposited, man dwelt upon the shores of the ancient river, and had left in the accumulations of gravel which the ice and floods then laid down, abundant evidences of his presence and handiwork. These evidences — then confined to a series of rudely chipped stone implements — were at the same time thoroughly discussed by others who had visited the locality — and no dissent was offered to the essential correctness of the views I then expressed.

Since then, now nearly two years, several excellent opportunities have occurred for further examination of these gravels, and with the following results.

In consequence of the removal of many thousands of cubic yards of this gravel, by the R. R. Co., there has been, near Trenton, for years an, extensive exposure of this deposit, which constantly presents a new section of the mass in an undisturbed condition, as hundreds of car-loads are removed. This has afforded an opportunity of examining the structure of the deposit, and resulted in the determination of the fact, that there have occurred breaks in the progress of the accumulations, indicated by the exposure of strata of sand, sometimes a foot or more in thickness, this again, being overcapped by a fresh accumulation of large boulders and the coarse material of which the deposit as a whole, is composed. A rapid flow of water passing over fine sand would necessarily have the effect of carrying most of it away, and leaving only the coarse material beneath, upon which the gravel borne by the flood would be laid down. Occasionally, it is evident, that fragments of these layers of sand have escaped obliteration — not only this, but have retained such objects as happened to be resting upon them at the time of their burial beneath an additional mass of transported material, especially here where the rapid current met with the tide waters of the river, and the force of the flow was materially checked, if not wholly obliterated.

One such stratum of fine sand, averaging a foot in depth and extending nearly three hundred yards along the exposure, I had the good fortune to examine when exposed, and found lying upon it, not only the typical palaeolithic implement which I here exhibit, but these four chipped stones of less definite shape, but which are unmistakably artificial. They are all of argillite.

These, it appears to me were left by the ancient man of the Delaware valley, upon this little sandy island as it then was, at a time when there was a cessation or diminution for a while, of the floods that were derived from the melting of the glaciers that still lingered in the mountains of the upper valley of the river.

Just as to-day, any object left upon the sandy islands of the present river will surely be covered by the deposit of sand and mud, which the freshets of the coming spring will bring from the upper valley of the stream, so these five argillite implements were left and covered by a subsequent gravel-bearing flood. These objects, five in number, taken from an undisturbed section of the gravel were over capped by a deposit nearly seven feet in thickness, itself wholly undisturbed, and containing several boulders of large size.

This I consider one of the most important of my " finds," as I have never heretofore discovered any specimens, in situ, except singly, just as they had been dropped into the water covering the gravel at the time, or were transported by the water and ice that brought to its final resting place the gravel then and there associated with each specimen. In this instance, on the other hand, it seemed to me highly probable (to say the least) that these objects had been left by man on the sand where they were found, and subsequently buried by fresh accumulations of gravel.

Considering how few, indeed, are the specimens of palaeolithic implements, as compared with the entire mass of the deposit, it would be very strange if so many of these objects had chanced to be lost at once, or were together transported from a distance and left lying in such close proximity.

The association of these five specimens, and the fact that they were resting on a sand bar deeply buried by coarse gravel, together go far to show that man fashioned these clipped stones, and that as long ago as the deposition of the Trenton gravel, they were lost or discarded by him.

That they could have gotten to this buried sand from the surface, is absolutely impossible. However strongly inclined one may be to consider that all deeply buried single specimens have by some unexplained means become inhumed, this supposed possibility with reference to single objects is wholly inapplicable to five objects, such as these, found, as these were, very near each other. Can any other explanation, then that I have suggested, be given? Do not these five chipped implements confirm both the age and origin of all previously discovered specimens?

I desire now, before referring to a recent and unique "find," in these implement-bearing gravels, to call attention to a specimen of chipped pebble, which presents several points of interest. This object is a quartz palaeolithic implement. Now, this particular form is one quite common, made of argillite. I have probably fifty which are in no way different, except the material of which they are made. Quartz of this character is a common mineral in the mass that collectively constitutes the Trenton gravel; it occurs, not only as boulders, but as pebbles of such size that but little chipping is required to convert them into implements of this type. Considering this fact, it is not to be wondered at that it was occasionally used by the people who habitually used argillite for a similar purpose. The interest centering in this specimen, however, lies in the fact that it is of this material that the ancient and extremely rude implements found in New Hampshire by Professor Haynes, are made. Whatever may be the final judgment as to the age of these New Hampshire specimens, it is interesting to know that the ancient dwellers in the valley of the Delaware likewise used this mineral, although but rarely, and fashioned from it, at least in this instance, a better implement than the majority of those discovered by Professor Haynes.

If judgment as to age is passed solely upon the relative merits of the workmanship in the case, this would lead to the conclusion that the New Hampshire specimens ante-dated those found in the gravel deposits of the Delaware River — but is this warrantable? Are there not very many other conditions to be considered? If the character of the implement alone is indicative of antiquity, then we can draw no distinction, in America, between a palaeolithic and a neolithic age.

Again, the rude implements found near Little Falls, Minnesota, and which Professor Winchell, Geologist of that State, claims are of palaeolithic age, are likewise of this same material, although the Minnesota specimens, as a class, are considerably smaller.

While the European palaeolithic implements, as a class, are made of pure flint, I find on examining the series in the collections of the Peabody Museum, that specimens made of other minerals are not wanting; and so, while in the Delaware Valley the typical implement is of argillite, there do occur others of a different, and in some cases less easily worked, material.

Such instances as this confirm the impression that all who examine the localities receive: that the evidences of man, in the so-called palaeolithic or river-drift age, is essentially the same both in Europe and America.

As most of those who live in New Jersey have good cause to remember, there occurred, late last month (Sept., 1882), a very remarkable rain-storm; in sixty hours, there fell at Trenton, the enormous rainfall of eleven and one-half inches. The cut through the gravel through which the railroad passes, was in part converted into a river. A short-lived stream, to be sure, scarcely holding its own for forty-eight hours, but it made good use of its time, and spread out hundreds of tons of gravel over a level space, and thus rendered less difficult the task of determining what treasures it had concealed for centuries.

As soon as practicable after the disappearance of the water, I went to the gravel exposures as they then were, anticipating interesting "finds." Careful search resulted in finding three chipped pebbles, all in loose gravel, that but two or three days before had been washed from the adjacent bank. The interest centering in them is lessened of course from the fact of their previous position in the gravel being unknown. That they came from the gravel, however, is unquestionable; there was no other point within reach of the flood, from which they could have been derived.

One of the three merits a moment's attention. It is evidently an implement, although the smallest I have found, as yet, in the gravel. It is oval, or nearly so, chipped to an edge along the entire circumference, and finally has been rolled until its original shape has been much modified — subsequently, it has been exposed to the atmosphere until the entire surface has been weathered to a marked degree — then, it has been caught up by the floods derived from the melting of the glaciers, and deposited in the gravels, where lately found.

This little pebble scarcely showing traces of man's handiwork, is, nevertheless, suggestive of man's antiquity to a marked degree. The implements generally found might readily have been made during the accumulations of the gravel; but here is one that would appear to indicate a still earlier time, coeval with the glacial epoch proper and not of its declining days, or of a more remote time even, antedating the Great Ice Age. We must in this case, account for its original chipping; its rolled condition; then the protracted weathering; and lastly, its position in the gravel.

The tendency of geological investigations of these implement-bearing grounds, has been to render them *recent*, even archaeologically considered, but the careful study of such objects as this rolled, weather-worn, but clearly artificially-shaped pebble, may possibly lead us farther into the past, and present a glimpse of primeval man, more ancient than we dared to think. This same day, I walked along the line of the gravel as exposed by the railroad, to a point beyond the limit of the recent flood, and then took, for the thousandth time, a look at the undisturbed deposit. Passing slowly along, I finally noticed what I took to be the point of a chipped implement, projecting from the gravel. It was but a mere point, a splinter of stone, as it were; but thinking that it was only the tip of a larger object I pulled it out and found it was a mere chip, thin, flaky and slightly curved.

For the moment, of course, I was quite chagrined; but happily, in removing the flake, I detached a mass of gravel, a cubic foot or more, and by the merest accident, I noticed in the *undisturbed* gravel, back of that which had fallen, a white pebble, as I supposed it to be, surrounded by a mass of black, red, yellow and slate colored stones. Why I paused to pick it out from its resting place, I cannot say. There was nothing artificial in its appearance, certainly; and small white, pebbles are not rare in these gravels. At all events, I *did* take it from the undisturbed gravel and examined it carefully, as I stood there. Taking it to a muddy pool near by I washed it as well as practicable, and then my doubts, as to the object being stone at all, arose, and with some lingering doubts, I forwarded it to Cambridge for critical examination. The result was, that the supposed pebble proved to be a *wisdom tooth of a man*, so rolled, scratched, polished and otherwise altered in shape, that its real character is not, at once, apparent.

A word here about the fossil remains found, up to this time, in the Trenton gravels; particularly with reference to the association, in America, of man and the mastodon. In the Geology of New Jersey, Prof. Geo. H. Cook remarks — "there has been found in the terrace of modified drift at Trenton, the tusk of a mastodon, which was evidently washed there when that mass of matter came down from the valley of the Delaware with the torrents of water from the melting ice. It was about fourteen feet under the surface, and the gravel and stones were partially stratified over it. From these the inference seems plain that the climate at that time admitted of the growth of animals like the elephant in size and habits." Either this, or the mastodon lived prior to that ice-age, that, in the end, produced these gravel deposits, wherein his remains are now found. And the same inference is to be drawn with respect to man; for under precisely the same conditions, within a dozen rods of where the mastodon tusk occurred, and buried almost as deeply, was found this rolled, scratched, polished, human tooth. Nothing can be said of the one fossil *as such*, not applicable to the other. The same agency that brought the one from the upper valley of the Delaware, brought the other, and after long years, they come again to light, and jointly testify, that in that undetermined long ago, the creatures to which they respectively belonged, were living together, in the valley of the river.

In one respect, these two fossils *do* differ, and perhaps the variation possesses some significance. The mastodon tusk has not been subjected to any protracted exposure to running water, or sand and water. It is not, in this respect, like the water-worn pebbles of the gravel deposit, as is true of the tooth. It has, without doubt, been subjected to a prolonged exposure to every agency that goes to make a pebble from a fragment of rock, and therefore suggests the possibility that it was a veritable fossil prior to the floods that brought it finally to its place in the Trenton gravels. We will give the benefit of the doubt, however, in favor of those who advocate man's recent origin, and still there remains the *indisputable* fact, that remains of the mastodon and man have been found associated in no uncertain way.

In a recent article on early man in America, in Harper's Magazine, I find it stated that the further study of Trenton gravels "may yet conclusively establish the fact that the aboriginal American man was contemporary with the mammoth"—but adds "must we not admit that in our efforts to explain the origin of the first American man, it is necessary, after all, to end with an interrogation mark?"

The secret of man's origin in America may never be revealed —but these gravels lie upon the outskirts of that origin; and I point to these implements and this tooth and claim that we can assert the contemporaneity of the mastodon and man, and end the sentence with a triumphant exclamation mark!

In conclusion, I desire briefly to call attention to another phase of the archaeology of the Delaware Valley, which is well worthy of attention.

As has been mentioned frequently, the typical palaeolithic implement is made of argillite. Were no other stone implements found in this locality, of this mineral, the evidence would be even stronger than it now is, that they mark a remote and distinct phase of humanity in this region; but other objects of argillite do occur, and in the greatest abundance. While they have been generally classed with Indian relics, and by some held to be the connecting link, binding the palaeolithic implements and later Indian handiwork as the work of one people; I am equally confident that, in truth, they indicate the true palaeolithic age of the gravel implements most forcibly, and are not of Indian origin.

I know of but one way of determining such a question, and this is by careful examination of deep sections of the gravel deposits and of the overlying soil. We have seen that the railroad has afforded a magnificent opportunity for examining a section. Besides this it happens that a short distance from Trenton, these gravels rest upon clays of much value. These are extensively mined, and the necessary removal of the overlying gravel has afforded numerous opportunities for examining the soil above the gravel as well as that deposit itself. Taking an average from a large number of these sections, I find that there is a deposit *of sand* of about two feet above the gravel. In many places there is scarcely six inches remaining, and elsewhere the sand is several feet in depth, before gravel is met with; but the depth I have mentioned, two feet, is a fair average. The uppermost six inches, or perhaps a little more, of this sand is of a dark color, and largely charged with vegetable matter is, in fact, the soil proper. In this black soil, if I may so call it, and not often below it, the relics of the Indians of historic times occur in the greatest abundance. These may be described as consisting of finely wrought jasper and quartz arrow and spear-heads, and *polished* stone implements. Associated with them is an abundance of fragments of pottery. It not unfrequently occurs, that in a section made at some clay pit, in the surface soil, relics like these will be found, and below them, but with an intervening stratum of sand two or three feet in thickness, will be found one or more palaeolithic implements. When the two classes of objects are thus seen in situ, with the intervening space containing no trace of man, the greater antiquity of the more deeply buried objects is, at once, apparent; and thenceforth all doubt upon the subject vanishes.

But in many localities there is a variation from this, in that the sand that separates the gravel and the surface soil is an implement bearing one, these objects being of a uniform type and material. While in workmanship they exhibit a marked advance over the palaeolithic implements, they are so uniform in character and so inferior in finish as compared with the unquestioned handiwork of the Indian, that I venture to assign them to an earlier date. But it is their position in undisturbed soils that best demonstrates this fact.

I will not here dwell upon other facts that add to the strength of the proposition that these argillite spears are not of recent Indian origin. Let it suffice, for the present, to say that they are absent from the workshop sites, where jasper and quartz solely were used; and no workshop sites have been discovered where it exclusively was used. Should such be found, I should expect to find evidences of age greater than any indications of antiquity attaching to such sites as I have found as yet.

These rude argillite spear-heads are all greatly weathered — yet the mineral is not one that readily yields to atmospheric influences. Yet now, as you see by breaking them, they are quite rotten.

Finally, if we examine the alluvial deposits along the river, which constitute the tract of meadow that intervenes between the bluff or terrace formed in part by the gravel and the river, we will find that here too, the position characteristic of these argillite spears in the uplands, obtains. I have made many sections of this deposit — a stiff, black, sandy loam—and found that near its base, and less frequently as we near the surface, these spear-points occur, while the reverse is true of the jasper and quartz weapons of the Indians. From these considerations, thus imperfectly set forth, I am led to conclude that these specimens may be accepted as traces of a people intermediate between that of palaeolithic man and of the Indian of historic times.

The relationship borne by this intermediate people to those that preceeded and those that followed, is a vexed question; but taking into consideration the prominent fact that these spear-points are of argillite, are rudely fashioned, and evidently, as shown by their position in the ground, of great antiquity — I am disposed to class them as the handiwork of the direct, post-glacial descendents of palaeolithic man; possibly, they were the ancestors of the historic Indian; but more probably they were Eskimos.

Section of Entomology, October 25, 1882.

Mr. S. Henshaw in the chair. Five persons present.

The following paper was read:

PAPILIO MACHAON.[1]

BY H. A. HAGEN.

The principal characters for distinguishing Papilio Machaon and the so-called species which I believe to be different forms of it (P. sphyrus, Hospiton, var. asiatica, Hippocrates, Aliaska, Zolicaon, oregonius) are taken from the more or less predominance of black or yellow, and from the spot in the red anal macula of the secondaries. Besides this there is an important character in the band on the underside of the primaries, whether of equal breadth or sloping near the costal margin. Also the separation of the red macula of the secondaries from the superior blue crescent by a black band or none. The size of the imago, the length or the shape of the tail, the general form of the wings, are so variable, that they are of no use in separating the species.

There are giants as well as dwarfs to be found among all the forms sufficiently known.

I consider as the type the European P. Machaon, not because it is the oldest known, but because it is found around the whole world in the northern hemisphere; the North American specimen (I have only seen the type of P. Aliaska) cannot be separated from the European form. The more convex external margin of the primaries, noted by W. H. Edwards, is well marked, but of minor value, as some of the other forms show at least a similar tendency. In the typical P. Machaon the yellow is predominant in Kamtchatka specimens to an exaggeration. The external band on the underside of the primaries is of equal breadth throughout, the red macula in the anal angle of the hind wing is not separated from the blue crescent by a black line. There is no black

[1] I have given in Papilio, Nov. — Dec. 1882, a detailed paper on the same subject. I prefer after a repeated study to give the results here arranged in a different manner.

spot in the red macula, but the internal black border is prolonged finely below it. The cell of the underside of the primaries is more yellowish than black; the abdomen above more or less largely covered with a black band. The maculose yellow band along the external margin of the primaries consists of spots of very different shape and size, which have been observed in an aberrant specimen to be united into a yellow band. Another aberrant form (figured by Freyer) wants the red macula. In southern Europe, near the Mediterranean, is found a spring form, P. sphyrus, which differs from the typical form by a larger predominance of black color. It is not certain if the caterpillar of P. sphyrus belongs to the black form, observed in the fourth moult, instead of the green form which belongs to the type. In the islands of the Mediterranean exists a very exaggerated variety, P. Hospiton, perhaps an extravagant spring form modified, as is not uncommonly the case with insular forms. The cell of the primaries is black below, the external band sloping to the costa, the red macula separated by a black band from the blue crescent.

In Asia the variety asiatica Koll, is identical with P. sphyrus and common in the Himalaya to an altitude of six thousand feet; higher up, at ten thousand feet, the specimens are very like, or scarcely different from the type; in Siberia the true Machaon exists; but Kamtchatka specimens show an exaggeration in the predominance of the yellow main color, the external bands of the wings are very narrow, and on the primaries sloping to the costa. In America the specimens from Aliaska and from Hudson's Bay belong to the typical Machaon. One specimen quoted as P. Machaon from the Dalles, Or., by Mr. W. H. Edwards, is P. oregonius. West of the Rocky Mountains appears P. Zolicaon, and in Oregon and Washington Territory, P. oregonius. The first is said to have the black color predominant, the cell of the primaries black below, in the red macula an isolated black spot, the abdomen above very largely blackish. The description of P. oregonius states that no character belongs exclusively to this species, and that the color of the abdomen would be the only one to separate the two species. A large number of P. oregonius and Zolicaon collected in Oregon and Washington Territory, June 24 to 28, were examined carefully and show the following differences. I have purposely taken all specimens collected at the same day, June 25, for the following table.

1. **P. Zolicaon, Type.**
   a. Spot isolated above and below.
   b. Cell of primaries black.
   c. Abdomen largely black above.
2. **P. Zolicaon.**
   a. Spot isolated above, connected below.
   b. c. As in 1.
3. **P. Zolicaon.**
   a. Spot connected above and below.
   b. c. As in 1.
4. **P. Zolicaon — oregonius.**
   a. As in 3. *b.* Cell black.
   c. Abdomen with a narrow black band above.
5. **P. oregonius.**
   a. Spot connected only in one wing.
   b. Cell yellow; *c.* as in 4.
6. **P. oregonius.**
   a. Spot slightly connected above and below.
   b. Cell half black, half yellow.
   c. As in 4.
7. **P. oregonius.**
   a. Spot not connected above.
   b. As in 5; *c.* as in 4.
8. **P. oregonius, Type.**
   a. Spot connected above and below.
   b. Cell yellow.
   c. Abdomen with a narrow black band above.

Giants and smaller specimens of all forms are found.

If these statements are carefully compared, it will be impossible to speak of two different species, and P. oregonius is so near to P. Machaon that a specific separation will be impossible. The external band of the primaries is sloping in P. Zolicaon and oregonius, but some specimens of P. var. asiatica show a very similar tendency; besides, the Kamtchatka form, P. Hospiton, and the Japanese form have the band sloping. In Japan exist two forms both with exaggerated insular characters. A spring form of the size and pattern of P. Machaon with predominant yellow color, the bands smaller, the cell yellow, but all spots and lines somewhat exaggerated. The summer form, according to Mr. Pryer, is P. Hippocrates, very much larger, and very dark above, especially the female; on the contrary the whole underside is very pale yellow; the length of the tail is exaggerated, and the band of the secondaries larger. But there is no character of value to separate the Japan form from Machaon, and indeed it was described long ago by De Haan as belonging to this species.

Concerning the larval and pupal stages, those of P. Machaon are well known. Of Zolicaon and oregonius only the chrysalis and caterpillar are known of each, but not so well as to allow a comparison with P. Machaon. The caterpillar of oregonius had in the middle of the first transversal black band behind the head a large gap, which is not yet mentioned in P. Machaon, nor in Mr. Stretch's description of the same caterpillar.

The materials in my hands for study are, I believe, unprecedentedly large for the European P. Machaon, for var. asiatica, for oregonius and Zolicaon. For P. Hippocrates I have seen eight specimens, for the others only one or two specimens. I consider all as local forms of one and the same species P. Machaon — and P. sphyrus, var. asiatica, Hippocrates, and perhaps Zolicaon, as seasonal forms.

It has been objected to me "that when the two ends of a line are represented by such distinct forms as Zolicaon and oregonius, which in certain districts breed true to their respective types, they are to be considered as good species." I cannot accept this statement before more facts are at hand. P. oregonius breeds in the same place in Washington Territory and Oregon together with Zolicaon. But all specimens of the P. Zolicaon collected this year were more or less worn and certainly older than the fresh developed P. oregonius.

As sometimes spring forms are protracted and partly lap over the summer form, it should be proved by new observation whether P. Zolicaon is a spring form or not. That P. oregonius has not so far been found in the other known localities of P. Zolicaon is of small value, because the fauna of those localities is still imperfectly known. I have since seen P. oregonius from the Black Hills.

But I think other well proved facts show positively that the above quoted objection is untenable. Mr. Weismann quotes from Lycaena Agestis a summer and winter form in Germany — and in Italy a summer form (which is the German winter form) and a new winter form. Both breed true in their districts, and the two ends of a line are thus represented by distinct forms, although nobody will claim them to be different species. P. Hippocrates is also a similar form. I believe that all forms quoted above are nothing but local cases of one species, of which the first described is P. Machaon. Perhaps the list of local forms of P. Machaon may even be still larger than given by me here.

General Meeting, November 1, 1882.

The President, Mr. S. H. Scudder, in the chair. Nineteen persons present.

The following papers were read:

SOME REMARKS UPON THE PETROGRAPHICAL COLLECTION OF THE GEOLOGICAL EXPLORATION OF THE FORTIETH PARALLEL.

BY DR. F. ZIRKEL.

The first criticisms which Dr. M. E. Wadsworth in his paper "On the Classification of Rocks" [1] made upon the lithological determinations of the specimens collected by the U. S. geological survey of the fortieth parallel, I have preferred not to answer. Moreover, any reply from me has been lately rendered unnecessary by a paper [2] written by Dr. N. F. Merrill — without my knowledge — in which he has undertaken to show that Dr. Wads-

[1] Bull. of the Museum of Comp. Zool., Harvard Coll., Cambr., Mass., Vol. v. No. 13 (a).
[2] Proc. Bost. Soc. Nat. Hist., Vol. xxi, Oct. 19, 1881, p. 234.

worth's method of criticism was highly objectionable and that some of his statements appeared to indicate that he lacked the proper qualifications for his work.

Now, however, that Mr. Wadsworth in a second paper [1] " Some points relating to the Geological Exploration of the Fortieth Parallel " continues his peculiar criticism in a still more striking manner, I think it proper to put into form, as my first and last words in this matter, the following points.

1. The chief reason for the difference between Mr. Wadsworth's determinations and my own consists in that — to use his own words — " the writer (Wadsworth) rejects the common lithological method " (b. 245) ; that is, he does not admit, that, in determining a massive rock, not only its mineralogical composition and its structure, but also its geological age, should be regarded, or that there exists a difference between the habitus of the pre-tertiary rocks, and that of tertiary and post-tertiary rocks, a contrast which has found its ample expression in our old and generally adopted terminology. Surely I cannot be called to account for adhering to this common lithological method which I consider far more reasonable and natural than Mr. Wadsworth's " new classification." With a geologist like Dr. Wadsworth, who does not believe in any ante-tertiary precursor of andesite, basalt trachyte or rhyolite (b. 258), who wishes that the name diorite may soon be dropped (a. 279), who uses the terms melaphyre and diabase to indicate altered and therefore generally old basalts (b. 259), and who even considers the peridotites as altered, coarsely crystaline basalts (a. 279) — with such a geologist all possibilities of further scientific explanation and discussion is precluded. The standpoints of the customary and of the " new " classification are so far apart, that I decline to enter into special debate.

2. Mr. Wadsworth demands that my work, written in 1875, should conform to his extraordinary principles published by him in 1878 in an abstract in which he utterly rejects the method of petrography as taught to-day.

3. Mr. Wadsworth is entirely wrong in saying : " It is to be remembered that Richthofen's and King's classification is not ac-

[1] Ibid p. 243, (b). Mr. Wadsworth's papers will be referred to by the use of the letters, a and b.

cepted in Europe and was not adopted by Zirkel until his visit to New York" (b. 246). Whence does Mr. Wadsworth derive his authority for writing such a totally unjustified phrase? Richthofen's theory has met with warm sympathy among German geologists; and as for myself, since the time (1867) when my eminent friend sent me a copy of his admirable "Natural System of Volcanic Rocks," I have always considered the chief results of his investigations as an extraordinary step in scientific progress. It is really not easy to understand how Mr. Wadsworth can assume the boldness to say that all my previous work had been done according to a different method of classification (b. 249). That arrangement of the feldspar-bearing rocks which I have given on page 6 of the incriminated Vol. VI (of the Geol. Expl. Fortieth Parallel) is literally the same as that which I have used in my "Mikroscopische Beschaffenheit der Mineralien und Gesteine," 1873, page 290, and which since the year 1863 I have always made the foundation of my University lectures on Petrography.

4. Mr. Wadsworth gives to his readers an account of how the work on the lithological collection of the Fortieth Parallel Survey was done (b. 248). This narrative, either by unacquaintance with the facts or by accident, is incorrect in one rather important point. In the summer of 1874, many of the sections prepared in America were sent to me in Leipzig; they bore only a number with no lithological name, and they were not accompanied by any catalogue. Of this collection of slides, which represented all the different occurrences, I made a preliminary study *before* I went to New York, endeavoring to determine the petrographical nature of the thin sections without any knowledge of the hand-specimens of the rocks from which they were derived, and without any acquaintance whatever with their field relations. Afterwards, through personal intercourse with Mr. King, it afforded me much pleasure and gratification to learn that my diagnosis, in the majority of cases, had been made quite correctly: that those sections which I had determined in Leipzig as belonging to diabases were, according to the results in the field, really pre-tertiary plagioclase augite rocks; that those considered by me as basalts indeed belonged to the tertiary epoch, and that my microscopical distinctions between the sections of felsite porphyries and those

of rhyolites were sustained to an almost unexpected degree, the geological survey having labelled, without my knowledge, the corresponding specimens with the same names in accordance with their geological occurrence. The real method of work, therefore, was exactly the *contrary* of the method as detailed by Mr. Wadsworth and of which he complains in my preliminary investigation. I had *not* the slightest clue to the field relations or to Mr. King's conclusions (b. 250), and I wish to respectfully refute the charge which Dr. Wadsworth has been pleased to prefer against me, that I could not properly determine the species a rock belonged to without being informed as to its field character (b. 271).

My purpose in making these remarks is simply to show that Mr. Wadsworth is quite wrong in believing that my petrographical determinations and descriptions were influenced by Mr. King's classifications and determinations. I did "return from the visit to Mr. King a professed believer in his classification" (b. 249) only in the sense that I had observed that my distinguished friend's nomenclature agreed with that which I had learned and taught in Germany. This nomenclature, commonly accepted by scientific people, now suffers the misfortune of being spurned by Mr. Wadsworth.

5. Mr. Wadsworth gives evidence of being further misinformed in saying that the hand-specimens corresponding to the described sections were taken to Europe (b. 250, 272), and Dr. Merrill is quite right when he states that the slides were studied apart from the hand-specimens. Merely the fragments, chipped off from the hand-specimens, necessary for the preparation of the sections were sent to Leipzig. Mr. Wadsworth quotes in support of his erroneous statement Renard's free French translation of my paper, "Ueber die krystallinischen Gesteine langs des 40 Breitegrades in N. W. America." If he were to take the trouble of glancing at the original German,[1] he would perceive that *no* mention is made of the transportation of "hand specimens" to Europe.

None of these have ever been sent twice across the Atlantic as Mr. Wadsworth is informed (by whom?), and as he prefers to believe in opposition to the correct statement of Mr. Merrill.

[1] Sitzungsb. d. k. s. Gesellsch. d. Wiss. z. Leipzig, 1877, 156.

6. Concerning the silvery-white mica-slate of the Red Creek, Uinta Mts., upon which Mr. Wadsworth lays so much stress, the gentlemen may rest assured that, when I examined the collection in New York, there *was* one specimen containing blue cyanite. If, at the present time, this specimen is not to be found in the collection, I am not responsible for its absence. What could possibly have been my object in quoting " excellent large crystals of pale blue disthene " if they really were not present. Mr. Wadsworth instead of arriving at this simple explanation of his own accord, prefers to accuse me of error.

7. Of course the geological classification of the granites came primarily from Mr. King and his colleagues. Mr. Wadsworth knows that sufficiently well, himself, and nevertheless he says, that it was I who stated the eruptive nature of one granite, who regarded another granite as Jurassic, etc. In the same manner he accuses me of having erroneously stated that the augite andesites are younger in age than the rhyolites (b. 265).

8. Few will be likely to accept the odd doctrine of Mr. Wadsworth, that rocks, in which the feldspars are nearly all triclinic, should be called granites (b. 255), that orthoclase horneblende rocks should be named andesites (b. 257). With a petrographer of this stamp, who overthrows the most common and simple nomenclature familiar to every juvenile student, a scientific discussion is out of the question.

9. I have not stated, that the hornblende of the Fortieth Parallel diorites isin part an alteration *product*, but that it is (itself) partly in a *state* of alteration — a distinction which Mr. Wadsworth seems not to understand.

10. Mr. Wadsworth is convinced that the true propylite is an altered andesite. I may be permitted to ask, if he has ever carefully traced the alteration of a real andesite, of such andesites, for example, as those from the Siebengebirge or from Hungary; if he had done so, he would have seen, I think, that altered and decomposed andesites never become propylites. Or has Mr. Wadsworth ever observed an instance wherein the brown horneblende of a true (not of a " so-called ") fresh andesite alters into a green hornblende and into abundant epidote, or wherein the clear feldspars become laden with green hornblende dust, or wherein this latter material is developed in the groundmass itself?

The question whether propylite is a "distinct species" or merely a "variety" has ever been and still is a totally unessential point for me, and I do not wish to argue about that with Mr Wadsworth, maintaining my opinion (with his permission) that the rocks in question may be readily distinguished from true andesites.

11. Mr. Wadsworth need not doubt that I was sufficiently familiar with the strange prussian-blue grains which so often occur on the surface of the thin sections in the Canada balsam, long before he began to study rock sections at all, and that I have not mistaken them for hauyne. Had I done so, I should have had to quote hauyne as an ingredient of many hundred of the Fortieth Parallel rocks, instead of quoting it in only two of them. If Mr. Wadsworth will study the sections Nos. 300 and and 301 with a little more care, he will find (perhaps accompanied by the other blue grains — impurities — of which I have taken no account whatever) those little blue crystals in the groundmass and in the feldspars, which I have supposed to be hauyne; he will succeed the easier and better, the more his knowledge of European hauyne-bearing rocks is advanced.

12. Concerning the quartz in the rhyolite from the north end of Wachoe Mts. (VI, p. 197), which contains fluid inclusions, if this quartz belongs to an included fragment of granite, as I have supposed and as Mr. Wadsworth has confirmed, it has nothing to do, of course, with the rhyolite itself, and Mr. Wadsworth has no right to complain of any inconsistency between my statement, that rhyolitic quartzes carry glass inclusions only and the assignment of this rock to the rhyolites. Specimen No. 201, in which some of the primary quartzes bear fluid inclusions, I have assigned on this very account to the trachytes and *not* to the rhyolites (the entire habitus of the rock was not at all propylitic) in accordance with my statement quoted by Mr. Wadsworth, that all tertiary quartziferous rocks, other than propylites, *i. e.* dacites and rhyolites, contain only glass inclusions in their quartzes. In other words, the fact that the quartz of this rock carried fluid inclusions, was to my mind, a more important diagnostic distinction, than the fact itself, that the rock carried quartz and was otherwise rhyolitic. I think that this would appear plain to the

ordinary reader of my report, and I believe, that my text is guilty of no inconsistency whatever.

13. Mr. Wadsworth's phrase, "the quartz found in the rhyolitic groundmass is regarded by me as a devitrification-product." (b. 269) is unintelligible; if he means by the expression devitrification product a product of the solidification of a molten mass, Mr. Wadsworth's opinion is commonly shared by lithologists the world over. If, however, he regards this quartz as a product of the alteration of an originally glassy rock, how are its abundant hexagonal glass inclusions to be explained?

14. Mr. Wadsworth opposes the separation of the andesites into hornblende- and augite-andesites (b. 265). It seems such a hopeless task to endeavor to explain to one holding the extreme views of Mr. Wadsworth the reasons why all petrographers of the world *maintain* such a distinction, that it may not appear unreasonable if that question be set aside peremptorily.

15. The members of a series of trachytes (b. 266) are held by Mr. Wadsworth to be basalts. This seems to render it proper to instruct him, that a rock in which sanidine prevails and which does not contain olivine never can be named a basalt.

16. Mr. Wadsworth asks naively, how the absence of olivine absolutely separates a rock from the basalts (b. 267). It might be replied, that the absence of olivine separates a rock from the basalts just as the absence of quartz separates a rock from the granites.

17. In referring to the rocks in which I have sought to demonstrate the presence of nepheline, Mr. Wadsworth allows himself to distort my words in a very bold and unjustifiable manner. In the case of one rock which does not contain olivine, I have concluded from its gelatinization that the colorless ingredient, which resembles nepheline, *is* nepheline. In the case of another rock, which does contain olivine besides the same colorless mineral, I have supposed the latter to be nepheline again from the fact that the rock gelatinizes *much more strongly* than it would, were only olivine present. I should not be likely to take for granted the presence of nepheline simply from the fact that a rock gelatinizes.

18. For the changes made in the original numbering in my manuscript, for the alleged confounding of the labels of the hand-specimens and for all entanglement eventually ensuing therefrom, of course I am not responsible.

If, now, we set aside all of these cases, wherein Mr. Wadsworth's accusations are based upon his own arbitrary and individual terminology in petrography, or upon his improved doctrines about the connection of rocks with one another through process of alteration, or upon his misunderstandings and his unacquaintance with the facts and events—what remains? The reproach of my having said, in two instances, that quartz and biotite were absent, whereas Mr. Wadsworth found them to be present.[1] If this reproach be well founded, which, at present, I can neither contest, nor grant, I may indeed experience a certain degree of satisfaction in the fact that such unessential points are the only ones in which Mr. Wadsworth has a right to correct me, after his examination of my studies made upon nine hundred and fourteen thin sections. If my decided adversary himself could not detect more weighty errors, I think that I may accept his paper as an involuntary testimonial to the correctness of my long and arduous investigations.

University of Leipzig, June, 1882.

THE STRUCTURAL VALUE OF THE TRAP RIDGES OF THE CONNECTICUT VALLEY.

BY WILLIAM MORRIS DAVIS.

The following article is the substance of a paper read before the Harvard Natural History Society, Oct. 17, 1882. It summarizes the method of study as well as results of a vacation's work on the Triassic formation. Full details of observations and a more extended historic account and discussion of the subject will appear in the Bulletin of the Museum of Comparative Zoology, Cambridge, Vol. VII; (geol. series, Vol. I.)

On our Atlantic slope, there are several long, narrow patches of sandstones and shales of a prevailing red or gray color, and more or less interrupted by ridges of trap rock. It is now gen-

[1] I must deny having mistaken a greenish altered groundmass for olivine.

erally admitted that the fossils they contain show them to be of rather early Mesozoic age, though whether strictly Triassic, Liassic or Oölitic remains an obscure problem.

The several patches are found on Prince Edward Island, in Nova Scotia around the Bay of Fundy; in the Connecticut valley from Northern Massachusetts to the Sound at New Haven; in a small, oval basin about Waterbury, Conn.; in a long, nearly continuous strip from the lower Hudson across New Jersey, Pennsylvania, Maryland and Virginia into North Carolina; and in several disconnected patches in Virginia and North Carolina east of the long strip. The best known of these are probably the Connecticut Valley and the New Jersey areas: to certain points in the history of the former this paper is devoted.

The ordinary view of the formation of these Triassic deposits is that their sands and muds were washed into long, narrow lakes or estuaries from either side, and strewn about in flat layers; that later they were tilted into a peculiar monoclinal position (of which more beyond), and at about the time of tilting or after it, the trap was injected in sheets between the inclined layers, seldom reaching the surface then, but exposed now by a long acting erosion which has worn away a considerable share of the old deposits. The trap, as now laid bare, stands up in long ridges, because it is harder than the adjoining sand-stones and has more stubbornly resisted the down-wearing of erosion; and as the sheets are inclined with the sandstone layers, the ridges formed by their outcropping edges show steep bluffs on the side of outcrop, and present long, gently sloping backs toward the dip. West Rock by New Haven, Mt. Tom by Northampton, the Palisades on the Hudson, and the Newark (or Watchung) Mountains of New Jersey, are familiar examples of these peculiar forms of relief, and all these are much alike in surface features; but in relative position they are remarkably contrasted. All the ridges of the Massachusetts-Connecticut area face boldly to the west, and slope gently to the east; while in New Jersey, these direc tions are reversed; further, the ridges are not straight, but are curved, and in such away that all those in the former area are convex to the west; in the latter, to the east. The dip of the sandstone shows the same contrasts in the two regions. The general statement may therefore be made that in either region, the dip of the strata, the back of the trap-ridges and their concave sides are all turned one way; eastward in the Connecticut Valley: westward (or west-north-west) in New Jersey.

The uniform dip or monoclinal arrangement of the sandstone in either strip is very peculiar; and it has seemed so difficult to account for it by any supposition of disturbance in originally horizontal sandstone patches of about the present area, that two explanations have been suggested to avoid this difficulty.

In 1839, H. D. Rogers, then State Geologist of Pennsylvania, proposed that the monoclinal dip should not be considered the effect of disturbance after deposition, but should be looked on as the result of original oblique deposition — as cross-bedding on a great scale. He thought that the long Virginia, New Jersey strip was a deposit in a noble river that rose in the mountains of North Carolina and flowed north-easterly to the Atlantic about at New York Bay; and as all these sediments have a north-westerly dip, they must have been washed into the river from its south-eastern banks; the departures from the general dip were considered the effects of eddies in the mighty river. A similar explanation was applied to the Connecticut area. Now apart from the inherent improbability of cross-bedding on this vast scale, a very serious objection to the theory is found in the coarse conglomerate deposits very commonly found on the dip-side of each estuary; on the north-west in New Jersey, on the east in the Connecticut Valley. These cobble-stones and pebbles have in many places been traced to their sources in the neighboring hills or banks of the old estuaries; when they were washed into the water, there must have been also a large quantity of fine detrital material carried along with them, and deposited as a rule farther from shore. But how could all this sediment be deposited dipping *toward* its source as it is now found? This is a mechanical impossibility, and is alone sufficient to negative the theory of cross-bedding. The detritus washed into the Connecticut estuary from its eastern side must have originally lain in horizontal strata or dipped gently to the west; and the fact that these strata now dip distinctly to the east is ample proof that they have been disturbed since their deposition.

A second theory that was proposed to account for the monoclinal arrangement, supposed that the present area of the sandstone strips is but a small part of the surface originally covered by the Triassic deposits. Kerr suggested in 1874 that two parallel strips of opposite dip in North Carolina had been once connected by a broad intermediate deposit, which after its formation was bulged up into a great arch; the middle parts were worn away and only the marginal remnants with their opposite dips now remain. Russell proposed the same explanation for the opposite dips of the Connecticut—New Jersey areas in 1878. Here again there are many reasons against so wholesale an explanation.[1] The vast amount of erosion required; the absence of outliers that escaped destruction; the lack of symmetrical opposition of the Connnecticut and New Jersey areas, for the southern end of the former is north of the northern end of the latter; and finally the occurrence of conglomerates again serves us as a test. If the Triassic strata ever reached across the supposed arch, the intermediate area must have all been under water; and none of its rocks could have furnished sands for the sandstones or pebbles for the conglomerates; and yet, along the outcrop-margin (west in Connecticut, east in New Jersey) of the existing strips, there are certain coarse sandstones and conglomerates that seem to be derived from the adjacent granitic hills; thus showing that they were not submerged, as this theory of anticlinal remnants supposes, but were above water and furnished a share, probably a large share, of the material toward the filling of the Triassic estuaries. It is proper to add, however, that the identification of the source of these conglomerates is not so satisfactorily made out as in the previous case; more work is wanted here.

We conclude therefore that the best evidence favors the view that the sandstones were laid down in essentially horizontal layers, in troughs of an area not greatly exceeding the present area of the sandstone strips; and that the present dip of the strata is owing to a subsequent disturbance. We have next to inquire the character of that disturbance.

Some observers have been so impressed with the regularity of of the monoclinal dip, and the (supposed) absence of faults and folds, that they have been driven to admitting that a single sim-

[1] See Dana, Amer. Journ. Sci., XVII, 1879, 328.

ple tilting must explain the entire disturbance. Hitchcock took this view; and he is followed by Leconte.[1] The difficulties in the way of accepting the explanation are again the enormous amount of erosion it involves; the enormous thickness of sandstones it requires; but more important still, the incorrectness of the supposition that faults and folds are absent. Both faults or folds can either be proved or shown to be of so likely occurrence, that there is no necessity of supposing the unbroken monoclinal: a faulted and gently folded monoclinal corresponds better with the observed facts and avoids the difficulties of great thickness and great erosion of strata. It is worth noting that Rogers, Hitchcock, Kerr and Russell were rather driven to their theories in order to avoid difficulties, than called to them by direct evidence; and theories based thus on absence of any other means of explanation are not as a rule well founded. The theory of the glacial erosion of lake-basins and fjords is a case in point.

How then are the faults and folds proved?

Faults are occasionally determined by the direct visibility of their fissure and displacement: and a few such of small throw are known in the Triassic strips. Yet by far the greater number of faults marked on geological maps and diagrams have never been seen directly, but are only inferred to exist on account of the displacement or reappearance of certain identifiable strata on the two sides of their fissure. Such inferences may be well or poorly based, according as the repeated stratum or series of strata is surely or doubtfully identified at its two outcrops. In attempting to apply this method to the study of the Triassic belts, we are seriously embarrassed by the monotonous character of the sandstones and shales that make up these deposits, so that the second outcrop of any given stratum cannot be ascertained. Only in the Richmond coalfield has this difficulty been overcome; there the coal-beds have served as indices to the displacements of the mass. Elsewhere, no faults of any considerable throw have hitherto been safely determined.

The trap sheets here come in to play an important part.

As stated at the beginning of the paper, it is generally taught that these sheets were intruded between the sandstone layers; but this is in large part an error. While some of the sheets,

[1] Elements of Geology, New York, 1878, 440, 441.

notably the West Rock range in Connecticut, and the Palisades in New Jersey, are demonstrably intruded, by far the greater number of trap-ridges in the Connecticut Valley at least are outcropping edges of well-proved contemporaneous trap overflows poured out from fissures, not now determinable, upon the unfinished accumulation of sandstone strata, and buried under later deposits. This origin was first stated by Hitchcock in 1833 and 1841; again by Dawson for Nova Scotia in 1848; but since then it has generally found but little acceptance. The cause of its neglect seems to be two-fold: in the first place, the two sheets already mentioned as intrusions, and so known because they break across the enclosing strata at certain points and bake the rocks on their back as well as below them, are of easy access from two centres of observation, New Haven and New York; and as the external form of these intruded sheets is essentially the same as that of the other trap ridges of less convenient access and examination, they seem to have been taken as the types, and their explanation has served for the others as well. In the second place, the most important point of observation for the distinction between overflow and intruded sheets is the contact of the trap with the overlying sandstone; if an intrusion, this sandstone is baked; if an overflow, the sandstone is not in the least baked, and it may contain fragments from the pre-existent trap below it. But these upper contracts as a rule are rarely visible, the overlying sandstones have generally been worn away below the present lines of drainage, or are covered by soil and drift; and in their usual absence, the evidence taken from the baked sandstone on the intruded sheets has been improperly extended to the overflow sheets. But in addition to the character of the overlying sandstone, there is another feature of the overflow trap sheets that has good probability of serving to detect them; this is the vesicular or amygdaloidal condition of their upper surface, the result of the giving off of gas by the molten rock when the external pressure allowed of such expansion, that is when the trap lava escaped from its deep fissures and flowed over the Triassic sea-bottom, and became bubbly on its upper surface after the manner of modern lavas. So far as observed, the trap sheets that are prevailingly vesicular at their upper surface are all overflows; the intruded sheets are as a rule dense and compact above as well as below.

When therefore it is demonstrated and admitted that most of the Connecticut Valley trap ridges are old overflows, they assume a considerable importance in explaining the structure of the enveloping sandstones, for they may be taken as horizons in the sandstone series, easily followed and in some cases safely identified in their several faulted outcrops. So long as the trap was considered intrusive, it could not serve thus as a guide; for if intrusive it need not always break up between the sandstone strata, but may sometimes have broken across them and so fail to mark any single horizon: and so long as its general overflow origin has been neglected, the peculiar structure of the Connecticut sandstones has not been correctly determined.

Wherever the trap-sheets are known to be overflows, their igneous origin may be neglected in the present inquiry, and they may be considered as conformable members of the sedimentary series; recognizable strata among the monotonous sandstones and shales, and we may now return to the question, how are the faults and folds determined?

The most conspicuous example of a large fault is that one by which the heavy trap sheet of the Hanging Hills, near Meriden, Conn., is brought again to the surface in Lamentation Mountain some five miles to the eastward. The evidence for this is the similarity in series of strata found on the face of each outcrop-slope, as described by Percival in his Geology of Connecticut, 1842; and though the case is made very probable, more examination is needed before it can be generally accepted. Under the heavy trap there is found in descending order, shale, limestone, amygdaloidal trap and sandstone on both of these slopes; and the probability that this agreement should be accidental is very small; it much more probably shows a double outcrop of the same series of rocks; and as the dip is eastward in each case, the repetition must be the effect of a fault. There is no likelihood that this fault will ever be seen directly, for the valley where it is hidden is occupied by heavy masses of drift — the irregular kame-like hills about Beaver Pond, on the line of the New Haven and Hartford R. R., a few miles north of Meriden; but although unseen, it is nearly as well proved as the often-mentioned faults of Virginia and Tennessee. Several smaller faults have similar but less complete evidence.

It is noticeable that the throw of the large fault is in the direction to increase the breadth of country occupied by a given set of strata; and thus to reduce the estimate of the thickness of the sandstones demanded by the simple monoclinal tilting without faults; such faulting is therefore a very economical modification of the Hitchcock-Leconte supposition.

While the faults are indicated by the repetition of the trap outcrops, the gentle folds or waves are fully proven by the curved outline of the ridges, and by the complete conformity of the adjoining sandstones to their curving. But the occurrence of these folds has been generally denied, and the explanation of the supposed monoclinal greatly retarded by an assumption of regularity in the strike and dip of the sandstones, that does not exist. The curved or crescentic form of the ridges shown by Percival in 1842 to be constant in each belt and to have a constant relation to the dip of the sandstones, has generally been taken as marking a curved fissure up through which the trap has been ejected. But such explanations completely fail to explain the overflow trap sheets which are shown to be essentially interbedded members of the Triassic series, and which have consequently suffered just the same distortion as their enclosing sandstones and shales. In order that an originally flat sheet shall have a curved outcrop, it must be folded; and conversely, if folded, it must have a curved outcrop. In this simple way, therefore, the puzzling crescents may be explained. The fact that the crescents of the Connecticut area are all convex westward is the result of their folds taking part in the general monoclinal structure, and canting over a little to the eastward; and also because these folds are often faulted up to a second appearance in another fold on their eastern side.

One fact of capital importance remains unexplained. We may admit that the Connecticut strip of sandstones is not greatly reduced from its original area; that its dip is not the result of oblique deposition, but of post-Triassic disturbance; that most of the trap ridges are the edges of contemporaneous overflows of lava; that their curvature and their occasional reappearance are the results of folding and faulting which they suffered with the sandstones; but there has as yet been no satisfactory reason assigned for their general monoclinal structure. This most striking physical feature of the Triassic belts is still a mystery.

Some of the results named above are better established than others; and all deserve scrutiny and re-examination in the field. It is largely with the hope of exciting local observers to this work that the above outline of a method of investigation has been written. Many facts of a kind that can be well learned from thorough observation within a comparatively small field must be collected; and the results from these many small fields must be collated for the Triassic district that the fields make up. When this is done, there is some chance that the cause as well as the facts of the monoclinals may be discovered. The most important questions for local observation are: the identification of the source of the conglomerate pebbles; the proof of intrusive or overflow origin for all the trap sheets; and the discovery of faults by the repetition of similar series of strata.

ON THE ELEVATED CORAL REEFS OF CUBA.

BY W. O. CROSBY.

One of the most striking, and, to the northern eye, one of the most novel, features presented by the island of Cuba, when viewed from the sea or from salient portions of the coast, are the broad, level and vertical-walled terraces or shelves of rock which rest against the jagged mountains of the interior and form the shore around almost the entire island. I have observed these terraces lying at various levels from twenty up to nearly two thousand feet above the sea. Even when seen from a distance, and for the first time, the observer feels satisfied that they must be composed of horizontal beds of either some sedimentary rock or of basalt.

Landing on the first terrace, which, for hundreds of miles, has a sensibly uniform altitude of about thirty feet, and is unbroken, save where rivers have cut through it to reach the sea, the most casual observation shows that the indescribably jagged and ragged rock is a limestone, and largely made up of several kinds of modern-looking corals. In other words, the terrace is a fringing coral-reef that has been lifted above the level of the sea; and looking from the perpendicular front of this ancient reef we can see distinctly that the adjacent sea-bottom is paved with growing hemispheres of Astrea and Meandrina — the summit of a new reef which will probably be elevated in its turn.

This lowest platform varies in width from a few rods to a mile or more. Sometimes the ground descends away from the shore, indicating that the reef, during its formation, was a barrier-reef at these points. Near the landward side of the reef, and especially toward the bottom, as may be observed in the natural sections, the coral-limestone is interstratified with layers of sand and gravel, material washed from the hills while the reef was growing. These beds are generally horizontal or slightly inclined toward the sea. As we should naturally expect, this fragmental material is most abundant near the mouths of the rivers, where the reef is sometimes principally composed of it, showing that the modern river-valleys are older than the reef.

The second reef rises steeply, often perpendicularly, from the inner edge of the first; and, along the north coast, where most of my observations were made, its altitude varies from 200 to 250 feet, the variation being due to unequal erosion. This reef, owing to its longer exposure to the agents of denudation is much less continuous than the first, and more frequently reposes directly upon the ancient and non-calcareous mountains, though a well-marked valley often intervenes, running parallel with the reef and the coast. Being much older than the lower reef, the limestone is distinctly more crystalline, and the corals and shells are in great part obliterated, so that much of the rock appears quite destitute of organic remains. But the points of resemblance between the two reefs are sufficient to show that, in origin, they are identical.

The altitude of the third reef is about 500 feet. It differs from the second very much as that differs from the first, having suffered greater erosion and being still more solid and crystalline. And the same is true concerning the relations of the third reef to the fourth, which can be observed only at infrequent intervals along the coast. In the neighborhood of the Yumuri River, 15 to 20 miles east of Baracoa, it is well preserved, with an elevation of probably not less than eight hundred feet.

These limestone terraces or ancient coral-reefs extend, with slight interruptions, around the entire coast of Cuba. And in the western part of the island, where the erosion is less rapid than farther east, they are the predominant formation; and are well preserved on the summits of the highest hills. Mr. Alexander Agassiz states that the hills about Havanna and Matanzas, which reach a height of over twelve hundred feet, are entirely composed of reef-limestone.

Five miles west of Baracoa, and thirty miles from Cape Maysi, rises a singularly bold and interesting mountain, called by the Spaniards El Yunque (The Anvil).

It is a very prominent landmark, known to all sailors in these seas, and indicated upon nearly all maps and charts of eastern Cuba, the altitude, when given, ranging from 2500 to 3000 feet.

It stands about four miles, in a direct line, from the sea, with only slight undulation of the ground intervening, so that the eye takes in the entire altitude at a single glance. This probably accounts for the fact, of which I have no doubt, that the altitude of the mountain has been very generally and very greatly over-estimated. I have visited the summit twice; and my closely accordant observations with the aneroid and plane-table show that the true altitude cannot vary from 1800 feet. The ground-plan of the mountain is distinctly rectangular; and at the summit it is about three-fourths of a mile long and one-third as broad, with the longer axis parallel with the coast. The slopes, except at two or three points, where only, ascent is possible, are vertical or nearly so for the first 300 to 600 feet below the summit.

The form of the mountain points very clearly to its origin; and before making the ascent I felt that it must be simply the last remnant of an ancient coral-reef, differing from those already described chiefly in its great altitude. This theory was confirmed by observation. The base of the mountain, up to a height of about 800 feet, is composed mainly of the ancient eruptive rocks of the island with some slates; while upon this foundation rests not less than one thousand feet of limestone, forming the entire upper half of the mountain. The limestone is crystalline, and I observed in it no traces of corals or other organisms. In fact, it is very unlike the modern reef-rock; and, taken by itself, there is little evidence that it had a similar origin. But when, as its form warrants, we regard El Yunque as the highest and oldest of a series of reefs, and compare it with the reef approaching it most nearly in altitude, and that with the next in descending order, and so on down to the modern reef, the evidence is perfectly conclusive; for the differences at each step are of the same kind and in the same direction. Notwithstanding its solidity, the limestone of El Yunque weathers in the same irregular, ragged and cavernous way as that of the lower reefs.

The erosion which has swept away, for a distance of many miles up and down the coast, all but this solitary remnant of a reef more than a thousand feet thick, must certainly have diminished the height of El Yunque by as much as two hundred feet; and we may safely conclude that the original altitude of this reef was not less than two thousand feet. On the island of Jamaica precisely similar reefs have been observed at an elevation of three thousand feet; and Mr. Sawkins, in his report on the geology of that island, says that the reef-limestone has a maximum thickness of not less than two thousand feet, and that the oldest of it was formed after the close of the Tertiary period.

The concentric coral-reefs of Florida, it is well known, have their summits all on nearly the same level, which is but little above the level of the sea; constituting an important exception to what for the last forty years has been regarded as the general rule, viz., that extensive coral-reefs are formed on areas of subsidence. Mr. Alexander Agassiz points out [1] that the great Alceran Reef, on the Yucatan Bank, which is atoll-like in form and stands on an area of elevation, is another exception to Darwin's theory; and he also adds both the ancient and modern reefs of Cuba to the list.

That Cuba has, in recent geological times, been an area of extensive elevation, the reefs fringing its mountains to a height of nearly two thousand feet afford indisputable evidence. But does it necessarily follow that these reefs were formed while the land was actually rising? It is a fact well known to geologists that all great movements of the earth's crust are oscillatory. Thus, during the Paleozoic era, the middle portion, especially, of the Appalachian system in North America was an area of profound subsidence; but, although the general tendency was

[1] Bulletin of the Mus. Comp. Zool., Vol. v, No. 1, p. 2.

downward, yet the character of the sediments deposited during that time shows that the movement was frequently reversed, periods of elevation alternating with periods of subsidence, the latter, however, predominating. Similarly in the case of Cuba, during post-Tertiary time this region has experienced a powerful elevation; but there are good reasons for believing that the upward progress of the land was not uninterupted. The reefs, in fact, are witnesses for both sides, testifying with nearly equal distinctness to both elevation and subsidence.

The coast of Cuba is probably not rising now, at least not at all points. On the beach near Baracoa the erect stumps of large trees may be seen, standing where they grew, near the low tide mark.

The numerous harbors of Cuba are nearly all formed on one plan, of which Baracoa harbor is a good example. It is an approximately circular and almost completely land-locked basin, communicating with the sea through a narrow but deep passage between broken walls of coral rock. The larger harbors depart from this plan chiefly in their more irregular outlines, all agreeing in having deep narrow mouths. Every harbor is at the mouth of one or more rivers; and their narrow inlets, as I conceive, are the work, not of the sea, but of the rivers at a time when the land was higher than now. While the main body of the harbor, in each case, is simply the broader and older portion of the river valley behind the barrier-reef which has been invaded by the rising sea. The circular form of many of the smaller harbors is largely due to the fact that the sand brought down by the rivers is thrown up by the sea into curved bars, cutting off the inequalities of the shore.

During the formation of the most recent of the elevated reefs, which, as already stated, forms a level floor about thirty feet above the sea, the mouths of the smaller streams were behind the reef, discharging into irregular channels or basins between the reef and the shore. On account of the turbidity and freshness of the water, the reef, especially on its inner border, grew less rapidly at these points than elsewhere, the basins behind the reef becoming filled with débris from the land. When the reef was finally raised to something above its present level, each river scoured out a large part of the sand and gravel which it had deposited and cut a narrow channel through the reef itself. During this period of elevation, Cuba, like most rapidly rising lands, had few harbors; but when subsidence began, the sea occupied the channels and basins which had been excavated and cleared out by the rivers, and thus a large number of harbors came into existence.

Opposite the mouths of the larger rivers, such as the Toar and Molasses in the vicinity of Baracoa, the reef in question was completely interrupted, and these streams discharge into broad, open bays; while the lower portions of their valleys show, equally with the harbors, that the land is sinking. They are half drowned valleys filled to a considerable depth with land detritus, conditions which could not exist if the land were rising or had recently risen.

But the most satisfactory evidence that the ancient reefs of Cuba were not formed during periods of elevation is found in the great thickness of the reefs themselves. The reef which, in eastern Cuba, reaches a height of five hundred feet above the sea includes not less than four hundred feet in vertical thickness of coral-rock, and in this estimate no allowance is made for what the reef has lost by erosion. The giant reef of which El Yunque is, perhaps, the last remnant, has still, after suffering enormous waste, a thickness of more than one thousand feet. While, according to Mr. Sawkins, the maximum thickness of the ancient reefs of Jamaica is two thousand feet. It follows, from Mr. Agassiz's theory, that the El Yunque reef, for example, began to grow in water much more than one thousand feet deep; for to the present thickness of the reef we must add, not only what it has lost by erosion, but also the amount of elevation which took place during the ages when the reef was growing. A depth of even one thousand feet is, however, entirely inadmissible, in view of the well established fact that reef-building corals are limited to depths of less than twenty fathoms.

We have, then, apparently, no resource but to accept Darwin's theory as an adequate explanation of the elevated reefs of the Greater Antilles; and, therefore, to admit that the upheaval of this portion of the earth's crust has been interrupted by periods of profound subsidence during which the reefs were formed.

The subsidence of two thousand feet, of which El Yunque is a monument, must have reduced the Greater Antilles to a few lines of small, but high and ragged, islands; and, as Mr. Bland has shown, fully accounts for the absence in these immense tracts of all large land animals, although they were abundant here in Pliocene and earlier times.

THE ARGILLITE AND CONGLOMERATE OF THE BOSTON BASIN.

BY M. E. WADSWORTH.

In a paper published in the Harvard University Bulletin (1882, II, 431, 432) " On the Relations of the So-called Felsite to the Conglomerate on Central Avenue, Milton, Mass." it was pointed out by the present writer that the supposed felsite of that locality was simply a portion of the conglomerate somewhat altered by water action (thermal) and therefore the conclusions that were drawn from that locality by Mr. W. O. Crosby needed to be revised.[1]

The question of the relation of the argillite to the conglomerate of the Boston basin was briefly touched upon, hence it is advisable here to call attention to some additional evidence bearing on those relations, derived from various localities in this basin.

The best locality for observing the junction of the argillite and conglomerate that I have thus far seen is on the north side of Beacon street, Newton Center, near the stream running from Hammond's Pond. This locality is on the land of Hon. R. R. Bishop, and by the side of the street.

The argillite is very fine grained and continues the same in character up to the conglomerate. The lamination is well marked and frequently contorted. At the junction the argillite is found to have been irregularly eroded, and the conglomerate laid down unconformably over it. In places the layers of argillite are cut off and the conglomerate abuts unconformably against and over

[1] Amer. Journ. Sci. 1880 (3) XIX, 166-122; Occas. Papers Bost. Soc. Nat. Hist., 1880, III, 89, 220, 221, 270, 271.

them. Pebbles of this argillite were also found in the conglomerate, while the junction of the two is distinctly that of a conglomerate laid down on an older eroded surface. If the two were the same formation it is difficult to conceive how the argillite and conglomerate could be so absolutely distinct as they are.

Naturally, if they were the same formation we should expect to find a gradual passage between them, or at least a few pebbles inclosed in the argillite. The supposition of a fault is not admissible, because the two rocks were found united in a solid mass with a definite line of contact. The unconformability and the occurrence of argillite pebbles in the conglomerate also forbid any supposition except this: that the argillite was laid down, solidified to its present condition, or nearly so, and then eroded; while upon this eroded surface the conglomerate was deposited, nearly coinciding in its strike and dip with the argillite. The "conglomerate" is found to be at its base, either a conglomerate or a sandstone passing in places into an argillite. The denuded argillite beneath is found both in pebbles in the conglomerate and in material redeposited as argillaceous mud, in and about the conglomerate, giving rise to bands and irregular patches of argillite.[1] Examination of quarries in the conglomerate in the vicinity of Beacon and Station streets shows numerous pebbles of the underlying argillite in the conglomerate.

Studies made by the writer at this locality and elsewhere in the Boston basin, prove to him that there are at least two distinct argillites. One a fine grained and decidedly argillaceous rock generally of gray color, like that underlying the conglomerate on Beacon street, and resembling in some of its characters the Paradoxides argillite at Braintree. The other, of coarser grain, often decidedly arenaceous, and generally of a gray, black or reddish color. The latter argillite (oftentimes a true sandstone) is, so far as its relations have been ascertained, a component part of the conglomerate (Roxbury).

The slate rocks so well exposed in Somerville are of similar character to this latter argillite, although their relations are not definitely known.

We have then at least two argillites in the Boston basin, to the first of which the Paradoxides rock of Braintree most proba-

[1] Occas. Papers, Bost. Soc. Nat. Hist. III, 190.

bly belongs; and to the latter of which the Somerville argillites ("Cambridge slates") are assigned, at least until further evidence can be obtained.

The proof of the unconformable superposition of the conglomerate upon the argillite in Newton, and the greater age of the latter has been overlooked by Mr. Crosby, who, in conformity with his theoretical views that the argillite was the younger rock, explained the structure by the supposition of a closely folded synclinal;[1] — a supposition which the evidence above given precludes.

Whether the conglomerate, composed of the debris of the Quincy granite on Adams street, Quincy, mentioned in my paper previously referred to, is the same as the common Roxbury Conglomerate or not can only be told by actually tracing their relations. The former conglomerate, however, resembles the carboniferous conglomerate of the Norfolk basin, as described by Messrs. Crosby and Barton.[2]

It is well known that many writers have held that the Roxbury conglomerate is of Carboniferous age, but of this proof is as yet wanting, although from the evidence obtained to the southward (Norfolk basin) the view is not improbable.

It may be concluded from the above evidence that the Roxbury conglomerate overlies part of the argillite unconformably, while part of the latter is of the same age and a constituent portion of the conglomerate. This explains and unites the discordant observations and views of the various local geologists; the truth in this case, as in many others, lying partly with both sides, wholly with neither. Further it is possible that two or more conglomerates exist here of different ages. It may be mentioned that quartzite, like that found so commonly in the conglomerate, has been brought up in fragments by the diabase and is also found by boring in some parts of the Boston basin.

So far as we have any evidence at present the oldest surface rocks in this basin are the argillites and the schists of allied character. Of these we only know the age of a very small area in Braintree and Quincy. Through these schists and argillites have been protruded immense quantities of eruptive rocks in the form

[1] Occas. Papers, Bost. Soc. Nat. Hist., 1880, III, 238-244.

[2] Amer. Journ. Sci., 1880 (31, XX, 420).

of lava flows, ashes, dikes, bosses, etc., leaving the geology in an intricate state; the same as it would be anywhere, when eruptive action has prevailed a long time, the sea action going on at the same time, mixed deposits being formed, and the whole exposed during countless ages to denudation and metamorphism.

Older rocks than the Braintree (Paradoxides) argillites may exist, but of their existence we thus far have no proof. We can only ascertain the age of the other rocks, unless more fossiliferous deposits can be found, by tracing, as the writer has begun to do,[1] the relation of the adjacent rocks to the Braintree argillites, the relations of the former to their surrounding rocks, and so on in a constantly widening circle—guided by facts.

As an illustration of the confusion produced in this region by eruptive action attention may be called to another paper by myself, relating to the Stoneham limestone, in the Harvard University Bulletin (1880, II, 359, 360), in which it is shown that the argillite has been cut through and through by dikes and greatly indurated and altered, so that one class of observers claimed that all were of sedimentary origin and another class that all were eruptive, when in truth part were eruptive and part sedimentary.

In this connection it may be pointed out that the rock in the Quincy granite which is marked as amygdaloid on the Geological Map accompanying the third volume of the Occasional Papers of the Boston Society of Natural History, is, in part at least, a well-marked argillite, which the writer has followed westward from the Quincy granite to the Randolph Turnpike. This covers quite a large extent of the district, but how much the writer has not ascertained, since his observations were made some years prior to the publication of the map.

[1] These Proc. 1881, XXI, 274-277.

General Meeting, November 15, 1882.

Vice-President, Mr. F. W. Putnam in the chair. Fifty-seven persons present.

The following candidates for associate membership were elected : Messrs. Charles R. Hooper, John F. Hooper, George H. Thatcher, and Mrs. Marie A. Hooper.

The President then introduced Dr. William B. Carpenter, of London, who gave an account of the history and present status of the controversy on *Eozoon Canadense*, and stated the arguments for its organic character.

Section of Entomology, November 22, 1882.

Mr. S. H. Scudder in the chair. Ten members present.

The following paper was read :

CONTRIBUTIONS FROM THE NORTHERN TRANSCONTINENTAL SURVEY. NOTES ON THE GENUS PIERIS.

BY DR. H. A. HAGEN.

Pieris (Neophasia) menapia.

P. menapia ♂, ♀ Felder, Wien. Ent. Monatsschr., III, p. 271. transl. Morris Lepid., p. 19; Catal. p. 4. Weydem., Catal. p. 8.

P. tau ♂ Scudd. Proc. Bost. Soc. Nat. Hist. VIII, p. 183, (separate p. 6).—repr. Morris Lepid. p. 322. Weydem., Catal. p. 9.

P. menapia ♂, ♀ Felder, Novara, Lepid. II, p. 181, pl. 25, f. 7 ♂.

P. ninonia ♂, ♀ Boisd. Am. Soc. Ent. Belg., XII, p. 38.

N. menapia, Behr, Trans. Amer. Ent. Soc. II, p. 303.—Stett. Ent. Zeit. XXIX, p. 300.

P. menapia ♂ W. H. Edw., N. A. Butt. I, Pieris pl. I, f. 1–3. Catal. p. 12, suppl. notices.

N. menapia ♀ W. H. Edw., Trans. Amer. Ent. Soc. IV, p. 63; Mead, Wheeler's Exp. V, p. 743.

N. menapia, H. Edw., Proc. Cal. Acad. 1873, p. 161 (separ. No. 2, p. 5)—Chrysalis.

P. menapia ♀ Strecker Lep. Rhop. II, p. 14, f. 4. Catal. p. 74, p. 183.

P. menapia Kirby, Catal. p. 450, p. 791.

P. menapia ♂, ♀ Bull. Brookl. Ent. Soc. I, No. 5. Synopt. table.

P. menapia Stretch var. suffusa ♂, ♀. Papilio II, p. 103, pl. 2, f.1-4.

N. menapia Butl. Journ. Linn. Soc. 1882, Vol. XVI, p. 479.

It would seem like "carrying coals to Newcastle" to give so soon after the paper of Mr. Stretch a communication about this species. But as this species and the discovery of its life history is one of the more important entomological facts made out by the members of the Survey, and Mr. Stretch (p. 108) "was unable to determine whether or not the insect is worthy of a special name, not having types before him for comparison," and such types are present in the collection of the museum, additional remarks seem to be justified. As he had no access to Felder's description (p. 109), and to other works (the description of the female by W. H. Edwards, Tr. Am. Ent. Soc., as well as the supplementary notices was not known to him), I have tried above to prepare a bibliography of this species.

The large apical black spot of the primaries "reaching the second inferior nervule, where it is rather abruptly broken" (Scudd.), of the males, gives an easy character to decide whether an author has described and figured a male or a female, where the apical spot by extension along the margin reaches the inner angle of the wing. Mr. Felder has described both sexes from 2 ♂ 1 ♀ from Great Salt Lake, Utah, collected by Lorquin. The short description in the Wien. Monatsschr. would not decide that he had seen the female; but the detailed description in the Novara Voyage made from the same material shows that he has described a female, which is not var. suffusa (Str.), but belonging to the form more similar to the male. Mr. Scudder's description agrees so well with the male, that by this alone it is obvious that he has not seen a female. He mentions only once the female, "as repeating slightly at the outer angle (on the upper side of the secondaries) the markings of the lower surface." Two such specimens are indeed in the collection of the museum labeled in his handwriting as females. I have to acknowledge that the end of the abdomen is much crushed. All the specimens were collected at the Gulf of Georgia, W. T., by Mr. A. Agassiz, and there are a large number of them. Mr. Boisduval describes P. ninonia from five specimens collected by Mr. Lorquin, " dans la partie la plus orientale de la Californie."

If the female described by Mr. Boisduval belongs to this sex, which is probable, it is *not* var. suffusa. Dr. Behr gives only the description of the genus Neophasia, based upon P. menapia. His specimens were found on a certain elevation of the Sierra Nevada, Cal. (perhaps also by Mr. Lorquin?)

Mr. W. H. Edwards does not state the locality of the specimens figured by him. In Wheeler's Expedition Mr. Mead speaks about the specimens collected in Colorado by Mr. Allen (sent to Mr. Edwards by the Cambridge Museum), and states that the outer half of the costal margin of the secondaries of the male are tinged with vermillion, which he believes is not shown by the Californian specimens. The female described by him, Tr. Am. Ent. Soc., IV, p. 63, was collected by Dr. Bremner in the Island of San Juan, Gulf of Georgia, and judging by the far more detailed description in the Supplem. Notices Buttfl. Vol. I, corresponds exactly to the var. suffusa, which was not to be decided by the description in Tr. Ent. Soc. Vol. IV, 63.

I have before me 26 females, one each from Colorado and British Columbia, all the others from the same place in Colville Valley, W. T.

The size varies from 55 mm. to 47 mm. expansion, only the Colorado specimen is larger, 58 mm. exp.

The color is sordid white or yellow, but six specimens are nearly as white as the males above, and below just as white. To these belong the specimen from Colorado, from British Columbia and the others from Washington Territory. The black apical spot of the primaries always extends beyond the second inferior nervule reaching the third; sometimes it is longer and goes straight down to the angle of the wing. The number of the white or yellow spots is mostly six but the last one often less marked, and sometimes wanting. The secondaries have in two specimens an uninterrupted black marginal band; mostly the large, white inclosed spots reach the margin and are tipped there by orange. The nervures on the underside of the secondaries are broadly bordered with black, in two specimens so broadly that they are, except the disk, nearly black. A few specimens show also black scales along the nervures on the upper side of the secondaries. I can affirm for P. menapia Mr. Scudder's statement, that "the outer angle of the secondaries is more prominent, and so the whole hind margin less curved." Of 133 males before me (111 from Colville Valley) some represent differences of minor value. Average expansion 52 mm.; the largest from Colorado, 58 mm., the smallest 42 mm. from Washington Terr. The apical spot of the primaries is very large, even exceeding sometimes the second nervule, but never reaching the third; in one the spot is only half as broad; the white spots within differ in size; the black bands on the under side of the secondaries are not rarely repeated on the upper side, mostly on the external half of the wing.

Habitat. Port Townsend, W. T. A large number collected by Mr. A. Agassiz, May 16, 1859. A dozen are still in the Museum, the others according to the catalogues of the Museum have been sent in exchange to a number of entomologists (H. Edwards, Reakirt, etc.); so far as I know all were males; the females labeled by Mr. Scudder are males.

Garden of Gods, near Manitou, Col., August 1, 1871, Mr. J. A. Allen collected a large number, which were exchanged with many entomologists, and mentioned in Mr. Mead's Report. Two males and one female, which is white and nearly identical with the male, are still in the collection. A similar female from British Columbia collected by the late Mr. G. R. Crotch, after June, has no nearer data. The Museum received in 1876 in exchange 14 males from Oregon by Mr. Strecker. During our trip in Washington Territory, 1882, we found the first specimens July 21, in Spokane Falls; probably the white butterflies we saw on the railway from Cheney the day before belonged to the same species, as well as those seen by Mr. Stretch, July 22, on his return. On the excursion to Colville Valley we saw, July 23, before Loon Lake a number in the forest. All were worn males but one, which is as I see now a female, white and nearly like the male, so that it was easily overlooked. Returning from Brown's farm to Loon Lake, July 24, we found the first yellow females. Their sudden abundance was wonderful and indeed only to be compared with an irruption. Every female before flying off was directly found out by the myriads of males and impregnated. I only once remember to have seen a similar but still larger sudden irruption during the destructive appearance of Bombyx monacha in Prussia. We saw also Aug. 1, the species in West Montana. Other localities recorded from which I have not seen specimens are Salt Lake, Utah, by Lorquin; Sierra Nevada, Lorquin, Dr. Behr; Vancouver's Island, H. Edwards; San Juan Island, Bremner; Mendocino Co., and Mt. Shasta, Cala., Mr. A. Butler.

The fact that Mr. A. Agassiz has found the species in large numbers in the middle of May proves without doubt the existence of a spring brood; as the other ascertained data Colville, W. T., and Colorado show a summer brood at the end of July and beginning of August, I am of the opinion that the exaggerated yellow females are probably the consequence of the immense multiplication of the species, as similar facts have been observed, if my memory is not wrong, in B. monacha. The whole brood of P. menapia was overcrowded. The chrysalids were in the furrows of the bark hanging down always half a dozen together, and perhaps not well developed. Everybody knows that in the artificially crowded broods of the common silkworm it is very rarely, if at all, possible to find females with well developed wings. Therefore I believe I am justified in concluding as follows:

1. N. menapia has in Washington Terr. a spring brood; female not yet known. Middle of May.

2. N. menapia has in Br. Columbia, Washington Terr., Colorado, a summer brood. End of July.

3. Females similar to the male when the brood is not crowded; Washington Terr., July 23, on a place not crowded, and Colorado.

4. Females var. suffusa where the brood is crowded.

Concerning the caterpillar and chrysalis I gave up the attempt to point out the differences from other Pierids and principally from L. sinapis because the statements in print are not sufficient. The chrysalis in places not overcrowded is exactly as described by Mr. H. Edwards; in crowded places very different in color, dark, nearly black.

Mr. H. Edwards states that the chrysalis becomes black shortly before transformation, and this seems very possible. The black stripes have darker blackish dots, three on each segment. The proof that there was an overcrowded hurried brood is shown by the fact that some seems not to have shed the skin of the caterpillars of the abdomen or only partially. The chrysalis belongs more to the Terias type.

There were found among parasites a large ichneumon, probably a Pimpla, and some larvae of a Tachina. But parasites were scarce.

A species of Simulium swarmed eagerly and incessantly around some trees, which had the furrows of the bark filled with thousands of chrysalids. The flies were so eager that by taking a bunch of chrysalids some could be almost caught by hand. Many of the chrysalids were dead. I believe that the chrysalids are sucked by the fly, as I saw them near the suspensory silk bands. The fact is not yet mentioned that Simulium will live upon insect blood, but by no means improbable. Certainly it would explain how the myriads of Simulium can live in places where red-blooded animals are comparatively scarce, even if present shunning as much as possible such places. May not the same manner of life apply to Culex? [1]

Pieris Beckeri.

Near the Columbia River at Umatilla, Or., and on the opposite side in Washington Terr., June 24 to 26, were collected 26 specimens ♂, ♀; one very old female, July 20, at Ainsworth, W. T., higher up near the same river. The species is very wild in flight.

Concerning the supposed identity with P. Chloridice (Strecker, H. Edwards) I have compared all figures and descriptions, as I have no Russian specimens.[2] Fischer, Entom. II, Lepid. pl. 8, f. 2, a, c, gives the female on both sides and f. 6 the male underside, from Volga and Ural.—Esper. I, p. 177, pl. 90, f. 1, gives the male from Siberia; I consider it to be a female. Herbst. Lepid. pl. 93, f. 4, 5, gives both sides of the female. Huebner pl. 141, f. 712 to 715 figures male and female, both sides; but there is no description in the copy seen by me. Boisduval, Icon. hist., pl. 6, f. 5, 6, p. 31, the female from Moscow.

[1] See: The Entom. Monthl. Mag., Vol. XIX, p. 254.

[2] I have since compared five.

All differ directly from P. Beckeri in one and the same character. The primaries of the female P. Beckeri have on the underside *two* very marked black spots, one near the hind angle, the other in the middle of the wing nearer to the margin. The males never show those spots so large, sometime faint or even wanting. I find in *all* figures of C. Chloridice only the black spot near the hind angle given, and no sure indication of the other spot. Besides, the upper and underside of P. Chloridice have a certain kind of twin marks not to be found in the specimens of P. Beckeri from Oregon, Washington Territory and California.

The smallest females (3) expand a little less than 45 mm., none 40 mm., as given by Mr. H. Edwards, all others 55 mm., or a little more. The first figures of P. Chloridice differ among themselves only in minor characters, which may be the result of different skill of the artists. My specimens of P. Beckeri agree perfectly with the excellent figures of Mr. W. H. Edwards, and none have the maculose bands connected as on P. Chloridice. The two spots on the underside have the same place on the upperside; only the very small spots between them are wanting on the underside.

The question of the identity of the two species, or if one is to be considered as a mere variety or a local race, can only be answered when a sufficient large series of P. Chloridice can be compared with a similar series of P. Beckeri. The examination of a few specimens would not be deciding. Farther all I know till now of P. Beckeri is the summer brood; the spring-brood is still unknown to me. Whether P. Chloridice represent summer or spring brood is not known. This gap in our knowledge is very important. P. Beckeri and Chloridice would be exceptional if they had no spring broods. My California specimens have no date on the label, but as Mr. H. Edwards has taken the species in April in Nevada and the specimens seem not to have differed from the specimens taken in June and July, perhaps the two broods of P. Beckeri are identical, which would be exceptional in the genus.

For the moment we can state that P. Chloridice differs from P. Beckeri only in its little larger size and the number of black spots, which are more isolated. The broken white band of the underside on the secondaries is represented in Esper's and Huebner's figures, but not in the others. If P. Chloridice should not show more variation than given in the figures and descriptions — which can only be decided when both species have been bred in sufficient number—the question would be, whether both are different species or only local races of one species. Considering the wide variation of other species of Pieris, I believe it more safe to accept the latter conclusion until the former has been proved beyond any doubt. Mr. H. Christoph in Sarepta, Russia is the only entomologist who had bred largely C. Chloridice.

Pieris occidentalis.

Collected 17 specimens at the Dalles, Or., June 23, along the Yakima River at Lone Tree, June 30; Yakima City, July 2, 4, mouth of Natchez River, July 5; below Ellensburg, July 14, and at Loon Lake, July 23, all in Washington Terr., and never in the same locality with P. Beckeri. I have before me P. occidentalis from Colorado, collected by Allen; between Great Salt Lake and Ft. Bridger, Wy., collected by Garman; from Arizona, collected by Palmer. I cannot find in the specimens nor in the descriptions characters proving the accepted separation of P. Protodice and its varieties. I have seen P. Calyce, which is regarded as the spring form of P. occidentalis.

General Meeting. December 6, 1882.

The President, Mr. S. H. Scudder, in the chair. Twenty-three persons present.

On behalf of the author, Dr. M. E. Wadsworth presented the following paper:

THE DUNYTE-BEDS OF NORTH CAROLINA.

BY ALEXIS A. JULIEN.

Olivine enters largely, or as a predominant constituent, into the composition of several rocks of frequent occurrence in Europe, viz.—

Eulysyte, consisting of the iron-olivine, fayalite, garnet and augite;

Lherzolyte, consisting of olivine, enstatite, diopside, and picotite; and

Picryte, made up of olivine crystals in a matrix of hornblende, diallage, or biotite, with magnetite and calcite.

Dunyte, however, the only rock which, when unaltered, consists entirely of olivine, with a little chromite or magnetite, is said to occur in the South of Spain, in Norway, and in several other European localities, of which little is known. The largest outcrop occurs at the Dun Mountain in New Zealand; of this Hochstetter has given a description in considerable detail.

On this continent the same rock has been also found in North Carolina, Georgia and Alabama, as well as more recently in Canada.[1] It is there found in important rock-masses in the immediate vicinity of the serpentines of Mt. Albert, North Ham, in the Province of Quebec. It is finely granular, slightly friable, yellowish to grayish-green in color, and contains a little chromite and perhaps enstatite.

In the western part of North Carolina, the chief outcrops of this interesting rock occupy mainly a zone in the mountain-plateau, between the Blue Ridge and the Great Smoky Range, about 250 kilometers long, and from 15 to 30 kilometers wide, from the Rich Mt. in Watauga County, to the State line at Shooting Creek in Clay County, and so on through South Carolina and Georgia into Alabama. The beds are everywhere and exclusively found enclosed in a stratum of hornblende-gneiss, black and slaty. This forms the upper layer, and largely occupies the central zone of the mass of gneisses and schists, entirely of types identical with those found in the White Mountains of New Hampshire, which make up the mountain plateau.

Many facts in regard to the general features, lithological characteristics and mode of occurrence of this rock have been already published: in the paper by Prof. C. U. Shepard on Corundum;[2] in the detailed description given in the Geological Report by Prof. W. C. Kerr,[3] and the paper by C. D. Smith in the appendix

[1] B. J. Harrington, Can. Nat., 1881, IX, 254.

[2] Am. Jour. Science, 1872, (III) IV, 109, 175.

[3] Geol. of N. C., 1875, I, 129, 130, 293, 298, 299.

to the same volume; by Dr. F. A. Genth of the University of Pennsylvania, in his excellent papers on Corundum;[1] and by R. W. Raymond, in a short report on a survey of the Corundum veins near Franklin. In the present brief sketch it is proposed merely to offer some additional facts to which there has been little or no reference, the general results of my study for several years, both in the field and on a large collection of specimens and thin sections.

Form. As the beds are always highly tilted, they are seen always in cross-section, and their tracts generally present irregularly oval or elliptical outlines, or, in the smaller masses, those of decidedly lenticular layers. The major axis of such a mass reaches the length of about 1.5 kilometers in the largest bed, that of Cullakenee (Buck Creek) in Clay County, and the width of about 200 meters, the creek having cut its way through the length of the deposit and affording a good section of the layers upon its bare, sloping banks.

Lamination. The rock always possesses a marked slaty lamination, exactly like that of the slaty hornblende-gneisses surrounding it, the distinct laminae usually varying from ½ to 1 cm. That these laminae really indicate the bedding planes of a mechanical sediment, and not the characteristics of a chemical deposit, is shown by three facts,—

1st. On microscopic examination of thin sections, transverse to the lamination, there is always shown an alternation of coarser and finer irregular grains, the certain mark of a sorting out of sediments deposited in water.

2d. The chromite-grains are not only dispersed through the dunyte, in exactly the same way as those of iron-ore through the siliceous sands on a sea-coast; but are often concentrated in laminae about a centimeter in thickness, alternating with those of olivine, or even in coarser layers of a chromite-breccia, with kaemmererite-scales acting as a cement. These coarser layers are often spoken of as "veins," but always lie in the plane of stratification, and often show the sorting process among their own grains.

3d. At a few localities, near the margin of a huge mass of dunyte, this rock is found to be interbedded with the hornblende-

[1] Am. Phil. Soc., Sept. 19, 1873, and July 17, 1874.

gneiss, in layers 1 to 6 meters in thickness. This was shown by a cross-section of the beds on the north side of the dunyte deposit at the Jenks Mine, near Franklin, in Macon County. Although the dunyte is thus enclosed in, or interbedded with the hornblende-gneiss, the latter was never observed to be enveloped by the dunyte.

Strike. The strike, as shown by the lamination, coincides generally, but by no means always, with that of the associated gneisses. Though often attended by slight curves and even small faults, the plane of lamination usually extends straight and uninterrupted throughout the mass of dunyte. Along the margin of the mass, however, at the ends of the layers wherever visible, a sharp break seems to occur between the dunyte and the gneiss, sometimes with a deviation of the strike of the former, amounting to 20° to 30°. To this fact and to the many flexures naturally occurring near the centre of the anticlinal in which the dunyte-beds lie, may be attributed the idea sometimes advanced, that the dunyte is found in erupted dykes. All its characteristics, on the contrary, are simply those of a chrysolite-sandstone, which, wherever unaltered, and thus without accessory fibrous constituents as a cement or binding-material, is pulverulent and friable. The explanation of these differences in the strike is founded, I think, on the difference in specific gravity of the olivine-mass (3.3) and of the gneiss (2.6), and, it may be, on the greater rigidity of the former. Thus in the course of the plication and contortion of the mass of the gneiss, during its ancient plastic condition, the small enclosed dunyte-masses have sometimes been moved in some degree independently, and their strike slightly disturbed.

Weathering. The weathering of dunyte everywhere presents very interesting features: not only in its naked surface and dun color, which render an outcrop of dunyte distinct and desolate to the eye, as far as it can be seen, among the forest-clad mountains of North Carolina, as well as of New Zealand: but also in an extreme ruggedness, due to the irregular projection of laminae and of rough, jagged points — the pitted and honeycombed surface being often similar to the fretting of a coral-reef by the surf of a tropical sea. The chemical decomposition, however, is generally more rapid than the disintegration, the resulting ochreous mass being bound together by a network of plates of quartz or fibres of actinolite. Still there are localities where the upper surface of a dunyte outcrop in North Carolina is clothed with forest. Here the aluminous content of the soil, shown by its analysis, indicates an increment of foreign material in some way, perhaps by sand or dust blown by the wine.

Alteration.

The various processes of alteration, which have attacked and modified the lithological character of dunyte, are as important as they are novel and interesting. Although substantially the same reactions and results are involved, the discussion of these processes may be separately considered, with reference to that which took place in fissures, and to those which progressed throughout the rock, within its interstices. The respective results were, from the first process, the formation of *veins* — from the others, the conversion of the dunyte, partially or completely, into different rocks.

Veins. These vary in form, from vertical sheets, intersecting the rock to unknown depths, to elliptical or lenticular pockets with vertical axes; in thickness, from mere films to a width of two meters. In the veins of ordinary type, which are very common, the walls are lined with successive laminae of actinolite in transversely fibrous crusts, sometimes partially or wholly altered into talc, and the interior is occupied by ripidolite. The latter mineral almost invariably serves as the matrix of the corundum, with its associated minerals, these corundum veins being particularly abundant and large in the southern part of the dunyte-belt. In regard to the varied series of minerals which are found in association with the corundum, and in regard to their paragenetic relations, it will suffice for the present purpose to refer to Dr. Genth's valuable paper,the general accuracy of which on these points my field-observations everywhere confirm. It may be added that brownish-green enstatite is a common member of the vein-series; sometimes occurring in huge masses, nearly a meter in diameter, lined with actinolite; sometimes in minute disseminated granules; and less commonly in brilliant bronze-colored scales, to which the name bronzite is more pertinent.

Indigenous Alteration. Four common modes of alteration may be observed throughout the dunyte-belt, in all stages of each process.

1. Chalcedonic. In this process all the constituent silicates of the rock are decomposed, the bases sometimes remaining as reddish brown, soft ochreous grains, and sometimes completely removed. The silica entirely remains, generally as a white or yellowish chalcedony, passing into white, yellowish or reddish chert. When all the bases have disappeared, and the chalcedony remains as an exceedingly cellular mass of thin scales and plates, parallel or anastomosing with the greatest irregularity, a chalcedonic schist, or siliceous sinter is the result, often bearing some resemblance to a buhrstone.

2. Hornblendic. In this process, microscopic spicules of greenish actinolite first become more or less abundantly interspersed among the olivine-grains. Other varieties present actinolite-grains visible to the eye; and these may predominate until the alteration becomes complete. The final result is a green actinolyte-rock or schist, or grayish-white amphibolyte or tremolyte-schist, which may be fine grained or very coarse, consisting of huge fibrous masses of grayish-white amphibole, 2 to 3 decimeters in length, crossing each other in the greatest confusion. Even among these coarse masses, where the conversion and disappearance of the dunyte seems complete, a few grains or small bunches of unaltered olivine may be sometimes found in the interstices, on a fresh fracture of the rock.

3. Talcose. The development of the talc-scales throughout a dunyte is brought about in two ways: by the conversion of the olivine-grains, partially or completely, into talc, which either envelopes them as a microscopic crust, with an ochreous core (*i. e.* the separated iron-oxide), or has crystallized out in scales among the interstices of the olivine-granules; or again, by the alteration of the actinolite-fibres and grains into talc, which is then seen as fibrous pseudomorphous films or scales within the cleavage-planes of the actinolite, or entirely replacing it. The process has often attacked the rock in both ways in the same mass, and has resulted in the production of talcose dunyte, talcose actinolitic dunyte, talcose amphibolytes and actinolitic steatyte and talc-schists. One novel variety is a white granular steatyte, in which the granules are pseudomorphous after those of the original olivine, a rock often denominated a "white serpentine."

4. Ophiolitic. In this common process, well shown near Bakersville, Webster, etc., the olivine has suffered alteration in

exactly the same way as that fully studied and described by Zirkel and others in the chrysolitic lavas, etc., of numerous foreign localities. All the transition-varieties occur in abundance, from that in which the serpentine is diffused among the olivine-granules, merely as a minute fibrous network, or as films enveloping olivinec-ores — to that in which only minute particles of olivine survive as the nuclei of the granules — and to the final result of a true and complete serpentine, always, however, granular in structure, and often retaining the original lamination. The serpentine is also generally found in such localities as a vein-deposit, *i. e.*, white or greenish marmolite, filling or lining the fissures of the rock, or occupying branching contraction-cracks throughout the mass. The talcose alteration has generally progressed more or less in association with the ophiolitic, and then a talcose serpentine has resulted, rich in disseminated scales of talc and hematite (göthite?). It is in such serpentines that bronzite is found, in brilliant bronze-colored scales, two to three mm. in diameter.

5. Dioritic. The last and perhaps most interesting alteration of all, confined to a single locality, consists of an internal conversion of the olivine into amphibole (a bright, grass-green variety which Dr. Genth has identified as smaragdite or kokscharoffite) and albite, sometimes with abundantly disseminated particles of ruby red corundum, producing a peculiar variety of dioryte or gabbro.

Again, this very rock has been subsequently attacked by a secondary process of alteration, the albite-grains being enveloped by an alteration-crust of margarite, and the condition of the hornblende modified. The result of this action is a coarse margaritic gabbro, whose weathered surface is peculiarly rough and warty.

On the whole, it appears that the view which has been suggested,[1] founded on certain phenomena observed in the corundum-veins, that these secondary rocks and many schists have been mainly derived from the alteration of corundum, finds not the least confirmation from my studies, and is, indeed, strongly contradicted by facts observed in the field. The corundum itself is in all cases, both in the veins and the particles found in the gabbro a secondary or alteration product. All the phenomena of altera

[1] F. A. Genth, loc. cit., 31, 45.

tion, both in the veins and rock-masses, absolutely require, and can be simply explained by the introduction of a solution of soda and alumina into the fissures and interstices, during the period of alteration and metamorphism. The combination of soda with silicates of aluminum and iron, perhaps previously formed, has produced all the minerals of the vein-series; while the precipitation of the alumina naturally ensued from the separation of its alkaline solvent. The question then presents itself of the evidence of the introduction of such a solution. This is found in the strata of hornblende-gneiss, which everywhere surround the dunyte-beds, and are abundantly traversed, all along the dunyte-belt, by the huge veins of endogenous granyte, now largely exploited to supply mica for commercial purposes. Into these there has certainly been an introduction, by subterranean thermal solutions, of soda and alumina, as shown both by the development of a long series of crystallized mineral-silicates, containing those with other elements, and elsewhere even by the precipitation of corundum itself (in association with muscovite, margarite and albite), in a certain class of small veins in the gneiss, of limited occurrence but great interest.

It is a natural enquiry, whether there is any evidence of the former occurrence of dunyte at other points along the Appalachian belt between North Carolina and Canada? Of this I have no doubt. The actinolytes, amphibolytes and hornblende-schists, as well as many of the steatytes, talc-schists and serpentines, which occur all along to the northward throughout these Montalban rocks, are in many cases, I believe, the equivalents, usually more crystalline, of their southern congeners.

The question of the origin of the olivine in this concentrated form has been met by three hypotheses:

First, that the material is of an eruptive origin.

Secondly, that it is a chemical precipitate.

Thirdly, that it is a mechanical accumulation, in the form of ancient olivine-sand.

It has already been briefly indicated that both the petrographical and lithological phenomena observed present, in my opinion, insurmountable objections to the first two hypotheses. It remains then to suggest the source from which such olivine-sands have been derived. Doubtless from some ancient terrane, perhaps of lower Laurentian age, of chrysolitic lavas or gabbros, now worn down and buried beneath the later sediments, beyond our view. Olivine-sands, it is true, are of rather rare occurrence at the present time, but only because the chrysolitic rocks are rarely found on the present seacoasts. Such sands do occur in abundance, however, at the Hawaiian Islands, at the foot of the congealed streams of chrysolitic lava which have flowed down to the seashore. Aside from the dunytes, there are few rocks, capable of yielding olivine-sands, which now happen to be exposed over the territory east of the Mississippi River. However, the number of these, constantly increasing with closer observation (*e. g.*, the huge, erupted masses of chrysolitic rocks near Montreal, and elsewhere in the Province of Quebec, the chrysolitic iron ore of Rhode Island, the chrysolitic hornblende and pyroxene rocks of Cortlandt, New York, the olivine-gabbros of Wisconsin, etc.), all imply that olivine formed by no means an unimportant constituent in the rocks of Archean Age and therefore in the beach-sands of those ancient shores.

The President gave an account of a trip to Colorado last June; most of the time was spent at Fairplay, but two or three days were devoted to Florissant. Two new species of fossil butterflies were found.

The age of the fossiliferous beds at Fairplay was the particular object of study, as Mr. Lesquereux had maintained that the plants were Permian, while the speaker had concluded the insects indicated a Triassic Age. This view seemed to be seconded by the collection made the present season. Among the finds at Florissant was the stump of an ancient Sequoia 44 ft. in circumference.

General Meeting, December, 20, 1882.

The President, Mr. S. H. Scudder, in the chair. Seventy-eight persons present.

The President introduced Miss Alice C. Fletcher, who gave an account of the celebration of the "sun dance" by the Ogallala Indians.

Dr. C. S. Minot made some remarks on the phenomena of growth in man, the rate of which he showed by plotting a curve of "first differences." In such a curve extending from six to eighteen years of age, two slack periods of growth, at seven to eleven years, were noted.

The Curator called attention to a fine cast of the Pterodactyle, Rhamphorhynchus, the original of which from the Solenhofen slates is the property of Prof. O. C. Marsh, by whom the cast was presented to the Society.

A vote of thanks for the gift was unanimously passed.

Section of Entomology. December 27, 1882.

Mr. George Dimmock in the chair. Ten persons present.

The following paper was read:

CONTRIBUTIONS FROM THE NORTHERN TRANSCONTINENTAL SURVEY.

The genus Colias.

BY DR. H. A. HAGEN.

American lepidopterologists have worked on the North American species of Colias only during the last twenty years. The only exceptions known to me are the short notice on C. philodice in Harris Injur. Ins. and A. Fitch, notice of the species of Colias in New York in his Insects of Algiers, 1853. (Trans. N. Y. Agric. Soc. Vol. 13.—separ. p. 9–11.) This short notice is rather vague in its statements, and has been criticised by Mr. Scudder.

Mr. S. H. Scudder published an elaborate paper, 1862, describing three northern species; and later a fourth one. Mr. W. H. Edwards published, 1863, three new species and in the following years seven; two of them now considered by him as synonyms. Mr. Reakirt described one species. A very elaborate paper by Mr. H. Edwards was published in 1877. In the meantime Mr.

W. H. Edwards had commenced the publication of his splendid Butterflies of North America, which now contains the figures of 13 species out of the 23 accepted by him in his last synopsis.

Notwithstanding all the valuable work mentioned the genus Colias is still a stumbling block for entomologists here and in Europe. Though formerly a large part of the North American species was considered to be identical with European species, this has been strongly denied in later times.

The breeding of C. Eurytheme and its related forms by the late J. Boll in Dallas, Texas, has been the first step to a better knowledge and to a scientific reduction of the species of Colias. Mr. J. Boll had raised C. Eurytheme through two years, 1874 and 1875, and had sent in the summer of 1876 his paper accompanied with numerous specimens to Hamburg. The paper was read at the meeting of the Association of Naturalists, Sept. 20, and printed directly in the Tagblatt, p. 176-199. (See Zool. Record 1876, p. 146.) The paper has been reprinted twice, in Verhandl. naturw. Unterhalt. Hamburg, 1878, Vol. III, and in Deutsche entom. Zeitschr. Berlin, 1880, Vol. XXIV, p. 241.

The excellent paper by Mr. W. H. Edwards, N. A. Buttfl., Vol. II, was the result of similar experiments by N. Am. Lepidopterologists. But it should not be overlooked that all those experiments were made only in N. Texas, in Illinois and Nebraska, and that we know the changes of C. Eurytheme only for these regions. The experiments will have to be repeated with the same care in the west, and principally in the north-west and north, before we are sure to know all about C. Eurytheme and its related forms.

In the same number with C. Eurytheme Mr. W. H. Edwards published his observations on C. Philodice. This excellent paper, though chiefly based upon experiments in West Virginia is very remarkable and should indeed be considered as the standard for the work on all other species of Colias. It is probable that similar experiments on C. Philodice in the north-east and north will considerably enlarge our knowledge. The experiments made in Virginia show from Mr. Edwards explicit statements (p. 5. of the text) that not one of the characters is constant. Nevertheless just the same characters are the only ones used by him and others to separate the larger number of all American Colias. A careful study of his statements about C. Philodice apparently justifies the doubt if other species, some described after a few specimens, are to be accepted as reliable species, the more so when females are considered as belonging to males, only for the reason that they arrived in the same lot. The most carefully worked out species, C. Philodice and C. Eurytheme, are so nearly related to each other that obviously reliable differences are still a want.

Colias Edwardsii.

C. Edwardsii (Behr in lit.), W. H. Edwards, Tr. Ent. Soc. Phil. III, p. 11, Jan. 1870.—N. A. But., Vol. I, no. VI. August, 1870.
C. Edwardsii, Mead, Wheeler's Expl. Vol. V, p. 749.—1875.
C. Edwardsii, H. Edw. Proceed. Calif. As. Feb. 1877.—separat. p. 10.
C. Edwardsii, Bull. Brookl. Ent. Soc. Vol. I, March 1879. No. 11. Synopt. Tabl. no. 6.

The species was described from one male and two females, taken near Virginia City, Nev., at high elevation, in the collection of Dr. Behr. The figures in N. A. Butt. No. VI disagree with the description in having the secondaries greenish instead of pale yellow in figs. 2 and 4, and in having the fringes in figs. 1 and 2 throughout strongly pink, instead of "yellow on the secondaries, and at and above the inner angle yellow on the primaries." Both characters are of importance for the comparison of C. Edwardsii with C. Alexandra.

The following remarks are made from 129 specimens collected in Oregon and Washington Territory; some were identified by Mr. H. Edwards as the true C. Edwardsii.

Male.

I have separated the 83 males in several series representing certain differences. The discal spot of the secondaries is wanting (as given by Mr. Edwards) in 29, present in 54; but among the latter 14 show all intermediate forms of a more or less obliterated discal spot.

The black marginal band of the primaries, measured in the middle of its length, is from 1.5 to 4 millim. broad; its average breadth is from 2 to 3 millim. The inner edge of the band is regular or strongly erose, with all intermediate forms; its spur is excavated or attenuated, short or long, broad or narrow; near the costal margin the band ends abruptly. The black marginal band of the secondaries varies in the same manner; it ends commonly at the lower median vein, or a little before, but sometimes advances farther, near to the hind angle. Both marginal bands are cut by yellow veins, either entirely or nearly to the fringe, or only the inner half of the band.

The discal spot of the primaries is circular or ovate, or a small streak or irregular; black or yellow within, sometimes yellow surrounded by a very faint black ring, which can be obliterated except on its upper and lower part. One third of the males have the discal spot marked within yellow, sometimes only on one wing. The fringe is roseate mostly on its external half, more or less, and in some specimens entirely yellow. The main color of the wings is bright lemon-yellow; the secondaries have a greenish tinge on the inner half or none. The outer half shows often a shade of a deeper yellow than on the primaries, sometimes with an orange tinge.

The color of the underside of the secondaries is greenish or yellow, more or less sprinkled with black scales. In some of the greenish ones, when examined with a stronger lens, the green disappears; as the black scales covered by paler ones make it appear a green tinge. Therefore older, rubbed specimens which have lost the superficial cover of the paler scales, appear darker and sometimes blackish. In specimens where the main color of the underside of the secondaries is decidedly yellow, the black scales are less numerous. All intermediate shades occur between such males and those with a pale greenish main color, even in freshly exclosed specimens.

A pink spot at the base of the secondaries on the underside is visible on 12 specimens; on many others a faint trace of pink is present, but often it is wanting. The discal spot on the under side of the secondaries is very variable in size and color, white or roseate, or surrounded by a more or less dark ring; sometimes the discal spot is nearly wanting. I will speak later about the occasional appearance of a sub-marginal series more or less incomplete of ferrugineous patches, and of one at the costa. A few males have along the veins on the upperside of the primaries black scales, giving to them a faintly striped appearance.

The cut of the primaries is very variable ; generally the external margin is oblique ; in many specimens it is somewhat concave, by which the costal angle appears to be more protracted and more pointed ; 17 specimens have the external margin more or less convex and the angle rounded, which in a few specimens is exaggerated. The hind angle of the secondaries is in one-third of the specimens more strongly produced and angular ; in some exaggerated cases this angle reaches 100°. The collar of some specimens is pink, the other ones show all intermediate shades to yellow.

The size of the males varies in expansion of the wings from 60 to 43 millim. ; the average size is about 55 millim. ; five specimens (dwarfs) are 46 to 43 millim., one of them was caught copulated with a large female.

Female.

I have before me 46 females from Oregon and Washington Territory, six of them caught in copula. Only two are white, five more whitish than yellow, five pale yellow, the other ones lemon-yellow as the males. The primaries have a broad incomplete marginal band of black scales, which mostly does not reach the edge ; it is expanded in a larger patch near the costa, and reaches the hind angle in some specimens. The submarginal band is followed in half of the specimens by a similar but narrower internal band, which reaches or not the hind angle. The submarginal band in one-third of the specimens has prolongations along the veins to reach the inner band, and so to form more or less well enclosed yellow (in one specimen white) spots. In some specimens such prolongations are sent out, where no inner band exists. The secondaries in eight specimens have a faint marginal band of black scales, reaching the outer angle. The wings of two specimens, one of them white, have no marks at all. The discal spot of the primaries is similar to that of the males ;

large or small, rounded or angular or a streak, black or yellow in the centre, or yellow with a darker ring around, even only with the remnants of a ring. The discal spot of the secondaries is an orange spot or ring, and is large or small, in five specimens entirely wanting. The underside of the wings is similar to the male; the green of the secondaries is more grayish, rarely yellowish green; the discal spot is surrounded or not; the pink basal spot, when present, is very small. The expansion of wings varies from 65 to 47 millim., the average size is 54 millim. The cut of the wings differs as in the males. Some, which have to be mentioned later have the hind angle only 90°; these wings appear to be shorter and broader. The outer angle of the secondaries is sometimes produced and angular.

In C. Edwardsii, as in most species, occurs on the underside of the wings in some specimens a series of faint submarginal brownish spots and a larger dash on the costa. Seven specimens have such a series more or less complete and faint; sometimes very few spots or only on one wing are present; three have a second spot above the discal spot. Six from Umatilla, Yakima, Klikitat, have the brown dash near the outer angle more or less visible, but the submarginal spots very faint, sometimes only one; two of them have a second spot above the discal spot. The females are alike in varying. Of the six couples collected in copulation of one the male is Philodice the female Edwardsii. Another pair show the male without, the female with submarginal spots, and a third pair in just the reverse. The brown dash is to be seen on three females and in some others only indicated.

All specimens were collected from June 24 to July 26, at Umatilla, Or., and in Washington Territory, east of the Cascade Mountains along the Yakima River to 6000 ft. elevation, and in July at Spokane 4900 ft. and higher in Colville Valley. In June the specimens were freshly developed and probably belonged to a second brood, as a few old and very worn males of a former brood were still alive. In Colville Valley only the remnants of the summer brood were observed. The species is very common at Umatilla.

Mr. H. Edwards (in Mr. Mead's Rep., Wheeler Surv., Vol. v, p. 491) states, that near Virginia City, Nev., this species flies very wild, appearing at the beginning of April and lasting to the end of June, but is a decidedly rare insect. This would represent the spring brood. In the Brooklyn Bull. the species is recorded from Utah; Mr. Mead quotes it from Owen's Lake, Cala.

Colias Alexandra.

C. Alexandra. W. H. Edw. Proc. Ent. Soc. Phil. II, p. 14, pl. XI, fig. 1-3, 1868.
N. A. Butt. Vol. I, Colias I.
Reakirt, Proc. Ent. Soc. Phil. VI, p. 135.
Mead, Wheeler's Rep. V, p. 749.
H. Edwards, Colias, p. 10 (Calif. Acad. 1877).
Brookl. Ent. Soc., Jan. 1879.
Strecker, Butt., p. 81.

There are before me a male and a female named by Mr. W. H. Edwards, 7 specimens from Ft. Hays, Kansas 2000′, June 12 to 27, and 3 specimens from Montgomery, Col., 11,000 ft., all collected by Mr. J. A. Allen, and one type from Colorado by Mr. Reakirt. About a dozen more have been communicated to correspondents. The species was not rare in these localities in 1871.

Messrs. Reakirt, H. Edwards, Strecker, and the author of the paper published by the Brooklyn Entom. Soc., suppose that C. Edwardsii may prove to be a variety of C. Alexandra. The most careful examination of the text and the figures in N. A. Butt. Colias I, and the specimens show no difference of any importance. The characters given by Mr. W. H. Edwards are the greenish tinge on the inner half of the secondaries; fringe yellow; primaries with a broad black band; no pink tinge at the base of the secondaries below; discal spot of same wings below silver-white, without a border.

A comparison of the characters given above for C. Edwardsii will show that they contain every one considered as peculiar to C. Alexandra. The size and the cut of the wings vary in the same limits. Therefore C. Alexandra and C. Edwardsii belong to one and the same species. C. Alexandra is said to have only one brood in the season; but with the single exception of Ft. Hays it is observed on considerably higher elevations than C.

Edwardsii. The young larva (Mr. Mead) closely resembles that of C. Philodice. The eggs of C. Alexandra, presented to the Museum by Mr. Mead, are similar to those described for C. Philodice. The food plant sent by Mr. Mead is Astragalus plattensis Nuttall, from Mr. L. Lesquereux's determination.

Colias Emilia.

C. Emilia W. H. Edwards, Trans. Ent. Soc. Phil. III, p. 12. Jan. 1870.
H. Edwards, Colias, p. 10 (Calif. Acad. 1877).
Brooklyn Ent. Soc., March 1879.

The species was described from one pair taken in Oregon, in the collection of Dr. Behr. Of C. Edwardsii it is stated "this species is near Emilia" and of C. Emilia, "this species resembles C. Alexandra, from which it differs in the breadth and form of marginal borders, in color of fringe, in discal spot of secondaries beneath, in the presence of a pink spot at base, and in the absence of greenish shade to both surfaces. It also differs from any Colias with which I am acquainted in the shape of the hind wings, which are remarkably produced at outer angles." W. H. Edwards.

Among the C. Edwardsii males and females from Oregon and Washington Territory are specimens with more or less produced outer angles of the secondaries. They form an uninterrupted series from rounded corners to angles of 95°. One of those examined by Mr. H. Edwards was declared to be a doubtless C. Emilia. A careful comparison of the descriptions of C. Emilia and C. Edwardsii shows the following differences; those of C. Edwardsii are put in brackets.

Male. Black band of primaries cut to the edge by the yellow nervures [nearly to the fringe]; erose within [inner edge nearly regular]; a slight excavated spur on the inner margin [a short, attenuated spur]; discal spot yellow edged by black [black]; underside on costal edge deep pink [roseate]; secondaries below inclining to buff [ground color very pale yellow]; at base a small pink spot [a small roseate spot]. By comparing these differences with the range of variation given above for C. Edwardsii, no one will doubt that both belong to one and the same species. I have to add that two C. Alexandra before me have produced outer angles of about 100°. Mr. H. Edwards states, p. 10, "described from a single male (female not mentioned) in Dr. Behr's collection. The wings are remarkably angular about the middle, and the marginal border follows the shape of the wing. In other respects it resembles C. interior, and may be a form of that species."

The female type seems no longer to be in Dr. Behr's collection. The short description by Mr. W. H. Edwards contains nothing which would help to separate C. Emilia and C. Edwardsii.

Colias Astraea.

C. Astraea W. H. Edw. Trans. Ent. Soc. Phil. IV, p. 61. 1872.
H. Edw. Colias p. 7 (Calif. Acad.).

This species was described from a single male, antennae wanting, taken near Yellowstone Lake by the Hayden Expedition in 1871. "On the underside this species is nearest Alexandra, on the upper of a different shade of color from any of our species." This different shade is as follows: "Upperside pale ochraceous, *very little* tinted with orange on disks of secondaries from cell to marginal border and from base to base to hind margin of secondaries below cell, *this color being not decided but only a tint.*" All the rest of the description agrees with C. Alexandra and with some specimens of C. Edwardsii. Mr. H. Edwards examined *two* males from the Yellowstone region in Mr. W. H. Edwards' collection, and says "it is singularly distinct in color from any other known Colias, being a pale buff, rather than yellow proper."

I have submitted to Mr. H. Edwards a female of C. Edwardsii from Washington Territory with similar color, and he decided that it was much like C. Astraea. Now this color was prepared purposely. When the specimen was taken, it was put in a freshly prepared cyanid bottle, which was still damp inside, so that both hind wings were thoroughly wetted. The supposed change in the color appeared after the specimen had become dry. I suggested the same reason for the color of C. Astraea, but Mr. W. H. Edwards objected decidedly. I have even more reason to suppose that the specimen had not the natural color, as I had sent to Mr. W. H. Edwards a few Colias from the same expedition and locality, which came with Neuroptera and other insects by chance in my hands. I made excuses for sending the specimens in bad condition, and was answered that these Colias were *especially interesting* to him. As no other species is mentioned by him from Yellowstone I always believed them to be C. Astraea, but I am informed by him that this is not the case. I would remark that a number of insects of this expedition arrived infested with pests and were treated by myself with benzine. As the specimens were not spread, I could not observe the color. The change of yellow by cyanide is long known, but Mr. W. H. Edwards denies strongly the possibility for this specimen. That benzine changes yellow I have learned only later through experiments made for this purpose. Specimens of Colias stained by chance with human blood — I have before me a specimen taken with fingers just before pricked by thorns — show on both wings corresponding spots, which are even with the microscope difficult to be recognized as artificial. That may be as it is, the time is past when such very insignificant characters are accepted as sufficient to characterize a species. Until more important characters are given, we have to rely upon the description, which is in no way sufficient to separate C. Astraea from C. Alexandra and C. Edwardsii.

Colias interior.

C. interior. Scudd. Proc. B. S. N. H., IX, p. 108, 1862.
H. Edw. Colias, p. 10 (Calif. Acad.).
Brooklyn Ent. Soc. March, 1879.

I have before me four males (types) and the female type. Two of the males and a third in Mr. Scudder's collection are from the Portage at the rapids near the mouth of the Saskatchawan River and these three are all the types collected by him (Mr. Scudder informs me). Besides those are two males and one female (one male from the collection of the Bost. Soc. Nat. Hist.) from the northern shore of Lake Superior, from Prof. L. Agassiz's expedition. According to a memorandum in his copy of his paper Mr.

Scudder afterwards received for examination a specimen from Moose River by Mr. W. H. Edwards, who also notes C. interior taken in Vancouver's Island by Mr. Crotch, Tr. Ent. Soc. Phil. v, p. 15.

Mr. Scudder's description, which I have most carefully compared, is thoroughly exact in every detail. The only addition to be made is the existence of a small pink spot on the base of the underside of the secondaries in all males and the female. I feel myself obliged to state that I owe to the study of Mr. Scudder's excellent paper — it was his first scientific paper — and to the sound philosophical views contained in them important information.

The males of C. interior agree in size, in color and pattern with the specimens of C. Edwardsii which have the discal spot of the primaries more or less rudimentary and the secondaries below yellow. I have similar specimens from Washington Territory before me. One of the male type has the marginal band of the primaries larger, and its inner edge varies between erose (see Mr. Scudder's figure) and more regular. The discal spot of the primaries is wanting in one male. Concerning the female, which is much rubbed, I possess similar ones but with a more yellow tinge from Colville Valley. The cut of the external margin belongs to the form of C. Edwardsii with a more rounded costal angle of the primaries, followed by a more convex margin; but two of the types have the margin less convex, nearly oblique.

Mr. Scudder has objected to the identity of C. interior with C. Pelidne Bd-.Lec. p. 66, pl. 21, f. 4, 5, and Bd. Icon. p. 41, pl. 8, fig. 1–3. Plate 21 in Bd.–Lec. is apparently a rather inferior one, in comparing the fig. 1–3 said to represent C. Philodice. The figure of C. Pelidne, fig. 5, fails to agree in two characters with the description — discal spot papillé de rougeâtre et un point rougeâtre à la base ailes — and the statement "un peu plus grande que la C. Paleno, à laquelle elle resemble beaucoup." The comparison with C. Palaeno is misleading and the statement that the discal spot of the primaries below is "rougeâtre" and of the secondaries "rouge au lieu d'être d'un blanc argentin, surmonté dans le male d'un autre point semblable, mais beaucoup plus petit," does not agree with the types of C. interior. Boisduval gives as habitat

Greenland and Iceland, also Labrador. Iceland is certainly an error, for as yet no Diurna have been observed there.

In the Icones the old description is reprinted with new figures. The description is changed in so far as it says: C. Pelidne has "quelques rapports" with C. Palaeno. The small spot near the discal one is sometimes wanting; the primaries of the female are a little blackish on tip, with a sinuous interior band, often very feeble, of the same color. Among the localities Greenland is dropped, but Siberia and Kamtchatka added. The figure cannot have been made from the same specimen as before, as the cut of the wing is different, here very convex on the margin, and the coloration of the underside of the secondaries is intensely green, similar to Palaeno. The female resembles C. interior, but does not belong perhaps to the figured male. It is possible that some difficulty in recognizing Boisduval's species is due to the colorist, as different copies show a different coloration. Werneburg, Stett. Ent. Z. 1865, p. 287, says: The underside in C. Pelidne Boisd. Icon. pl. 8, f. 2 of the male is yellowish as in Palaeno, though the typical C. Pelidne has decidedly a more greenish-yellow underside. Now in my copy the same fig. 2 is dark grass-green colored.

After all I believe Mr. Scudder is right in accepting C. interior as different from Boisduval's figures, and I think the name C. interior should be retained, unless the types now in Mr. Oberthur's collection should prove the identity with C. Pelidne Bd. The name of C. Pelidne I adopt till this is proved for Staudinger's species.

The description in the Brooklyn Bulletin differs, perhaps partly by typographical errors. As habitat is given Ontario, Quebec, British America and Alaska. Mr. W. H. Dall, Alaska p. 587, quotes C. interior from Ft. Yukon, June 25. Cf. Scudder, Ent. Notes, II. 44. Mr. H. Edwards after comparison of a type of C. interior states that in his collection are two specimens from Soda Springs, Cala., and from Labache, Br. Col. Apparently Mr. H. Edwards is right when he states C. Emilia may be a form of C. interior, which it resembles, except the angular production of the secondaries. There is no possibility of separating C. Edwardsii from C. interior.

C. Scudderi.

C. Scudderi. Reakirt, Proc. Ent. Soc. Phil. IV, p. 217. 1865. — VI, p. 136.

W. H. Edw., N. A. Butt. Vol. I, Col. 8.—Canad. Entom. XIV, p. 56.—Trans. Ent. Soc. Philad., v, p. 14.
H. Edwards, Colias, p. 10, (Calif. Acad.).
Strecker, Amer. Macro-Lep., p. 81.
Mead, Wheeler's Rep., v, p. 749.

I have before me some pairs determined by Mr. W. H. Edwards; they belong to a large lot collected by Mr. J. A. Allen, 1871, July 9 to 25 in the Colorado Mountains, some at Montgomery above 11,000 feet, males and white females, no yellow female among them; a white female from Dakota, collected by Dr. Mark.

Mr. Strecker has first put C. Scudderi as a synonyme of C. Pelidne. In comparing the figures and descriptions of Mr. Reakirt and Mr. W. H. Edwards no difference whatsoever is shown to exist. The figures of C. Scudderi look at first different in the discal spots, which represent large black blots. Apparently the silver in the red wing is changed to black, as is mostly the case when the silver is not perfectly pure and comes in contact with colors containing cinnabar. I wish to draw attention to this fact as also in other figures; for instance C. occidentalis and the four species of Argynnis in the first part show the silver spots more or less changed into black blots.

The description of Mr. W. H. Edwards omits to state, that the wings above are strongly powdered with black at the base of both wings and along the inner margin of the secondaries, a character well represented in the figure. For the female the description and figure are equally insufficient; no one will be able from them to separate the yellow female of C. Scudderi and C. occidentalis.

The range acknowledged for C. Scudderi by Mr. W. H. Edwards is through the whole of Arctic America from Hudson's Bay (Canad. Entom. XIV, p. 56) to Lake Labache, Br. Col. Mr. W. H. Edwards says probably, Mr. H. Edwards undoubtedly, C. Scudderi, and the latter statement is true, as I have three males collected by the late Mr. Crotch in this locality. Mr. W. H. Edwards had only three white females. The female from Dakota proves that the species flies also in large tracts of land between the far east and west. That it appears in the higher mountains of Colorado and is common there is by no means a surprising fact. The specimens before me vary in the cut of the primaries rounded or not just as other species.

Colias Christina.

C. Christina. W. H. Edwards, Proc. Ent. Soc. Phil. II, p. 79, 1863.—N. A. But. Vol. I, Colias II.
H. Edwards, Colias, p. 6. (Calif. Acad.)
Brookl. Bull., March, 1879.

This species is described after 4♂ 1♀ taken at the Portage of the Slave River. That the female belongs to the male seems to be assumed merely from the fact that both arrived in the same lot. I have two females from Umatilla, Or., and Yakima, W. T., June 25 and July 5, entirely like the figured one. They were collected among numerous C. Edwardsii, and are entirely pale yellow without a border. As similar ones with a faint beginning of a border were taken in copula with C. Edwardsii, there can be no doubt that the females without border belong also to C. Edwardsii. A male from Dease Lake at the same latitude with the Portage of Slave River only a few miles farther west, proves that the species goes so far north; until a sufficient proof is given to the contrary, this female of C. Christina cannot be separated from C. Edwardsii.

The orange male of C. Christina has the primaries entirely, and the secondaries nearly, covered with orange, which is at variance with the description, "that about one half of the space inside the border is occupied by orange." Only one of the males has below a submarginal series of brown dots—as sometimes appears in C. Edwardsii. I have not seen C. Edwardsii with such an orange patch, but as similar varieties are recorded for Palaeno from Greenland by Scoresby, for Pelidne from Labrador by Moeschler, for Philodice by Mr. W. H. Edwards, there is no improbability that some may exist of Edwardsii. It would certainly need a stronger proof to consider those males of Christina as a separate species, the more so since they are associated with an undoubted female of C. Edwardsii.

Colias occidentalis.

C. occidentalis. Scudd. Proc. B. S. N. H., IX, p. 109, 1862.
W. H. Edw., N. A. Butt. Vol. I, Colias 7.— Can. Entom. Vol. XIV, p. 56.
H. Edw., Colias p. 9. (Calif. Acad.)
Brooklyn Bull., Jan. 1879.
Strecker, Amer. Macrol. p. 82. Philodice var. e.

In the collection of the museum are one male and two females of Mr. Scudder's types; all collected by Mr. A. Agassiz, May 16, near Port Townsend, Wash. Terr., Gulf of Georgia. Mr. Scudder states he compared two males and three females, among them some from Fort Simpson communicated by Mr. W. H. Edwards. None of the types is in Mr. Scudder's collection, as he has informed me; so the specimens not here are probably those communicated by Mr. Edwards. Mr. Scudder has not seen the yellow female.

As I stated under C. Scudderi the yellow female of this species and of C. occidentalis do not show in the figures and description of Mr. H. W. Edwards any difference whatsoever, and must be considered as identical till information is given which would justify Mr. Edward's views.

The white female is described by Mr. Scudder and figured by Mr. W. H. Edwards. His description is only "upper side greenish white, secondaries with a broad border enclosing whitish spots as on primaries." It would be impossible to form an opinion from this description, if there were not the type before me, which agrees exactly with Mr. Scudder's very detailed description. There is no doubt that these white females belong to C. eurytheme. Mr. Agassiz has collected on the same day and place one male of C. occidentalis, numerous males and females of C. eurytheme and two white females. The last are a little paler than commonly and the black bands and marks more grayish. I have before me similar females from Colorado, which I sent years ago to Mr. W. H. Edwards, to get his opinion about it, and the label "Eurytheme, white female," in his handwriting is still on the pin. Another similar female, also collected together with numerous specimens of C. eurytheme in Oregon is before me. The more yellowish tinge especially of the underside is not an objection to my determination. I possess a large white female of C. eurytheme from Texas which has the secondaries yellow above, and both wings with a yellowish tinge on the underside. Unfortunately the figures of C. occidentalis in N. A. Butt., Vol. I, Colias VII, do not agree with the description (here also the silver discal pots are black blots) in some characters.

In comparing the detailed description of the white female by Mr. Scudder, with which his types agree perfectly, with Mr. Edwards' figures and descriptions of C. occidentalis, it is evident that the latter's specimens do not belong to Mr. Scudder's species, or else that his figures and descriptions are insufficient. There is nothing in the figure or description of the yellow female different from C. interior (Edwardsii). I possess a male of this species from Dease Lake, only a few miles distant from Fort Simpson, and as no warrant has been given that the yellow female belongs to the male except that they arrived in the same lot, this female has to be considered as C. interior. The white female is C. eurytheme, which flies at Port Townsend also together with C. occidentalis male, which last is synonymous with C. Scudderi. I have to remark that one of the three males from Lake Labache shows (like Mr. Edwards' specimens) the obsolete submarginal series of ferrugineous patches and the larger patch on the end of the costa.

According to Mr. W. H. Edwards, Canad. Ent. XIV, p. 56, he saw a couple of C. occidentalis from Hudson's Bay.

Colias Harfordii.

C. Harfordii. H. Edwards, Colias p. 9 (Calif. Acad. Febr. 1877), male.

C. Keewaydin. W. H. Edw., N. A. Butt., Vol. I, Colias IV, fig. 7, male.

C. Barbara. H. Edw., Colias p. 7 (Calif. Acad. Febr. 1887) female.
Brooklyn Bull., March 1879, female.
Canad. Entom. XIV, p. 56.

In the eastern part of Washington Territory were collected in Colville Valley, together with some C. Edwardsii, four males and five females, July 23 to 25, half of them old rubbed specimens. Mr. H. Edwards recognized instantly that they belong to his C.

Harfordii and C. Barbara, which two species were shortly before by him and Mr. W. H. Edwards declared to be male and female of one and the same species. All his specimens are from California. None of his nor mine were taken in copulation. Besides those before mentioned, Mr. H. Edwards recognized a female from Squaw Creek, W. T., in the middle of the Deserts, July 16, as also the typical C. Barbara.

These specimens indeed make a different impression from the numerous C. Edwardsii by the more or less rounded external margin of the primaries, and the very faint discal spot. The females of the same size, 51 millim. exp., are yellow, half of them with a very incomplete black border of the primaries, sending out prolongations along the veins, and two showing an indication of an inner band. The cut of the primaries of the type and of most of the specimens from Colville Valley is peculiar; the external margin more convex, the hind angle less obtuse, in one only a little more than 90°. Only one has the wings of the common shape.

A detailed comparison with Mr. H. Edward's descriptions shows that all males have no indication of a row of submarginal dots below. No other difference is shown.

A very close examination of the specimens shows that they can not be separated from C. Edwardsii except as a somewhat extravagant variety connected to the type by intermediate forms. The type male of C. interior from Lake Superior in the Bost. Soc. Nat. Hist. represents the type of C. Harfordii. The facies of the specimens reminds one by the cut of the wings of C. Philodice.

Colias Laurentina.

Eurymus Philodice var. Laurentina Scudd. Proc. Bost. Soc. Nat. Hist., Vol XVIII, p. 181.
H. Edwards, Colias p. 7. (Calif. Acad.) — Brookl. Bull., March 1879.

Of this very interesting form 39 specimens were collected at Cape Breton, N. S., in July by Mr. R. Thaxter. Two pairs of the types are before me. The specimens of 44 millim. exp. have entirely the appearance of a dwarfed edition of C. Harfordii. The marginal black band of the primaries of the female is larger than in the typical C. Barbara, but one of the females from Colville Valley is nearly like it. Mr. Scudder remarks very justly that the specimens can not belong to C. Pelidne and brings them as variety to Philodice, with which I would directly agree, except for the impossibility to separate it from C. Harfordii. Mr. H. Edwards considers them to be a species, as also the author of the Brooklyn Bulletin. Mr. W. H. Edwards in his Synopsis (1882) has placed C. Laurentina as var. of C. interior. C. Harfordii and C. Laurentia seem by the shape and color of the upperside to be nearly related to C. Philodice, but otherwise to belong to C. Edwardsii = C. interior. Till the contrary has been proved, they should be so placed.

Colias Philodice.

Fifty specimens selected out of a much larger number for the collection of the Museum represent the Atlantic States from Canada to Maryland; the northern border to Michigan and to West Dakota; and in the interior, Missouri, Kentucky, West Virginia, Kansas, Texas. Some are determined by Mr. W. H. Edwards. From Dallas, Texas, Mr. Boll had sent six specimens with the note "some collected in March, the other larger and more common in September and October." Those specimens have been examined by Mr. W. H. Edwards; two small males are marked in his handwriting var. Philodice; the larger ones ♂ ♀ differ in nothing from the larger Philodice; the smaller ones ♂ ♀ have a narrower marginal band of the primaries and mimic well C. Ariadne. Mr. Reakirt, Proc. Ent. Soc. Phil. Vol. IV, p. 218, has given a detailed description of C. Philodice and varieties.

Mr. W. H. Edwards has published (Vol. II, N. A. Butt.) a very elaborate and excellent paper about this species. The exposition of the numerous variations in color and pattern is decidedly exhaustive. In an equally detailed paper on C. eurytheme in the same volume he comes to the conclusion, that both species have exactly the same variations and only differ by color. "The larvae are scarcely, if at all distinguishable in the earlier stages, and in the later are often just as much alike." If those two papers are to be considered as the standard from which all the other described species have to be judged — and they merit fully this preference — it is directly obvious, that a large number of species, formerly accepted by the same author, must be considered as mere varieties or even less. At least it is precisely the reiterated and careful study of these two papers that has induced me to make the numerous reductions in the present paper. Nevertheless it is fair to state, that Mr. Edwards is of an entirely different opinion. Only three months ago in a letter concerning my views he stated : "My experience with Philodice leads me to believe that there is not and never was any connection between Philodice and Eriphyle [but Trans. Ent. Soc. Phil. v, p. 15, he has named *himself the same specimens Philodice*, which he describes, p. 202 same volume as Eriphyle] or Occidentalis or Chrysomelas or other of the American species. If Philodice ever had a close connection with any other, that one was Eurytheme to my mind, but I don't assert it, for it can't be proved, and it is useless to add one more to the heap of guesses."

Apparently he has forgotten that he persistently separated Eurytheme, Keewaydin and Ariadne as different species, till the late Mr. Boll proved that all three belong to the same species. Here certainly it was proved by breeding through two years, and the suggestion that the same will happen for other species, therefore, cannot be considered to be a useless guess. Such spurious species based upon one, or three or a few more specimens, even without any reliable proof that the males and the females belong together, must be rejected by science as long as their validity has not been shown in an incontestable manner by equally careful experiments as those for Eurytheme. Until that has been done, one is perfectly justified to unite with Philodice, all species which have been characterized *only by differences falling in the wide range* of those given in Mr. W. H. Edwards' paper.

In the text of C. Philodice, C. Palaeno (Cramer, Vol. I, pl. 14) is quoted by Mr. Edwards as a synonyme, but this species is from the Cape of Good Hope and, doubtless as well, the female in Cr. Vol. IV, pl. 340, C. Electra L. About the identity of Philodice with C. Anthyale Hb. there can be no doubt. I have never seen so large specimens of C. Philodice as 2.6 inch (Edw.) and 2.66 (Reak.); the largest before me is 2.3 inches. I have before me a male from New York with absolutely no trace of the extra discal spots on the underside of the wings.

Colias Eriphyle.

C. Eriphyle, W. H. Edw., Trans. Ent. Soc. Phil., v, p. 202. 1876.
H. Edw., Colias, p. 7, (Calif. Acad.).
Brooklyn Ent. Bull., March, 1879.

Mr. H. Edwards has kindly labelled several of my specimens from Washington Territory, male, female and a white female, as C. Eriphyle; therefore there cannot be any question of the identity of the specimens considered here. When the characters given for C. Eriphyle are compared with the range of variations observed by C. Philodice no difference is left, except canary color (primrose H. Edwards) instead of sulphur yellow.

I have before me ten males and five females from Umatilla, Or., and Washington Territory along the Yakima river, Spokane and Colville Valley collected from June 25 to July 25, together with C. Edwardsii. The males have the black marginal band cut to the edge (just as one Philodice from Coalburgh, W. Va., presented by Mr. W. H. Edwards) or not. On the underside they represent all shades of variation of the series of submarginal brown dots, complete or incomplete, or only indicated; the brown dash on the outer angle is present or wanting. The discal spot of the secondaries is as in Philodice. Mr. W. H. Edwards states that this spot is only occasionally bright orange in C. Philodice, but among the large number before me from the Eastern States, more than half of them possess a bright orange spot.

The yellow females are similar to C. Philodice. The black marginal band is more dusted with yellow scales, but not much more than in a female from Osage, Kansas; the only white female from Umatilla was fresh colored and has the secondaries below grayish, but as the wings are still crumpled, the color may be not well developed.

Concerning the interesting question of the spreading westward of C. Philodice, I may only state, that the collection of the Museum possesses a number of typical C. Philodice collected at Osage, Kansas, by Mr. Stolley before 1861.

Colias Chrysomelas.

C. Chrysomelas, H. Edwards, Colias, p. 8. (Calif. Acad. Feb. 1877.)

This species has not been figured, but I had the privilege to see the types, and have before me a male presented to the Museum by Mr. H. Edwards. The species is described as most nearly allied to the original types of C. occidentalis of Mr. W. H. Edwards. What those types are becomes more doubtful by this statement, as the figures of C. occidentalis and the description show indeed no palpable similarity with C. Chrysomelas. The species were collected in Napa Co., Cala.

A careful comparison of the male type before me shows it to be identical with the C. Philodice collected in Washington Territory at different localities along the Yakima River. I have no female type.

In the males of C. Chrysomelas the discal spot of the primaries varies from a small dot to a larger one. I cannot find any other difference between the typical C. Chrysomelas and C. Philodice. One male presented to the Museum by Mr. W. H. Edwards from Coalburgh, W. Va., is above and below not different from C. Chrysomelas; the black marginal band is cut on both wings by yellow veins; the small discal spot is only surrounded by a very few more black scales. In consequence of this the species must be considered as C. Philodice till more sufficient information is at hand. All females of C. Chrysomelas were pale yellow, and no albino was seen.

Colias Palaeno.

The European literature is very large and can be found in the works of Ochsenheimer and Staudinger. C. Palaeno is a northern species and lives along the shore of the Baltic and in Scandinavia in swamps. More to the south and west it appears only at higher elevations in the mountains (cf. Speyer, Geogr. Verbr., Vol. 1, p. 266); Lacordaire's statement, Introd., Vol. II, p. 603, that Palaeno is common in Iceland is apparently a mistake; probably Mr. Lefebvre is his authority for this statement. C. Palaeno was first described by Uddman without name in Novae Ins. Spec. 1733, p. 28, and later by Linnaeus. He says the caterpillar lives on Pteris aquilina. Esper, Suppl. I, p. 42 in a communication from Pommerania describes the egg on Vaccinium uliginosum. The caterpillar hatches the third or fourth day and is yellow with blackish bristles, and feeds only on the plant mentioned. After the first moult they fastened themselves to the leaves for hibernation. Freyer Neuere Beitr. pl. 541, p. 98 describes and figures the full grown caterpillar. It is sea-green with a dark yellow lateral band and covered with small black dots; head small, legs greenish yellow, prolegs yellowish; spiracles below the lateral band; the body is fusiform. The caterpillar was from the Silesia Mountains, and lived on V. uliginosum, a plant also common in boreal America. The European specimens vary considerably in size. The smallest male figured by Freyer has only 37 millim. expanse; it is from the Silesia Mountains; all intermediate sizes to 60 millim. are on record. The variation in color from yellow to white for both sexes and the variation of the pattern are numerous. It has been entirely overlooked, that W. Scoresby, Journal of a voyage to the northern Whale-Fishery, Edinb. 1823, p. 424, states that C. Palaeno and Pap. (Argyn.) Dia occurred in great numbers on Jameson's Land at Cape Lister and Cape Hope July 24 (p. 188) both on the northern shore of Scoresby's Sound in the 70° 30′ Lat. on the eastern Coast of Greenland. The specimen was carefully examined by Prof. Jameson and Mr. J. Wilson and declared to be C. Palaeno with a tinge of orange on the wings. Among the plants found by Scoresby and recorded by Dr. Hooker is mentioned Vaccinium pubescens, considered as a dwarf of V. uliginosum; cf H. Hagen, Entom. M. Magaz. 1883, July No. 230, p. 42. The literature except the above quoted books is found in Stettin. Ent. Zeit., Vol. 26, p. 272, by Werneburg; Vol. 27, p. 44, by Staudinger; Vol. 31, p. 113, by Moeschler; Vol. 34, p. 157, by Schilde and Wien. Ent. Monatschr., Vol. 4, p. 329, by Moeschler.

All these papers discuss at some length C. Palaeno and C. Pelidne from boreal America; Mr. Bremer quotes C. Palaeno from the Amurland.

Of the European form, thirteen (♂ ♀) yellow and white are before me, all from the Jura and Swiss Alps. Of the N. German form I have only a colored drawing made by myself in 1830. Of the Labrador form ten yellow males and yellow and white females, all collected by Professor Packard, are before me, belonging to the collections of the Peabody Museum and of Mr. Scudder. The males expand 42 to 48 millim., one yellow female 50 millim. The cut of the wings varies as in Europe; the black marginal band is as broad as in some from Swiss Alps; those from the

Jura have it half broader. The black band is cut more or less near to the margin, or not at all. Of the European only one from the Jura has an indication of yellow veins; Herrich-Schaeffer mentions one with some veins yellow. On the secondaries below, some of the Labrador specimens have a brown dash near the outer angle, which the European ones fail to possess. The females are not different. As it is now generally accepted that the European and the American form belong to the same species, I have only to speak about the C. Pelidne Staud. and W. H. Edwards. Both authors are of the opinion that Palaeno and Pelidne are different species, at least they are quoted so in their catalogues. Both authors give C. Labradorensis Scudd. as a synonym of C. Pelidne, but the original types labelled by Mr. Scudder himself belong to C. Palaeno. Of C. Pelidne three labelled by Mr. Staudinger, and five collected by Professor Packard, ♂ ♀ all from Labrador, are before me.

These specimens agree well with the figures and descriptions by Mr. W. H. Edwards and Herrich-Schaeffer, and differ from C. Palaeno by the smaller size, exp. 37 to 42 millim., and the narrower black band, which is cut by yellow veins. But those variations are also represented in European specimens. Of C. Palaeno Dr. Staudinger says, if both fly in Labrador at the same locality, he would consider this to be a proof, that both are different species. But Ariadne and Eurytheme also fly together. That the Pelidne form has not occurred in Europe is not of importance, when we remember that Keewaydin is undoubtedly the same as Chrysotheme, and nevertheless the form Eurytheme is not developed in Europe. I agree with Mr. Schilde that for this Labrador form, if it is not a protracted and overlapping seasonal form, the name C. Pelidne can be retained as an aberration. Mr. Moeschler, Stett. Ent. Z. Vol. 31, p. 114, says: concerning the C. interior, occidentalis and Labradorensis, Scudd., I believe that the first and the last are synonymous with C. Anthyale (Pelidne, Staud.). Mr. W. H. Edwards, to whom I communicated some of the Labrador species, writes to me that he is of the same opinion, but not for C. occidentalis as the female is totally different.

Mr. H. Christoph, Stett. Ent. Zeit., Vol. 16, p. 112, states the occurrence of C. Pelidne on the northern shore of Baring's Island, Lat 74°.

Mr. Moeschler, Wien. Ent. Mon., Vol 4, p. 354, records two varieties of the male from Labrador. One has the disc of all wings orange, the other has the primaries entirely orange, and the secondaries orange on the disc; the discal spot of the primaries is black, of the secondaries very large and orange. In the Brooklyn Bulletin, March, 1879, C. Pelidne is quoted from Alaska; by Mr. H. Edwards from Alaska, Sitka and from the mouth of the Yukon river, and also C. Palaeno from Alaska.

Colias Chippewa.

C. Helena, W. H. Edw., Proc. Ent. Soc. Phil. II, p. 80, 1863.—N. A. Butt., Vol. I, Colias I.

C. Chippewa, W. H. Edw., Synops., p. 8.—Catal. p. 17. (Helena preoccupied).

H. Edw., Colias p. 11. (Calif. Acad.).

Zeller, Stett. Ent. Z., Vol. 35, p. 438.

Strecker, Amer. Lepid., p. 81.—Rhopaloc., p. 133.

The couple figured is said to be from the Mackenzie's River in the two first works, from the Great Slave Lake in the Catalogue and Synopsis. The number of specimens is not stated. Professor Zeller's opinion, of which Mr. H. Edwards believes, "it is more than probable that he is correct," is that C. Chippewa is a form of C. Palaeno, similar to those of the Swiss mountains. Mr. Strecker affirms also the identity of C. Chippewa and C. Palaeno.

Comparing the description and the figures with a number of Palaeno from Labrador and the Swiss Alps there is no reason to doubt the truth of these statements. It should be remembered that Mr. W. H. Edwards at the time of his publication has probably not been able to compare C. Palaeno from North America.

Conclusions.

The species of Colias found in North America are from our actual knowledge as follows:—

1. **C. chrysotheme = Keewaydin.**

Seasonal forms Ariadne and Eurytheme.

I remark that Professor Zeller, when he wrote the quoted criticism (Stett. Ent. Z. 1874, p. 437) could not have any knowledge of Mr. Boll's discovery, published in 1876.

Hab. West of Mississippi to the Pacific; south to Texas; north to New N. and S. Wales, west from Hudson's Bay between 53° and 63°. (Strecker Rhop., p. 132.)

2. **C. Philodice.**

Seasonal form mimicking Ariadne in Texas.

Northwestern forms Eriphyle and Chrysomelas.

Synon. Anthyale Hb.; Santes A. Fitch.

Hab. East of Mississippi, overlapping the river to Kansas, and south to Dallas, Texas; south to West Virginia, and from Maryland northwards to Canada; along the northern border in Dakota reaching Eriphyle in Western Montana; Washington Territory to California.

Mr. Chas. V. Riley has kindly sent me a detailed letter written by him to Mr. W. H. Edwards, June 29, 1876. In this letter is stated the opinion that C. eurytheme and C. philodice are specifically not different. This opinion is proved by very full and detailed descriptions of the egg and all stages of the caterpillar. Mr. W. H. Edwards has apparently overlooked this letter which contains more detailed descriptions than those given by himself.

3. **C. interior.**

Should the type in Dr. Boisduval's collection belong to this species, which is yet at least not proved, the name C. Pelidne Bd should be accepted.[1]

Synon. Edwardsii, with Emilia and Astraea, Alexandra, Scudderi, Occidentalis, Christina, var. Harfordii, var. Laurentina.

The assumption that C. Pelidne Bd. is synonymous with C. interior is rather impaired by the fact, that in none of the countries quoted by Boisduval for C. Pelidne, Greenland, Iceland, Labrador, Siberia, Kamtchatka, has C. interior yet been found. The C. Pelidne from Labrador quoted by Mr. Strecker belongs to Palaeno and not to C. interior.

The range of C. interior is known from Quebec, Ontario, the northern shore of Lake Superior to Saskatchewan, Dease Lake, Vancouver's Island, Alaska.

[1] As this is going through the press, I am informed by Mr. Chas. Oberthur that the type is not present in the collection of Mr. Boisduval. Probably it will be found in the collection of the late Mr. Sommer in Hamburg.

C. Scudderi is known from Hudson's Bay, Lake Labache, British Columbia and on the higher mountains of Colorado.

C. Edwardsii from California, Oregon. Washington Territory, Montana, Utah and Yellowstone.

C. Alexandra from Kansas and Colorado, up to 11,000′.

C. occidentalis from Washington Territory and Br. Columbia.

C. Christina from Great Slave Lake and Athabaska.

C. Harfordii from California, Washington Territory, Montana.

C. Laurentina from Cape Breton, Nova Scotia and N. Maine.

This species therefore goes through the whole continent from the 45° to 55°; in the Rocky Mountains it goes farther south to Ft. Hays, Kansas, 2000′; in the north it goes perhaps mostly to 60°, and at least farther up to the Great Slave Lake.

4. **C. Palaeno.**

Var. C. Pelidne, Boisd., Staudinger.

C. Chippewa.

If Scoresby's specimens belong here it reaches 70.30° on the eastern coast of Greenland at the Scoresby's Sound. It is common in Labrador down to Caribou Island. Christoph quotes Baring's Island 74° for C. Pelidne; both forms are quoted from Alaska, and C. Pelidne from Sitka and the Yukon River.

C. Chippewa is quoted from the Mackenzie River and the Great Slave Lake. The range of this species is from 54° to 64° through the whole continent, with the exception of the two localities quoted 70.30° and 74°.

5. **C. Meadii.**

Only on the higher mountains of Colorado. Strecker, N. A. Macrol., p. 83, says: "So close to Hecla that I almost doubt its being distinct." No C. Hecla is before me. Zeller after comparing C. Meadii specimens determined by Mr. W. H. Edwards, and communicated to him by the Museum, says, Stett. Ent. Zeit., Vol. 35, p. 437: "The presence of the mealy spot just as in Myrmidone makes the difference between both species somewhat doubtful. I consider now only as a specific character the faint discal streak of C. Meadii, instead of which C. Myrmidone has a considerable spot. Should C. Meadii also appear with such a spot, which I think to be very probable, I would recognize this species undoubtedly as a smaller form of C. Myrmidone." Mr. H. Edwards, Colias, p. 3, states: "By some great error of judgment, it has been considered by Professor Zeller to be only a form of Myrmidone, which wants the gland at the base of the secondaries, so strongly characteristic of C. Meadii." Perhaps Mr. H. Edwards'[1] species was not C. Myrmidone, at least in series before me from Europe and Asia, every male has the gland just as C. Meadii. Though I have before me C. Meadii with a discal spot instead of the streak, I cannot see that both species are identical.

6. **C. Behrii.**

From the highest mountains in California. I have only one specimen.

7. **C. Hecla.**

From Greenland; in Europe from N. Lapland.

I have none before me, and chiefly compared Guenée, Ann. S. E. Fr., 1864, p. 198, who had before him the types of this and the next species.

8. **C. Boothii.**

From Boothia Felix by Captain Ross. Only 3♂ and 4♀ were brought home. One of the types is now in Dr. Staudinger's collection. I am not aware that a specimen is present in any American collection. The excellent description by John Curtis with beautiful figures in Captain Ross voyage and the description by Guenée are the only ones for this species.

Its var. Chione one male from the same locality.

9. **C. Nastes.**

From N. E. Labrador and its var. Rossii from Boothia Felix. I have only one couple before me. C. Werdwandi Zett. from Lapland is stated to be the same species. W. H. Edwards, N. A. Butt, Vol. II, Colias, pl. I.

Postscript.

Mr. A. Keferstein the well known veteran of the lepidopterologists has published a paper on Colias in Wien. Z. B. Ges. 1882, p. 449. I am indebted to Mr. S. H. Scudder for the use of a separate copy, as the volume has not yet reached this country. In the introduction of this paper,

[1] Mr. H. Edwards asks me to state, that all his Myrmidone possess the gland and thus his statement quoted above is erroneous; cf. also H. Hagen, Nature, 1883, No. 715, p. 244.

which gives a full classification of the Colias of the whole world, Mr. A. Keferstein enumerates the characters which are variable, and therefore not to be used as specific characters.

1. The discal spot of the upperside of the primaries. He is black or wanting sometimes in Palaeno, Behrii, Pelidne.

2. The submarginal series of black spots of the underside of the primaries, which are wanting sometimes in Aurora, Philodice.

3. The same series of the underside of the secondaries, wanting sometimes in Myrmidone.

4. The discal spot of the underside of the secondaries is on the same species surrounded by a darker ring or not; so on Behrii, Nastes.

5. The mealy spot above near the costal margin of the secondaries of the male is on Electra, Edusa and probably on other species only *exceptionally* present, after the examination of a series of specimens. This statement is very important and corroborated by the similar occurrence on Pap. Priamus.[1]

Concerning the reduction of the American species it is of importance that Hecla is considered to be a variety of Myrmidone. Eurytheme is not united with Chrysotheme. Interior and Labradorensis are, after Moeschler, united with Philodice.

A large number of American species were not represented in the author's collection.

I am also indebted to Mr. S. H. Scudder for the use of a separate copy of Une nouvelle Colias du Caucase, 1882, by the Grand Duc Nicholas Michailowitch. The species C. Olga is particularly interesting by its variations and by the comparison with four nearly related species. All are figured.

The London Entomologist, Vol. XI, 1872, p. 49, has a very interesting paper on Colias Edusa by Mr. E. A. Fitch. The unusual abundance of this species in England in 1877 was normally double-brooded and occasionally triple-brooded. Among the numerous specimens placed at the disposal of the author, twelve varieties were especially interesting and are all figured.

" Could we but get (p. 53) series of each supposed species of Colias, such as could be procured of C. Edusa this year in Britain, and allowing for the variation attributable to geographical distribution or climatal causes, it is more than likely that the most discriminating speciologist would be baffled." I am well aware, that the reductions proposed by myself will be chiefly objected to by entomologists not being able to study similarly large series of specimens.

[1] Nevertheless Mr. Alpheraky, Stett. Zeit. 1883, p. 488, contradicts the statement.

Practically, when a naturalist can unite by means of intermediate links any two forms, he treats the one as a variety of the other; ranking the most common, but sometimes the one first described, as the species and the other as the variety. But cases of great difficulty, which I will not here enumerate, sometimes arise in deciding whether or not to rank one form as a variety of another, even when they are closely connected by intermediate links; nor will the commonly assumed hybrid nature of the intermediate forms always remove the difficulty. In very many cases, however, one form is ranked as a variety of another, not because the intermediate links have actually been found, but because analogy leads the observer to suppose either that they do now somewhere exist, or may formerly have existed; and here a wide door for the entry of doubt and conjecture is opened.

General Meeting, January 3, 1883.

Vice President, Mr. F. W. Putnam, in the chair. Nineteen persons present.

Prof. Henri Milne-Edwards and Prof. Rudolph Virchow were elected Honorary Members. Dr. Wm. B. Carpenter, Prof. Joseph Prestwich, Prof. Alphonse Milne-Edwards and the Marquis de Saporta, were elected Corresponding Members. Capt. A. R. McNair, U. S. N., and Mr. Bernard P. Verne were elected to Associate Membership.

Mr. C. O. Whitman described a rare form of the blastoderm of the chick, in which the primitive groove extended to the very margin of the blastoderm, terminating here in the marginal notch first observed by Pander.

The blastoderm was eighteen hours old, and nearly one centimeter in diameter. The extension of the primitive groove to the marginal notch was regarded as a re-appearance of a developmental feature, which is constant in some of the lower vertebrates and their nearest invertebrate allies, but which has ceased to be a normal occurrence in the development of the chick.

The blastoderm interpreted at an atavistic form, was held to be an important confirmation of the theory put forward by His and Rauber, according to which the vertebrate embryo arises by concrescence of the two lateral halves of the germ-ring. The objections made to this theory by Balfour were reviewed, with a view to showing that they presented no serious difficulties to the acceptance of the concrescence theory.

Mr. Whitman maintained that Balfour's objections were not broad enough to cover his own theory of the origin of the vertebrates from annelids, — a theory which gave us a right to expect some fundamental agreement in their modes of development. This agreement, he contended, was seen, first, *in the origin of the embryo from a germ-ring, by the coalescence of the two halves along the axial line of the future animal;* and secondly, *in the metameric division*, which followed in the wake of the concrescence. The theory of the annelid origin of the vertebrates was inconsistent with the denial of the concrescence theory, since concrescence of the germ bands is a well established fact for both chaetopods and leeches.

The theory of differentiation set up by Balfour in opposition to that of concrescence entirely ignored the annelids, and offered no explanation of the uniform relations of the embryo to the germ-ring.

Dr. S. Kneeland read a number of notes made in travelling through the Philippines, and showed and presented a large number of specimens collected in many localities. Among the most interesting was a fine specimen of the snout of a saw-fish, which was taken in fresh water, 20 m. from the sea near Manilla. Dr. Kneeland thought that the saw was wrongly supposed to be an offensive weapon, but was more probably used in throwing up the mud and sand of the shallow waters in which the fish lives, in search of molluscs and cray fish. Among the other specimens were many fossils and a fine collection of woods of the Philippines. Dr. Kneeland also described the geysers of Tiwi, and presented a series of volcanic products from Mayon and also from Aetna and Vesuvius.

The following paper was read:

A CONTRIBUTION TO THE GEOLOGY OF RHODE ISLAND

BY T. NELSON DALE.

The Island of Aquidneck, which includes the townships of Newport, Middletown and Portsmouth, R. I., has been the object of no little study on the part of geologists. Dr. C. T. Jackson, Pres. Edward Hitchcock, and Professors C. H. Hitchcock, W. B.

Rogers and N. S. Shaler have expended time and thought upon it, and their writings on the subject form a considerable literature, as may be seen from the following list.

CHAS. T. JACKSON. Report on the Geol. and Agric. Survey of the State of Rhode Island, made under a Resolve of Legislature in the Year 1839. Providence, 1840.

EDWARD HITCHCOCK. Final Report on the Geology of Massachusetts. (Pages 532-554.) Amherst and Northampton, 1841.

" Report on Certain Points in the Geology of Mass. (Contains a map of the Bristol and R. I. coal-field.) State document, Boston, 1853. Abstract of this in Am. Journ. of Science, 1853. Vol. XVI, II Ser. p. 327, entitled: The Coal-fields of Bristol Co. and of R. I.

W. B. ROGERS. On the Causes which gave rise to the Generally Elongated Form and Parallel Arrangement of the Pebbles in the Newport Conglomerate. Proceedings Boston Soc. Nat. Hist. Boston, 1859.

CH. H. HITCHCOCK. Geology of the Island of Aquidneck.

" Synchronism of Coal-beds in the New England and Western United States Coal-basins. Proceedings Am. Association for the Advancement of Science for 1860. Cambridge, 1861.

" Geological Map of Aquidneck, or the Island of Rhode Island. Presented by the City of Newport to members of the Am. Association for the Adv. of Science. Aug. 1, 1860.

W. B. ROGERS. On the Recent Discovery, by Mr. Norman Eastop, of Fossils in the Conglomerate of Taunton River. Paper read before the Am. Association for the Advancement of Science in 1860, but only published by title.

EDWARD HITCHCOCK. On the Conversion of certain Conglomerates into Talcose and Micaceous Schists and Gneiss by the Elongation, Flattening and Metamorphism of the Pebbles and the Cement. Am. Journ. of Science, Vol. XXXI, II Ser. 1861.

HOLMES AND HITCHCOCK. Sixth Annual Report of the Secretary of the Board of Agriculture of the State of Maine. (On Newport Conglomerate, p. 178.) Portland, 1861.

N. S. SHALER. On the Geology of the Island of Aquidneck and the Neighboring Parts of the Shores of Narraganset Bay. (Extracted from a report to Benj. Peirce, Supt. of the U. S. Coast Survey.) Art. I, Topography; Art. II, Glacial Deposits and Ice Marks; Art. III, Physical Condition of the Carboniferous Time. Am. Naturalist, Vol. VI. (Pages 518, 611 and 751 respectively.) Salem, 1872.

W. B. Rogers. On the Newport Conglomerate. Proceedings Boston Soc. Nat. Hist., Vol. XVIII. Boston, 1875.

T. Sterry Hunt. Special Report on the Trap Dykes and Azoic Rocks of S. E. Penna. Vol. I, p. 189, 190. Vol. E, Second Geol. Survey of Penna. Harrisburg, 1878.[1]

The following list includes topographical maps and works of interest in connection with the geology of the Island although bearing less directly upon it.

U. S. Coast Survey. Narraganset Bay from a Trigonometrical Survey. Scale $\frac{1}{40000}$. Report of the Supt. for 1870. Charts XX, XXI. Washington, 1873.

" Topography of Narraganset Bay. Transfers from Plane Table Sheets. Sheet No. 21. Scale $\frac{1}{10000}$. Washington, 1872.

" Coast Chart No. 13. Cuttyhunk to Block Island including Narraganset Bay. Scale $\frac{1}{80000}$. Washington, 1876.

Anon. An enquiry into the chymical character and properties of that species of coal lately discovered at Rhode Island; together with observations on the useful application of it to the arts and manufactures of the Eastern States. pp. 21, Boston, 1808.

Ch. Lyell. On the Probable Age and Origin of a bed of Plumbago and Anthracite occurring in Mica-schist near Worcester, Mass. Paper read May, 15, 1844. Quarterly Journal of the Geol. Soc. of London, Vol. I. London, 1845.

I. R. Barbour. Coal-beds in Rhode Island. Mount Hope Coal Mine. (This pamphlet contains Dr. Jackson's special report on that mine.) New York, 1852.

G. L. Vose. On Distortion of Pebbles in Conglomerate. Mem. Bost. Soc. Nat. Hist., Vol. I. Boston, 1866.

Wm. P. Blake. The Plasticity of Pebbles and Rocks. Proceedings Am. Association for the Advancement of Science. Salem, 1869.

Society for the Encouragement of Domestic Industry. Report on Coal and Iron in Rhode Island. Providence, 1869.

T. S. Ridgeway. (Geol. and M. E.) Memorial in Relation to the Coal-field of R. I. Presented to the Gen. Assembly, Jan. 1868, with supplement, Feb. 15, 1870. 12 pp. Providence, 1870.

James D. Dana. Depression of Southern New England during the Melting of the Glacier. Am. Journal of Science, Vol. X, III Ser. (Narraganset Bay, p. 431.) 1875.

[1] See also an article by the same writer in the Proceedings Bost. Soc. Nat. Hist., Vol. XIV. Boston, 1869.

Wm. O. Crosby. Contributions to the Geology of Eastern Massachusetts. Occasional Papers of the Boston Soc. Nat. Hist., Vol. III. Boston, 1880.

Wm. O. Crosby and G. H. Barton. Extension of the Carboniferous Formation in Massachusetts. Am. Journal of Science, Vol. XX, III Ser. Nov. 1880.

Although these works include several geological maps, two general sections and pretty full discussions of the coal-beds, the conglomerate and the glacial phenomena, as well as some very minute observations in one or two localities, and several general remarks and surmises as to the succession of the strata, yet no satisfactory sections illustrating the stratigraphy of the south-eastern end of the Island appear to have been published, nor are the geological maps sufficiently accurate to enable one to construct them.

The writer has taken a number of rambles with a view of meeting this want as well as of verifying and, if possible, supplementing the observations of preceding geologists. This paper confines itself to the southeastern part of the Island, embracing Easton's Point, Sackuest Neck, "Paradise," the "Hanging Rocks," and a strip along the eastern shore as far north as "The Glen," in other words, the southeastern portions of the townships of Middletown and Portsmouth. In order to bring together the somewhat scattered information on each locality, quotations from, or references to the observations of others always precede or accompany his own.

Easton's Point.

This is the angular promontory jutting out southwards between the Bathing or Easton's and Sachuest Beaches. Prof. Charles Hitchcock gives a long list of measurements taken with great minuteness along both sides of this point.[1] He finds a series of schists, 473′ 1″ thick, occupying the centre and a large part of the west side of the Point, *overlaid* on that side by 464′ 1″ of conglomerates and grits, and *underlaid* on the east side by an older conglomerate, which forms the cliffs about "Purgatory." These rocks strike N. 20°–25° E. His map shows this older conglomerate as continuous with that of the region called Paradise.

[1] Geology of the Island of Aquidneck, p. 119–121, 135.

The following is a brief resumé of the writer's notes taken in passing from the east end of Easton's Beach along the shore, around the Point to Sachuest Beach (see Map I.[1]). At Easton's Beach conglomerate of quartzite in the pebbles of which faint traces of shells, possibly Lingulae,[2] longer axis of pebbles about N.NE.[3]; quartz veins generally W.NW. but also N.NW.; glacial grooves N.—S. nearly. Before pt. 24 dip 10°-15° W.NW., at pt. 24 almost vertical, strike N. 30 E. The conglomerate becomes more and more interstratified with argillaceous schist until near Half Tide Rock the *underlying* schist predominates, and a little beyond the conglomerate ceases entirely. At Half Tide Rock dip 70° W.NW., strike N.NE. The dip diminishes to 50°, and at pt. 25 to 15°, still W.NW. Here the schists are ripple marked, the ripples running about parallel with the strike, and small enclosures of earthy chlorite abound, and occasionally cubes of pyrites. Between pts. 26 and 27 the dip runs from 25°–15° W.-NW., and between pts. 27 and 28 it comes down to 5° W.NW. Just here is the summit of an anticlinal, and at pt. 28 the dip 15° S.SE. A boulder of conglomerate, 8′ × 8′ about, lies upon the schists. Rounding the point and going northeasterly, the dip increases to 45° S.SE; at 29 the conglomerate *overlies* the schist conformably, both dipping toward the eastern horizon; at pt. 30 the conglomerate dips 25° E.SE.; at pt. 31 glacial grooves N. 10° W. The tongue of rock, 31, called the "Whetstone," owes its gable shape to the meeting of a plane of stratification and that of a joint. It requires great care not to be misled; the dip is only determinable from a close scrutiny of layers of schist enclosed in the conglomerate. Near pt. 32 the conglomerate contains a boulder or mass of stratified quartzite, 8′-10′×1′-2′. A little westward the dip is 45° S.E. Fissures and quartz veins run W.NW. as does the chasm called Purgatory. The conglomerate forms bluffs 60′ high; its surface is highly glaciated showing both furrows, striae and polish; many of its pebbles and boulders consist of a *finely stratified* or *laminated* quartzite containing a little mica; the laminae often form an angle with the longer axis of the pebble. Some of the quartzite pebbles contain regularly dissemi-

[1] Numbers are affixed to localities not otherwise designated.

[2] See Rogers, op. cit. 1875.

[3] No allowance has been made throughout, except on the maps and sections, for magnetic variation. It is now about 10° 50′ W.

nated grains of crystalline quartz from $\frac{1}{16}''-\frac{1}{8}''$ in diameter. Octahedral crystals of magnetite abound in the argillaceous and micaceous cement of the conglomerate.[1] The trenchant manner in which the fissures and veins cleave alike both small pebbles and large boulders in the conglomerate,[2] as well as the uniform parallelism of the longer axes of the pebbles with the strike,[3] so often referred to in geological literature in connection with this locality require no further description. From the highest point of the Purgatory cliffs a line of hills may be seen in the line of their strike *i. e.* N. 30 E. These data warrant Section A.

Paradise and the Hanging Rocks.

The region so named is situated between the Swamp Road, which runs north from the west end of Sachuest Beach, on the west, and the high land which forms the east shore, on the east; and it extends about a mile back from Sachuest Beach covering altogether about a square mile. It consists of a series of more or less parallel, rocky, precipitous or rolling ridges and hillocks of varying altitude, the highest measuring from 80′ to 173′ above the sea. The sides of several of these ridges are covered with their débris, the intervening spaces are sprinkled with boulders and the whole tract bears evidence of the destructive element in geological history. The name Hanging Rocks is applied to the easternmost elevated ridge.[4] (See Map II.)

President Hitchcock examined this locality and observes:

"About a quarter of a mile from the coast, three precipitous bluffs, a, b, c, several rods wide, separated by salt marshes from 15 to 20 rods wide, rise 100 or 200 feet, trending northerly, and converging; so as apparently to unite at no great distance. The two most easterly ridges are very steep, and exhibit evidence of having been powerfully abraded. The outer ridges,

1 See Jackson, op. cit. p. 93.

2 See: Jackson, loc. cit. Ed. Hitchcock, Geol. of Mass., p. 296, 536. Am. Journ. Science, 1861. Ch. Hitchcock, Geol. of Aquidneck, p. 114, 115.

3 See Rogers, op. cit. 1859. Ed. Hitchcock, Am. Journal Science, 1861. Holmes and Hitchcock, op. cit.

4 The picturesqueness of this spot attracted Dean Berkeley 150 years ago, who introduces one of the dialogues of his Alciphron with a description of the locality: "We went down to a beach about a mile off, where we walked on the smooth sand, with the ocean on one hand, and on the other, wild broken rocks, intermixed with shady trees and springs of water, till the sun began to be uneasy. We then withdrew into a hollow glade, between two rocks." George Berkeley. Works edit. by A. C. Fraser. Oxford, 1871, Vol. II, p. 58.

a, c, consist of the peculiar conglomerate above described; the central one consists of a hard Graywacke slate, and a very singular and puzzling rock, which I shall venture to describe as a metamorphic slate. — The layers of the Graywacke slate and amphibolic aggregate run north and south and dip west 60° to 70°. And this, as already mentioned, is the direction in which the nodules and schistose layers of the cement of the conglomerate are placed. But no strata planes are to be seen corresponding to the dip and direction of the slate."[1]

This is accompanied by a rough diagram answering the purpose of both a topographical and geological map, in which three converging ridges are figured. On his general geological map the whole tract appears as "Gray Wacke," but, on page 548, in describing the lithological character of this "amphibolic aggregate," he remarks: "Had I found it among primary rocks, I should have regarded it as by no means an anomaly there; especially after finding in it a vein, four inches wide, of crystallized zoisite."

Prof. Ch. Hitchcock merely alludes to this locality:

"The range is more than a mile wide, showing itself most southerly below Purgatory, composing the Hanging Rocks and Paradise, and probably underlying the drift as far north as Sandy Point in Portsmouth. — There are three ridges of this conglomerate at its southern part, — Purgatory being located in the western, and the Hanging Rocks composing the eastern one. The middle ridge is a hard, gritty rock."[2]

In his map the whole of Paradise is set down as conglomerate and grit.

Prof. N. S. Shaler remarks:

"The mass of conglomerate and associated materials known as Paradise Rocks also shows some interesting phenomena. These rocks consist of a set of ridges of steeply inclined beds of various hardness, which owe their position to a number of parallel faults extending in a north and south direction with a considerable throw, so that the projecting edges of the rocks rise at sharp angles to the height of from 50 to 150 feet above the sea level. Carefully tracing these rocks in the direction in which they are continued to the northward, it becomes evident that, at the time when they were formed, the ridges continued for several hundred feet to the northward of the base of the slopes which lead down to the comparatively low land which now bounds them on that side. We cannot resist the conviction that the powerful agent which has cut away these solid masses of rock was

[1] Geol. of Mass., p. 535, 536.

[2] Geol. of the Island of Aquidneck, p. 113.

the ice stream which has so clearly scored their surfaces and left the marks of its power on every square foot of their remaining surfaces."[1]

As the complex topography of Paradise somewhat obscures its stratigraphy a brief description of it seems necessary. There are no less than seven ridges, five high and three low ones, all trending N.NE. but in places somewhat curved, in others coalescing to form a lesser number of ridges.[2] The first one on the west, I, the north-eastern extension of the bluffs at Purgatory already referred to, embracing pts.: 1, 34, 52, 2, consists of a chain of rolling hills and knolls. Its highest point, I, measures 173′.[3] Ridge II, to the eastward, embracing pts.: 3, 4, 33, 5, 6, 7, 8, is similar in its character to, but not always distinct from I; its northern summit, 3, is 100′ but it rapidly descends southward including the two long, low ridges, 5, 6, and two protruding rocks, 7, 8. Ridge III consists of three masses: 11 and 9, which rise but 10′–20′. from the marsh, and 10, a hillock of 30′–40′. This ridge is continued northwards in a line of rocks, 35 and 36, and then disappears in a crowd of extraneous boulders. Ridge IV is a long, 80′ high cliff, pts.: 14, 39, 46, 48, presenting an abrupt western face but on the east a gradual slope which forms, with the western declivity of ridge V, an elevated valley. Ridge V, about 60′ high, pts.: 53, 47, 54, 37, resembles IV; its eastern face abrupt and covered with débris; its northern part forms a blade of rock. Ridge VI, more isolated, attains 100′ but varies much in altitude; its western side is a bare wall of rock somewhat shattered toward the north, but its eastern side is much more broken up. The most eastern ridge, VII, embracing pts.: 43, 50, 42, 44, 49, consists of a long, 10′–20′ ridge with two or three masses 30′–40′ high.

Geological observations: *Ridge I* consists entirely of siliceous conglomerate with occasional layers of argillite striking uniformly N. 30 E. At 34 on the western base of the ridge the conglomerate rests upon clay schists abounding in minute crystals of magnetite and dipping variously 20°–45° E.SE. and E.NE. Some of these schists are very finely stratified. The conglomerate forming the summit, 1, contains some boulders of quartzite, 4′×1′, and is so highly polished by glacial action as to reflect the sunlight.

[1] Am. Naturalist, Vol. VI, p. 616.

[2] The ridges are indicated by Roman numerals on Map II.

[3] Prof. B. Pierce, U. S. Coast Survey Report for 1870 p. 19. Washington, 1873.

Grooves run nearly N.–S. At 52 the dip is about 45° E.SE. The southern part of this ridge is traversed by numerous fissures running W.NW.

Ridge II consists of the same conglomerate and schists with the same strike. At 8, on the beach, faint traces of shells, probably Lingulae, in the quartzite pebbles in situ. The ledge 6–33 is a plane of stratification. At 33 the schists dip 45°–50°E.SE.; at two points north of 5 the dip is 50°–60° W.NW.

Ridge III. The distance between the conglomerate of ridge II and the nearest outcrop of this ridge is about 200′; measurements taken near 35 and 9. The low hillock, 9, consists of the following, beginning on its west side: About 40′[1] of finely stratified mica schist gradually passing into a coarsely stratified hornblende schist, measuring about 90′, followed again by an uncertain thickness of the mica schist succeeded by hornblende schist. These are all conformable, strike N.NE. and dip at a high angle W.NW. The second hornblende schist reappears at 35 and 36 where the ridge disappears. This rock in weathering shows the feldspar plainly, at 35 it is traversed by veins of quartz containing chlorite, and also by a vein of zoisite. The mica schist in passing to the hornblende schist becomes more siliceous, in places a finely stratified quartzite, then darker in color. The second hornblendic layers reappear to the south forming the bulk of hillock 10, where they measure about 75′, and again at 11. On the east side of 10 they may be seen resting upon mica schist and at 11, in a perhaps more inclined position, between argillaceous schists on the west and the east. At 11 the edges of the western argillaceous schists are planed in graceful curves and striated by glacial action. Striae nearly N.–S. The hornblende schists there are likewise striated but, probably owing to some irregularity in the surface, striae run NE.–SW. The layers of 10 and 11 strike N.NE. Therefore, eliminating the duplicated beds, ridge III consists of three beds of mica schists with one of hornblende schist after the first and another after the second.

Ridge IV. The uppermost layers of this ridge are exposed at pt. 38. They consist of mica schist dipping 50° W.NW., and striking N. 30° E. and are followed easterly by hornblende schists, pts. 14, 39, 46, which form the entire western face of the cliff

[1] These measurements are approximations merely.

to 48 and beyond. At 14 a stray fragment of zoisite vein matter 3″ thick with quartz in the centre. Numerous quartz veins occur in this ridge; near 48 they contain crystals of feldspar. Here and there this schist contains flakes of bronze colored mica. Descending the east side of the ridge toward 45 there is finely stratified mica schist, such as are used for the manufacture of scythe stones, dipping W.NW. 40°–45°, under the hornblende schist just described, and it appears again on the west side of the ridge near 14. Between 55 and 47 these mica schists form the west side of ridge V, and at 54 they form the extreme northern end of that ridge, reappearing, however, as a dark grey or black, very finely laminated slate in a series of mounds which terminates at 37.

Ridge V is best studied between 47 and 40. Its jagged and blade-like crest is hornblende schist underlying the mica schists of ridge IV, and measuring about 40′. Next eastward come about 30′ of mica schists (scythe stone variety) dipping 55° W. NW., underlaid by hornblendic schists which descend to the glen between this and ridge VI, where they are covered by dêbris from the crest but measure at least 40′–50′ with a W.NW. dip.

Ridge VI. The shortest distance between the hornblende schist of the preceding ridge and the nearest outcrop on this one is not far from 75′. The width of the southern extremity is perhaps 75′. This is an abrupt face, a fissure plane with the usual W.NW. direction and consists of quartzite conglomerate. These vertical fissures recur along the whole ridge every 10′–20′, as may be seen on the west side. Crossing these in a horizontal direction may be seen a series of fractures, joints, which dip E.SE., and cut up the whole west side into parallelograms. The dip of the conglomerate is visible on the east side of the southern end, 50° W.NW., and again at 41, 45°–60° W.NW. The alcove called Berkeley's Seat on the southern face is due to the meeting of planes of a joint, a fissure and several planes of stratification, together with the disintegrating influences of the weather.[1] The pebbles of the conglomerate as well as the cement abound in crystals of magnetite.

The general dip of the west face of the ridge is about 70° W. NW. At 40 the conglomerate is overlaid by about 40′ of hard

[1] Indian fires have also probably enlarged the opening.

argillaceous and siliceous schist with minute crystals of magnetite. This may be traced northwards to opposite 54, but the conglomerate reappears here and there for about half a mile as does that of ridges I and II.[1]

Ridge VII likewise consists of conglomerate and argillaceous schists; the former at 43, 50, 42, 49 and 44, the latter about 50′ thick at 51, SE. of 44 (plate 1). The dip is evident at 42, 60°–70° E.SE.; at pt. 44, E.SE. steeply; at 49 large masses of conglomerate without schist appear to dip E.SE. As ridges I and II form a synclinal so ridges VI and VII formed a ruptured anticlinal the ruins of which are alone now visible. The conglomerate of VII is highly metamorphic, the pebbles having unmistakably been elongated and also coated with scales of mica. Fissures run W.NW.

These data warrant the sections B′, B″, B‴ for Paradise. The numbers of the ridges are added and the beds numbered in one series to show duplications.[2]

Wood's Castle, Taggart's Ferry, Black Point, Sandy Point.

These are on the east shore of the Island. Prof. Ch. Hitchcock refers to these localities: "Certainly there is a fold (in the conglomerate) to the east of Paradise, which may be traced along the east coast of Middletown, between Sachuest Beach and Taggart's Ferry."[3] He also gives the dip of the conglomerate north of Sachuest Point on the east shore,[4] 45°–50° E. and also W, further north in the water, E.; Taggart's Ferry slates, 45°–50° W.; south of Taggart's Ferry, 75° W.; town line of Middletown and Portsmouth, 30° E.; and in his map conglomerates and grits cover the whole tract between Purgatory, Sandy Pt. and Smith's Beach with the exception of a strip of coal measures west of

[1] Wm. S Haines, C. E. of Providence, finds a local magnetic attraction in the vicinity of Ridge VI deflecting the needle 32′. The average deflection on three lines between the beach and all the ridges was 3′ 10″. This may be attributed to the magnetite in the conglomerate and schist or to the hornblende.

[2] In drawing these and the other sections the actual strike, ascertained by a comparison of field notes with the location of the rocks on the U. S. Coast Survey Maps, has been followed. This gives for the Paradise tract N. 21 E. true.

[3] Geology of the Island of Aquidneck, p. 116.

[4] Ibid. p. 135.

Taggart's Ferry running parallel with the shore. Professor Shaler[1] also observes: "At one point, Wood's Castle, on the eastern shore of the Island, the conglomerate is immediately overlaid by carbonaceous shale with faint traces of coal plants; above the coal comes a greenish shale of unknown thickness."

My observations follow. In passing from the northern end of Smith's Beach along the shore to Sandy Pt. (plate 1), close to the beach, conglomerate like that of Purgatory and Paradise forming a high bluff which extends to Taggart's Ferry, no dip is determinable before Wood's Castle, a projecting tongue of rock 150′ by 50′–120′, where about 100′ of carbonaceous schists and slate lie upon the conglomerate dipping 55°–60° E.SE. and striking N. 30 E. The schist in contact with the conglomerate is ferruginous. These layers are followed easterly by about 50′ of light colored grit. No dip determinable until Taggart's Ferry where the shore recedes westward and conglomerates alternating with carbonaceous and argillaceous schists and grits dip 40° W.NW. The bluff between this and Wood's Castle is therefore a sharp anticlinal. No outcrops of these schists observed west of the landing. They continue to 23, south of the Portsmouth boundary stone, dipping there 80° W.NW., and striking N. 30 E. The conglomerate follows without determinable dip forming high bluffs; at 21 and 22 it seems to dip S.SE. with fissures W.NW. South of Black Pt. about 50′ of gritty schists intervene dipping 25°–30° SE. or S.SE. From Black Pt. the conglomerate extends westward about 150′, with same dip and strike, exposing the narrow ends of its pebbles to the north and much disintegrated. At 20 fine conglomerates and coarse grits measuring about 75′ dip 25° S.SE. and continue to 19 becoming finer in character with the same dip, strike and W.NW. joints. No further exposures until 17. At 18 bluish diluvial clay. At 17 reddish argillaceous schists dip 30° S.SE.; at 16 dark gray argillaceous schists 20°–25° S.SE.; at 15 similar layers dip 15°–20° E.SE. No further exposures until pt. 12, north of Sandy Point, where light colored, gritty, micaceous schists dip 20°–25° S. 80 E., with fissures E.–W. underlaid by carbonaceous schists dipping 5°–10° S.SE. At the "Glen" half a mile north of Sandy Pt., about 60′ of horizontal

[1] Am. Naturalist, Vol. vi, p. 759.

carbonaceous schists are exposed. The surrounding land is 140′ high and those 60′ are very near sea level. The shore from Black Pt. to Sandy Pt. is strewn with boulders of quartzite conglomerate from the north. One of these contained a few pebbles of gneiss or syenite. In this connection, although strictly speaking outside the geographical limits of this paper, the following is of interest. A large boulder of this conglomerate on the north side of Quaker Hill near the northern side of the Island contains two plant stems. One is 14″ × 3″, the other, about 8″ off, is 24″ × 3″. They are not determinable but may be described as flattened stems marked on the outside with irregular, fine, longitudinal and diagonal striae. The outer film was tested by Dr. F. A. Gooch, then chemist at the U. S. Geol. Survey and Census office, and pronounced to be highly carbonaceous. These stems are not *on* but *in* the conglomerate and the pebbles in close proximity to them measure 1″–2″ in diameter. Could these be drift wood of conifers such as Principal Dawson finds in the Nova Scotia grits and conglomerates?[1]

From these data for the east shore it may be inferred that north of the Portsmouth boundary the sharp folds gradually disappear until at the Glen the strata become horizontal. The carbonaceous schists of the Glen overlie the argillaceous schists which crop out between that place and pt. 17., and the conglomerates of Black Pt. and the south either overlie the Glen series or else thin out so as to be absent there. At Taggart's Ferry the carbonaceous schists overlying the conglomerate probably form, as suggested by Prof. Ch. Hitchcock, a synclinal to the west. Still further west we come upon the conglomerates of ridges VI and VII, Paradise. This furnishes the basis for section C.

Sachuest Neck.

This forms the south-eastern extremity of the Island. In the diagram of Paradise by President Hitchcock he represents to the southeast of the conglomerate a ridge of "quartz rocks" to which he further alludes:[2]

"The most remarkable of these varieties (of metamorphic slate) is developed very distinctly at the southern extremity of Rhode Island; as may be

[1] Acadian Geology.

[2] Op. cit., p. 546.

seen by the sketch already given of that portion of the Island. It consists of coarse grains of hyaline quartz, of a purple color, passing to deep blue and black, with talc or mica (it is difficult to say which); the materials having a schistose arrangement. The quartz bears a strong resemblance to peliom, and constitutes a large part of the rock. The aggregate exhales an argillaceous odor when breathed upon. This same rock may be seen at the mouth of Fall River in Troy, R. I., where it is associated with an argillaceous slate, passing into mica slate, and of a quite dark color from the carbonaceous matter it contains. At this place, this slate and quartz rock are contiguous to granite; and they may be seen in Tiverton, lying directly upon the granite."[1]

Prof. Chas. Hitchcock[2] states that the lowest rocks upon the Island consist of "talcoid grits, often largely composed of grains of sand and pebbles," and he remarks further:

"Lower schists and conglomerates. — The only place upon the Island where these are developed, is upon the promontory which is terminated by Sachuest Point. Lithologically, the rocks are whetstone talcose schists, grit, and soft slates, often containing many pebbles of quartz and grains, so that they might be termed talcoid conglomerates. We noticed a few pebbles of red jasper among the constituents. This fact distinguishes this group of rocks from the overlying conglomerates. These schists have a direction of N. 20° E. and dip to the west 45° towards the coarse conglomerates at Purgatory. Cleavage and jointed planes are abundant in these rocks upon Sachuest Pt. The age of these strata is probably older than the Carboniferous series, though there is little difference in their external aspect from that of the slates west of Purgatory. There are no beds of coal or other fossils in them, and this exposure of them is an outlier isolated by denudation from the same strata in Little Compton. Their thickness upon Sachuest Pt. cannot be less than 1000 ft. These rocks have been more or less metamorphosed, so that some of the pebbles appear like crystals of quartz and feldspar in a crystalline schist."

In passing from the eastern end of Sachuest Beach southwards to Sachuest Pt. (Plate 1), near the beach the first outcrop is met, a dark gray or black, coarsely stratified rock consisting of grains of crystalline quartz, $\frac{1}{16}$–$\frac{1}{8}$ in. diam., with an argillaceous cement. The waves wash out the argillaceous matter leaving a nodular surface of quartz. The grains are held together in part by silica, and in some places thus form a compact quartz rock traversed by

[1] This rock is now finely exposed at Tiverton in an abandoned quarry close to the station.

[2] Geology of Aquidneck, p. 112, 113.

quartz veins. Dip at a very high angle, strike about N.NE. At 13 this rock *encloses* several thin layers of fine black slate traversed by minute veins of quartz and satin-spar, and containing coal plants. The only determinable specimen found was *Annularia longifolia*, Brgt., which species Lesquereux states to be "very common in coal measures especially in the lower strata above the Millstone Grit."[1] This siliceous rock crops out at several points southwards with the same strike but dipping W.NW., and constitutes the Point. Rounding the Point and following its east side it is found to extend as far as the northern end of Checker Beach with the same dip and strike, and is there conformably underlaid by a compact, greenish, slaty conglomerate, containing some small quartz pebbles and rarely a pebble of red jasper. Near Sene's Pt. there are many large quartzite pebbles on the beach containing Lingulae. The quartzite has a little mica and the Lingulae are in a fair state of preservation. These pebbles, however, do not belong to the conglomerate of Sachuest Neck, but evidently came from the north. At the "Shelf" this greenish conglomerate passes into an argillaceous and siliceous serpentine with the same strike and dip and forms also the high ground back of the shore. At 56 the conglomerate strikes N. 30 E. and dips W. NW.; opposite the "Flints" the same. The "Flints" are projecting points of a mass of black schist and siliceous rock, like that on the west side of the neck, traversed in all directions by small quartz veins; dip and strike the same. The sea erodes the schist leaving a net work of veins. At 57 the greenish conglomerate recurs striking N. 30 E., and a little beyond, on the line of the strike of the rocks at Checker Beach, the quartz and clay aggregate appears and continues to Flint Pt., where a milky quartz vein 30′ in diameter intrudes. In the vicinity of this vein the strata are evidently much disturbed, for the last outcrop near Smith's Beach dips toward the eastern horizon. Leaving out the disturbances at Flint Pt. and at the Flints these data warrant section D.

[1] Leo Lesquereux. Description of the Coal Flora of the Carb. Formation in Penna. and throughout the U. S. Vol. I, p. 45. Vol. P of the II Geol. Survey of Penna. Harrisburg, 1880.

The Little Compton Shore.

As a check upon the correctness of the preceding observations the shore of Little Compton was visited. Jackson's map merely indicates a strip of "Grau Wacke," beginning near Stone Bridge in Tiverton and extending along the shore nearly to Brown's Pt. in Little Compton and separated from the adjacent granite by a strip of "Metamorphic Rocks."

The following observations were made: At 58, south of Fogland Pt., grits dip 25°–30° E.SE. and strike about N. 30 E., are overlaid at 59 by quartzite conglomerate which forms High Hill Pt., about 35′ high, and continues to 60. These are evidently the same rocks as between 20 and Black Pt. cut by the "River." The next outcrop, going south, is at 61 where gray argillaceous schists and shales dip 25°–30° E.SE. and strike N. 30 E. At 62 carbonaceous and argillaceous schists and shales with same dip and strike. The carbonaceous layers exposed contain traces of fossil plants. Quartz veins with traces of graphite traverse them. On the beach fragments of ferruginous schist like that at Wood's Castle, with which these schists strike. At 63 fine, soft, slaty conglomerate, schists and grits dip 30°–35° E.SE.; a little beyond 20° S.SE., with quartz veins 1′ thick near by. At 64 the same rocks dip 30°–35° S.SE. The next outcrop is at Brown's Pt. where a light green chloritic schist with crystals of magnetite stands out of the water striking roughly NE. by E. Back of this Point, at 65, a great mass of schist is exposed, fragments of which have afforded numerous cyclopaean walls thereabout; strike the same as at the Point, dip at high angle. These schists are of two kinds: a chloritic, argillaceous schist with lenticular passages of calcite or dolomite, a dark gray argillaceous and micaceous schist with like passages. Both are finely stratified and plicated. At 66 the highway crosses the same beds. The next outcrop is at 67, just north of Church's Pt., where schists of a somewhat similar character appear, dipping 35°–40° SE. by E., and striking N. 30 E. The green layers overlie the gray ones. These rocks continue to 68. The next outcrop is at 69 near Church's Cove where a light colored rock composed of fine plicated layers of mica schist and quartz strikes about N. 30 E. A few rods further south chloritic schists exactly like those of pt. 65 dip 45° SE. by E. and strike N. 30 E. These rocks are at points hardly recognizable owing to partial decomposition by sea water. Veins of quartz with chlorite traverse these schists. The strike of Brown and Church Pts. is with that of the eastern side of Sachuest Pt. From 69 no other outcrops are visible. West Island is Protogine.

Conclusions.

All these observations lead to the following results.

Stratigraphical: Jackson does not give any detail section of the whole series of strata of the state but gives several special sections and descriptions. According to these the lowest rocks are (1) granite and gneiss followed by (2) mica slate, (3) chlorite slate (in some places with soapstone), (4) hornblende schist (in some places alternating with mica schist or followed by dolomite or serpentine).[1] The "Flinty slate" of Newport Neck he regards as an altered clay slate not forming a part of the above series. The "Grau-Wacke," (Carboniferous) series, consisting of: (1) clay slates, carbonaceous slates and anthracite beds, (2) fine "Grau-Wacke," (3) quartzite conglomerate,[2] rests, he says, upon the different members of the older series.[3] Prof. Chas. Hitchcock observes:[4] "The strata (of conglomerate) are a succession of small folds, — there being more than six anticlinals in the whole belt of rock." And in his general section for the southern end of the Island[5] he represents the following series, beginning at the east with the lowest rocks and looking north: (1) "grits and schists of Sachuest Pt.," (2) "the first conglomerate" (that of the eastern shore, Paradise and Purgatory) with six or seven plications, (3) the schists of Easton's Pt., (4), "the second conglomerate' (that of the west side of Easton's Pt.), followed by (5) the carboniferous shales of "the Cliffs" at the west end of Easton's Beach. He also gives the following estimates and measurements of thickness[6]: (1) 1000′, (2) 500′, (3) 473′ 1″, (4) 464′ 1″, (5)

[1] See pages 70, 74, 75, 76, 79, 80, 81, 87, 90, 91, 92, 104, 111.

[2] See pages 37, 38.

[3] Contact with granite, p. 79, 104; with mica slate, p. 76; with alternating hornblend and mica slate, p. 76; with dolomite, p. 80; with serpentine, p. 81.

[4] Geol. of the Island of Aquidneck, p. 116.

[5] Ibid., p. 119.

[6] Ibid., p. 134

920′ concealed along Easton's Beach, besides 2500′ of coal measures further west. Professor Shaler gives the following as an approximation for the whole Island: Beginning below (1) "Primordial" felsites without conglomerates 800′–1200′; (2) "Carboniferous" conglomerates with carbonaceous shales 500′–1000′; (3) blue and greenish slates 300′–600′; (4) carboniferous slates with about six seams of coal more than one foot thick, some conglomerate, 200′–500′.[1]

Putting sections A, B, C, D, together, eliminating the duplicated portions and adding the observations made between Brown's Pt. and Church's Cove, the general section (plate 3) is obtained.

The section line has been extended on the west to include Easton's Beach[2] and the Cliffs, and on the east to include the granite SE. of pt. 69. While it is not an exact section on any one line it will found to include the main features of a belt two miles in width, that is from near Purgatory to within a short distance of Taggart's Ferry. The accompanying map (pl. 1) embodies the actual geological facts. In neither of them has any distinction been made between the conglomerate and the accompanying grits or slates, nor between carbonaceous schists and the accompanying argillaceous schists. The fold in the chloritic schists is inferred from the contrary dip of the strata at 68, 69 and the east side of Sachuest Neck, but they may be unconformably related to No. 3. The presence of the Easton's Pt. schists (5) and conglomerate (6) and the carbonaceous schists (7) all forming a synclinal between Sachuest Pt. and Wood's Castle, is inferred from the easterly dip of the two latter at Wood's Castle and 22, etc. The anticlinals at Taggart's Ferry and between ridges VI and VII in Paradise have already been shown. The hornblende and mica schist layers (1) have evidently been thrown up from below in a faulting of the conglomerate, as suggested by Professor Shaler. Their probable position in the series is indicated by Jackson's sections[3] to be below his Grau Wacke series and above the

[1] Am. Naturalist, Vol. VI, p. 752.

[2] At the east end of Easton s Beach the conglomerate forms a synclinal, the dip changing to E.SE. 5°–10°–20°. The next exposure is about 1-2 mile further eastward at Bliss' Cave, 5-8 of a mile back of the beach and on the north side of Easton's Pond, where the conglomerate recurs with a dip of 30° W.NW.

[3] p. 80, 81, 111.

chloritic schists, but I think they belong below the latter. Their presence on the east of Sachuest Neck is not probable, for if hornblende schists occurred between beds 1 and 3 their toughness would have insured some traces of them on the shore of Little Compton. These layers (1) consist of five beds of hornblende schist alternating with as many beds of mica schist. Jackson describes a similar series:[1] "Returning to Providence, by the route through Cranston, we passed over hornblende rock obscurely stratified, and dipping to the N.W. Then we came to mica slate alternating with hornblende rock on Neutaconkanut Hill, and passed over the conglomerate of the Grau-Wacke series, until we reached Providence." The anticlinal at Easton's Pt., and the identity of the conglomerate on both sides of it have already been shown. The discrepancy between Prof. Charles Hitchcock's construction of this locality and the writer's is due to the former having mistaken joints for layers, and as their directions are nearly opposite the two results are equally different.

The chronological order and the approximate thickness of the beds described are as follows, beginning with the oldest.

1. Hornblende schist alternating with mica schist.[2]	950′
2. Chloritic schists and associated argillaceous and micaceous schists.	500′–750′
3. Greenish, slaty conglomerate with argillaceous and siliceous serpentine. (Congl. I.)	500′
4. Quartz and clay aggregate.	750′
5. Argillaceous schists and associated slates, etc.	600′
6. Quartzite conglomerate with grits and some arg. schist. (Congl. II.)	750′
7. Carbonaceous schists and shales with argillaceous schists.	500
8. Fine argillaceous conglomerate and grit.	500′
Total,	4950′–5450′

Flexures: There are four anticlinals and as many synclinals in this portion of the Island but the folds disappear to the north, and north of the Portsmouth boundary a different system prevails. The same causes which powerfully folded the strata produced also the fault at Paradise.

1 p. 75, 76.

2 Possibly later than No. 2.

Fissures: The strata are fissured at right angles to the axes of these folds which may indicate another system of depressions and elevations with axes running W.NW.–E.SE.,[1] but operating in a less powerful manner, as would be the case if the strata had been previously corrugated in an opposite direction.

The cleavage of the pebbles of the conglomerate is partly due to the fact that the adhesion of the cement was equal to the cohesion of the pebbles at the time of the fissuring. A Silurian conglomerate even occurs in France in which the siliceous pebbles weather more easily than the cement which binds them together.[2] Prof. Wolcott Gibbs has suggested to the writer two possible explanations of these fissures. *I, Wave theory*: the conglomerate having been acted upon by a wave motion resulting in a succession of vertical breaks at pretty regular intervals. *II, Contraction theory*: the conglomerate having been heated, as seems probable, and beginning to cool at the extremities of the deposit, the resulting contraction would produce a series of fissures and leave the spaces which were subsequently filled with silica.

Historical: Mr. W. O. Crosby, after studying the band of hornblendic gneiss which runs from Concord S.W. to Westborough, Mass.,[3] and visiting the hornblendic and chloritic rocks of Smithfield, R. I.,[4] and also examining the granite in the towns of Rhode Island to the S.W. of Fall River,[5] at first hesitates whether to call them Huronian or Montalban, but finally assigns them to the Montalban series. If the lithological and chemical tests which underlie Professor Hunt's system may be relied upon for this district that classification is probably correct; certainly thus far no paleontological evidences have been found in the hornblendic, chloritic, serpentine and mica slates, Nos. 1, 2 and 3, to bring any of them into the Paleozoic. On the other hand in view of the highly metamorphic character of many of the overlying rocks it is quite possible that some of these lower rocks belong to the Paleozoic Time. The first member of the section

1 President Hitchcock finds a double system of elevation. See Geol. of Mass. p. 540.

2 Oehlert. Silurien de la Mayenne. Bull. Soc. Géol. de France. III Sér., Vol. x, 1882, p. 349.

3 Geol of Eastern Mass., p. 107, 108.

4 Ibid., p. 133, 134.

5 Ibid., p. 127.

which can be definitely assigned to a geological period upon paleontological grounds is No. 4, the quartz and clay aggregate of Sachuest Pt., in the upper part of which characteristic fossils of the lower Millstone Grit occur, which fact, therefore, also determines the Carboniferous age of the overlying rocks as far as 8, and including the anthracite beds which overlie the entire series. The conglomerate II, as pointed out by Prof. W. B. Rogers, is made up largely of fragments of a rock which may be as old as the Primordial. A thinly stratified sandstone or, if in a metamorphic region, quartzite with a little mica and Lingulae, if not entirely eroded, must still represent the ancient source of this Carboniferous conglomerate. Perhaps it may be looked for successfully among rocks which are now regarded as of Archæan Age. The exact source of the boulder of conglomerate containing the fossil plant stems could not be determined ; whether from a stratum of conglomerate overlying the anthracite beds or from an intervening or underlying one is uncertain. It was, however, quartzite and resembled in character the boulders which strew a large part of the Island. The occurrence implies that while conglomerate was being deposited, vegetation was present at no very great distance. The discoveries of Messrs. Crosby and Barton in the Massachusetts extension of the Narraganset Carboniferous basin [1] point, though less strongly, to a similar conclusion, and any theories as to the glacial origin of the conglomerate must be made to conform to these facts.

Physiographical: Professor Shaler has dwelt upon the physiography of the Island and attributes its peculiar features to preglacial, subaerial erosion followed by glacial erosion. We can certainly observe in this portion of the Island the effects of two causes: 1st, a system of anticlinals trending N. 20 E., and 2d, glacial erosion running almost N.–S. The peculiar features of Paradise are due to two folds of conglomerate, the one faulted and the other ruptured (compare General Section and Section B.) together with the forcing up of highly inclined strata of hornblende and mica schist, whose alternations, affording different amounts of resistance to erosion, resulted in a series of ridges and glens parallel with the strike. The angle at which the ice

[1] Op. cit.

stream struck the folds of conglomerate and the edges of the hornblende rocks as well as the exposure of the upturned edges of the layers to the weather, accounts for their shattered condition and curved outline. The sudden dying out of both folds and fault to the north explains the abrupt transition from a scene of devastation to one of rural orderliness. Along the shore the headlands generally consist of the conglomerate and harder rocks while the receding inlets and beaches mark the places of the softer slates and shales, but not without exception, notably between Black Pt. and High Hill Pt. where the conglomerate is cut by Sakonnet River, and on Sachuest Beach where ridge VI suddenly terminates owing either to a transverse fault or erosion. The sanding up of the inlets and the formation of beaches with brackish water ponds behind them, as at Sachuest Beach and between the Paradise ridges, is part of a process which is gradually enlarging and rounding the coast line as may be seen in studying maps of Block Island, Martha's Vineyard and Cape Cod.[1]

Explanation of Plates.

Plate 1. Map of part of Aquidneck Island, etc. Scale $\frac{1}{80000}$.
Plate 2. Map of Paradise Rocks near Newport, R. I. Scale $\frac{1}{10000}$.
Plate 3. Sections.

A. From near east end of Easton's Beach across Easton's Point, E. by S., to near Purgatory. Length 1070 yards. 1, Argill. schists, etc., 2, Quartzite conglomerate.

B. From near Swamp Road across "Paradise," and the Hanging Rocks, about E. by S., to Gardiner's Pond. Length 1000 yds. Horizontal scale double that of the other sections.

1, Quartzite conglomerate; 2, argill. schist; 3, 5, 7, 9, 11, mica schist; 4, 6, 8, 10, 12, hornblende schist. 2, reappears east of section B'.

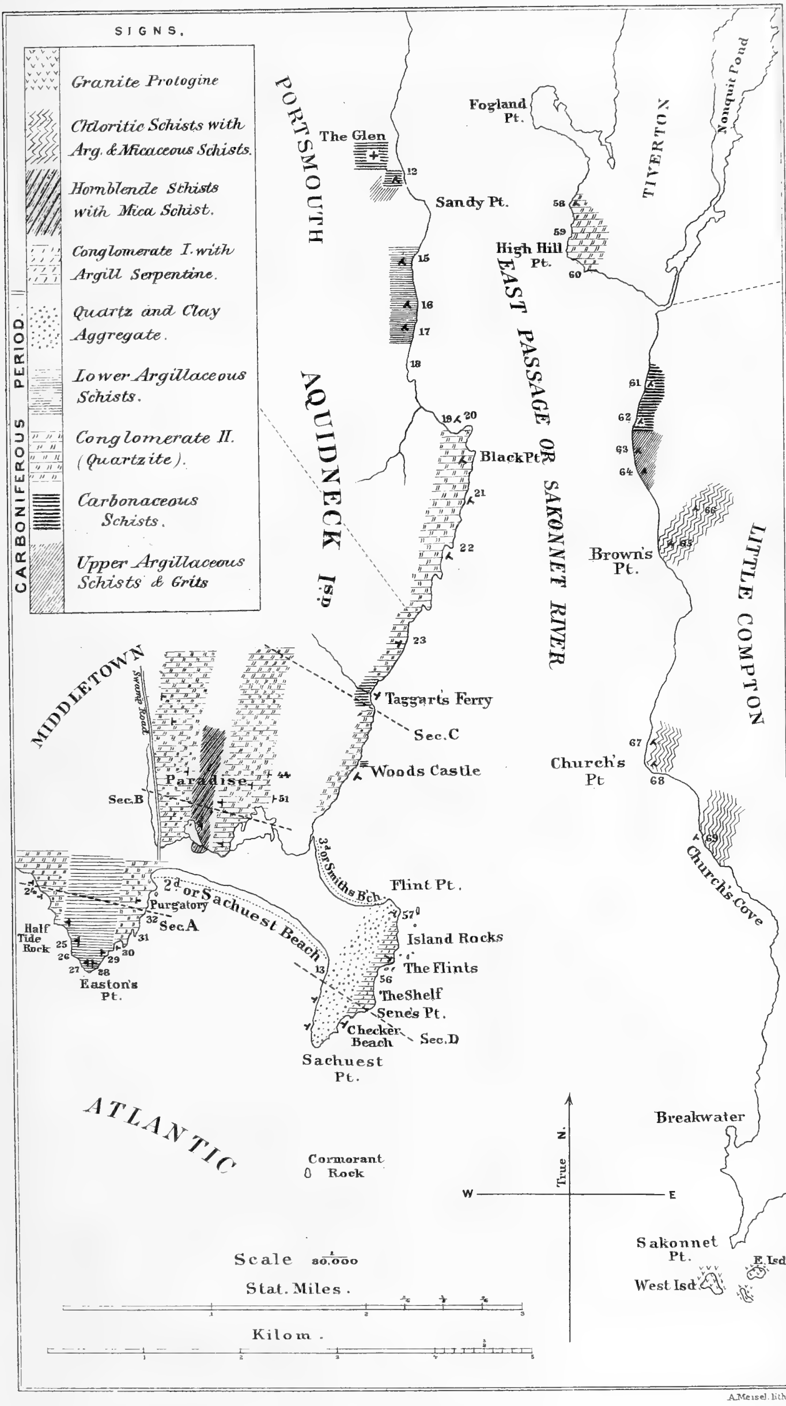
C. Across the shore, close to Taggart's Ferry in an E.SE. direction. The projecting rocks, called "Wood's Castle," south of section line, are added. Length 1100 yds.

1, Quartzite conglomerate; 2, alternating carbonaceous schists and grits with some conglomerate; 3, unobserved, probably same as 2.

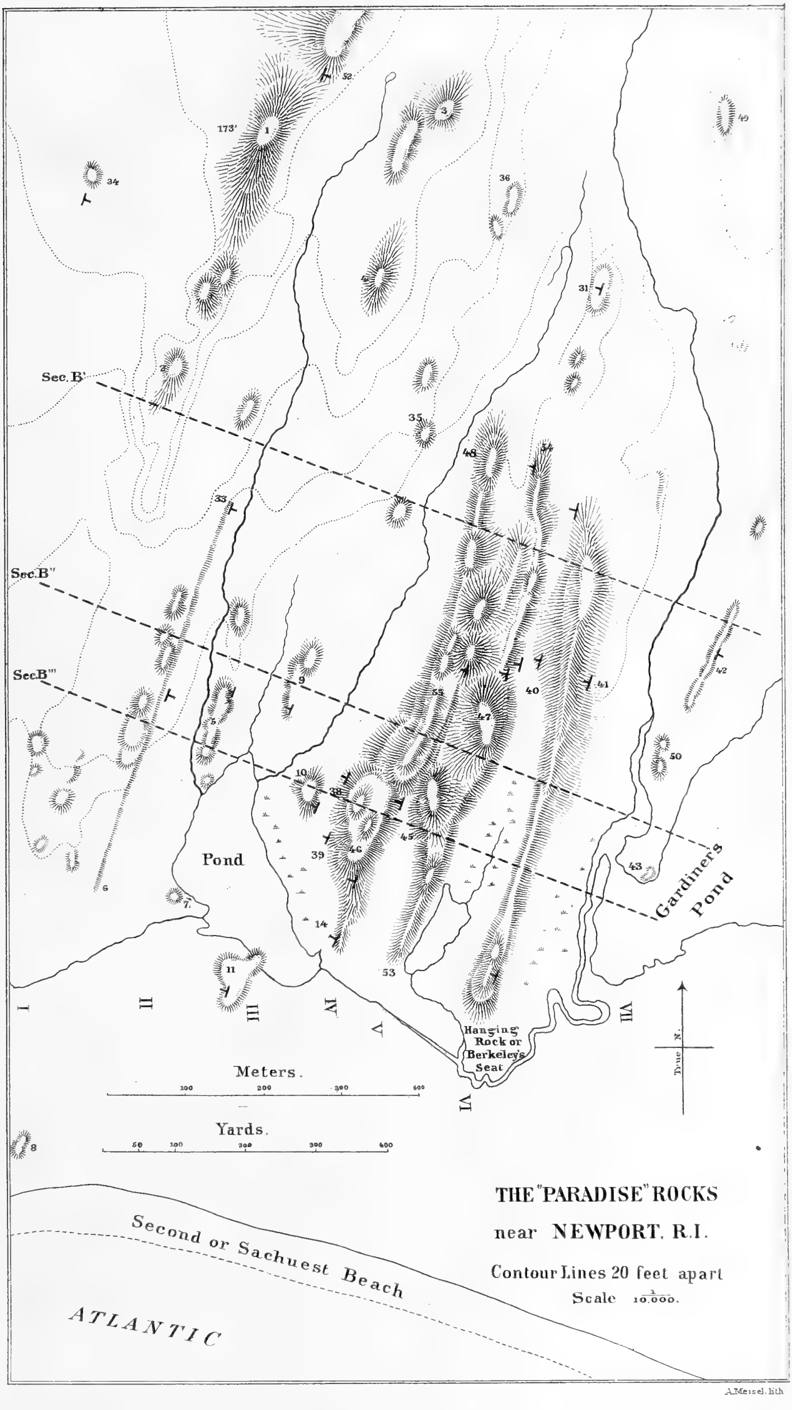
D. From west side Sachuest Neck, E.SE., to Sakonnet "River." Length 600 yds.

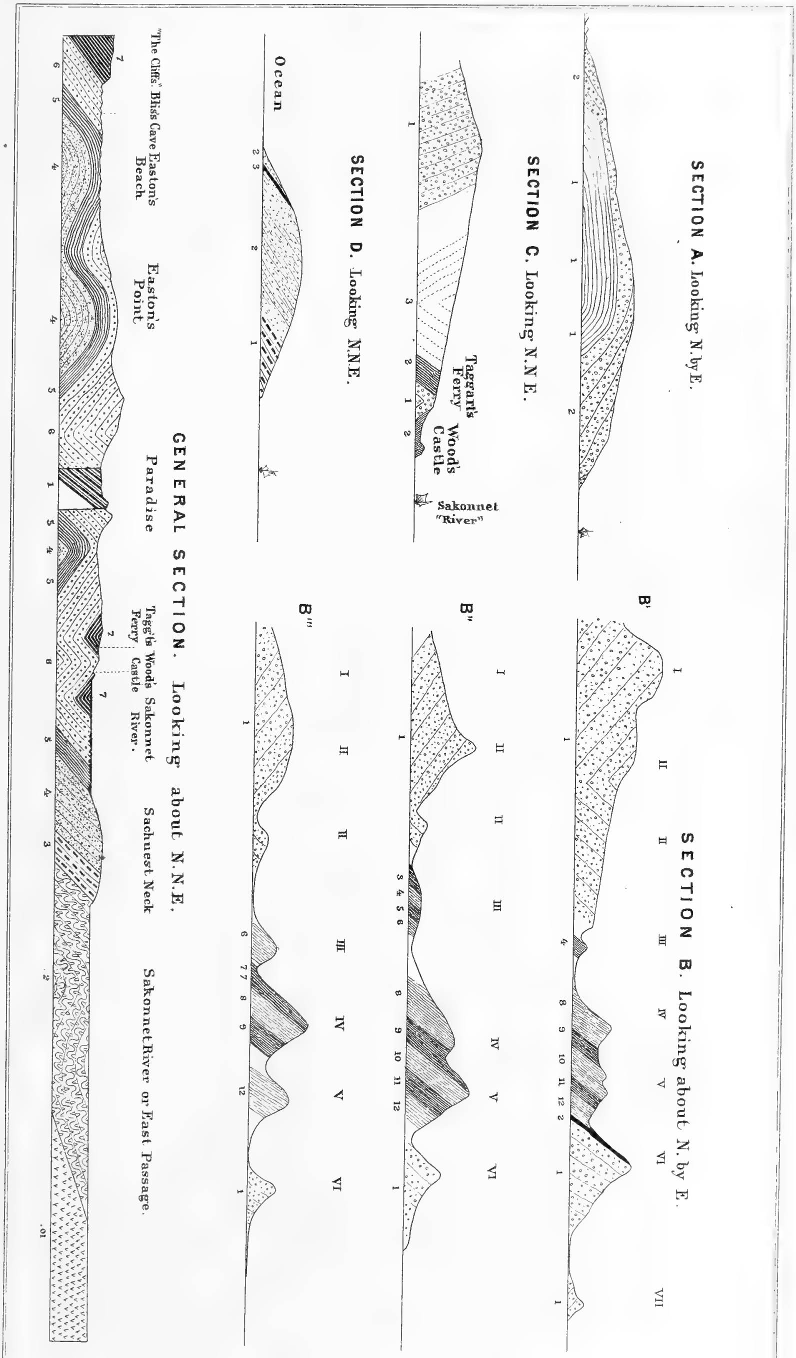
1, Conglomerate and argill. serpentine; 2, quartz and clay aggregate; 4, black slate with coal-plants.

[1] See Oscar Peschel. Neue Probleme der vergleichenden Erdkunde als Versuch einer Morphologie der Erdoberfläche. Cap. 13. Die Entwickelungsgeschichte der stehenden Wasser auf der Erde. 2d Ed. Leipzig, 1876.



DALE, GEOLOGY OF RHODE ISLAND.


Sec. B'
Sec. B''
Sec. B'''
Pond
Gardiners Pond
Hanging Rock or Berkeley's Seat
Meters.
Yards.
True N.
Second or Sachuest Beach
ATLANTIC
I
II
III
IV
V
VI
VII
THE "PARADISE" ROCKS
near NEWPORT, R.I.
Contour Lines 20 feet apart
Scale 1/10,000.
A. Meisel, lith.



A.Meisel lith.

DALE, GEOLOGY OF RHODE ISLAND

GENERAL SECTION.

From the line of the "Cliffs" near Easton's Beach, E.SE., to that of Church's Cove in Little Compton. Length 5 miles.

01, granite, Protogine; 1, hornblende and mica schist; 2, chloritic schists; 3, conglomerate I (serpentine); 4, quartz and clay aggregate; 5, lower argill. schists; 6, conglomerate II (quartzite); 7, carbonaceous schist, (incl. upper argill schists, 8).

NEWPORT, R. I., Oct., 1882.

GENERAL MEETING, JANUARY 17, 1883.

The President, Mr. S. H. SCUDDER, in the chair. Twelve persons present.

Dr. S. Kneeland read a paper on the characteristics of the human races of the Malay Archipelago, particularly of the Philippines, showing a considerable collection illustrating their dress, implements and industries. To explain the various ethnological problems of this region, Dr. Kneeland believed the hypothesis of a sunken Pacific continent the most natural one, and well borne out by many facts.

GENERAL MEETING, FEBRUARY 7, 1883.

Vice-President Mr. F. W. PUTNAM in the chair. Thirty-eight persons present.

Mr. Lucien Carr read a chapter in the social and political influence of woman among the Huron-Iroquois Indians.

The following papers were also read:

SOME INSTANCES OF ATMOSPHERIC ACTION ON SANDSTONE.

BY M. E. WADSWORTH.

The object of this brief paper is simply to place on record some observations made a number of years ago, and to call the attention of others to the subject, in the desire that similar facts may be observed and more fully studied elsewhere.

That ordinary atmospheric agencies produce a greater effect upon rocks of a siliceous character than is generally believed, I have long deemed probable. This conclusion has been derived from field observations especially upon sandstone and quartzites.

As examples of the power of the ordinary atmospheric agencies over rocks I would cite some cases observed by me in 1871, '72 and '73 near Mazomanie, Wisconsin, in the friable St. Peter's and Potsdam sandstone. The St. Peter's sandstone is composed almost wholly of a pure quartz sand, and in the outliers of it found on the hill tops south of the town, the parts covered by the soil were more or less friable and the grains distinct; while the exposed portions of the same blocks and slabs were greatly indurated, the grains almost obliterated, and the rock possessed the conchoidal fracture and other characteristics of a quartzite.

The Potsdam sandstone east of the town likewise possessed similar characteristics. In this, concretions of an indurated character were found forming on the surface, in size from three-fourths of an inch to an inch in diameter; while in the sandstone a few inches only their rudiments could be observed in minute spherules, and a few inches farther in the sandstone was incoherent, easily crumbling under the touch and showing no trace of concretionary structure. At another locality the sandstone showed in cavities formed by weathering a distinct lining of quartz crystals, while a few inches beneath the surface the rock had the common friable character. The formation of these crystals, as well as the surrounding surface induration of the rock, is to be attributed to atmospheric agencies; as hot waters would have consolidated the sands beneath, and not as is seen so extensively in that vicinity only the surface rock left by denudation. In the autumn of 1872 a block of clear white Potsdam sandstone was found on the side of a hill, the protected side of which was friable, while the other sides, especially the one most exposed to the prevailing storms, was nearly a quartzite. This block was only about two feet square, and as a test of the correctness of the above conclusion the indurated surface was broken off, and a comparatively friable surface exposed. This locality was visited the following spring when it was found that this fresh surface was much indurated and approached towards a quartzite.

This change had taken place in the few months that had elapsed since the fractured and friable surface had been exposed and there could be no doubt that the change was due to the action of the elements. Many observations were made regarding the induration of these sandstones, which are not here given, but all tended in the same direction — to show that atmospheric agencies exercised a strong indurating influence upon the surface and immediately underlying portions.

THE EPIDERMAL SYSTEM OF BIRDS.

BY J. AMORY JEFFRIES.

The epiderm of birds possesses a much larger variety of appendages than that of any other vertebrate group. These appendages have, from time to time, been compared in various ways to the epidermal appendages found in the other groups; and of late years an effort has been made to show the direct homology of feathers, hairs and scales. Indeed this has gone so far that all the epidermal appendages have been reduced by some to one type.

To investigate these homologies and to compare the varying products of the epiderm of birds with those of the other groups are the objects of this study. The structure of feathers, scutae, claws, spurs, toe-pads, bills, combs, wattles, and spines of the tongue and mouth, have all been studied as found in the adult, and their development has been followed from the third day of incubation. As much has already been writen on the structure of feathers any description of their adult form is omitted in this paper.

My embryological studies have been made for the most part on the chick and duckling, yet many forms of the other orders have been examined. In all cases they have been found the same, so that any statement made for the chick may in all probability be extended to cover the entire group of carinate birds.

A word as to the method or order of this article. First, the naked skin is considered, and then one after another of its products. In each of these separate subjects the literature is first considered, then the adult structure, and then its development. All questions of morphology and the like are deferred to the end, where they are discussed in the light cast upon them by the previous descriptions.

Finally, as to the methods of investigation. Being fully convinced that accurate ideas can be obtained only by long and careful study, everything that offered the faintest glimmer of light has been followed up. Every structure has been studied in at least two different ways, in order to exclude as far as possible errors introduced by reagents.

The objects have been hardened either by freezing, by a chromium compound, or by alcohol; mostly by the latter reagent. Carmine, hematoxyline, eosin, French blue, picro-carmine, nitrate of silver and chloride of gold, were the chief staining reagents used. The neutral solution of a mixture of eosin and French blue used by botanists has been found of great value. The active portions of the tissue are stained red, while the dead or inactive parts are stained various hues of blue and purple. Not only this, but the blood globules, in virtue of the action of their haemaglobin on the blue, are stained a peculiar yellowish red. By this means the capillaries are easily traced.

Above all, every structure has been examined in situ as a whole and its relation carefully noted.

ADULT SKIN.

The skin in adult birds has, as in all the vertebrate groups, an epidermal coat, the representative of the embryonic ectodermal layer. It is this epiderm in its undifferentiated parts that we now have to consider, leaving the appendages and spots of peculiar structure till later.

The base of the epiderm is formed by a layer of cuboidal, or columnar cells, resting directly upon the cutis vera, and usually known as the mucous layer, or rete Malpighi; the first name is the one adopted in this paper. It has often been stated that a basement membrane exists, separating the mucous layer from the cutis vera, and some state that it is made up of polygonal[1] cells. Such a membrane I have never been able to find. By no manner of manipulation have I been able to separate such a membrane, even where the cells have been broken from the ends of thin section. But the cells of the mucous layer and, indeed, all the epidermal cells are held together by a homogeneous intercellular substance, which forms in large part the "walls" of the cells. It is this intercellular substance forming the basal walls of the mucous layer which, I believe, has been mistaken for a basement membrane.

Except where organs of special sense are developed, the mucous layer rests smoothly on the surface of the cutis vera, no papillae occurring. The cells (pl. 4, fig. 1 *c*) of the mucous layer vary in size in different birds, being somewhat smaller in very small birds than in larger ones. In the Cormorant they measure about .0075 mm. by .0125 mm., being columnar in shape. The nuclei are oval or elongated parallel to the long axis of the cell and measure about .006 mm. The nucleoli are quite small and difficult to distinguish. In number they seem to vary from one to two.

Outside the mucous layer is a bed of polyhedral cells, *b*, which much resemble the mucous cells in structure. As a rule, however, they seem to have but one nucleolus. These cells vary considerably in number, according to the part, and they are destined to form the outer horn-cells.

The horn, or outer epidermal, cells (*a*) form the external coat of the skin, which is thinnest on the parts protected by the plumage. The cells are flattened, polygonal, without distinct nuclei and arranged in more or less perfect layers. Nuclei can be brought out by proper reagents as caustic potash and the like. Like the cells below, these scurf cells are joined together by an intercellular substance. Desquamation shows a strong tendency to occur at fixed periods, the moults, and in large patches, as in frogs. This tendency is most marked on the tarsus and will be considered when describing the scutae.

Nerves and lymphatics have not been noticed in the epiderm, yet both have been clearly seen in the cutis vera. I am therefore inclined to doubt if many nerves enter the epiderm except in parts specially endowed with sense organs. Lymphatics have been well injected in the true skin yet nothing has been seen of this system in the epiderm.

The cutis vera, or true skin, though properly beyond the province of this paper, is built up of fine branched connective tissue filaments, with more or less connective tissue corpuscles, on the outside. Deeper it is composed of fibres of considerable size running in bundles in all directions. The whole is supplied with abundant capillary systems for the blood and lymph, which extend out to the mucous layer and supply it with food. Pigment, when found in parts of the skin not specially modified, is limited to the cutis vera, there being a bed of small pigment cells (fig. 1 *d*) directly below the mucous layer and large masses of pigment in the deeper parts of the cutis vera.

DEVELOPMENT OF THE EPIDERM.

The epiderm, which is the representative of the epiblast of the embryo, is formed during the earlier hours of incubation in a way not necessary to describe. About the second day of incubation the epiblast becomes roughly two-layered. At first both of these layers consist of roundish cells with conspicuous nuclei and nucleoli embedded in an intercellular substance. The outer cells, however, shortly become flattened out into a layer of polygonal cells, thus forming the epitrichial layer of German authors. This layer is usually distinct by the fifth day, from which time the growth of the skin may be said to date.

During the middle of the fifth day the mucous layer consists of large cuboidal cells (fig. 2 *b*) of about .01 mm., with a large nucleolus .004 m.m.,— with one or more dark nucleoli. Contrary to the observations of Frommann the cells of the mucous layer seem to be distinct and not to form a uniform mass or symcitsium. The basal walls[1] of the cells are distinct and rather thick, while the walls between the different cells are thickened at the base and gradually thin out towards the top of the cells. The walls of the top, or outer surface, are very indistinct and often not to be seen; a natural result of all the outer cells being cut off from the outer ends of the mucous cells. The cell walls or intercellular substance is easily stained with a few drops of a strong alcoholic solution of eosin dropped into true benzole, or by nitrate of silver,—the first method however is the easier and more permanent.

The epitrichial layer (fig. 2 *a*) though perfectly distinct, is in a very elementary condition. It consists of cells, in nature like those of the mucous layer, more or less flattened into discs, dispersed through a mass of intercellular substance. The nuclei

[1] This word is used to represent the parts which act as walls, even if composed of intercellular substance.

and mucleoli are like those of the mucous cells. The cells of this layer seem to undergo division, though dividing cells have not been noted. My reasons for supposing this are, first, that at a later period of growth the cells form a compact layer; second, that two nucleoli are present.

By the middle of the sixth day, though in places the epiderm is the same as before, a decided change has occurred. Cells have already begun to divide off from the mucous layer and to form a more or less continuous layer between the mucous cells and those of the epitrichial layer. In nature and dimensions of parts they are very much like those of the mucous layer, but differ in that, as a rule, only one nucleolus is to be seen. I have not actually traced the formation of these cells, but judging from sections (fig. 3) it would seem that they are simply divided off from the ends of the mucous cells. At all events, in the places where no cells intervene between the mucous and epitrichial cells the former are columnar and provided with rather long nuclei with a nucleolus at each end. On the other hand, where cells do come between the two primary layers the mucous cells are cuboidal and provided with a roundish nucleus and a single nucleolus.

From the sixth day on cells are slowly divided off from the mucous layer. These, when first formed, closely resemble the mother layer, but gradually undergo changes which tend to the formation of the adult skin. By the fourteenth day but slight advance has been made. The epitrichial cells are still very irregular in shape (fig. 4) and show large patches of intercellular substance between them.

By the twentieth day the epitrichial layer (fig. 10) has assumed its final form which is the same over the entire body. It now consists of a continuous layer of flat polygonal cells, with broad divisions between them, of about .015 mm. in width and one-fourth to one-fifth that thickness. The protoplasm of the cells is aggregated in little patches or spots, in fact it looks as if it had curdled, while the nuclei and nucleoli are quite indistinct. When fully developed the epitrichial cells are not easily stained with carmine or hematoxyline, but become a dark purple when treated with the mixture of eosin and analine blue before mentioned. Thus showing that the activity of the cell is much diminished or, perhaps, arrested. The cells (fig. 5) divided off from the mucous layer form a bed from one to three cells deep, in nature the same as during the sixth day. The condition of the mucous layer is unaltered.

After hatching the epitrichial layer and some of the subjacent cells dry up and are shed. Previous to this, the cells divided from the mucous layer, which I shall call transitional cells, increase in number, and the middle ones by a process of drying and consequent shrinkage become the horn cells of the adult skin.

During the third week of incubation, or before, pigment cells are apt to make their appearance in the mucous layer, and after a few days to disappear. Since these cells are more abundant in the appendages, as in the scutae and feather, descriptions of them will be deferred till we come to those parts.

The above description fairly embodies all the important conditions of the developing epiderm as considered from a morphological point of view. The dates given for the various stages are only approximate. The development of the epiderm is very irregular and eggs of the same age and from under the same hen present marked differences.

During the latter part of incubation the cutis vera is slowly developed from the outer cells of the mesoblast. This is done by the gradual growth of the vessels and nerves, each after their own manner, and the transformation of other of the undifferentiated cells into connective tissue and dermal muscles. Yet some of the primitive cells remain unaltered and form the connective tissue corpuscles of the adult cutis vera. These, by methods the same as in the embryo, develop into the elements of the cutis vera and greatly increase its thickness and tenacity.

DEVELOPMENT OF EMBRYO FEATHERS.

The development of feathers is best divided into two parts, that of the first feathers, which takes place during embryonic life, and that of the feathers developed to replace those shed during the moults.

The development of the first feathers has been studied by Engel(2)[1], Pernitza (2) and Studer (16). The first author worked

[1] The numerals refer to the Bibliography at the end of this paper.

out a most remarkable theory of growth for feathers; the realization of which it is difficult to find. He seems to think that the various elements of the feather are formed by division from little bulbs at the ends, each barb having its own bulb.

Pernitza studied the development with considerable care, and as far as he goes, my observations in the main agree with his. The same may be said of the paper by Studer. Indeed, were it not for the sake of uniformity and of new distinctions introduced into the study of the epiderm the whole subject might be passed over.

Since feathers grow from the base many of the stages of development can be found in any one of the larger papillae, but the whole history of a feather cannot, as stated by some, be revealed by any single papilla. There can be but one stage of each part in any single papilla. But since all the papillae do not develop at the same rate or even appear at the same time, nearly all, if not all, the stages may be found on the body of any well-advanced embryo. Accordingly I shall not trace the development by age — but by stages.

The first signs of the feathers appear about the sixth day of incubation as small hemispherical papillae usually arranged in quincunx order. They are composed of an inner core of mesodermal undifferentiated cells and the epiderm of only the two primary coats. The papillae grow rapidly in length and at the same time tend to sink below the surface, more especially at the posterior side. By this means the papillae become inclined toward the posterior end of the embryo. As each papilla slowly elongates a capillary loop is formed in the mesodermal core and the mucous cells produce a large number of transitional cells so that the epiderm becomes quite thick.

We now come to the first traces of the feather. Two thickenings of the epiderm (fig. 6 *d*) appear on the outer surface of the papilla. These, starting from the top, slowly extend towards the base of the papilla and encroach on the pulp. While these thickenings, destined to form the first two barbs, are growing, the epitrichial layer becomes more compact and the outer transitional cells more or less fusiform and horny. By this change they form a sort of sheath for the deeper parts of the epiderm.

The mucous cells are as yet unaltered. As the papilla grows, new thickenings are formed until from twelve to twenty exist (fig. 7). As the number of folds increase they become more and more cut off from the rest of the epiderm, so that they almost form columns. This is true of the tips only, the greater part of the folds remaining triangular in section (fig. 7). The difference is due to the lack of barbules at the tips of the barbs.

With the above changes in form are associated certain histological changes. The mucous layer ceases to produce new cells. Those already formed suffer various changes according to their position. The outer ones help to form the sheath of the feather which will be described later; the cells in the centers of the folds simply thicken their walls or form them. Here it is to be noted that most if not all the cells forming the surface of the barb-tips are derived from the mucous layer. The cells between the folds begin to degenerate about this time.

At a more advanced stage the development is complicated by the formation of barbules. This causes the ridges to increase considerably in size and offers a difficult problem to the investigator. The barbs are formed by the cells at the angle of the thickenings, as seen in section, while the cells on the sides arrange themselves in columns (fig. 8) which bend slightly towards the tip of the papilla and ultimately form the barbules. The cells nearest the surface are the smallest. These cells, as yet with distinct nuclei and nucleoli, rapidly elongate and loosen their connection with the cells of adjacent columns. By this means large intercellular spaces are formed, or rather the intercellular substance is much increased. The elongation of the cells of the columns begins at the ends, that is, at the parts destined to form the tips of the barbules. This growth in length of the barbules of course necessitates an alteration in the position of the barbules. The tips of the barbules slowly push their way towards the tip of the feather-sack or papilla; a change which would burst the feather-sack were it not that the cells of the barbules decrease in transverse section in proportion as they elongate. While the above changes are going on in the mucous cells and those next to that layer, the cells in the middle of the thickenings shrink and form a sort of connective tissue. The pulp also becomes very vascular and assumes an adenoid structure. Thus the mucous cells are offered every facility for the absorption of the nutrient fluids which saturate the pulp. Lastly, the cell walls of the barbs and barbules become converted into a sort of horn, and the protoplasmic contents dry up.

The quill, which may be regarded as the last stage in the growth of a feather, is formed from the mucous and adjacent transitional cells at the base of the papilla. In this part the epiderm never becomes folded or thickened as in the upper parts, but remains as a simple sheath about the papilla. The deeper cells become converted into long threads of horn and form a tube or cylinder which, when the pulp dries, forms the quill. The epitrichial and a varying number of transition cells dry up and remain in place only by virtue of their position in the feather-pocket.

The pulp slowly withers at the end as the tip of the feather becomes complete and needs no more food; so by the time of hatching it is quite small. At this time the epitrichial and outer horn-cells are shed, and the feather, by its elasticity spreads out and slowly sets into the adult structure.

So far nothing has been said of pigments, because they are accessory to, and not an essential part of feathers. In cases where a feather is destined to have a pigment the first traces appear in the epiderm about the middle of incubation,—from the twelfth to seventeenth days in chicks and ducklings. The pigment simply appears to accumulate, granule after granule, within the cells destined to form the feather-parts. Besides these pigments a brownish pigment may sometimes be seen in the epiderm of very young papillae.

It would be difficult to say what becomes of this brown pigment. It very probably disappears after the manner of the pigment in the epiderm of the scutae.

DEVELOPMENT OF PINFEATHERS.

Although much has been published upon the development of feathers nearly all the papers were written before the subject was thoroughly understood.

Thus Meckel (7), Cuvier (8), Reclam (12), Schrenk (11) and Holland (12), regarded the feather as a secretion moulded in a case. Their supposed case being the various parts of the pulp and outer epidermal coats. In 1840, Burmeister (9), in the first part of Nitzsche's Pterylography, explained how the feather-parts were made of cells, but did not show the origin of the cells or their morphological nature. In 1869 and 1870 Studer (13, 14) published two papers on the growth of feathers, showing them to be formed from epidermal cells, but paying little attention to the layers of the epiderm. In 1870 Samuel (15) published a valuable article on the development of feathers. This author, however, studied their growth from a physiological standpoint and passed over anatomical detail. Dr. Samuel's statement that castrated birds, capons, do not moult is ambiguous. It seems to be true that capons do not moult large numbers of feathers at one time; on the other hand, the old worn feathers are removed one by one[1].

In 1873 Studer (16) published his first paper on the development of feathers, and gave us by far the best description we have. The work will be repeatedly referred to later on and must not delay us here.

In 1877, Kerbert (4), in an article to which we shall refer frequently when considering the growth of scutae, made the following statements: First, that the shaft of the penguin feather is in reality no shaft, but consists of agglutinated barbs; second, that the feather pulp is permanent in this group.

In other words he saw in the feathers of penguins a link between feathers and scales.

Unfortunately, as Studer (17) showed, in 1878, neither of these statements is correct. The shaft is a true shaft, just as much as that of any other bird, but is more or less flattened. Normal, though sparse, barbs are also present. Lastly the pulp aborts in precisely the same way as in other birds. Thus the supposed link connecting feathers and scales proved too weak to support its own weight. In the same paper Studer also described the formation of the aftershaft in the Cassowary.

Passing now to the development of feathers we find the following points of interest.

First, the great complexity of the final structure, especially as regards wing and tail feathers.

The minute structure of these vary in the different groups of birds, as I have myself observed, and has, I believe, been pointed

[1] This statement is made on the word of the poultry growers in the vicinity of Boston; I have been unable to study the point.

out by Schroeder, though I have not seen his paper. Here it is well to note that the wing and tail feathers of birds which remain in the nest grow from the first like those of adult birds, *e. g.* Passares, Picariae, Accipitres and the like; on the other hand in birds which leave the nest they are preceeded by regular down feathers like those on the rest of the body. Secondly, the relation of the various parts of the feather to the parts of the adult skin, as pointing out the value of the divisions in the epiderm.

Thirdly, as a feather on an adult bird is a successor or continuation of a down-feather, the two may be regarded as representing the embryology and development of the feather. That is, assuming the down-feather to be nearer the form of the primitive feathers, the feathers of adult birds may be regarded as their evolved descendants. And thus we are able to see how far their embryology — *i. e.* growth of adult feathers — coincides with their evolution.

That the above assumption is correct I shall endeavor to show in the latter part of this paper.

So far as I know, the development of feathers never begins after a bird has left the egg. All the feathers-sacks seem to be formed during embryonic life. In this paper attention has been chiefly turned to the growth of the remiges and rectrices, though the common contour feathers have not been ignored. Much to my regret I have not been able to study the formation of any of the peculiar structures, as the waxes of certain forms of the Ampelidae.

The first step towards the formation of a new feather is the growth of the old papilla, which, after the perfection of the previous feather, shrinks to a small mass at the base of the feather. The papilla, by simply elongating forces out the old feather and with it the horn cells forming the inner coat of the feather pocket. I use this word in distinction to the feather sack, or coat, of a pin-feather. In every case examined by me the first step has been that described above. I have never seen a papilla developed below or beside the old feather as usually described for hairs, and as described by some for feathers. Again, according to my observations, the old feather is always forced out of the pocket by the growing pulp. The little feathers which Studer describes as growing out of the pockets beside the old ones figure 38 of his article, are not remiges, but coverts, the pockets of which, on account of their inferior size, are simply born out upon the pockets of the remiges. Even in Studer's figure, this is shown by the covert of the fourth primary, which is clearly in a separate pocket upon that of the primary.

Turning now to the structure of the papilla and pocket, it is clearly shown by longitudinal sections that the layers of the epiderm are continued from the walls of the pocket on to the papilla. At this period the structure of the epiderm is very simple and consists of the mucous layer and a thin layer of roundish transitional cells outside. The horn cells have all been shed with the old feather. Very shortly the transitional cells begin to form in large numbers and cause the epiderm of the papilla to excel greatly in thickness that of the pocket; soon after the tip of the pulp has appeared above the surface, or even before, several changes occur (fig. 11). The outer layer of cells (*a*) covering the feather-sack becomes very much flattened, polygonal, and forms a thin sheath (fig. 10) which resembles remarkably the epitrichial layer of the embryo. In position and structure it is very much the same, and cannot be told from the epitrichial cells covering the primaries of young passerine birds. Beneath this is a layer of flat horn cells (fig. 11 *b*) formed from the outer transitional cells. The inner transitional cells together with those of the mucous layer still retain their primitive character. Yet changes have occurred in their arrangments; they no longer form a simple sheath around the pulp of cutis vera, but two thickenings exist each one destined to form a barb. These are rapidly followed by others added on at the sides until the entire surface is occupied. The first two formed shortly join and start the two halves of the shaft and are later joined by those on the sides. So all but the two first folds do not run parallel to the long axis of the papilla, but slant towards the first two, or primary, folds; the folds on the left side joining the left primary fold, and those on the right the right primary fold. As yet the shaft is a solid rod, the composite nature of which can be traced in many adult feathers

After the feather is somewhat grown the composite structure of the two sides of the shaft is lost and a fold is seen growing from each side into the pulp. These folds growing round and finally meeting complete the wall of the shaft on the inner side. In those cases where the shaft is hollow a column of the pulp is enclosed which upon drying up leaves a space; in solid shafted feathers the sides are simply flattened against each other and do not enclose any of the pulp.

The direction of the folds destined to form the lateral barbs is also changed. They now run from a line (fig. 12 *e*) on the inner side of the papilla downwards and shaftwards, so as to join the shaft at an angle of about forty-five degrees.

Studer, who seems to have overlooked the direction of these folds, states that those on the inner side are the youngest and least developed, and that the folds run from the tip towards the base of the papilla. This is a slight error; the folds on the inner side are smaller because they are destined to form the tips of the barbs, which are much smaller than the bases. As to their histology the folds are as well advanced on the ventral side, though they belong to barbs nearer the base of the feather. This is owing to specialization advancing from the tips, or ends, of the feather-parts to their bases. So the tip of any barb is complete before the base of the barb distal to it.

Thus far I have only spoken of the grosser structure, in fact, what may be seen by the unaided eye. We have still to consider the histology of the shaft and the formation of the barbs and their appendages.

The back of the shaft is formed by the transitional cells extending down the middle of the outer surface of the papilla. These become converted into long fibres of horn, as so admirably shown by Burmeister. The same is true of the other surfaces of the shaft. The sack has no part in the formation of the shaft as commonly stated. The cells in the body of the shaft, those destined to form the pith, undergo no change of form but remain more or less spherical, and by a process of drying finally form little, horny sacks. In these may be found a trace of the protoplasm and nuclei. The cells forming the walls of the cavity in hollow-shafted feathers form a simple, horny film. Here it is worthy of note that the cells lining the cavity and covering the inner side are true *mucous cells.*

The formation of the barbs and barbules is quite complicated, owing to the complexity of the final structure, but in plan is the same as in the down-feathers. The ridge of each fold forms the barb, and the sides the barbules and hamuli. In sections the ridge of the fold forms the apex of the triangular section. As in down-feathers the barbules form more rapidly than the barbs. In most cases the barbules are simple rods of elongated cells set end to end. When this is the case they are formed in exactly the same manner as in down-feathers. The barbs also are formed in contour feathers in the same way as in down-feathers; that is, the cells along the ridge of the fold become arranged in a column, and the outer cells of the column become flattened into a coat, while the inner ones retain their original form. The walls of all become converted into horn and the protoplasmic contents finally dry up.

In the wing feather, as of the common pigeon, where the barb is flattened, the flat portion is formed from the cells in the centre of the fold. The barbules in the wing-feathers are short and arranged nearly at right angles to the barbs. They are formed of transitional cells, which crystalize, to borrow a word from the inorganic world, in the form of the future barbule, with its hamuli. The outer cells become flat and turned into horn and the inner ones into little bladders as in the barbs. A good idea of the change can be formed by examining figs. 13 and 14, in which the shaded portion represents the cut barbs and barbules.

While the mucous and adjacent cells have been arranging themselves in the form of a rolled up feather, the transitional cells outside have become converted into a sort of connective tissue. This tissue forms a framework which supports the outer parts of the feather, and doubtless represents the various membranes described by Cuvier. The pulp within also sends thin laminae in between the barbs.

Passing now from the shaft and parts of the vane we come to the quill. The formation of this is extremely simple. No folds are formed in the epiderm and as a result the whole remains of one uniform thickness, and is continuous with the shaft and barbs forming the whorl. The mucous and transitional cells of this sheath become converted into threads of horn, while the feather sack and pulp dry up and die. By this means the quill, which is nothing but a tube of horn is formed. The umbilicus is simply the place where the pulp formerly lay. It is commonly stated that the sheath takes part in the formation of the quill; this is an error, it simply remains in contact with the quill since it is held there by the skin.

I have not been able to secure satisfactory pin-feathers in which to study the formation of after-shafts. Studer, however, has shown that they are formed in the same manner as the main shaft but opposite to it.

As the tip of the feather becomes complete, long before the quill is begun, the feather sheath dries up and is rubbed off by friction, thus allowing the feather to unfold and set in its proper form. This gives the appearance of the feather being pushed out through the sheath as stated by the old authors. Samuel, to disprove this, cut all the nerves of a pigeon's wing, thus paralizing it and then plucked out some of the primaries. The feathers which grew to replace those plucked out retained their sheaths since there was no friction. Much the same thing may be seen in nestlings.

The pulp dries up at the tip as the feather becomes formed and leaves only a light cuticular film, the pith of the quill; most of the substance of the pulp is absorbed.

Pigment when present is simply formed inside the cells of the feather, and is often different from the color given off by the feather.

To sum up: First, the feathers of adult birds are developed on the same plan as the down-feathers,—by a renewed growth of the primitive papillae; yet in the formation of the feather the conditions found in down-feathers are never present. Secondly, the same distinctions can be introduced as into the epiderm of the embryo. Thirdly, the under surface of the vane and shaft is the inner surface of the epiderm, which in all other cases in the vertebrates is in connection with the cutis vera. Finally, the cutis vera is exposed to the air at the umbilicus; or, more accurately, would be exposed were it not for the cellular films which form the pith of the quill, left by the retreating pulp.

SCUTAE.

The scutae, or scales, on the tarsi of birds are folds or flaps of the skin, which point towards the tip of the limb but do not overlap one another. Their occurrence and gross appearance are so well known that they may be passed over. I would only call attention to the fact that feathers may grow from the edge or beneath the scutae, as shown by certain breeds of hens. (Figs. 18, 19, 21.) In such cases the feathers are set in regular pockets, as in the rest of the body.

Though all the general works on comparative anatomy have more or less to say about the structure of the scutae, I know of but two papers which enter into detail. Kerbert (4) gives two figures of the histology of the scutae, and figures certain branched papillae which he says extend from the cutis vera between the cells of the epiderm. The other work, that of Hanau, I have not been able to procure, nor even to find any summary of it.

An adult scuta has but three different layers of the epiderm. (Fig. 22.) These are the mucous layer, the transitional cells and the horn cells. The mucous layer rests evenly on the corium without the intervention of such papillae as occur in the toe-pads, which will be described later. The cells vary more or less in size in different species of birds, and in different parts of the scuta. At the edge of the scuta, where the mucous layer of the outer and inner surfaces nearly meet, the cells are apt to be cuboidal; higher up, above the flap, they are columnar, as a rule. The nuclei are of good size, roundish and often with two or more nucleoli. The cell walls are difficult to stain, but owing to their different density show up as irregular lines. It is these cell walls, which assume all sorts of branching appearances, that, I believe, represent the papillae of Kerbert. At all events, no papillae are to be seen in very thin sections, while the cell walls and intercellular substance are quite distinct. Here it is of interest to note that these supposed papillae will not stain with the same reagents that stain the true filaments in the tongue and papillae of the toe-pads.

The transitional cells near the mucous layer are much like the mucous cells. The outer ones, however, are distinctly fusiform [1] in shape, and have their nuclei correspondingly elongated. These

[1] There are two classes of horn-cells: those forming the outer coat of the epiderm in general and those forming claws and the like. The first owe their name to the toughness of their walls and lack of active protoplasm and are of variable shape. Horn-cells, properly speaking, are fusiform, very solid, and have wrinkled walls; they occur in all hard appendages.

cells are simply getting ready to be converted into cells like those of the outer horn-coat. In form they resemble the horn-cells, but differ in that they are protoplasmic and stain deeply with picrocarmine.

The horn layer is sharply marked off from the transitional cells; no cells existing, as in embryos, which are half horny in texture. The cells are fusiform, dense and very compact. Specimens hardened in alcohol show the cell walls well; the nuclei can often be brought out by eosin in benzole. The cells may be softened and separated by a 33% solution of caustic potash.

Pigment is to be found in the epiderm, in the mucous and adjacent cells, in many species of birds. The pigment is of an oily nature and simply diffused through the cells. Another class of pigment, namely, a dark pigment in cells, like that described when speaking of the skin proper, is to be found under the epiderm in dark-legged birds.

In speaking of the skin the tendancy to moult the outer cells in mass was referred to. The same thing, only more marked, is to be seen in the scutae. The whole of the outer layer of horn-cells is shed in pieces of about the size of the scutae. I have observed this process in canary birds, and have studied sections taken from a pigeon in the act of moulting the horn layer. In this case the outer coat of horn split off very easily, but could be kept on by careful manipulation. Beneath the layer, which was splitting off, was another layer of the same nature and thickness but firmly attached to the deeper layer. The transitional cells were fusiform, but not so numerous as is often the case.

The centre of a scuta is formed by a fold of the cutis vera composed of rather compact connective tissue. Just below the mucous layer there are often to be found well developed, abundant capillary and lymphatic systems. Nerves seem to be very scarce, but I have not employed special reagents to bring them out. That there is little sense of touch in this region can easily be proved by the difficulty of arousing caged birds by pricking the tarsus, as compared with the toe-pads or soft parts of the head.

DEVELOPMENT OF SCUTAE.

The development of the scutae, or scales, on the tarsi of birds has been studied by Kerbert (4) in the chick. Accordingly the description given by him will be followed in this paper. Scutae occur on the tarsus and dorsal aspect of the foot, and are distributed and modified in ways well known to systematic ornithologists, hence they need not be considered here. We must, however, bear in mind that feathers as well as scutae occur on the tarsus and even on the toes, so that we may not mistake the one for the other in studying sections.

The first signs of scutae appear at or about the tenth day as little ridges or folds of the skin, and are thus distinguished from the feathers, which are true papillae. Kerbert[1] describes their appearance in the following words: "Die durch Wucherung der Cutis entstandene Papille wächst nun noch eine Zeit lang radiärsymmetrisch weiter, so dass sie von der Anlage der Embryonaldune gar nicht zu unterscheiden ist." This is a mistake due to describing longitudinal sections of the tarsus and disregarding surface views; the appearance of longitudinal sections of down papillae and scutae are the same.

Until the appearance of the scutae the skin on the tarsus and toes follows the general rule of development and consists of the "epitrichial" layer, the basement mucous cells and about one layer of cells between. The epitrichial cells are as yet much like the other cells of the epiderm and do not form a compact layer of hexagonal cells. They are simply rather flattened cells, with nucleus and nucleolus, of a roundish form when seen from above. Accordingly there are considerable spaces between the cells that are filled up with some sort of intercellular substance. The mucous layer is built up of a layer of cells varying from cuboidal to columnar in form packed close together. The cell walls are thick on the inner surface, that is the side next the derm, and form a sort of membrane. The walls between the cells are thickest near the base of the cells and thin down towards the outer end. The cells between the epitrichial and mucous layer are polyhedral and packed quite close together. Both the mucous cells and those outside are full of protoplasm, and provided with large nuclei for the most part oval in form, though some seem cuboidal. The mucous nuclei contain as a rule two nucleoli, one nearer the base of the cell than the other, sometimes one or

[1] Ibid., p. 40.

three, while the cells divided off from them as a rule have only one nucleolus. At no time during the development of the scales have I found the distinction between the cells to be wanting.

About the end of the twelfth day marked changes have occurred in the scales both as regards form and structure. They no longer form ridges pointing up from the surface, but folds towards the tip of the limb. Kerbert states that by this time they have begun to grow in a bilateral symmetrical manner, while the down feathers continue to grow in a radial symmetrical manner. The cells (fig. 15 *b*) next to the epitrichial layer have by this time begun in various spots to assume a fusiform shape, as seen in section, their nuclei at the same time becoming elongated. The number of cells between the epitrichial and mucous layer is very variable, there being most on the tarsus and least on the toes. All, however, are as yet protoplasmic and have none of the structural characteristics of horn. The mucous layer itself is much the same as before, the cells varying from columnar to cuboidal, according as they have just divided or are about to divide. The epitrichial cells are spread out and come much nearer a true cell-coat than on the tenth day.

By the fifteenth day the flap of the scale has become quite long, and marked differences between its outer and inner surface also exist. The epitrichial layer has become distinctly a layer of cells ; though the cells are still very variable in size and shape. Beneath the epitrichial layer is the "granular layer" of Kerbert and others. This he figures as one layer of polygonal cells, with large nuclei and marked granular contents. According to my observations, which cover all the distinct parts of the epiderm except the cloaca, this layer is only the cells divided off from the mucous layer, just after the epitrichial layer, that do not become converted into horn-cells.

In thickness this layer varies much, in some parts it is one cell thick, in others many cells thick, and in others does not exist at all.

Below this granular layer is the horn layer of very different thickness in different parts. It is thickest about the middle of a scale and thins out on the inner side. At this time the horn layer varies from one to four cells deep where it exists. The cells appear fusiform in section, have thick walls and small cavities containing the nuclei. These for the most part are long and have but one nucleolus. As a whole the horn cells do not stain readily with carmine solution and but poorly with any water or alcoholic solutions. They can, however, be easily stained by placing the object, after treatment with alcohol in a benzole-eosin solution.

Kerbert describes a layer of cells between his granular layer (Körnerschicht) and horn layer of polygonal cells with toothed edges, though he says they are not true "Riffzellen." These cells as forming a distinct layer are difficult to find and seem to be only the oldest true horn-cells; the toothed appearance being due in part at least to the granules collected along their walls.

The mucous layer which up to this time formed a very even line has now become slightly irregular. The cells are the same as before. Between the mucous and the horn cells are cells in various steps of transition into horn-cells.

Besides the several layers of cells described above, pigment cells (figs. 9 and 16) have made their appearance in considerable numbers in the mucous layer, and cells divided off from it, which up to this time have not been very much modified, that is, turned into granular or horn cells. Kerbert considers these pigment cells, which he describes as quite branching, to be derived from connective tissue pigment cells that wander from the mesoderm into the epiderm. Accordingly he describes cells with their branches in the epiderm and their bodies in the derm, others in the epiderm and yet others in the derm. I have examined a good many sections containing much pigment, but have been unable with any power varying from $\frac{50}{1}$ to $\frac{1500}{1}$ to find such half-way cells. Pigment cells in the derm are to be seen, also blood globules; and branching patches of pigment apparently in cell walls in the epiderm. These often appear to stand out into the derm as figured by Kerbert. But if the focus of the glass be properly adjusted the apparent membrane between the mucous layer and the derm will be seen inside. The apparent projection of the pigment cells into the derm would seem to be due to their dark color. This makes them visable below the lighter cells in focus, and hence, since the epiderm is often seen slightly slantwise, seem to project through into the derm. This pigment whether it comes from epiderm or derm is the same as that in feathers.

By the eighteenth day, or rather during the nineteenth day, many changes have occurred. The epitrichial layer (figs. 17*a* and 23) has assumed its final form; the cells have become irregularly polygonal; regular hexagonal celled patches are rare; the nuclei are decidedly indistinct and the contents granular. In fact the cells resemble, except in their regular hexagonal outline, Kerbert's figure of the granular layer at this age. That this is the epitrichial and not the granular layer I believe for the following reasons:—

Kerbert does not describe the epitrichial layer but says it becomes lost.

I have specimens showing this layer outside the granular layer.

I have specimens showing this layer in the depth of folds where the two surfaces are touching and nothing could have been shed.

That this is the true state of affairs I feel more certain on account of some section of the toe and claw which were doubly stained with eosin and French blue. Such a mixture turns all acid substances deep blue, while all alkaline and protoplasmic bodies take on the eosin red color. Now, fortunately, I have on two or three occasions in staining sections, colored this coat deep blue and all the rest red. Such specimens of course are more easily studied than those worked out by caustic potash solutions alone.

Below the epitrichial layer (fig. 17) the granular layer remains much the same and both show a tendency to split off from the horn-cells below. The horn-cells have become more numerous and the oldest denser. The rete mucosum cells seem to be smaller and more irregular. The pigment cells spoken of before have entirely disappeared.

From this time on no important changes occur in the epiderm. The horn-cells continue to be formed from the mucous layer and mature. At hatching the epitrichial and granular layers are shed thus leaving the scutae in their final condition.

CLAWS.

Claws exist on the ends of the toes and often on the end of the first finger; on the end of the second finger they are rare.[1]

[1] For a detailed list of the occurrence of claws, see my article in Proc. Bost. Soc. Nat. Hist., Vol. XXI (1881) pp. 301-306.

The shape of the claw varies according to the kind of bird and some have claws with a serrated edge. Whatever their shape may be, they are composed of horn-cells produced by the mucous cells covering the ultimate phalanx of a digit. The base of the claw is sunk in a socket or overlapping fold of skin. The growth of the claws is not directly outwards from the mucous layer, but outwards and tipwards, so that the claw is constantly sliding off the end of the digits just the same as our finger nails slide off the ends of our fingers.

There is very little to say about the histology of the claws; it is much the same as in the mammals. The mucous cells are columnar and separated by walls as in the scutae. Outside the mucous layer is a thick bed of transitional cells much like those of the scutae. The outer ones, however, show in texture a gradual change to the horn-cells. So when sections of the claw are stained with picrocarmine there is no sharp line between the red and the yellow, but the red slowly fades out towards the surface. The horn-cells form a thick layer, being thickest in the large scratching birds and thinnest in the small arboreal species. Beneath the mucous layer is the cutis vera, and below this the bone. The outer part of the cutis vera is very vascular and large capillaries may be seen running just below the mucous layer.

How the combs on the claws are formed I cannot say. According to Macgillivray (20) they are absent in the young bird, and are later formed by the splitting of an even lamella. This may be the correct solution of the problem, but more data must be got before it is accepted. It seems probable that the gaps are formed by some of the cells being softer than others and falling out, as we shall later find to be the case in the tongue.

I know of no data pointing to a moult of the claws, though such a moult may exist. The claws would seem simply to grow and wear off like our nails.

DEVELOPMENT OF CLAWS.

Nothing, so far as I know, has been written on the embryonic growth of bird's claws. Their development is of interest since there can be no doubt of the morphological identity of claws throughout the higher vertebrate groups. Hence they may be taken as a basis from which we can recognize any layers of the epiderm, which are of morphological value, rather than the accidental results of the laws of growth.

Claws seem to be marked out on the ends of the toes as soon as these members are developed. By the sixth day the claws can be perceived in form, but histological distinctions do not begin till later.

By the twelfth day a claw is clearly visible to the naked eye It is simply the smooth skin covering an ungual phalanx which is roughly claw-shaped. Longitudinal sections through the toe and claw show that the epiderm is thicker than the proximal part of the toe; the increase in thickness being due to the larger number of developing horn cells. The whole is more advanced than the rest of the toe; layer for layer, however, the claw is just like the rest of the toe skin.

By the middle of the fourteenth day marked distinctions exist. (Fig. 24.) The claws have a more solid appearance to the eye, and sections show considerable differences. The epiderm is two or three times as thick as on the rest of the toe. Here it must be borne in mind that the thickness of the epiderm varies in the young claw as in the adult; so the end is thicker than the base, The epitrichial layer is thinner, if anything, and the cells closely joined; thus in section they seem to form a structureless membrane, but in surface views the polygonal cells are clearly seen. Beneath the epitrichial is the granular layer (fig. 24*b*). This is built up of cells placed close together, almost fused into a mass, with indistinct nuclei. In parts the granular layer is only one cell thick, in others very much more. The whole has the aspect of being made of cells which have begun to develop into horn and then gradually lost their activity, and been squeezed up by those below. Next follows the horn layer. This is built up of fusiform cells, running lengthwise, provided with elongated nuclei and dark nucleoli. The protoplasm at this period is distinct. The horn layer and the forming cells below are the chief cause of the increased thickness of the epiderm in the claws. At the base of the claws both layers are very thin, but thicken up at the tip of the toe. Beneath the horn cells are the transitional cells and the mucous cells, very much like those of the rest of the body.

By the sixteenth day, in some cases earlier, the mucous layer has become more irregular and assumed a streaked appearance, due to the distinctness of the cell walls.

By the seventeenth day (fig. 23) other changes have occurred. No more layers exist, but the horn layer is much thicker and the horn cells have become well developed. That is, they have assumed a roughish surface, rather shrunk in size, and have lost their active albumen. Most reagents will not stain them, and picrocarmine gives the yellow color peculiar to horn. When stained with a solution of eosin they also assume a peculiar yellow color.

A little later other changes occur, which bring the embryonic development of the claw to a close. The granular layer begins to dry up and becomes fibrous, thus loosening the epitrichial layer. These two layers are shed at or about the time of hatching and leave us the adult claw.

In no case, even in black chickens where the scales were full of pigment granules, have I observed pigment in the claws; yet there is no reason, so far as I know, why it should not occur there.

The claws on the wing develop very much later than those on the foot. The horn does not seem to form until near the time of hatching. I have sections from both ducks and hens, cut on the sixteenth and seventeenth days, where no claw is formed. The skin, however, in such cases is smooth and thicker than in other parts. The time of development of the hand claws is variable, as one would expect of aborted organs. It is always late, and probably does not occur till after hatching in many species.

To sum up, the layers of the claw are continuous with those of the tarsus, and like them in structure, the only difference being in their relative thickness.

THE BILL.

In reality the structure of the bill in adult birds is often complex, owing to the development of sensory organs. But, for our purposes, it may be regarded as being built just like the claws, and in fact this is the structure in hard billed birds. Soft billed birds have the mandibles covered with ordinary skin with many sense papillae. Lamellae, such as those found in the Mergansers, are produced by the more rapid growth of the horn cells in ridges, and by folds of the epiderm.

DEVELOPMENT OF THE BILL.

In tracing the development I relied upon the chick as being the bird best adapted to show the different layers as well as the egg tooth to advantage.

The time usually given by embryologists for the first appearance of the horn cells is about the twelfth day; I have seen both the bill and the shell tooth distinct by the middle of the seventh day. The first step towards the formation of the bill is the great increase in number of transitional cells. These form a mound on the upper surface of the mandible, which is separated by a little groove from the tip of the bill, and by a groove with a flap in it from the skin of the head.

By the sixth day the epiderm of the mandibles is much more developed than in any other part of the body. The epitrichial layer has very nearly assumed its final appearance (fig. 25) and the granular layer below has attained greater proportions than in any other part, over the middle of the bill it is at least four cells deep, shading off to nothing on the sides. It is made up of polyhedral cells packed close together, and connected by a transparent intercellular substance. The cells themselves have fair sized nuclei and are charged with granules about the size of the nucleolus. So in its structure and dimensions the granular layer of the mandibles at six days strongly resembles the same layer as developed on the claw at the tenth to the twelfth day.

Below the granular layer comes the true horn layer. The outer cells of this seem in patches to fail of development, and form a sort of irregular transition between the granular layer and the well developed horn cells. The latter are fusiform, their long axes running parallel with that of the mandibles. The walls are thick and tough, being composed of horny material, arranged in such a way as to give, when stained, a peculiar appearance easily recognisable but almost impossible to describe. The nuclei of the horn cells are of good size, slightly elongated, and placed in the body of the cell. Each nucleus is provided with a fair-sized, very dark, highly refractive nucleolus. The whole mass of horn cells forms a layer about twelve cells deep in the thicker parts, gradually shading off to nothing on the edges. Beneath the horn cells are a few transitional cells; their small number being presumably due to their rapid transition into horn cells. Lastly comes the mucous layer, composed of the usual cells and the same irregular basal border that has been described in the advanced claw. In fact sections at this time of the mandible and claw are very much alike structurally.

By the thirteenth to the fourteenth day there are further changes; I refer to the formation of the egg tooth. This is, in reality, nothing but a sort of conical prominence of horn cells, developed over the body of the premaxillary bones. It is formed by the more rapid growth of the horn cells below, and by the greater solidity attained by them. By the fourteenth day they are unstainable with the ordinary reagents, though a benzole eosin mixture will stain an occasional patch of protoplasm or nucleus, and become bright yellow by the action of picric acid. So their activity has ceased. In certain individuals at least, zones of pigment granules can be seen in the egg tooth.

Below the hardened horn cells comes a bed of horn cells like those described in the six-day chick. Yet again below the horn-cells are the transitional cells and the mucous layer, in certain cases charged with pigment. From this time until after hatching there are no changes worthy of special description. There is simply a gradual growth of the horn cells, as a consequence of which the egg tooth is slowly pushed through the granular and epitrichial layers. At or about birth the epitrichial, granular and ill-formed horn cells are shed. Thus we see that the growth of the bill in the chick is much the same as that of the claws; the difference being the presence of the egg tooth. In the lower mandible there is really no difference.

COMBS AND WATTLES.

The combs and wattles are simply flaps of the true skin, covered by the epiderm. The epiderm on them is simple, composed of mucous, transitional and flat horn cells, and usually thin in order to allow the blood to be seen. The cutis vera is very vascular and supplied with abundant lymphatics, as shown by Kostarew (21), for combs, and as I have myself seen in the wattle of turkeys. Both structures owe their color to the flow of blood. The lateral flaps, or ears of the Guinea hen, on the other hand, have a bright pigment, and the cutis vera is very compact.

The comb of hens is developed as a simple fold of the skin, and involves all the layers of the epiderm. After hatching the outer layers are shed, as in the rest of the body. The first steps are often visible by the eighth day.

SPURS.

Spurs, of which those of the cock will be taken as an example occur in various groups and in various places. Where they occur they are composed of a bony core, which is covered by the cutis vera and epiderm; the bone being attached to subjacent skeletal bone. The epiderm is just like that of a claw.

The first signs of the spur appear about the tenth day of incubation. At this stage it is simply a disc of the same structure as the surrounding scuta but not forming a fold. In the histology of the developing epiderm (fig. 26) a spur is precisely like a scutum, claw, or mandibular coat. The distinction lies solely in the shape, which becomes little by little slightly hemispherical, by the thickening of the cutis vera. After birth the bony core is formed by ossification in the cutis vera from one or more centres. The bony core thus formed later on anchyloses with the tarso-metatarsal bone; so the spur is in origin purely dermal.

TOE PADS.

The pads on the palmar surface of the toe are of interest, since they have peculiar functions and structures. They are papillae or mounds of the skin packed close together and consequently polygonal. The result is, that the sole of the foot is quite rough, and admirably adapted for grasping. On the sides of the foot, more especially of the toes, they gradually pass over into the scuta. There is no hard and fast line between the two, yet the well developed pad never forms a flap, while the scutum always does.

The peculiar points in their structure are the papillae of the cutis vera, which extend into the epiderm in the same manner as in the mammals (fig. 31). The epiderm is built up of the usual elements. The mucous layer, here a rete mucosum, is on account of the papillae very irregular, the transitional cells form a deep layer slowly passing over into the horn layer. The latter is quite thick and the cells are arranged in peculiar wavy or ziz-zag lines.

The core of the pads is formed of cutis vera, composed of connective tissue, a fair amount of large capillaries and a fairly free lymphatic system; the blood and lymphatics extending to the very tips of the papillae. The nerves also run to the ends of the papillae, though not seen so abundantly as I had expected, probably owing to my crude modes of research.

In development the pads are formed in precisely the same manner as the other papillae, the epitrichial and outer horn cells being shed at hatching. The date of formation of the papillae of the cutis vera must be quite late, long after the form of the pads is completed.

SPINES OF MOUTH.

We have now considered all the peculiar appendages of the epiderm, which are to be found on the exterior of the body. There yet remain the various papillae and setae to be found in the mouth, more especially on the tongue.

The distribution and form of the spines have always been studied by systematic zoologists; they have been called "hairs," "spines," "papillae," "setae," and a variety of other names. Outside the general anatomies, the descriptions in which are macroscopic, I know but two articles on the setae of the mouth. Weinland (22), in 1854, gave a description of the tongue setae of the parrots. According to him they are hairs with an outer horny coat, a pith and a papilla below. Later Fraisse (23) in 1881, described the papillae and their growth in certain forms of ducks. To use his phraseology the papillae in many adult birds are "einfache mit Hornepidermis bedeckte Cutis-papillen." (p. 311.) In speaking of the tongue of a duck two days before hatching he writes as follows: als ich jedoch dieser Zunge in feine Längsschnitte zerlegte, sah ich sofort, dass die grossen Papillen in viele einzelne zerfielen, welche iher innerseits nun in kleinen Follikeln sassen und selben bei schwacher Vergrösserung schon das Bild einer Embryonalfeder darboten.

Bei stärkerer Vergrösserung sieht man, dass dieselben von den Embryonalfedern, welche die Körperoberfläche des Thierchens in diesem Stadium bedecken, nur dadurch abweichen, dass sie etwas kürzer sind."

Fraisse's statement of the setae in adults is correct as far as it goes, but by no means gives a complete idea of the setae of a duck.

In adults the setae are of all shapes from simple conical papillae to branched or brush-like, as in many of the ducks. Whatever their shape they are all reducible to simple papillae, with a mesodermal core, and an epidermal coat of the usual layers (fig. 27). The brushes like those found on the sides of the tongue in ducks are the result of peculiar modifications of the horn layer. The horn cells from certain patches of the mucous layer do not reach maturity but remain soft and loose (fig. 32 *a*). Thus, since the horn layer slowly slides over the mucous layer towards the tip of the papilla, streaks of soft tissue are left between the harder horn cells. The hard layers (fig. 32 *b*) accordingly split apart from the tip of the seta down towards the base, and thus divide the horn layer into a brush. The cell elements are the same as in the other appendages, with the exception of the cells in the soft streaks. These, while they dry up and become more or less horny, keep the irregular form of the deeper transitional cells.

The skin of the mouth follows exactly the same course in development as that of the rest of the body. First, the epitrichial layer is formed, and below this, in young birds with soft mouths, mucous cells of a polyhedral form, no granular layer intervening between the epitrichial layer and the mucous cells. These mucous cells keep on growing and wearing away during the life of the bird.

The development of parts covered with horn at birth is precisely like that of the claws or bill.

Up to the twelfth or thirteenth day the epiderm is composed of the mucous layer, the transitional cells and the epitrichial layer (fig. 29). About this time horn-cells begin to form from this layer, and thus separate the first transitional cells from the mucous layer. These outer transitional cells, dying or becoming partly converted into horn, form a granular layer of varying thickness. The horn cells continue to form during the life of the bird. At or about birth the outer layers are shed.

The setae are developed as papillae of the cutis vera (fig. 30), which at first are indistinguishable from the feather papillae, but never become sunken. They appear on the posterior edge of the dorsum of the tongue about the seventh day, and then gradually spread over the surface of the mouth and fauces.

About the twelfth day horn cells appear and keep on forming, so by the eighteenth day we have what may be regarded as the perfect seta of embryonic life (fig. 28), with the following layers, epitrichial, granular, horn, transitional and mucous. These are all so exactly like the rest of the body that it is only necessary to refer to the figure.

I have carefully sought in ducks and hens of all ages for any resemblance between the mouth papillae and feathers; in no case have I found the least resemblance between the two. Nor, so far as my observations go, do small papillae run together and form large ones.

Though properly beyond the province of this paper, it may not be amiss to take a hurried glance at the development of the glands of the epiderm. These are confined to the inner surface of the head, the oil-gland and the cloaca. Of the glands of the cloaca I can say nothing.

The mouth glands all originate as solid ingrowths of the deeper layers of the epiderm, with subsequent formation of a lumen and duct, in the same manner as the mucous glands in the vertebrata. The epitrichial layer plays no part.

The long gland on each side of the tongue, in the floor of the mouth is formed, according to Götte (24) by a number of mucous glands opening into a longitudinal furrow in the floor of the mouth. Besides glands crypts are to be seen in the tongue of ducks, these are formed as simple insinkings of the epiderm.

The oil-gland is formed, according to Kossmann (25), by two insinkings of the epiderm, and then the development of glands from the epiderm of the pit. That is, very much as in the sublingual glands.

Here it is of interest to note that there is absolutely no difference between the first stages of a mammalian hair and the small glands of a chick or mammal, yet few would consider hairs and glands homologous structures.

SUMMARY.

We now come to the last part of the subject, — to the comparison of the various structures already described. Before going farther it is as well to explain the meaning of certain words as here used. Animals may be regarded as built on certain types, the animals formed on any type forming groups, genera, species and so on, according to the degree of specialization of the type; a type being not an ideal form, but the form transmitted by inheritance. It is of course evident that specialization of sub-types may involve the loss of parts as well as their addition. Now, each part of the type form which is separable from the rest, may be regarded as an element. Parts of animals formed from the same elements of the type, may be regarded as morphologous, provided the parts are inherited from the type form. The type forms may have parts like in themselves but differing in their relations to the whole. Such parts may be termed homologous. Finally, parts alike, in a greater or less degree, as to structure, form, position or function, may be termed analogous in so far as they resemble each other. Here it must be borne in mind that completely analogous organs, which do not exist in a major type, may exist in sub-types; such organs, though having the appearance of being morphologous, lack the necessary genetic connection.

Before passing to the appendages it is necessary to review the epiderm, and form a general idea of its nature, to decide what layers are due to transmission, what to simple laws of physiology. The lower, or mucous layer, may be regarded as *the* epiderm, since from it all other layers are derived. This is of course the most important layer. Next in extent and time of development comes the epitrichial layer. This forms the external coat of all vertebrate embryos and is renewed in cases where a general moult takes place; as among snakes. In embryos it forms from the one layered epiblast in the first stages of growth, or both mucous and epitrichial layers are formed together. Balfour considered the first as the primitive method, and with this opinion we must agree. Accordingly the epitrichial layer is to be regarded as a layer transmitted from some of the early ancestors of the vertebrates, and second only to the mucous layer.

The epitrichial layer, or the name thus applied to the outer layer of cells in reptiles and to the outer coat of pin feathers, is not so easily explained. Is the name properly applied, or is the resemblance in both cases to the embryonic layer due to similarity of position? To my mind both seem probably true. In the formation of a pin feather there is a return to embryonic conditions and a similar mode of growth which results in an outer coat of undifferentiated cells. These cells being on the outside naturally flatten and become polygonal, while later, nutriment being cut off by the cells below, death and a resulting coagulation takes place. I doubt if the primitive epitrichial layer, provided the epiderm was ever only two cells deep, had its present final structure.

The horn layer is common to all the purely terrestrial vertebrates, that is to the Mammalia, Aves and Reptilia; in the other groups it does not exist. Its place is occupied by parenchymatous cells much like horn cells in their early development. Again it is of comparatively late development, so I am inclined to regard it as an adaptation to, or a result of, an aerial life and consequent drying of the surface; and this the more since the eye, ear and nostrils do not develop horn cells. The epitrichial layer can be traced into the ears, nostrils, and perhaps eyes.

The other layers spoken of in the descriptive part are so irregular in their occurrence and so clearly the result of local condition that no value can be attached to them. The toothed cells described by Kerbert are not of definite extent, and curiously are often a product of imflammation in man. The granular cells are, as already stated, simply starved transitional cells.

The epiderm, therefore, may be regarded as primitively consisting of a smooth mucous layer, an epitrichial layer, and perhaps an intermediate layer of parenchymatous cells (transitional cells). The outer layer is lost in birds and mammals, and never renewed. The middle layer becomes thickened and subject to various modifications, as drying, keratinization (to coin a word), and the like, and enters into the structure of all the appendages.

The epiderm may also be considered in relation to the cutis vera. If this is done the epiderm will be found to be the primitive skin if not the true one. It is formed long before the corium of the outer embryonic layer and forms all the organs of sense, while the corium is a late, very variable product of the mesoblast

Of the homology of the claws in the group of birds there can be no doubt; that the claws of birds are homologous with those of reptiles and mammals is also apparent. Their relations to other appendages have been variously stated, comparisons to scales and "agglutinated hairs" having been made. There is, however, no similarity to either; a claw is simply a horny coat of the end of a digit. Claws have a decided histological resemblance to the beak, nothing more. So claws must be regarded as devoid of morphological relations to other epidermal structures. To follow out the definitions given in this article, claws, if on the same digit, are morphologous structures; if on different digits homologous structures.

Passing from the claws we come to the scuta. These have been assumed "*a priori*" by many authors to be morphological with the scales of reptiles; a proceeding totally unscientific. Not only this, but feathers, scales and hairs have been said to be the same thing! There are three ways by which we may follow morphological relations: by comparison and formation of series in adults, by palaeontological successions, and by similarity in development. In each case care must be taken to guard against mistaking resemblances due to general physiological laws for resemblances due to genetic connection, and confounding analogous with morphologous structures.

The evidence in favor of the idea that scuta are scales may be set down as follows: first, both look more or less alike and have similar functions, *i. e.*, those of protection and ornamentation; secondly, they are both essentially flaps or folds of both layers of the skin, pointing to the posterior end, and arranged in quincunx order, and to the superficial glance seem to form a fair series; lastly, the first stage of their development is much the same, the same layers of the epiderm being distinguishable in each. No other evidence, so far as I know, exists.

On the other hand the evidence against the morphology of scuta and scales is overwhelming, and the foundation of the three preceeding arguments rests on an unsubstantial basis. The first is of no value as evidence, and is only the foundation for fallacious *a priori* conclusions. The second has but little more worth. Reptilian scales have invariably a certain number of epidermal layers which in birds are only to be found in the embryo, and in reptiles occur promiscuously over the body as the result of physico-physiological causes. The minute structure of the two is never the same. The embryological resemblance has already been shown in the descriptive portion to be the result of necessity; any appendage *must* be covered by them and they themselves have here no value.

But various other facts point against any such morphological relations. Scales undergo a regular moult and renewal, scuta do not. Scuta bear epidermal appendages, feathers, — scale never do; thus pointing to scuta as simple folds of the skin, not as appendages. The toe-pads which have no resemblance to scales may be seen on the sides of the toes of any bird with small scuta to pass over into scuta. Hence, were the theory true, the toe-pads must be scales, which is an absurdity. Again the scuta of birds resemble the cutaneous flaps on the opossum's tail to a wonderful degree. Their form and arrangement is precisely the same, both bear true appendages, and both have the same histological structure. Like the scuta the opossum flap has a mucous layer and outer horn coat with a mesodermal core. Hence, if resemblance is of any value the flaps on the opossum's tail must be scales if scuta are scales. Yet no one would dare to call the former scales.

Spurs on the wing and tarsi are special modifications and occur in such diverse groups of birds and yet in limited numbers that they must be regarded as of recent origin in the separate groups where they exist.

They are not to be classed as modified scuta as has been done by those who consider scuta and scales to be the same thing. The wing spurs and tarsal spurs are like organs; thus the theory would require the existence on the wings of birds of scales ready to be evolved into spurs in a few isolated cases. Spurs, therefore, are in the whole group analogous organs, but the spurs of the pheasants, for instance, are *inter se* morphologous.

Though perhaps not in place here, I would suggest that the first function of these spurs is as claspers not as organs of offence. By this means their existence in the developing stage is explained.

Combs, wattles and the like must also be regarded as recent structures of no general morphological value.

We now come to the feathers. These have often been compared in various ways to hairs, and many feathers have been described by the older writers as hairs. No hairs, however, exist among birds; all the plumage is composed of feathers and developed on the same plan.

The modern view of feathers and hairs is that they are allied structures, yet Gegenbauer, in his Comparative Anatomy, speaks of them as divergent structures. The supposed genetic relations of hairs and feathers were based on the supposed identity of the early forms. It is now known, however, that their early stages are the exact reverse of each other. A hair is formed *in* a *solid* ingrowth of the epiderm, while a feather is formed from the epiderm of a large papilla of the skin. Again a hair does not contain any of the mucous cells, while a considerable part of a feather consists of them. Yet again, a hair never conflicts with the almost universal law, that the mucous layer shall retain its vitality, and its under surface remain in contiguity with the cutis vera; a feather does, — the under side of a feather being the inner side of the epiderm.

The resemblance between hairs and feathers consists only in their being both horny structures of the epiderm, with their bases in sacks, while their differences are many. We must, therefore, consider feathers and hairs as *distinct* structures.

Certain authors have stated that feathers and scales were homologous, thus completing the magic circle. The basis for comparison being that both originated as papillae and the supposed scale-like nature of the remiges of penguins. But scuta (I know not about scales) do not originate as papillae, but folds, and remain so during life. At no period of life is there the faintest resemblance in form. Again, Studer has shown that the imagined scale-like nature of penguin feathers is an absolute fallacy. Finally, all the peculiarities of the mucous layer separates the feather from the scale.

It hardly seems necessary to return to the papillae of the mouth. When treating of these appendages I endeavored to show that their resemblance consists in both being formed from papillae.

Notwithstanding various statements to the contrary, the fact that feathers grow upon scuta shows them to be distinct structures. From the first to the last scuta are folds, at no time papillae. The belief that they are papillae must have arisen from the examination of sections only, or by mistaking feathers on the tarsus for scuta.

When we come to consider feathers themselves and ask what was their primitive form, we are left in a maize of uncertainty. It is clear that the remiges and rectrices are not of the first or type form. They stand at one extreme and down-feathers at the other, being connected by the contour feathers. Palaeontology throws no light; the Archaeopteryx had both rectrices and contour feathers. It is of note, however, that the down feathers are those of the young bird, are the simplest in structure and well adapted for warmth. They are connected with the contour feathers by the half down feathers of the various struthious birds, a group now generally regarded as the most primitive extant. Again, the bases of nearly all feathers are downy, that is the part protected from various modifying causes.

I am well aware that at the present time, when the tendency is to ascribe everything to one common origin, the above conclusions will be distasteful to many. Yet, when examples of the separate origin of like structures — analogous organs — are so abundant, it seems rash to consider a slight resemblance a proof of genetic relationship. The laws of growth, though flexible, are invariable, and imprint resemblances on all their products, especially during development. Again, in the epiderm at least, physical relations are much the same, and must imprint their stamp on organisms.

To meet one argument I call attention to the fact that the Amphibians, from which the higher groups have probably been derived, have no special epidermal appendages except perhaps claws. The scales of the Coecilians are simply flaps, neither fish nor reptile-like scales. Hence it is a mere assumption to suppose that Dinosaurs had scales and still another that the scales of birds and reptiles came from them. Indeed the nakedness of Amphibians is a strong argument against the identity of any of the avian dermal appendages with those of Reptiles or Mammals.

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The few titles marked with an asterisk have of necessity been taken second hand.

EXPLANATION OF PLATES 4, 5, AND 6.

Fig. 1. Section of naked skin from the head of a gannet. (Sula bassana.) Hartnack obj., 7 oc. 2. *a*, horn-layer; *b*, transitional cells; *c*, mucous layer; *d*, pigment cells; *e*, cutis vera.

Fig. 2. Section of epiderm of 111 hours chick. Obj. 7 camera. *a*, epitrichial; *b*, mucous layer.

Fig. 3. Same of 134 hours chick.

Fig. 4. Surface view of epitrichial layer of 14 days chick. 7 camera.

Fig. 5. Section of epiderm of 17 days duckling. 7 camera.

Fig. 6. Transverse section of feather papilla near tip, duck 20 days, 7 camera. *a*, epitrichial; *b*, loose horn cells, *c*, granular horn cells; *d*, one of the two primitive barbs; *e*, pulp.

Fig. 7. Transverse section of feather papilla low down, duck 18 days. 4 camera. Letters the same as before.

Fig. 8. Longitudinal section of feather papilla of duck 20 days. 7 camera. *a*, epitrichial; *b*, horn cells; *c*, row of forming barbules; *d*. barbe, capillary of pulp full of blood globules.

Fig. 9. Section of scutum, duck 17 days. 7–2. *a*, epitrichial; *b*, mucous layer; *c*, pigment.

Fig. 10. Epitrichial-like coat from the pinfeather of a robin. (T. migratorius). 7 camera.

Fig. 11. Longitudinal section of adjacent walls of feather papilla and sack, 7–3. *a*, epitrichial-like coat; *b*, horn cells; *c*, transitional cells; *d*. mucous layer of pocket; *b′ c′* and *d′* the same of pocket.

Fig. 12. Section of pinfeather of robin. ×20. *a*, shaft; *b*, horn case; *c*, outer cell layer; *d*, vane; *e*, point of division of the two vanes; *f*, pulp; *g*, pith of shaft.

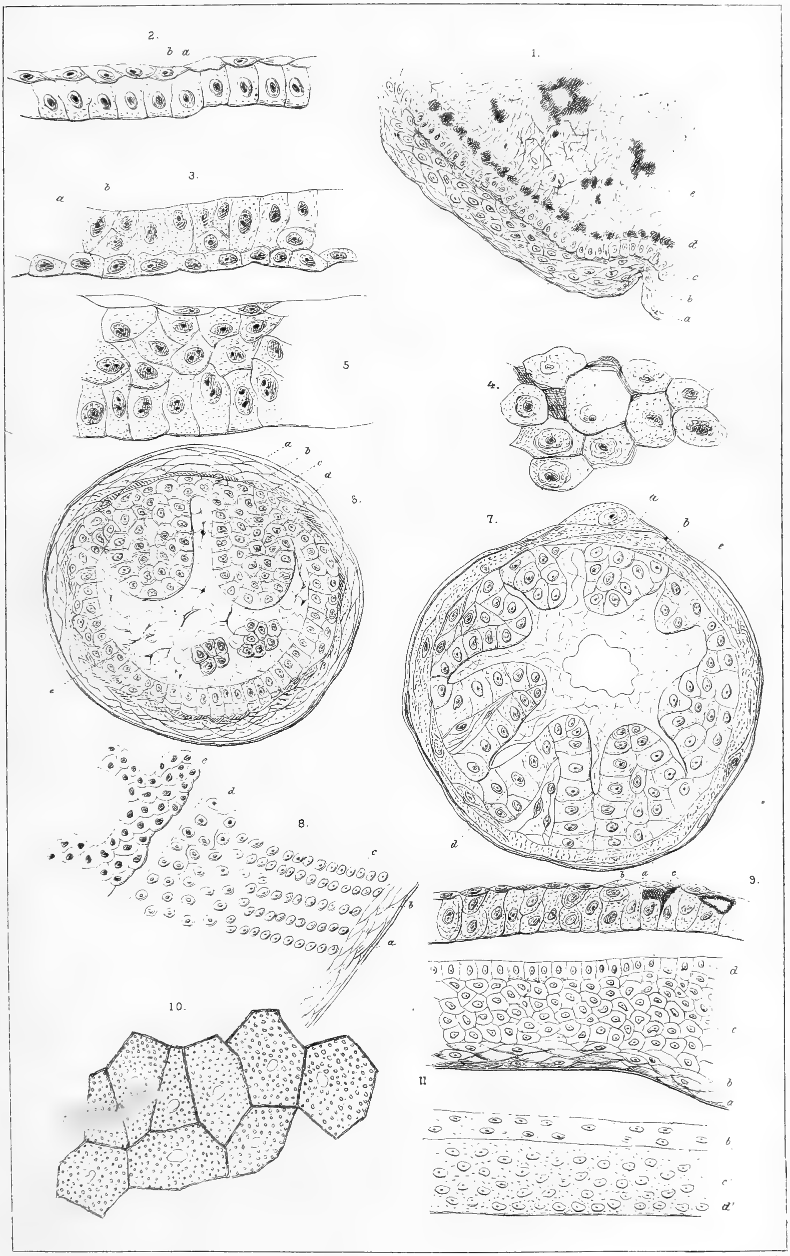
Fig. 13. Transverse sections of forming barb and barbules of pinfeather. 7 camera.

Fig. 14. Same of nearly complete barbs. 3 camera.

Fig. 15. Longitudinal section of tarsus of 12 days chick, 9 im.–2. *a*, epitrichial; *b*, transitional cells; *c*, mucous layer.

Fig. 16. Same of 14 days chick. 7 camera. *p*, pigment.

Fig. 17. Longitudinal section of scutum of 18 days chick. 7–3. *a*, epitrichial; *b*, ill developed cells; *c*, transitional cells; *d*, mucous layer; *e*, mesoderm.



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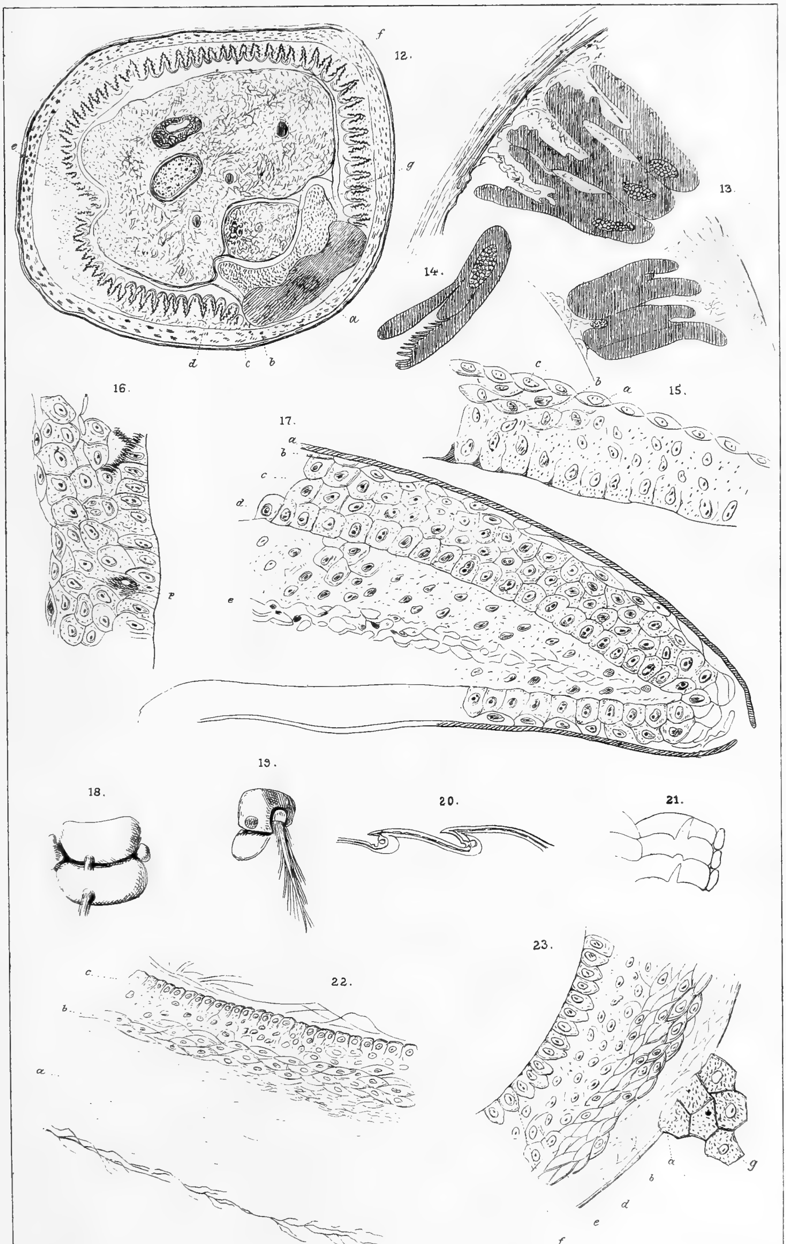
JEFFRIES, EPIDERMAL STRUCTURES IN BIRDS.



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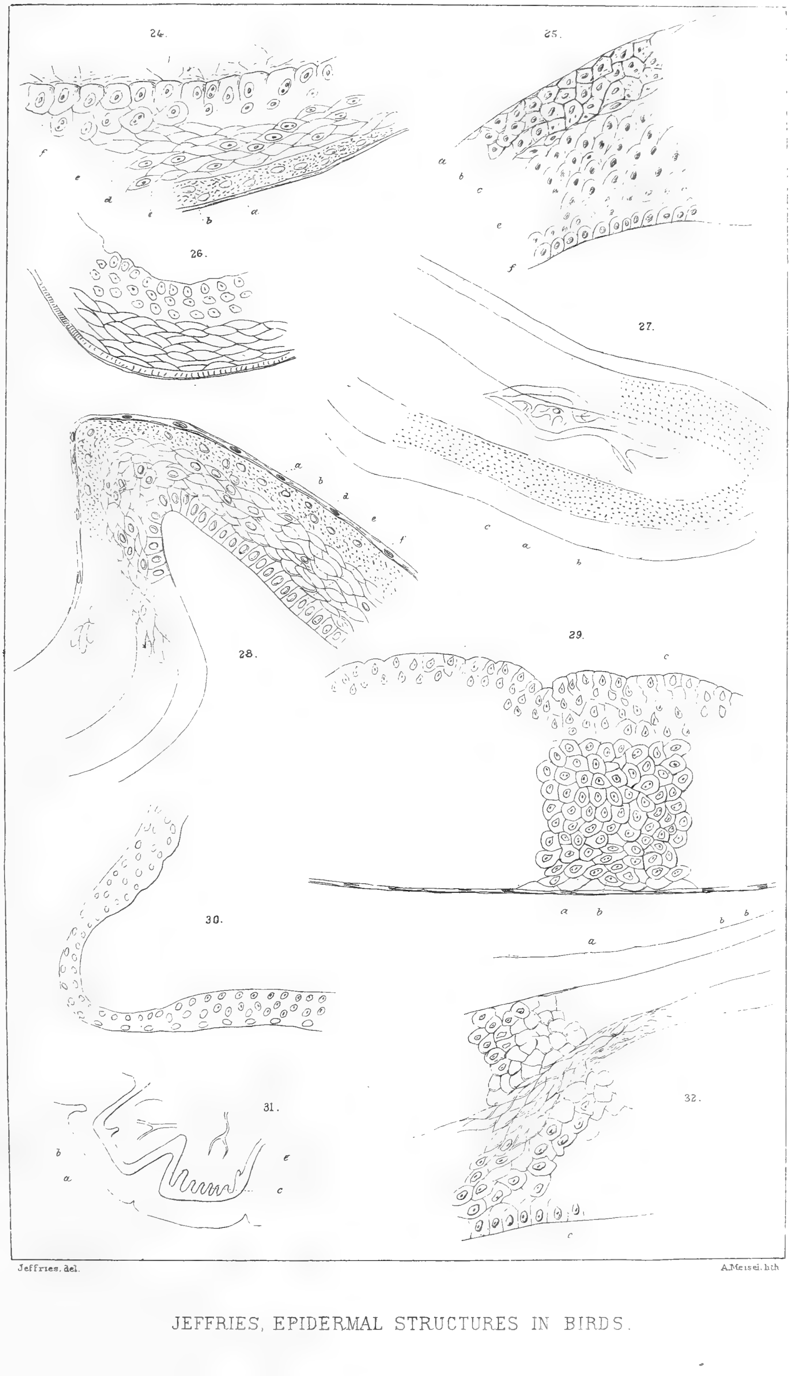

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JEFFRIES, EPIDERMAL STRUCTURES IN BIRDS.

Fig. 18. Scutae and feathers on tarsus of young cock.

Fig. 19. Same of another bird.

Fig. 20. Longitudinal section of scuta of hen. $\frac{4}{7}$.

Fig. 21. Feather and scuta of chick 14 days.

Fig. 22. Section of scutum of pigeon 7–2. *a*, transparent horn-layer; *b*, transitional cells; *c*, mucous layer.

Fig. 23. Transverse section of claw of 18 days chick. Letters same as in following figures.

Fig. 24. Longitudinal section of claw of 13 days chick, 7–2. *a*, epitrichial; *b*, granular layer; *c*, poor horn cells; *d*, horn cells; *e*, transitional cells; *f*, mucous layer.

Fig. 25. Transverse section of bill of 6 days chick. Letters as before. 7–2.

Fig. 26. Section of edge of spur 18 days chick. 7–2.

Fig. 27. Longitudinal section of spine from tongue of a cedar-bird (A. cedrorum) 5–camera. *a*, horn layer; *b*, lower part of epiderm; *c*, pulp.

Fig. 28. Longitudinal section of tip of tongue 18 days chick 7–2. Letters as before.

Fig. 29. Section of epiderm on dorsum of tongue, chick 18 days, 7–2.

Fig. 30. Section of tongue spine of 12 days chick, 7–2.

Fig. 31. Outline figure of a section of a toe pad of a pigeon, showing papillae.

Fig. 32. Section of tongue spine of a duck (Erasmatura subida) 7–2. *a*, soft horn cells; *b*, hard horn cells.

General Meeting, March 7, 1883.

Mr. T. T. Bouvé in the chair. Nineteen persons present.

Messrs. Warren H. Manning, Francis W. Morandi, Nathl. T. Kidder, Allan V. Garratt, and John C. Kimball, were elected Associate Members.

Prof. G. Frederick Wright described the terminal line of glacial action in Ohio, beginning with a point in Pennsylvania, where he had left it a year ago, and following its generally southwesterly trend to the Kentucky border, east of Cincinnati, and discussing its various features.

Mr. Bouvé showed a very fine specimen of Strontian from

Sicily, and a specimen of carbonate of copper and zinc, both the gift of Mr. Thomas Gaffield, who had also presented to the Museum some fine concretions. A vote of thanks for the gift was passed.

Mr. Bouvé also spoke of the recent illness of Dr. D. H. Storer, the only original member now living, who, he was glad to say, was at present convalescent.

It was unanimously voted that the Secretary express to Dr. Storer the Society's sympathy for his past suffering, and the pleasure with which it learns his progress to recovery.

General Meeting, March 21, 1883.

The President, Mr. S. H. Scudder, in the chair. Twenty-seven persons present.

The following paper was read:

TURKS ISLAND AND THE GUANO CAVES OF THE CAICOS ISLANDS.

BY S. P. SHARPLES, S. B.

Directly south from Boston at a distance of about one thousand miles is the terminus of the long coral reef known as the Bahamas. This reef with its banks, rocks and islands, stretching from Florida to the eastern end of Cuba, forms an almost impenetrable barrier to the Gulf of Mexico. It has but few passages through it, and these are so poor, that the sailor is thankful when he has escaped their dangers.

Chief among these passages is Turks Island Channel which is taken by most of the vessels going to the southern ports of Cuba and to San Domingo.

Turks Island is the most easterly of these islands and is separated from the Caicos by the Turks Island Channel; this channel is quite wide and deep, but it is bordered by many dangerous reefs and has strong currents setting across it; anything set adrift on Turks speedily finds its way across the channel to the Caicos. Vessels are apt to follow the same course and wrecks are frequent.

Approaching the island from the north the first object that attracts the eye is the tall white light house which crowns its northern extremity; this stands on a sharp high point which projects into the ocean, and which is surrounded on three sides by coral reefs; on the north and east these reefs extend for miles making the coast an exceedingly dangerous one to approach, as many captains have found to their sorrow.

Passing down to the westward of the island a number of singular white structures are seen on the shore; these are pyramidal in shape, and have the appearance from the water of fortifications made of white sand. They are heaps of salt, which is piled upon the beach to cure, and to await the arrival of vessels, for the island has no ships of its own and depends entirely upon foreign vessels. These never charter to carry salt so long as they can find more profitable cargoes. Our steamer anchors in front of the Custom House, as this is the principal port upon the island. There is no harbor at this point and vessels must lie in the open roadstead, where they are protected from the prevalent winds and waves by the island, but they must always be prepared to weigh anchor and run, if the wind shifts to the north or west, which it sometimes does very suddenly. As the ship comes to anchor she is surrounded by boats large and small; all the white people that are in any way interested in the vessel come off as a matter of course, and with them come those who wish to hear the news, for it may be that they have not heard from the rest of the world since the steamer touched a month ago. At any rate they have not much else to do and the arrival of the steamer is a pleasant variety to the monotony of their daily lives.

With them come all of the colored population that can get the chance, for a vessel in port means pocket money to them. They swarm over the lighters, and are ready and anxious to take the passengers ashore. Most of the passengers land, as the steamer lies here several hours unloading part of her cargo, the inhabitants depending largely upon New York for the necessities of life. The negroes also bring off some of the curious or beautiful natural products of the island, delicate shells wrought into flowers by the skillful fingers of the colored women, and huge conch shells of several varieties which are common along the shores wherever the negroes have not exterminated them.

There being no wharves at the landing, the boats are run as far ashore as possible, then the crew jump overboard, take the passengers in their arms and wade ashore; shoes are rarely worn and cotton pantaloons soon dry. The freight that is too heavy to be landed in the same manner is brought ashore by means of a mule and a tip cart; the mule is driven into the water, the cart backed up to the boat and the freight loaded into it. Everything that can be carried on the head of a negro is carried in that way. There is only one wheelbarrow upon the island and it is looked upon as a great curiosity.

Every inhabitant on the island depends to a greater or less degree upon the salt crop for a living, and it is discussed in the same manner as the hay crop is with us.

This island and the neighboring ones are particularly well situated for the business. They are in the tropics far from the mouth of any fresh water river, and they have long rainless periods which may be calculated upon with considerable certainty. The process of preparing the salt pans is very simple. A place must first be chosen, that is not liable to be overflowed by the ocean during storms.

The natural configuration of the coral islands render this an easy matter, many of these islands, the Grand Turk forming no exception to the rule, have shallow ponds in the interior; in the wet season all of these ponds are filled with water, either fresh or salt according to circumstances; if they are at a higher level than the ocean they are generally fresh, if at a lower level salt, though these latter do not always communicate directly with the ocean but are fed by underground passages; if the ponds are so situated that the ocean water only flows into them during storms or a high course of tides and are quite shallow, they then form natural salt ponds; some of these ponds have been improved and crops of salt are gathered from them.

Near the centre of Turks Island is a large, shallow lagoon, which has been converted into salt ponds. This lagoon has been divided into one large and several small ponds by neatly constructed walls of stone cemented with coral mud. The smaller divisions are called pans and communicate directly with each other and indirectly with the large reservoir; the latter communicates directly with the ocean through a neatly walled canal, which is provided with suitable gates to admit the water at high tide and prevent its outflow at low tide. The water stays in this reservoir some weeks, evaporation continually going on by the action of the sun and wind. When it reaches 60° or more as shown by the salinometer — salt water from the ocean indicating from 10° to 12°— it is fit to be turned into the pans, which is done either by water-wheels worked by hand or by wind-mills.

During this preliminary evaporation, the water deposits the main part of the sulphate and carbonate of lime, which it contains, and also some of its organic impurities.

The pans vary in size, but are generally from one-eighth to three-fourths of an acre in area. These pans are so laid out that a constant circulation can be maintained through them. They are also arranged so that any one pan can be emptied into the adjoining ones, when for any purpose it becomes necessary. The walls between the pans serve as convenient foot-paths, some of them being wide enough for roads. They generally have two or even three seasons each year during which they make salt. Between the seasons the pans are cleaned and relined, if they need it. The lining is formed from fine coral mud.

The brine seldom commences to crystallize unless there has been a month's absence of rain. It becomes a saturated solution at 96° and commences to crystallize at 110° as measured by the salinometer.

The depth of the water in the pans varies from twelve to eighteen inches; the deep pans produce the best salt, but they make it much more slowly. When a pan is ready to rake it presents a beautiful appearance, the crystals of salt being sharp and well defined and of dazzling whiteness. When it has acquired a sufficient thickness it is broken up and raked into rows on the bottom of the pan, where it is allowed to drain. After this it is carted into the piles on the storage ground near the beach. Some of these piles contain as much as ten thousand bushels. The pans yield from five to eight thousand bushels per acre per annum.

The storage of salt as practised here is very wasteful, since it receives no protection from the rain, and may lie on the beach a year before shipment, and lose as much as one-fourth during that time. The heaps are built as high as a man can conveniently throw the salt when standing in the tail end of a tip-cart. At the time of my visit it was estimated that there was as much as a million bushels on the ground awaiting shipment. A single rain-storm sometimes occasions the loss of 25,000 bushels.

Salt is the sole support of a majority of the inhabitants as the island produces but little else. The island formerly had many cocoanut trees, but they were mostly destroyed by a hurricane which swept it several years ago, and the young ones are hardly in full bearing yet. The most flourishing industry, after the salt business, seems to be wrecking, which is followed with considerable profit by some of the islanders. The old pilot, who went with us to the Caicos, expressed himself in about this way, "that he had no ill will to any one, but if there were to be wrecks, he hoped they would come soon and land in a convenient place for the wreckers." The government, however, looks quite closely after wrecks and does not give much opportunity for illegitimate pillage.

The island is under the control of the English with Kingston, Jamaica, as the seat of government. The chief officer on the island is the commissioner, who is also collector of customs. There are about three thousand inhabitants from whom the government contrives to derive a revenue of $35,000, which comes largely from an export duty on salt; there are also considerable import duties, and the surplus revenue inures to the benefit of the island of Jamaica.

The light-house is supported by a special port charge levied on all vessels calling at the island.

At certain seasons of the year the salt ponds require much care as they are subject to the growth of a red alga which spoils the salt. This alga is mentioned by Prof. L. Agassiz as occurring on Salt Cay which lies to the south of the Grand Turk.

The larger portion of the salt which is made here is sent to the United States, but a considerable portion goes to Nova Scotia.

The main object of our visit, was not to see the Grand Turk, but an island to the west of it which is called Cape Comet, on the charts, but which is known locally as Breezy Point. This island lies about twenty miles to the west of the Grand Turk. A few days after our arrival at the Turk we embarked on a small schooner, belonging to an old man who was a pilot, smuggler, or wrecker, as occasion offered, and who was willing to turn an honest penny now and then by carrying passengers between the islands. Running down before the wind we came in about four hours to the island, and here we found, much better displayed than at Turks Island, all the phenomena of a coral island.

First, we came to the barrier reef where the water changes from the beautiful indigo tint of the deep sea, to the bright green or white of the soundings. Passing through the reef, by a narrow crooked passage where it seemed each instant that we were going upon the sharp points of the coral, we found ourselves floating on a sea of transparent green water resembling glass in its clearness, and so smooth that objects could be seen at the depth of fifteen or twenty feet.

Outside of the reef the huge waves were tumbling in one after the other, and broke on the reef in one long line of foam, while inside, the boat was only gently rocked by the swell of some wave larger than its fellows, which overtopped the reef. The whole northern shore is surrounded by reefs, which are generally at some distance from the shore, but occasionally a long point extends from the shore line to the reef thus dividing the channel inside into a number of small bays.

These bays afford a safe passage for small boats from one end of the island to the other. They are, however, very narrow in places and have many shoals in them, and in several places one is invited to get out of the boat and walk across, while the men take the boat through the surf at the end of the point. The shore of the island offers a splendid opportunity for the study of the formation of a coral island. We have here the barrier or fringing reef, the lagoon inside of it, the coral sand beach, surmounted by a sand dune, crowned with palmettos, and then the low interior of the island, covered with a thorny underbrush.

The palmettos grow only on the windward sand dunes and rarely extend inward more than two hundred yards.

The guano caves, which it was our special object to visit, are situated at the western end of the island on a beautiful bay, which is large enough to afford anchorage for vessels drawing nine or ten feet of water. The caves are in a low range of hills which form the principal elevation on the island. These hills are never very high; the principal one being about 150 feet in height, and is called by the negroes "Filamingo Hill," otherwise Flamingo, from a pond at its base where this bird is frequently seen. The hills in which the main deposits of guano have been found do not exceed fifty feet in height. These hills have been most thoroughly honey-combed by the action of the waves at a date that must be comparatively remote, since many of the caves are now half a mile or more inland. There is, however, but little evidence of elevation of the land, though a rise of a few feet may have taken place. They seem rather to have been abandoned by the sea, the gradual growth of the land having closed their entrances. That they are true erosion caves, formed by the waves and not like the caves in our limestone stone valleys formed by under ground streams, is shown by their general character, and their great resemblance to the caves that are now being formed wherever the sea has access to a limestone bluff. In many places are found well defined bench marks, which correspond to the ordinary bench which is generally found where rocks of this character are acted upon by the waves. In one of the largest of the caves the water still ebbs and flows, although it is at least a quarter of a mile from the shore. The caves are remarkable for the almost entire absence of stalactites and stalagmites although they may occasionally be seen. This is accounted for by the compactness of the roof and its thinness, for it rarely exceeds a few feet in thickness. Access to these caves as a general rule is obtained through openings in the roof, where the thin roof has broken away. Many of these openings are not over a foot in diameter, and seem in many instances to have been caused by the growth of roots through crevices of the rocks.

At the largest entrance, where we made our first descent the opening is about ten feet across and is partially blocked up by the rocks from the roof; the pit is surrounded with roots of fig and other trees which make a convenient ladder for the descent. Growing in the centre of this opening is a pawpaw tree having a diameter of six or eight inches. At another opening the only means of access was a single fig root having a diameter of about two inches, down which the party slid sailor fashion. In passing through the caves we frequently found these roots coming through the apparently solid roof.

One of the negroes illustrated on one of these the use of the primitive big toe. We had observed the great development of the big toe among these people and now we found a reason for it; they use it as a thumb in climbing. He clasped the root in this manner with his hands and feet and ascended it with ease, though he was a fellow weighing over a hundred and fifty pounds.

The opening in the first cave led into a large, roughly circular chamber which in former times had evidently been a place of considerable resort, as the walls were blackened in many places by smoke and the fireplaces and ashes were plainly to be seen. On the walls of this chamber are a number of rude drawings, which in most cases are evident attempts to imitate the human figure. In one of the branches of this cave the first explorers found two bowls and a chair. They were evidently of aboriginal manufacture, being similar to those described by the early visitors to this region as in use by the inhabitants, and they must have been in the cave upwards of three hundred years, since it is about that time since the Spaniards took the Indians to the happy hunting grounds and depopulated the islands.

Everywhere, except under the openings, these caves contain a peculiar red earth; in some cases this is only a few inches in thickness, in other places it half fills the cave and in many it fills the cave to within a few inches of the roof, having a depth of over twenty feet.

The impression in passing through the caves is that of an immense warehouse in which the earth has been purposely piled. This earth is a mixture of sulphate and phosphate of lime with a small amount of alkaline chlorides and more or less organic matter. It seems to be almost destitute of organic remains. A singular circumstance connected with the deposit is the fact, that, while surrounded on all sides with carbonate of lime, it is itself almost free from this substance. It is very wet, the moisture when it is first taken out averaging forty per cent. A number of analyses have been made by myself, Dr. Liebig of Baltimore and others. The following may be taken as representing the composition of a fair sample partly dried.

Moisture	30.60
Bone phosphate of lime	33.35
Sulphate of lime	21.80
Organic matter	9.98
Silica	1.00
Potash	0.32
Soda	0.14

Chlorine, Alumina iron, Carbonic acid, etc.

The question naturally arises, what is this deposit and whence does it come? Dr. Liebig, of Baltimore, who visited the island shortly after I did, says of it, "It is a strictly organic deposit of recent origin." He seems to think that it has been thrown up in some manner by the waves and that it consists of the remains of "the organic matter so abundant in the surrounding ocean."

The evidence in support of this view is, however, very slight; the remains in it are very few and can readily be accounted for on other suppositions.

The deposit differs from most deposits of the kind in the fact that it is in the form of a fine moist powder; there was a deposit somewhat similar at Navassa, but it was mostly in the form of a rock, while I have not seen any of this too hard to be crushed by the hand. Some samples of guano, from Jarvis Island in the Pacific Ocean, have almost exactly the same composition as this deposit. That from Jarvis Island is an undoubted bird deposit. There are a number of caves in Texas which contain large deposits of bat guano. The bat guanoes are always easy to identify since they consist mainly of the hard parts of insects, which the bat has been unable to digest. In exploring these caves a bat was occasionally encountered and small piles of their droppings were seen, but these were few and far between. The occasional remains that are found are not such as would be deposited by bats, but are small fragments of fish bones.

A sample of guano from a neighboring Cay serves to throw some light on the subject. In this we find much organic matter, consisting largely of fragments of bone; in some cases these are so well preserved that the part of the body from which they came can readily be identified; the vertebra, of small fish are common among them.

I regard these deposits as simply fossil guano which has so long been exposed to the action of air and moisture that the ammonia has almost entirely disappeared. The earth is almost entirely destitute of odor, thus showing the completeness of the decomposition. The absence of recognizable remains is readily accounted for, bones buried in a manure pile quickly lose their integrity and tumble to powder.

The presence of so much sulphate of lime is more difficult to explain. Professor Dana, in speaking of some similar deposits which contain much sulphate, supposes it comes from the evaporation of sea water, as it is a well known fact that when sea water evaporates the first thing deposited is the gypsum. Just how this could have taken place in this instance I am unable to say. The gypsum and other soluble substances can be readily dissolved out of the deposit, as is shown in the guano from one of the caves into which the sea water flows freely. In this cave the guano from under the water contains when dried nearly seventy per cent. of bone phosphate, while the gypsum is quite low.

The entrance to the second cave that we visited was in a hill-side. At this place we descended over broken rocks to the water level where we found distinct evidence of the ebb and flow of the tide, though the cave is at least half a mile from the shore. We entered a boat and were rowed into the cave for about a hundred yards, through a channel from fifteen to twenty feet wide. By burning magnesium wire from time to time we could get some idea of the size of the cave and could see passages opening off from it on either side. Near the end the cave made an abrupt turn and opened into a large vaulted chamber, about forty feet in height, and fifty feet in diameter; at the apex of the vault there was an opening which admitted the light, so that it was well illuminated. The entire floor of the chamber was covered to the depth of twenty-five feet above water level with guano. It was estimated that there were at least one thousand tons in this one heap. In a side chamber adjacent to this one, there was also an opening in the roof through which the fig roots had descended, and we cut one of these and brought it with us as a trophy. It was about three-quarters of an inch thick and over fifty feet in length. The same absence of fossils was observed here as elsewhere. The enormous extent of these caves may be imagined from the fact that it is estimated that there is at least three hundred thousand tons of guano in them.

Since our visit a number of other caves have been discovered; in fact, caves were discovered almost daily while we were there. The temperature in these caves is very pleasant, and although they are of course damp, there was no feeling of dampness, being simply cool and pleasant after the hot sun outside.

It may well be asked why these caves were not discovered before. This arises partly from the fact that the island is rarely visited, partly from the nature of the chaparral. The region of the caves is almost inaccessible. The hills are covered with a low growth of the plants that are peculiar to dry tropical regions, among these the Cactaceae and the Euphorbiaceae are especially prominent; in short, if there is any tropical plant that is well provided with thorns, you may expect to find it here.

No progress is possible through this mass of vegetation unless a path is first cut; add to this the superstitions of the negroes who never venture under ground unless a white man goes first and not then if they can help it, and we have plenty of reasons why they should have remained unknown. The discovery of guano at Inagua in similar caves led to the examination of this island, as the caves have been known to exist here for a long while, such some of them are the favorite resort of the wild hogs that are found on the island. Mr. John Reynolds made a visit to the island, which he had leased from the government as a cattle ranch, and brought away with him samples of the earth which were placed in my hands for analysis. The results were so favorable that I was led to visit the island, where I was able to confirm all that I had been told in regard to it, the deposit far exceeding my expectations.

Mr. S. Garman sketched the geographical features of America in the Cretaceous Period, and the changes undergone in the Eocene, when the first traces of fossil horses are found. After showing the evolution of the latter, he discussed their disappearance in Pleiocene times, which he ascribed to the effect of a few somewhat severe winters, basing his argument on the destructive effect of any unusually severe winter of the present time on the cattle and other animals of our plains, and the circumstances in which the latest fossil remains of horses are discovered; the manner of preservation and petrifaction of the latter being similar to that obtaining in the so-called bone licks of much more recent date.

Letters were read from Professors Alphonse Milne-Edwards and Joseph Prestwich and the Marquis de Saporta acknowledging their election as Corresponding Members; and also from Prof. Henri Milne-Edwards acknowledging election to Honorary Membership.

General Meeting, April 4, 1883.

The President, Mr. S. H. Scudder, in the chair. Thirty persons present.

The following paper was read:

GENERA OF FOSSIL CEPHALOPODS.[1]

BY PROF. A. HYATT.

Univalve shells may be generally spoken of as cones, which may be either straight, curved, or coiled; and the coiled may be either loosely coiled, or close coiled; either in the same plane, or a descending spiral. The shell-covered Cephalopoda are straight, ex. Orthoceras; arcuate, ex. Cyrtoceras; loose coiled, ex. Gyroceras; close coiled, ex. Nautilus.

The larger number of the more ancient shell-covered Cephalopoda are straight cones. These predominate in the Silurian over the arcuate, which are often merely varieties of species of the straight cones, as demonstrated by Barrande, and as may be observed in all good collections. The young of nautilian shells are identical with the adults of the arcuate and gyroceran, and in different series repeat their forms, sutures, shell markings and

[1] This paper is preliminary to a monograph which will appear in the Memoirs of the Museum of Comparative Zoology.

the outlines of their whorl in transverse section. They are in succession, first, arcuate, then gyroceran, and lastly nautilian or close coiled.

In several series genetic lines of adult forms may be followed, which lead by gradation from arcuate, cyrtoceran forms to close coiled nautilian shells, the whole showing a connected series of transitions in the form and outline of section, sutures, structure, and position of siphon, and shell ornaments and apertures. In some cases these graded series are in accord with the chronological record, the straight appearing first, the arcuate either in company with them or later in time, and the gyroceran and nautilian latest.

We cannot of course claim that such perfect evidence has been found even in the larger number of the following series. In some of them, certainly, it is not an over statement to say that the chronology of the evolution of form, the development of the individual, the gradations in the adults, and the general differential characteristics all tell the same story, and are decisive for the opinion, that in all the larger series of shell-bearing Cephalopoda the nautilian shells belong to several distinct series and arose independently from straight cones through the intermedium of a graded series of arcuate and gyroceran or closely coiled forms. The generic terms, Cyrtoceras, Gyroceras and Nautilus are really only descriptive terms for the different stages in the development of an individual, and also the different stages in the development or evolution of the series of adult forms in time. In other words, each of these genera as now used, include representatives of all the different genetic series of Tetrabranchs, which are either young shells in the corresponding stage of growth, or adult shells in the corresponding stage of evolution.

Our qualifications do not apply to the theoretical correllations, which may be observed between the development of the individual in all its stages and the different forms of the group to which it belongs; these are very nearly perfect. It is impossible to imagine the exact correspondence which exists between the transformations of an individual during its growth and the different adult forms of its own group, of the larva to the more ancient forms, of the adolescent stages to the lower forms of its own genus or family, except upon the theory of descent with modifications.

The forms of the earliest fauna agree in their general aspect owing to the proximity of the septa, but they do not agree in structure, or in their embryos.

The embryo in the Nautiloidea is a shrivelled protoconch, which may have been rounded at first but must have become shrunken and shrivelled after the animal passed out of it and into the apex; it does not contain the siphonal coecum, and when broken away left a narrow cicatrix on the apex, the opening closed by a layer of shell. The umbilical perforation is an opening through the centre of the whorls of even the most completely coiled modern Nautilus, the hereditary mark of its uncoiled ancestry.

The siphon may be near the venter, but the funnels rarely, if ever, break the continuity of the suture.[1] The funnels of the siphon are simple posterior prolongations of the septa. The sutures are entire, they never have marginal lobes and saddles or more than two lateral lobes; the ventral lobe is usually undivided or simply V-shaped when it occurs,[2] the dorsal lobe is, also, usually undivided, but may be divided in rare cases by saddles, the annular lobe when it occurs is undivided.[3]

The siphon is variable in position, but the larger number of ancient genera have the siphon ventral or near the convex side. It shifts in nearly all the series to near the centre, or dorsal side of the centre in the higher and often later occurring nautilian forms.

The Ammonoidea have a globose protoconch, containing the coecum of the siphon, and when broken away it leaves the apex open. There is no umbilical perforation, except in the lowest and earliest of the Goniatitinae, the Nautilinidae. Some of this family have straight apices or young, others among them have arcuate and gyroceran stages, without the orthoceran, while the most closely coiled species in the adult are also close coiled in the larva and do not have arcuate and gyroceran stages. The higher Nautilinidae and all the succeeding genera have close coiled whorls in the earliest stages, with exceedingly rare exceptions,

[1] Except, perhaps, in the Prochoanoids?

[2] It may become divided by a broad saddle, the median saddle in rare cases.

[3] Except in Trematodiscus and similar forms, where a median saddle is developed.

only occurring in the Devonian and Carboniferous, and the umbilical perforation is reduced to a mere depression on either side of the broad neck of the protoconch.

The siphon is so near the venter that the funnel invariably breaks the continuity of the sutures with a slight lobe. The funnels of the siphon are not simple continuations of the septa, except in the Nautilinidae, and most forms of Goniatitinae. In some Goniatitinae, and all other Ammonoidea, a collar is formed around the siphon in addition to the funnel, the collar being open and directed forwards.

The sutures are entire in most of the Goniatitinae, but in some species of the higher and later occurring carboniferous Goniatitinae marginal lobes and saddles begin to be formed, and in nearly all the remaining genera of later periods, these are characteristic. There are two lateral lobes which arise in the Goniatitinae by gradation from the simple lateral lobe of the Nautilinidae and in the higher forms an indefinite number of auxiliary lobes and saddles. The ventral lobe is undivided only in the Nautilinidae, and in all other series of forms there is a median saddle, the sutures of this invariably divided by a minute funnel lobe.[1]

The dorsal or inner side is occupied by a saddle in the Nautilinidae as is the case very generally among the lower forms of the different series of Nautiloids, all the remaining Goniatitinae have a broad dorsal lobe, which is divided by small saddles as in the exceptional forms of the Nautiloidea.

The annular lobe is absent among the Nautilinidae, as it is also universally in the lower forms of the different series of Nautiloids.[2] It is present, but undivided, in the remaining Goniatitinae, and is divided by a median saddle only in the higher forms after the expiration of the Paleozoic.

The appearance of a decided dorsal lobe correllates usually with the closer coiling of the whorls and the development of an impressed dorsal zone. This enables us to see, that the impressed zone is due to coiling, and also to define the gyroceran and nautilian forms.

[1] I have found some rare exceptions, adult stages of abnormal varieties with continuous sutures over the venter as in the young of some Ammonites, Embryology of Ceph., Bull. Mus. Comp. Zool., Vol. III, p. 110, fig. 1. These facts show that we are right in calling the minute central lobe on the venter, the funnel lobe.

[2] Except some of the Endoceratidae according to Dewitz.

Thus, we can say, that a given form is still gyroceran though the whorls may touch in coiling, as long as the dorsum is rounded and gibbous, but if the dorsum has the impressed zone, it must be considered nautilian. This distinction enables us to add to the peculiarities of the Silurian fauna already noted by other authors (viz., the prevalence of straight, large siphoned forms, and those with septa closely approximate), the additional characteristic of the great rarity of true nautilian forms.

M. Barrande has claimed that there was no approximation between the ancient forms of the Nautiloidea and Ammonoidea.

We cannot understand the facts detailed above on any other supposition than the direct and independent derivation of the Nautilini from a straight cone. We think farther that this straight cone must have been a close ally and ancestor of the straight orthoceran-like Bactrites of the Silurian. This form agrees closely in all its characters with the young of the simplest known forms of Goniatites. The gyroceran and tubular whorls, and peculiar sutures and siphons of the young of Mimoceras are very similar to those of Bactrites. The series of the Nautilinidae is, therefore, similar and parallel to that of any one series of the Nautiloids. It must have been independently derived from a straight cone similar to Bactrites. All the remaining ammonoids are more concentrated in development, and skip the orthoceran, cyrtoceran, and gyroceran stages of their evolution in time. They are evidently descendants of the close coiled Nautilinidae and the evidence here is very strong that the whole order of Ammonoidea arose from a single organic centre of distribution, the Nautilini of the Silurian. The succession in time, the evidence of gradation in structure, and the development, exactly accord with this statement. Nautilinidae, Goniatites, triassic transition forms of Ammonitinae and the true Ammonites of the Jura form a perfect progressive series.

The main difficulty in the way of the theory that Ammonoids and Nautiloids belonged to the same stock and were derived both from the same common ancestor laid in the assumed universal absence of a protoconch in the latter. We have found the protoconch in several species of straight cones, and its absence in others can be readily accounted for. It was a useless hollow appendage and probably also on account of its conchiolinous structure easily separated from the thicker calcareous shell of the apex. To close the evidence it only remains to point out the close affinities of the Bactrites for Orth. pleurotomum Barr. Syst. Sil. pl. 296 of Bactrites for the young of Mimoceras (Gon.) compressum Beyr. Sand. Verst. Nass. pl. 11, and the straight young of Agonatites (Gon.) fecundus, sp. Barr. Syst. Sil. pl. 11, fig. 4.

The existence of the protoconch also removes a serious objection to the derivation of the Belemnoidea from the straight cones. We propose to remove another by homologizing the plug on the truncated cone of Orthoceras with the guard of the Belemnites. We find that the central trace compares with the pseudosiphon of the plug, and that the bilateral formation of the plug is similar to that of the guard. This indicates to our mind, not the existence of two secreting organs like the arms of Argonauta, which stretched back over the shell of Orthoceras, as supposed by Barrande, but on the contrary an organ probably the homologue of the dorsal fold of the mantle in Nautilus. This could readily have been larger than in Nautilus and covered in the whole shell, and been divided into two secreting lobes at the posterior end.

We are thus able to account for the inclosure of the shell among the Belemnoidea and the deposition of the guard, for the openness of this sac as shown by Branco in the transitional form, Aulacoceras of the Trias, and for its final closure as permanent sac among typical Belemnites without calling to our aid any extraordinary modifications of the known organs of Nautilus. The succession here would be Orthoceras, Silurian, Aulacoceras and Belemnites, Triassic.

The Sepioidea appear to be connected with Orthoceratites through Gonioceras, which resembles the broad internal shell of the Sepia officinalis in the striae of growth and differs from all other forms of Nautiloidea in this respect. It has also septa whose outlines approximate to the outlines of the calcareous layer in the interior of sepia shell, or cuttle bone. Gon. occidentalis Hall, Rep. Geo. Surv. Wiscon., 1861, p. 47, has shell and septa, and the outlines of the form are also similar to Sepia, being broadly fusiform, and much compressed. The loss of the protoconch can be accounted for in these forms in the same way that we can account for the resorption and loss of the siphon and degradation of the septa to a mere succession of calcareous layers. Namely, the shell having become internal and these parts being useless they gradually disappeared. They were first degraded, and then lost out of the roll of hereditary characters, the shell itself following in the same train, and disappearing at last in the higher and more specialized Octopods. We thus have Gonioceras in the Silurian, Paleoteuthis a true Sepioid, Devonian; Loligidae or Teuthidae, Jurassic; Octopods recent.

To clinch this evidence we can refer to the work of Lankester, "Development of the Pond Snail," in which he shows that the pen sac is not an enlargement of the shell gland, but must have been derived from a secondary sac formed by some extension of the mantle, which inclosed the shell and became a permanent addition to the organization, and we differ from this author only in imagining this inclosure as due to the extension of the dorsal flap of the mantle, as in Nautilus, instead of to two flaps of the mantle as in Aplysia.

We regard these two orders as distinct from each other but as forming a division together, which we can designate as a sub-class under the name of Dibranchiata equivalent to Professor Owens order of the same name. It is, however, not yet clear that they arose from the same type among the straight cones, though that they both came from some straight Orthoceras seems to be indicated by all the evidence now in our possession.

If now we return to the Nautiloidea and Ammonoidea we find these two orders to be unitable as having external shells a common form of embryo and chambered shell, the chambers pierced by a siphon; that they possess similar structures, similar imbricated layers in the shell, and similar external deposits; that they exhibit parallel series of forms in the independent reproduction of the nautilian shells out of straight cones, and of the parallel modifications described above among the Goniatitinae. There is, therefore, every probability that they have been properly united by Prof. Richard Owen as Tetrabranchs. We, however, prefer to consider this a sub-class with two orders according to the classification proposed by Prof. Louis Agassiz.

We have, after much observation, found that genetic affinities on a large scale are best exhibited by the siphon, particularly by the funnels of the septa, which are more invariable than any other parts of the shell.

Following out the history of these parts the Nautiloids can be subdivided into the following general genetic groups, [1] Holochoanoida, those having long funnels which completely close the intervals between the septa. We can subdivide this group into Prochoanites, those with funnels of septa turned forwards, ex. Bathmoceras, Metachoanites, those with funnels turned backwards and completely closing up the walls of the siphon, which has no intervening connective wall, ex. Endoceras, and Trocholites. [2] Ellipochoanoida, those with short funnels and the siphon completed by an intervening connective wall of distinct structure from the septal funnels.

There are many of the Orthoceratites which have funnels of considerable length like those above noted as transitional to Bactrites. These are, as shown by M. Barrande, directly connected with the extremely short funneled group of the Actinoceratidae. We, therefore, divide the Ellipochoanoida into the true Microchoanites, which embrace the Actinoceratidae and most of the true Nautiloids, including Nautilus, and the Macrochoanites.

The Macrochoanites may be said to include Bactrites and such straight forms as are transitional to Ammonoidea and all the Nautilinidae, and also the Clymeninae which have similar long funnels. The advantage of this name in trying to present natural relations is evident because we can thus bring all the forms which are transitional from Nautiloids to Ammonoids into one group, and present them under one descriptive name. In our classification we have, for obvious reasons of convenience, included some of the true Orthoceratites among the Macrochoanites, since there are some, as we have said, which can properly be included with Bactrites.

In the more complicated forms of Goniatitinae, while the young are quite generally macrochoanitic, the later larval stages and the adults are universally short funnelled. These short funnels are, however, quite distinct from the short funnels of the Nautiloids, and we propose to class them in with the next type to which they are transitional. The collar is present in all the higher forms or true Ammonitinae, and has been observed by Beyrich in one of the typical Goniatitinae, and the forms possessing this modification we propose to assemble under the name of the Cloiochoanites. This collared group, therefore, correlates with the median ventral saddle, which is present in all of these groups, namely all the Goniatitinae except the Nautilinidae, and all the Ammonitinae, and the funnel lobe is elevated upon it.

An important factor in this classification is the dorsal suture, and we find that the position of a genus may often be determined in any given series by the peculiarites of this part; whether it is present or absent, and whether it has, or has not a small annular lobe, or "spindle lobe," or a small saddle in the median line of the dorsum. All the series, with few exceptions, begin in time with arcuate forms which have dorsal saddles, and are succeeded by nautilian shells with dorsal lobes, and then these acquire the median annular lobes; if they retain saddles on the dorsum, the dorsal lobe invariably appears in descendants, but is apt to be divided by a small saddle in place of an annular lobe. So far as we know, the annular lobe appears in no species earlier than the Devonian.[1] The "endosiphon," here spoken of for the first time by that name, is the internal tube long known in Actinoceras, and lately demonstrated in Piloceras by Dawson, as having its own proper walls. To this we can add a similar apparatus observed in two good specimens of Endoceras, and also noted by the author in some specimens of Sannionites..

Among Nautiloidea there are no series traceable directly to arcuate forms after the expiration of the Carboniferous. This is the common story, and we can see that the series must have arisen very rapidly during the Paleozoic, branching out on every side from the common ascending trunk of the straight and arcuate forms. The same is true of the Ammonoidea in the Silurian, but only one short series, the Nautilinidae, arises from the common trunk of the straight cones. The close coiled shells of this series become the stock form for the whole of the Ammonoidea.

The Nautiloidea of the Mesozoic are all nautilian forms and their genetic series do not present the rapid changes of form observed in the Paleozoic, they are all close coiled and have as observed by M. Barrande small umbilical perforations.

This same statement applies also to the Ammonoidea, when near their point of origin in the Silurian their forms are very quickly evolved, but are much less quickly evolved after this period.

The smaller genetic groups in the Paleozoic are distinguished

[1] These statements apply only to Nautiloids. See description of Goniatitinae Nautilinidae, and Agoniatites.

by differences between the sutures which are marked and decided by structural distinctions. Thus the groups of Clymeninnae and Goniatitinae, differ widely in their sutures and position of siphon and smaller groups have also decided structural differences.

In later times the families and in fact the whole of the Ammonitinae are very similar in their sutures. There are, however, many genetic series, in the Jura families, which can be distinguished by the minor details of the outlines of the sutures, but these distinctions are not so marked as in the Paleozoic, and the form of the whorl in section, and costations and ornaments of the shell are decidedly characteristic.

In other words the field of variation is structually decidedly narrower, in the Mesozoic than in Paleozoic, whether we consider the Nautiloidea or Ammonoidea.

We have observed the same phenomena repeated in each formation and in the mode of appearance of all the genera and families. These groups originate suddenly and spread out with great rapidity and in some cases as in the Arietidae of the Lower Lias are traceable to an origin in one well defined species which occurs in close proximity to the whole group in the lowest bed of the same formation. These facts and the acknowledged sudden appearance of the larger number of all the distinct types of invertebrata in the Paleozoic, and of the greater number of all existing and fossil types before the expiration of Paleozoic time, speak strongly for the quicker evolution of forms in the Paleozoic and indicate a general law of evolution. This we think can be formulated as follows, types are evolved more quickly and exhibit greater structural differences between genetic groups of the same stock while still near the point of origin, than they do subsequently. The variations or differences may take place quickly in the fundamental structural characteristics, and even the embryos may become different when in the earliest period, but subsequently only more superficial structures become subject to great variations.

During this investigation we have been able to add to the facts we have already brought forward in support of the law of acceleration, or as we now prefer to designate it, the law of concentration of development. All more generalized or lower types have a direct mode of development and the more specialized or complicated progressive types have, when at the acme of their development, a more indirect mode of development. The types which are descended from these last have often a mode of development which in many forms is an apparent return to the direct mode of development again.

The first two modes occur in the progressive series, the last can occur only in the highly retrogressive or degraded forms and consists of the following stages, to which naturallists acquainted with the life histories of modern parasites will easily find parallels.

The degraded uncoiled forms of the Nautiloidea and Ammonoidea, wherever they occur, whether in the Silurian or in the Cretaceous, invariably have close coiled young, showing that they were the offspring of close coiled or nautilian shells, that is of progressive forms which have themselves been evolved from a series of straight, arcuate, and gyroceran predecessors. Their uncoiling then is a truly retrogressive character, and this tendency to retrogression is inherited in successive forms in several series. Their whole structure is finally affected, the whorl is reduced in size, and the complication of the sutures and shell at all stages of growth is degraded, until in their development only the close coiled young remain to testify to their exalted ancestry. In other words the forms inherit the degraded characteristics at such an early stage that it effects their whole life except the earliest stages. If we examine any of the progressive series we find that characteristic modifications or variations tend to appear first in the adults, then in successive forms they appear at earlier stages, and finally disappear altogether or become embryonic, and this is the case also with the degraded characteristics, and doubtless when carried far enough even the last fortress of the ancestral characteristics, the larval stages would be invaded and the shell become completely uncoiled and perfectly straight and cylindrical from the earliest age. We have found specimens of Crioceras, in which only a part of the first whorl was close coiled and the embryo of the Baculite, the straight cone of the Cretaceous, and Jurassic Ammonoidea still remains unknown. We have, therefore, in the life of a series heredity acting in such a manner that new characteristics are being continually introduced into the adult and adolescent stages to replace the ancestral ones which have disappeared or been crowded back into the earlier or larval stages.

It is an undoubted fact, as shown by the writer and especially by Barrande and Dr. Branco, that the embryo itself has varied comparatively little throughout time in the Ammonoidea, Nautil oidea, Belemnoidea, and Sepioidea.

But these statements do not apply to the earliest stages in the evolution of these types. During these earlier stages, when they all branched out from the common stock, the embryos of the Ammonoidea and Nautiloidea became quite different from each other, the embryos of the Belemnoids remained like those of the Ammonoids almost exactly similar to those of the Nautilini as shown by Chalmas and Branco, and finally in the Sepioidea the protoconch or embryonic shells changed more completely and soon disappeared. Attention is particularly called to this remarkable fact in the history of the evolution of these forms, that the separation of the orders took place rapidly, and in the embryos as well as in the adults near the origin of the orders, and the comparative invariability of the embryo was confined to the subsequent history of these types after separation.

We have here no space to discuss the apparent reasons for these changes, but we have been able to explain the mode in which they take place. The mode in each case is the earlier or concentrated development of ancestral characters, which as we have said follow the same paths, whether progressive and tending to preserve the characters of the type, or retrogressive and tending to destroy the characters of the type.

We mention the law of concentration of development because in looking at the young in the usual haphazard way, naturalists often do not find the strong marks of affinity which the ordinary modes of studying lead them to anticipate. The law of concentration leads to the disappearance of important characteristics often even in short and comparatively small series. It acts frequently within a small group like the Arietidae, so that the later larval and adolescent stages are exceedingly unlike the same stages in very nearly related species in the same family. Unless they are willing to take a small well characterized group and follow out all its transformations they cannot hope even to understand the remarkable phenomena which are shown more or less in the history of every complete series.

Slaves of the embryological lamp consider that they must associate all forms which have similar embryos, and dissociate in classification all forms having different embryos. As a matter of experience, the surest guides of affinity are the adult gradations of forms. These show that the Nautiloidea and Ammonoidea with comparatively distinct embryos are nevertheless closer related than the Belemnoidea and Ammonoidea which have precisely similar embryos, and Sepioidea and Belemnoidea which have very distinct embryos must also closely be affiliated.

The embryos of all these must have been precisely similar at their origin, but they afterwards became varied in the different orders, and we cannot lay down any hard and fast rule by which the embryo becomes an invariable criterion of affinity. We think there is ample reason in the structures of these shells themselves for the embryonic differences, and that it is possible to reconcile them with the affinities indicated by the gradations observed between the adults. These reasons which we have space only to allude to here consists in a series of correlations which are plainly apparent between the adult structures, and the habits of the animals, and the tendencies which the habits have to change the adult structures, and then by the action of the law of concentration in development to change even the embryos, either quickly in time when the habits are widely changed, or more slowly when they vary but slightly with the progress of time. The evolution is a purely mechanical problem in which the action of the habitat is the working agent of all the major changes; first acting upon the adult stages as a rule, and then through heredity upon the earlier stages in successive generations. Thus in the open fields of the periods of their origin they expanded into their different habitats, varying to accomplish this purpose with great rapidity, but once in their appropriate habitat inducements to change or open fields became rarer, and we get as a result comparative invariability. As time rolled on and the earth became more crowded, the variability was reduced to less and less important structural changes, except in the retrogressive types. These exceptions are our best proofs of the action of the habitat. The changes in these retrograde forms are again remarkable for the rapidity with which they take place, and all of these types can be shown to have occupied free fields where they met with new conditions, and to have changed their habits and structures rapidly to accord with these new conditions.

NAUTILOIDEA.

HOLOCHOANOIDA.

Prochoanites.

Bathmoceras, Barr. Syst. Sil., Vol. 2, Tex. 1, p. 74, 3, p. 792, supp. p. 92, equal Conoceras, Bronn.

Nothoceras, Barr., ibid., Vol. 2, Tex. 1, p. 72.

Metachoanites.

Endoceratidae.

Vaginoceras, nobis, type, (Orth.) multitubulatum, sp. Hall. The funnels extend posteriorly beyond the next septum to that from which they originated. The sheaths are very numerous, and continuous, according to Whitfield, with the funnels. Endosiphon unknown.

Endoceras,[1] Hall, Nat. Hist., N. Y., Vol. 1, p. 58. Funnels extend posteriorly only from one septum to the next. Sheaths not very numerous. Siphon not lined with an internal layer. Endosiphon present, but not so thick walled, as in the genera Sannionites or Piloceras, and generally destroyed by fossilization.

Sannionites, Waldheim, Orcyto. Mosc., 1837, equal to Cameroceras, Conrad. Shell has only one large thick-walled sheath, in connection, with the living chamber, not continuous with the funnel of the last septum. The funnels close the intervals between the septa as in Endoceras, but the siphon is lined by an inner, thick, continuous layer of shell, which is composed apparently of the unresorbed upper parts of the successive sheaths. Endosiphon is present, but only preserved in a fragmentary way, and often absent in the fossils.

Piloceras, Salter, as described by Dawson, Can. Nat. Vol. 10, Similar to Sannionites in every essential characteristic, except the walls of the siphon, which do not have the thick inner layer present in that genus, and in the form. This is brevicone, and arcuate, and often annulated, and has an enormous siphon with compressed sheath, and endosiphon ; the latter usually destroyed.

Cyrtocerina, Bill. Geol. Surv. Can., Pal. Foss. Vol. 1, p. 178, is similar in form to Piloceras, but the siphon is empty, in the few

[1] Colpoceras, Hall, Rep. Reg. State. Cab. 1850, p. 181, pl. 5, fig. 2, may be a siphon of Endoceras as stated by Barrande, but we have neglected to study the type.

specimens known. The funnels are as in Piloceras. We consider this genus as still very uncertain, since there are not enough forms known to characterize it properly, or make sure that it did not have sheaths, and endosiphon.

INCERTA SEDES.

Tainoceratidae.[1]

We provisionally include in this group a series of genera which appear to be affiliated by their forms, sutures, and style of ornamentation, though only a few of them are supposed to have holochoanoidal siphons. The sutures have ventral lobes, and no annular lobes until we reach the Mesozoic genera. The whorl exhibits a tendency to grow away from the spiral, but this is not constant and varies in the same species which may be gyroceran, lituitean, or nautilian in its mode of growth in different individuals, or varieties of the three first genera; the remaining genera are more constantly nautilian.

Trocholites, Conrad, Hall, Nat. Hist. N. Y., Vol. 1, p. 192, includes smooth or costated Silurian shells, whorl in section depressed ellipse varying to quadragonal, siphon holochoanoidal, and near the dorsum. Living chamber over one half of a volution in length, with large ventral sinus, lateral sinuses inconspicuous or absent and broad internal saddles. Sutures with ventral, lateral, and broad dorsal lobes, without annular lobes, and some specimens retain the straight outlines of the larva or have slight dorsal saddles. Type, Am. Mus. N. Y. Siphon near the dorsum or subcentral. This genus includes Troch. (Lituites) undatus and angulatus,[2] Saem. Paleontogr., Vol. 3, and other smooth shells with quadrate forms in section which have similar sutures,

[1] The first three genera appear to have holochoanoidal siphons, but these may be really similar in structure to the siphons of Aturia, which misled even M. Barrande, and the genera Enclimatoceras, Hercoglossa and Aturia certainly have ellipochoanoidal siphons. The absence of arcuate and gyroceran forms is also a notable peculiarity.

[2] Lituites, Breyn, and Hortolus Montf. are founded upon species with entirely distinct forms of whorls from either Trocholites or any of these genera. The young of Lit. lituus, according to Lossen Zeit. Geol. Gesell, 1860, pl. 1, is compressed and smooth. The genus appears to be represented in the Calciferous of this country by L. Farnsworthi, Bill. Pal. Fos. Vol.1 , p. 21, fig. 24, and L. imperator, ibid, which have similar whorls and siphon central.

siphon near dorsum and holochoanoidal. Types, Mus. Comp. Zool. This genus also includes Troch. (Lit.) trapezoidale Lossen, Ueber Lit., Zeit. Geol. Gesell, 1860, p. 25, pl. 1, fig. 2, with costae as in Plectoceras, and a median line of tubercles along the abdomen, but the sutures, and siphon as in this genus.

Plectoceras,[1] nobis, includes Silurian species having costae curved posteriorly on the sides and crossing the abdomen as in Trocholites and sutures similar, but with ventral saddles. The whorls quadrate, the abdomens narrower than the dorsum and the sides convergent outwards. The siphons are ventral and holochoanoidal. The young are precisely similar in form, smoothness of the shell and striae of growth, and in sutures to the straight sutured forms of Trocholites. Type, Plect. (Naut.) Jason, sp. Bill., Can. Nat. Vol. 4, 1859, p. 164, Mus. Geol. Surv. Can.

Litoceras, nobis, has similar characteristics and sutures to Plectoceras but the siphon is near the dorsum or below the centre in the adult, and the whorl has broad abdomen and divergent sides and is smooth. The young are until a late stage frequently costated and have the siphon ventral as in Plectoceras. Type, Lit. (Naut.) versutum, sp. Bill. Pal. Foss., p. 259, Mus. Geol. Surv. Can.

Diadiploceras,[2] nobis, includes species of the Devonian, with costae and two rows of tubercles on the sides. Sutures have ventral saddles, and in type the lower row of tubercles is represented by imperfect costae in the later adolescent stages. The whorl in section is quadragonal, and siphons above the centre. Type, Dia. quadratum, sp. Hall, not yet described. Professor Hall's Coll. Albany, N. Y. Diad. (Disc.) inopinatum, sp. Hall, would also answer as type, if the sutures and position of siphon should prove to be similar. Nat. Hist., N. Y., Vol. 5, pt. 2, suppl. pl. 110. Mus. Cornell Univer., Professor Williams' Coll.

Metacoceras, nobis, includes Silurian and Carboniferous species with broad, ventral, lateral, and dorsal lobes but no annular lobes. Siphon near the ventrum or central. Whorls quadrate, sides with one row of nodes along the external border, umbilical

1 Πλεκτός, twisted or plaited.

2 Διαδιπλός, doubled.

shoulders smooth but gibbous, the type has this part of the whorls elevated into a ridge. The forms are evidently transitions from the genus Plectoceras to Mojsvaroceras. Type, Meta. (Discus) Sangamonense, M. et W., Geol. Surv. Ill., Vol. 2, pl. 29. Meta. (Lit.) occidentale, sp. Hall from Trenton of Ill. Am. Mus. N. Y., is the transitional type from Plectoceras to Metacoceras.

Tainoceras[1], nobis, includes Carboniferous and Triassic forms with discoidal whorls, section quadrate and closely resembling Mojsvaroceras in every way, having also two lateral rows of tubercles, but possessing on the abdomen two additional rows of tubercles in the later stages of growth, and adults. The siphon is above the centre. The sutures have ventral, lateral, and dorsal lobes but no annular lobes. The young of the type species has not the abdominal tubercles, and is similar in all characteristics to the Mojsvar. (Naut.) Wulfeni. sp. Mojsis. Das. Geb. Hallst. Abhand. Geol. Reich. Vienna, Vol. 6, pt. 1, pl. 7. Type, Tai. (Naut.) quadrangulus, sp. McChesney, Trans. Chic. Acad., Vol. 1, pl. 3, figs. 5–7, in Mus. Comp. Zool.

Mojsvaroceras[2], nobis, of the Dyas and Trias includes the species described by Mojsisovics in Mediterr. Trias Prov. as Temnocheili. These have two rows of lateral tubercles, the form quadrate and very stout, the siphons below the centre, and sutures with ventral lobes, but also according to Mojsisovics with minute annular lobes. Type, M. (Temno.) Neumayeri, Mojsis., pl. 88.

Grypoceras[3], nobis, includes species of the Trias which are described by Mojsisovics, "Das Gebirge um Hallst.," with compressed and more involute whorls than the above, abdomen, however, truncated at some stage of growth, though acute in some species in the later adolescent and adult stages. Siphon below the centre, sutures like the above, but with deeper lateral lobes and narrow V-shaped ventral lobes. The forms have annular lobes according to Mojsisovics. Type, Gryp. (Naut.) mesodiscum, sp. Hauer, Mojsis. ibid., pl. 8. We include in this genus Gryp. (Naut.) haloricum, obtusum and Gumbeli. ibid., pl. 7.

Clydonautilus, Mojsisovics, Mediterr. Trias Prov. p. 281,

[1] Ταινία, a head band.

[2] Dedicated to Mojsisovics von Mojsvar

[3] Γρῦπος, hook nosed.

includes similar forms, but more involute than those of Grypoceras, the sutures similar, but with two pairs of lateral lobes. The outer pair arise from division of the ventral lobe by a saddle in the adolescent stages, according to Mojsisovics. The young are apparently identical with Grypoceras, though Mojsisovics states positively, that there is no annular lobe.[1] The siphon is above the centre in the type C. Noricus, but below the centre in some species according to Mojsisovics.

Enclimatoceras,[2] nobis, includes species of the Trias to the Tertiary inclusive, which are connected by the outlines of their sutures. The whorls are involute from an early stage, and compressed. The abdomens are rounded, but become acute in many species. The sutures have prominent ventral saddles flattened in species with rounded abdomens, and acute in those with acute abdomens, never divided by ventral lobes; the lateral lobes are deep, and the lateral saddles well marked. The ventral saddles in the young are broad, and closely resemble the ventrals of the Hercoglossae, as do also the broad, lateral saddles of the later larval stages in some species. There are no annular lobes at any stage in the Triassic according to Mojsisovics. They do not seem to be present in some of the Jurassic and Cretaceous species, at least during the early stages, and are very small in some adults. The Triassic species are nearly related to Grypoceras, according to Mojsisovics figures and descriptions in "Das Gebirge um Hallstatt." The siphon in this type is a little below the centre in the young, though ventral in adults, and this also agrees with the characteristics of Encl. styriacum, sp. Mojsis., of the Trias, and Grypoceras. Nevertheless there is no ventral lobe at any stage, the annular lobe is absent in the Trias forms, and young of later forms; and the siphon in two species is ellipochoanoidal. Type, Enclim. Ulrichi, White Bull. U. S. Geol. Surv. Vol. not announced, Little Rock, Arkansas, Cretaceous, Nat. Mus. Washington.

Hercoglossa, Conrad, Proc. Acad. Sci., Philad., 1855, p. 67 has for its type Her. orbiculatus, sp. Tuomey, which is described

1 We think this is probably present, but only to be found in the earlier stages. We desire to call attention to the extraordinary parallelism with the higher Goniatites occasioned by the division of the ventral lobe by a secondary saddle, the median saddle.

2 Ἔγκλιμα, bent or inclined.

as having central siphon, and sutures similar to Her. (Naut.) Danicus. The ventral saddles, and lateral saddles are broad, the lateral lobes deep, but not acute. There are annular lobes in the adults, but none in the young of most species. Siphon central, or subcentral, but never close to the dorsum. The shells are Cretaceous and sometimes costated like those of Cymatoceras.

Aturia, Bronn, Leth. Geog., Vol. 2, p. 1123, equal Megasiphonia D'Orb. Prod. de Pal. Vol. 2, p. 309, includes Tertiary forms, with smooth and involute shells. The sutures have broad, ventral saddles, acute, linguiform lateral lobes, broad, lateral saddles, and dorsal lobes with annular lobes. The siphon is extraordinarily large and close to the dorsum, but the funnels do not affect the sutures. It seems to be truly holochoanoidal according, to Barrande's and Chalmas' investigations; and M. Barrande's great authority, and comparisons of the structure of the siphon of Aturia, and Endoceras led us to represent this genus as perhaps belonging to the Holochoanoida even in our introduction to the present essay. The study of the siphon, however, in Aturia has finally satisfied us that Quenstedt's figure, Die Ceph., pl. 2, fig. 23, of the siphon, though imaginary, presents the typical structure better than Barrande's. Aturia, therefore, has a siphon consisting of the same elements as in the Ellipochoanoida, but with such excessively long funnels, that the connective wall is reduced to a minimum. It is not a reversion to the holochoanoidal siphon, but a morphological equivalent, or representative of the Macrochoanite forms of the early Ammonoidea, and some Nautiloids.

ELLIPOCHOANOIDA.

Microchoanites.

Actinoceratidae.

This family includes genera of longicones and brevicones having the nummuloidal form of siphon, with or without rosettes, and an endosiphon, but the brevicones all have the rosettes[1]. The shells

[1] For convenience sake we have named the separate elements or joints of the endosiphonal deposits, rosettes, each rosette being the annular ring gathered about the edges of the constriction formed by the funnel. Attention is called to the fact that these rosettes are internal to the true sheath deposit, or external wall of the siphon.

are generally smooth but may be either annulated or striated longitudinally. The sutures are generally more arcuate than in the Orthoceratidae, and the cones stouter in proportion to their length.

Actinoceras, Bronn, has several subdivision whose natural order seems to be as follows. Sub-genus Discosorus, Hall, Nat. Hist., N. Y., Vol. 2, pl. 28, includes isolated siphons apparently inseparable from the siphons of Actinoceras, but having some doubtful characteristics. They may be brevicone forms of the Actinoceratidae, as suggested by Barrande. Orth. infelix sp. Bill., seems to be in form at any rate an intermedium to Actinoceras, if the apex or young siphon was broken off, it would be difficult to separate it from Discosorus. Actinoceras, Bronn, Leth. Geog., 1834, equals Ormoceras, Stokes, 1837, Trans. Geol. Soc. Lond. 2 ser., Vol. 5. Conotubularia, Troost, Mem. Soc. Geol. France, ser. 3, pt. 1, p. 89.[1] The rosettes are globular and compressed, always discontinuous. The planes of discontinuity occur between the septa and are marked by tubes and spaces radiating from the long, central tube. This tube was in life occupied by a fleshy sheath at its anterior part, which was derived from the large siphon by shrinkage of its fleshy walls and was continued backwards into a still more shrunken part forming a long endosiphon, but not having a special wall as in Endoceratidae. The endosiphon, or fleshy shrunken siphon, was swollen at intervals between each septum and gave rise to flattened attenuated rings of membrane, which had radii of solid cords, or tubes, and often the ring became partly resorbed and these tubes or cords were alone left between the rosettes. They do not appear to penetrate the true external or sheath wall of the siphon. M. Barrande has already shown all of these facts clearly, we differ only on minor points. That eminent author regarded the rosettes as not homologous with the sheath of Endoceras though secreted by the same organ, namely a modified fleshy siphon. We regard the rosettes as internal, or extra endosiphonal deposits, and the successive sections of the outer wall of the siphon as strictly strictly homologous with the successive sheaths of the endosiphon of Piloceras and Endoceras. The Mus. Geol. Surv. Canda.,

[1] Conilites, Pusch, Polen's Pal. p. 150 is supposed by Barr. and others to be also a synonym of Actinoceras.

contains species which are apparently transitional to Huronia, as stated by Billings, but these species have large endosiphons, and the Actinoceran type of rosettes, and the siphons resemble those of Huronia merely in the external form of the rosettes. The genus is found in the Carboniferous, Act. (Orth.) giganteum, sp. Sow. De Kon. Calc. Carb., pl. 44, and throughout the Paleozoic. From typical Actinoceras the transitions are insensible into the forms of the next group.

Sub-genus Deiroceras,[1] nobis, has the septa more widely separated than is usual in Actinoceras and parts of the siphon between the septa assume a globular form. The rosettes are more irregular in their formation than in that genus, and the cavity of the endosiphon is an irregular narrow tube. The rings, and cords or tubes of the siphon are more abrupt at their junction with that tube, and more attenuated. Actin. (Orth.) crassiventre, as figured by Barr., pl. 237–233, is a transition form to typical Actinoceras. Act. Putzosi, ibid., pl. 211, 235 is very close to the type of this subgenus, A. (Orth.) python sp. Bill. Mus. Can. Geol. Surv. The transition to Huronia occurs through these forms.

Sub-genus Huronia, Stokes, Trans. Geol. Soc. Lond., ser. 2, Vol. 5, p. 705, is similar to the preceding, but has the septa more widely separated and only the posterior zone of each rosette is globular, the anterior zone of each rosette being tubular, with a swollen rim. It may be, also, that in this sub-genus the endosiphonal rosettes are habitually continuous. The endosiphonal tube is narrow and regular. Passing back to the radical form Actinoceras, we find that M. Barrande has traced a natural series in his preface to his second series of plates No. 245–350, p. 9. In his list, Act. vertebratum, cochleatum, crassiventre, imbricatum, Clouei are in our scheme true Actinocratites, and we draw our artificial generic line between the last species, and Sactoceras exoticum.

Sactoceras,[2] nobis, includes species in which the septa are in most species approximate as in Actinoceras, and the siphon nummuloidal, but much reduced in diameter. This is the result of a reduction in the size of the fleshy siphon near the living

[1] Δειρή, neck.

[2] Σακτός, stuffed.

chamber. The siphon becomes approximately reduced and the rosettes begin to be variable with age, and finally altogether disappear in the adults of extreme forms. Sac. (Orth.) docens, sp. Barr. pl. 250, is a transition form, but we place it in this genus because at an age, when an Actinoceras would have the rosettes large and perfect, this species begins to lose them, and the siphon decreases also. The reduction of the siphon is a degradational senile shrinkage, and it occasions the loss of the rosettes. M. Barrande views this old stage of the siphon as a return to the tubular siphon, but in our opinion we cannot call this a tubular siphon. As a matter of fact it is a modified nummuloidal siphon, as may be seen by comparison with others. Sac. (Orth.) Richteri, sp. Barr. is selected as the type and in the beautiful figures of M. Barrande we may read on plates 318, 322, 323, 349, that the young have an empty nummuloidal siphon, and that the adults have the usual imperfect rosettes of this genus, and that in the old these disappear again leaving the siphon empty. M. Barrande's species with mixed elements, *i. e.*, siphon on one side tubular and on the other nummuloidal are simply species of various groups with imperfectly developed siphon, or unsymmetrical anomalies of development. This genus is well represented in the Silurian, Devonian, and Carboniferous.

Tretoceras, Salt. Journ. Geol. Soc. Lond. Vol. 14, p. 179, has according to that author, Blake's British Cephalopods, and Barrande, conical prolongations, and a siphon which appears in Blake's figures to be microchoanitic. The cones compare closely only with Kayser's deformed Gomphoceras, "Missb. Devon. Gomph., Zeit. Deutsch. Geol. Gesell. Vol. 26, pl. 16. There is a similar central trace figured by Barrande on the casts of Bathmoceras, but reversed in position.

Orthoceratidae.

This family includes longicones with tubular siphons, and septa widely separated. We do not regard the Actinoceratidae as the ancestors of the tubular siphoned Orthoceratidae; but on the contrary, the Orthoceratidae as the normal form and the probable ancestral type. All the nummuloidal siphons are tubular in the early stages. M. Barrande in Syst. Sil. Vol. 2, Text 3, p. 748, has shown conclusively the passage of the Sactoceran forms into this group, and the evolution of the nummuloidal type from the various groups of tubular siphoned and straight cones.

Orthoceras, Breynius, should we think be confined to straight and comparatively smooth longicones with simple septa and sutures, it equals group 17 of M. Barrande. The author has met with but two species in North America, though doubtless others may exist, since the extreme smoothness of the shell is easily destroyed. The genus is present in all the paleozoic formations and in the Trias.

Geisonoceras,[1] nobis, includes various groups of the banded longicones of M. Barrande. They fade into true Orthoceras, and yet can certainly be distinguished by the transverse markings or bands, which are formed on the surface of the shell. We include in this series, groups 10, 11, 12, 13, 14 of M. Barrande. The young are either smooth or transversely striated. Type, Gei. (Orth.) rivale, sp. Barr., pl. 209, 216, 387. The banded longicones are directly connected by transitional forms with Cycloceras, and with the banded brevicones of the genus Rizosceras. The characteristic bands of the shells and the position of the siphon in some species make a close approximation to Bactrites. Silurian, Devonian, Carboniferous?

Cycloceras, McCoy, Synop. Carb. Foss. Ireland, 1844, includes the transversely striated, Paleozoic longicones, which at some stage of growth have annular costae. The young are invariably smooth, that is, marked only by transverse striae of growth, as in Cyc. (Orth.) Agassizi, sp. Barr., pl. 281, and the annulations are subsequently introduced. It includes group 9 of M. Barrande. Silurian, Devonian, Carboniferous.

Kionoceras,[2] nobis, includes the longicones in which the longitudinal ridges are more prominent than the transverse striae or ridges when these are present and are smooth throughout their entire length. Equal to group 4 of M. Barrande; type, Kion. (Orth.) doricum, sp. Barr., pl. 269. Silurian, Devonian, Carboniferous.

Thoracoceras, Eichw. Bull. Soc. Imp. de Nat. de Mosc., 1844, p. 761, was a name substituted for Melia proposed in 1829 by the

[1] **Γεῖσον**, a cornice.

[2] **Κίων**, a column.

same author. It includes all those longicone species in which the ridges become spiny, or are roughened by the prominence of the transverse striae or ridges. Silurian ? Devonian, Carboniferous.

Spyroceras,[1] nobis, includes the longitudinally ridged longicones, which at some stage of their growth are also annulated. The annular costae are usually large rendering the outline sinuous. The longitudinal ridges are present in the young, and the annular costae are developed later. Includes groups 5, 6 of M. Barrande. Type, Spy. (Orth.) crotalum, sp. Hall. Mus. Geol. Survey, Albany, N. Y. Silurian and Devonian.

Dawsonoceras,[2] includes forms like D. (Orth.) pseudo calamiteum, sp. Barr., pl. 286, and others which have longitudinal ridges in the larva and are annulated, but devoid of ridges in the adolescent and adults. The type is related to the series with large annulations and frilled transverse striae, sometimes with longitudinal ridges, though the young in D. (Orth.) dulce, sp. Barr., pl. 275 have no longitudinal ridges. The apertures have flaring lips as in Halloceras. Type, Daw. (Orth.) annulatum, Mus. McGill College, Montreal.

Rizosceras,[3] nobis, includes the straight cones figured by M. Barrande, Vol. 2, pls. 185–195, having simple sutures, and septa, and banded shells, whorl in section elliptical. The form is remarkably short, and increases very rapidly, the living chamber short, and widely flaring, with shallow ventral sinus. The siphon is variable in position, but is rarely near the centre. Type, Riz. (Orth.) indocile, pl. 185, figs. 1–6. We include in this group. also, such forms as are intimately connected with Rizosceras, like Riz. (Cyrt.) corniculum, pl. 121, sp. Barr., and (Cyrt.) apertum sp. Barr. pl. 146.

The larger part of the forms figured by Barrande, pls. 1–158, belong to our genus Maelonoceras, and to various other groups, pls. 149–153, however, exhibit almost exclusively cyrtoceran, forms with rizosceran affinities. An extreme form of this genus is the Riz. (Phragm.) imbricatum, sp. Barr. pl. 175. This group can also be subdivided according to the character of the siphon,

1 Σπιρίς, a basket.

2 Dedicated to Dr. J. W. Dawson of Montreal.

3 Ρίζα, a root.

whether nummuloidal, or tubular. Its direct connection with Geisonoceras is evident, as well as the intermediate nature of all its characteristics with reference to the Gomphoceratidae.

In this genus, as in Sactoceras, etc., the nummuloidal siphon is preceded by a tubular siphon in the earlier stages of growth, and this shows that we are justified in deriving this group from tubular siphoned orthoceratites, and considering it as transitional to the nummuloidal siphoned group of the Gomphoceratidae. Sometimes the nummuloidal siphon appears to precede the tubular, but in the cases figured by Barrande, and in others, which we have studied, the nummuloidal character was an adult peculiarity, and the so called tubular character was the result of degradation or shrinkage, due to old age.

Gomphoceratidae.

[Equilobates.]

The shells have apertures with median saddles in the dorsal outlines, and, therefore, an equal number of lateral lobes.

Acleistoceras,[1] nobis, includes brevicone forms with a fusiform shape, and partially contracted living chamber. The aperture has large ventral sinus, and a dorsal saddle, and is only slightly smaller in diameter than the living chamber, and the outline is usually subtriangular. The siphon remains ventral, and the form in section is an oval with the dorsum broader than the venter. Silurian, Devonian, and Carboniferous. Type, Acl. (Api.) olla, Saem., Paleontogr. Vol. 3, pl. 19. Mus. Comp. Zool., Cambridge. Apiocera has been used for insects by Westwood, and the original figure of Apioceras by F. de Waldh. Bull. Soc. Nat. de Moscow, Vol. 17, p. 779, pl. 19, fig. 1, is not identifiable.

Gomphoceras, Sow., Murch. Sil. Syst. Vol. 3, p. 620, includes all the straight and arcuate forms, which have symmetrical T shaped apertures; and, therefore, includes Phragmoceras, and the groups Dimorion and Dimeres of M. Barrande.

Tetrameroceras, nobis, includes Silurian species having four lateral sinuses, and equals to the groups Tetramorion, and Tetrameres of Barrande. Type, Tet. (Phrag.) bicinctum, sp. Barr. pl. 51.

[1] **Ακλειστος,** open.

Hexameroceras, nobis, includes Silurian species having six lateral sinuses in their apertures. Type, Hex. (Phrag.) Panderi, sp. Barr. pl. 48.

[Inequilobates.]

This series differs from the above in having an azygos dorsal sinus in place of the median dorsal saddle of the preceding genera. All the genera are, so far as we know, Silurian.

Trimeroceras, nobis, has only two lateral sinuses in addition to the median sinus. Type, Tri. (Gomph.) staurostoma, sp. Barr. pl. 73.

Pentameroceras, nobis, has four lateral sinuses. Type, Pen. (Gomph.) mirum, sp. Barr. pl. 82.

Septameroceras, nobis, has six lateral sinuses.

Trimeroceras was included by M. Barrande in his group of Trimorion, and Pentameroceras in Pentamorion. Septameroceras is founded upon a species in the Mus. Geol. Surv. Can., S. (Gomph.) inflatum, sp. Bill.

Mesoceratidae.

In this group we include all those brevicones whose short, contracted, bulbous, living chambers, and singular habit of truncating their shells, and general tendency to flatten the abdomino-dorsal diameters of the apertures, and imperfect septa in the living chambers render them very distinct as a group from all other forms except the Asoceratidae.

Mesoceras, Barr. Syst. Sil. Vol. 2, Text 5, p. 198, includes but one species. This has a much flattened aperture and very slight ventral sinus. It is an Acleistoceras without the vertical arm in the T shaped aperture.

Billingsites,[1] nobis, includes Silurian species having stout cones, almost globular on account of their truncation and which have dumb-bell shaped apertures, without ventral sinuses. Type, B. (Ascoc.) Canadense, sp. Bill. Rep. Prog. Geol. Can. 1853–56, p. 310, Mus. Geol. Surv. Can. This species shows that M. Barrande is in error, in supposing that the large posterior part of the living chamber can be considered as the siphon. The three last

[1] Dedicated to the memory of E. Billings.

[2] A fact already noted by Blake, British Foss. Cephalop.

septa are directly continuous with the septa on the dorsal side of the living chamber,[2] and these are merely large dorsal saddles. Associated species have these dorsal saddles separated as in M. Barrande's typical Ascoceras. The direct derivation of Mesosceras from Acleistoceras can hardly be doubted after comparing the apertures and the forms of the short living chambers.

Ascoceratidae.

European Silurian forms generally have annulated whorl, long living chamber, constricted near the aperture. The apertures are either open or obscurely Y shaped, the two arms of the Y being divided by a dorsal saddles, and the basal arm is the ventral sinus.

Aphragmites, Barr. Syst., Sil. Vol. 2, Text 1, p. 366, is regarded by that author as a form of Ascoceras, which has resorbed the imperfect septa in the living chamber. We, however, much prefer this eminent author's first opinion, that it is a distinct genus with simple septa and sutures.

Ascoceras, Barr. Syst. Sil. Vol. 2, Text. 1, p. 334, includes certainly two groups, one with annulated shells, like those of Aphragmites, and bearing relations to this genus similar to those which Billingoceras has to Mesoceras; and one with smoother or banded and striated shells, which have apertures similar to the typical Ascoceras and are in the same genus.

Glossoceras, Barr. ibid., p. 372, has a very slender whorl, and the obscurely Y shaped apertures described above. The species are Silurian, and the forms and markings of these fossils seem to indicate clearly derivation from an annulated stock like the Cycl. (Cyrt.) residuum sp. Barr. pl. 286, which has similar attenuated, annulated whorls, but open apertures.

Ophidioceras, Barr., includes Silurian shells closely coiled in the larval and adolescent stages and open in the later stages. The costated, compressed whorls have some resemblence to those of Ascoceras and the aperture is closely similar to Glossoceras. The shells are truly nautilian in the young and are evidently pathological derivatives of some ancestral nautilian form. The sutures are straight and the abdomen has a blunt keel. They appear to be the survivors of ancient ornamented series of costated shells. We place them provisionally near Ascoceras on account of the Y shaped apertures and form of whorl and costations.

Maelonoceratidae.

This family includes shells with whorls in section ovate, very short living chambers, often more or less compressed or with contracted apertures. The compressed apertures tend to become fusiform, and the contracted apertures become pear shaped. They are of smaller size than the Gomphoceratidae, and do not grade into that group, but have their own radical, open-apertured, cyrtoceran forms, which are included in the genus Maelonoceras. The sutures have ventral, and dorsal saddles, and lateral lobes. The siphons are near the venter and nummuloidal.

Maelonoceras,[1] nobis, includes Silurian species with arcuate cones, whorl in section compressed, ovate, the dorsum wider than the venter. The siphon is near the venter. The sutures have ventral and dorsal saddles, and slight lateral lobes. The living chambers are short, and the apertures vary from entirely open and partially subtriangular to contracted and pear shaped. Type, Mael. (Phrag.) praematurum sp. Bill. Can. Nat. Vol. 5, p. 173, fig. 19. A close ally of this is Mael. (Cyrt.) discoideum, sp. Barr. Syst. Sil. pl. 135. Mael. (Cyrt.) Metellus, sp. Bill. Pal. Foss. p. 191, fig. 175, 176, is an open-apertured species. Mus. Geol. Surv. Can. The genus may have arisen from the same common stock, in Rizosceras but is certainly not a direct derivative of Acleistoceras.

Oonoceras,[2] nobis, includes series of European forms, which seem to arise from arcuate forms with open apertures, but more elongated cones. They are annulated, and have even shorter and more compressed living chambers in proportion to their longer shells. They may either retain the open aperture, or produce a fusiform outline in the opening. Oon. (Cyrt.) acinacies, sp. Barr. pl. 118, Giebeli, pl. 123, exile and letheum, pl. 124, are examples of cyrtoceran, and probably gyroceran forms, and Oon. (Troch.) priscum and clava, pl. 12, oxynotum, pl. 14, anguis, pl. 16, are examples of the closer coiled species There exist, doubtless in other localities, congeneric, close coiled, symmetrical shells. These Silurian forms lead into those with fusiform apertures, such as Oon. (Cyrt.) multiseptatum, Roem. Paleontogr. Vol. 3, pl. 6, fig. 2, and Oon. (Phrag.) sub-ventricosum, sp. D'Arch. et Vern. Geol. Trans. Vol. 6, pl. 30, of the Devonian.

[1] Μηλον, a goat.

[2] Ωόν, an egg.

Streptoceras, Bill. Geol. Surv. Can. 1866, Antic. Foss. p. 88, fig. 28, appears to be identical with Acleistoceras, but the apertures are more like those of Maelonoceras. The form, however, is very distinct from both of these genera, and the living chambers one-third of the length of the whorl. This would not be important in most series, but in this one it is an extraordinary variation, and is perhaps an indication of essential differences. Mus. Geol. Surv. Can.

Cranoceras,[1] nobis, includes arcuate Silurian species, which have depressed elliptical whorl in section, and are very closely allied to Maelonoceras. The sutures straight, or with dorsal and ventral saddles, and lateral lobes. The siphon is near venter. In the later stages of more curved forms slight dorsal lobes are developed. Cran. (Cyrt.) hospitale, sp. Barr. pl. 151, nigrum, ibid., pl. 127, Turnus, ibid., pl. 483, 484, of the Silurian connect intimately with the Devonian type (Cyrt.), depressum, sp. Goldf., D'Arch. et Vern. Trans. Geol., Soc. Vol. 6, pl. 29, fig. 1, Schultze Coll. Mus. Comp Zool. The type has very short living chamber, and aperture very similar to that of Mael. praematurum, but wider transversely and with deep ventral sinus, as in some species of Acleistoceras. The general form, aspect, size, and siphon as in Turnus.

Naedyceras,[2] nobis, includes forms with whorls in section subtriangular, the dorsum broad and flat, the abdomen depressed, and subangular. The siphon is near the venter and nummuloidal. The sutures as in Cranoceras, but dorsal lobe more pronounced, no annular lobes, and no impressed zone on the dorsum. The genus includes Naed. (Cyrt.) anormale, sp. Barr. pl. 139, (Naut.) vetustum, ibid., pl. 35, in the Silurian, and also a series of degraded arcuate, and gyroceran, Devonian forms which show degeneration in their trochoceran mode of growth. They are also recognized by Professor Hall, as having marks of nautilian affinities. These characteristics could only have been derived from gyroceran ancestors, like Naed. vetustum. Type, Naed. (Troch.) Eugenium, sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pl. 58, 59, Mus. Geol. Surv., Albany.

[1] Κρανος, a helmet.

[2] Νηδυς, the belly.

Oncoceratidae.

This family includes forms with peculiarly attenuated apices, or young, the whorl increasing in the adult stages very rapidly in size. The living chambers are generally short, and constricted above, but the apertures are open. Siphon is near the venter, and generally, there is a ventral lobe. The young have straight sutures and these are retained in some adults.

Eremoceras,[1] nobis, includes arcuate Silurian species with open apertures, short living chambers, whorl in section elliptical; sutures with dorsal saddles, almost straight lateral sutures and ventral lobes. Type, Erem. (Cyrt.) Syphax, sp. Bill. Pal. Foss., Vol. 1, p. 194, fig. 178, Mus. Geol. Surv. Can.

Clinoceras, Mascke, Zeit. d. Deutsch. Geol. Gesell., Vol. 28, p. 49, pl. 1, includes species similar to Oncoceras but with siphon between the çentre, and dorsum; living chamber and aperture similar, but not swollen, and form very slightly arcuate; sutures with a minute annular lobe according to Mascke. Clin. (Cyr). exiguum, sp. Bill. Can. Nat. Vol. 5, p. 172, and Onc. mumiaforme Whit. Geol. Wisc., Vol. 4, 1873–79, pl. 7, have straight sutures and are closely allied to type of Clinoceras in form.

Oncoceras, Hall, Nat. Hist. N. Y., Vol. 1, p. 197 is similar in form to Clinoceras, but the whorl is more depressed, and the ventral aspect fusiform. It has sutures similar to Eremoceras, but the ventral lobe is often narrow, and pointed. The lateral sutures are deeper, and in some species there are dorsal lobes- Siphon is ventral. The living chamber is constricted near the aperture, and much dilated below. Onc. (Cyrt.) heteroclitum. Barr. Syst. Sil., pl. 118, 475, has the peculiar swollen living chamber of Oncoceras, and ventral siphon. Am. Mus. N. Y.

Hercoceratidae.

This family has, in the normal forms, trapezoidal whorls with abdomen broader than venter, one line of large tubercles along the edge of abdomen, and sutures with ventral and dorsal lobes. Shells not costated.

Ptyssoceras,[2] nobis, includes Silurian arcuate shells with

1 Ἔρημος, alone.

2 Πτύσσω, fold.

single row of large lateral tubercles, sutures nearly straight; siphon ventral, whorl in section depressed elliptical. Type, Ptyss. (Cyrt.) alienum, sp. Barr. Syst. Sil., pl. 127.

Hercoceras, Barr. Syst. Sil., Vol. 2, Text 1, p. 152, includes Silurian gyroceran forms, the type of which is Herc. mirum Barr.; but we also include in the same genus all the allied gyroceran, and trochoceran species, like Herc. (Gyr.) alatum, sp. Barr. pl. 44, and Herc. (Tro.) flexum, sp. Barr. pl. 44, all of which have similar striae of growth, sutures, and ventral siphon.

Anomaloceras,[1] nobis, includes but one Silurian species with a nautilian shell, Anom. (Naut.) anomalus, sp. Barr. pl. 34, which has a nautilian form, more involute than in Hercoceras, with smooth, much depressed whorls; siphon and sutures as in Hercoceras. The one-sided position of the siphon is found also in other cases among Tetrabranchiata, and is not probably a generic distinction.

Temnocheilus, McCoy, Syn. Carb. Foss. Irel. p. 20. Type, T. coronatus McCoy, pl. 4, fig. 15. Cryptoceras D'Orb, Prod. de Pal. Vol. 1, p. 58, has for type, Tem. (Naut.) subtuberculatus, Sandb. Verst. Nass. pl. 12, fig. 3, and is a synonym. It includes all the forms with smooth nautilian shells, trapezoidal whorls in section, the venter very broad, the sides divergent, the dorsum narrow and having always an impressed zone. A row of large nodes occurs along the junction of the sides and abdomen. The sutures have broad, ventral, lateral, and dorsal lobes. There are no annular lobes in the Devonian forms, but they appear in some Carboniferous species, as in Tem. latus, De Kon. Calc. Carb. The siphon is ventral in the Devonian forms, but near the centre in most of the Carboniferous species.

Centroceras,[2] nobis, includes a series of Devonian species with much compressed whorls, abdomen often hollow, sometimes narrow, with one row of tubercles along the edge of the abdomen on either side. The sutures have deep V shaped ventral lobes, deep lateral, and dorsal lobes; no annular lobes in species observed. The dorsum is frequently gibbous, and has an impressed zone only in the more compressed, and more involute species. Cent, (Cyrt.)

[1] Ανι'μαλος, anomalous.

[2] Κέντρον, a spur.

tetragonum, D'Arch. et Vern., Trans. Geol. Soc. Lond. Vol. 6, pl. 30, has young which are identical with adults of Temnocheilus, and adults similar to those of typical Centroceras, but less compressed. Type, Cent. (Disc.) Marcellense sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 65, 109. Mus. Geol. Surv., Albany.

Rutoceratidae.

Species in this family have exceedingly rough shells. The projecting lips of the apertures are more or less permanent and often form ridges, or lines of projecting spines or nodes. These may be indefinite in number, but there is a general tendency to reduce them to three rows on either side, and, if carried farther, to one line along the edge of the venter. Sutures have saddles on the venter. Siphon is ventral, or near venter.

Zittelloceras,[1] nobis, includes species of arcuate Silurian and Devonian longicones with whorl in section elliptical and an external frilled layer resembling Dawsonoceras, but no costae, and much larger ventral sinus in the aperture, and corresponding deflections of the frilled ridges and lines of growth. Siphon is small, tubular, and ventral. Sutures have ventral saddles, lateral lobes, and dorsal saddles. The living chambers are long, and apertures open. Type, Zitt. (Cyrt.) lamellosum, sp. Hall, Nat. Hist. N. Y., Vol. 1, pl. 41. Amer. Mus., N. Y.

Halloceras,[2] nobis, is confined to the Devonian. The shells have similar frilled layer, flaring lips to the apertures, etc., as in Zittelloceras, but the forms are Gyroceran, or nautilian. The whorl is subtriangular in section. The abdomen is broad, the sides divergent, and the dorsum forms the narrow apex of the section. Thick costae, or rather large nodes are formed along the angles of the sides in the adults. The sutures have ventral and lateral lobes, and in the impressed zone, when this occurs, there may be a corresponding shallow dorsal lobe. The siphon is small, and near the venter. The young are identical with the adults of Zittelloceras. Type, Halloceras (Gyr.) undulatum sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pl. 53, 54. Mus. Geol. Surv. Albany.

1 Dedicated to Prof. Karl Zittel of Munich.

2 Dedicated to Prof. James Hall of Albany.

Rutoceras[1], nobis, includes arcuate, Devonian forms closely allied to Zittelloceras in the imbricated structures, and flaring apertures of the shells, but having three rows of large nodes on either side. The siphon is ventral, but it is large and nummuloidal instead of being tubular, and small. The living chambers are shorter than in Zittelloceras, and the form in section is depressed elliptical. Type is Rut. (Cyrt.) Jason sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 50, and supp. pl. 124. This genus also includes shells similar to the above, but having the gyroceran form, and less rugged surfaces. The abdomen becomes more elevated and slightly narrower, the dorsum slightly flatter, and broader than the venter.

Triplooceras[2], nobis, includes the remarkable Silurian species Tri. (Naut.) insperatum sp. Barr. Syst. Sil., pl. 461, which has whorls in section like those of Rutoceras, and similar sutures, but with very slight ventral lobe, and the typical three lines of tubercles on either side; siphon between centre and venter.

Adelphoceras, Barr. ibid, Text 3, p. 788, et suppl. pl. 459, also Silurian, has three lines of tubercles on either side, and though the aperture is contracted as in Gomphoceras, we include it provisionally in this series. Siphon ventral.

Kophinoceras,[3] nobis, includes Devonian species, which have rough shells as in Rutoceras, and numerous ridges on the abdomen, more or less roughened or broken in adults by nodes formed by the permanent lips of the apertures. The species vary greatly, but are all probably gyroceran, and the normal forms have either two rows of tubercles along the middle of the venter, or a broad raised band as in some Halloceratites. There are also two rows of nodes along the angle of the junction of the sides and abdomen, which are large and persistent. The form in section is more depressed than in Rutoceras, the siphon nummuloidal, and ventral; sutures with ventral saddles, and in one species a small annular lobe. The type, Koph. (Cyrt.) ornatum, sp. D'Arch. et Vern. Trans. Geol. Soc. Lond., Vol. 6, pl. 28, Mus. Comp. Zool., Camb. has three persistent rows of nodes open to the front, or

1 **Pυlsτ**, a fold.

2 **Τριπλόος**, three-fold.

3 **Κόφινος**, a basket.

spout-like as in the tubercles of Rutoceras. The remarkable species with form and tubercles like Temnocheilus, but a ridged abdomen, the Koph. (Naut.) Coxanum, M. et. W. Geol. Ill. Vol. 5, pl. 23, is probably in this genus.

Strophiceras,[1] nobis, includes a Devonian gyroceran form Str. (Gyr.) binodosum, sp. Sand. Verst. Nass. pl. 12, which has a compressed whorl with gibbous tuberculated abdomen, and flattened sides. There are several rows of tubercles upon the abdomen as in Kophinoceras, but also a central row of tubercles. Sutures with ventral, lateral, and dorsal lobes, but no annular lobes. Form probably close coiled. Siphon ventral. The form is peculiar, the young unknown, and we refer the species to this series with great doubt.

Solenoceras,[2] nobis, includes species of the Carboniferous, Dyas, and Trias having remarkably heavy looking quadrate whorls with furrowed abdomens. Sutures, with broad ventral, lateral, and dorsal lobes, and in adults a small annular lobe may appear in some species. Siphons central and nummuloidal. Living chamber is one-fourth to one-half a volution in length, apertures with very deep ventral sinus. The shells are smooth except in the young and some adults of Solen. (Naut.) nodosum, which has a single outer row of large nodes along the sides. Type, Solen. (Naut.) canaliculatum, sp. Owen, Geol. Ken. Vol. 3, pl. 10. Mus. Comp. Zool. This genus[1] includes a series of Dyassic species described by Waagen Pal. Ind., ser. 13, no. 1. Solen. (Naut.) transitoriuum sp. Waag. ibid, pl. 6, fig. 4. They have quadragonal whorls, are costated, and have depressed or furrowed abdomens. Siphons below the centre slightly or central; Sutures with ventral, lateral, and dorsal lobes. Annular lobes?

Phloioceras,[3] nobis, includes the so-called Trematodisci of the Trias described by Mojsisovics in his "Mediterr. Trias Provinz." The shells are ridged longitudinally, and the ridges in the type roughened by transverse striae. Mojsisovics considers them as allies of Naut. cariniferus, and he may be right, but we have placed them in this series on account of the resemblance of gemmatus to Kophinoceras. The sutures have simple, lateral,

[1] **Στροφεῖον**, a twisted rope.

[2] **Σωλήν**, a groove.

[3] **Φλοιός**, bark.

ventral, and dorsal lobes, with small annular lobes. Siphon is central or below the centre. Phl. (Naut.) gemmatum, sp. Mojsis. Das Gebrig. Hallst. pt. 1, pl. 3.

Pleuronautilus, Mojsis. Mediterr. Trias Prov. p. 273, includes a series of forms with more or less tuberculated, and costated whorls, with sutures similar to the preceding. The siphon is also below the centre. The young of one species, Pleu. subgemmatum, as figured by Mojsisovics, ibid., pl. 85, is similar to the adult of Phl. gemmatum, and appears to settle the question of affinity. The sutures according to Mojsisovics vary from those having ventral lobes to some having straight ventral sutures in aged specimens. They have annular lobes.

Eudoceratidae.

This family includes forms in which the whorl in transverse section is some modification of the fusiform outline. The abdomen may be flattened, but is never hollow. The siphons are ventral, or between the venter and the centre. There is a constant tendency to reduce the breadth of the dorsum, and increase the venter. No sulcations or ridges are developed in any genus.

Eudoceras, Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, supp. pl. 117, includes straight shells of the Silurian and Devonian, with whorls flattened, sides angular. The sutures have broad, ventral, and dorsal lobes, the ventral lobe deepest; and lateral saddles, which are angular when the sides are angular, and more or less rounded when the sides are rounded. The ventral and dorsal sides of the whorl are equally convex, whorl in section being fusiform. Mus. Geol. Surv. Albany.

Tripteroceras,[1] nobis, has similar forms and sutures to the preceding, but the lateral saddles are acute. The venter is flattened, and broader than the dorsum, which forms the apex of the subtriangular section. The siphon is ventral, and nummuloidal, and the whorl arcuate in the young, though straight in the full grown, and the aspect altogether distinct from the shells of the preceding genus. The young are similar to the adults of Eudoceras. Silurian and Devonian. Trip. (Orth.) hastatum, sp. Bill., Rep. Prog. Geol. Surv. Can. 1853–56, p. 333, Mus. Geol. Surv. Can.

1 Τριπτήρ, a rubbing tool.

Edaphoceras,[1] nobis, includes species with the young arcuate until a late stage of growth, with whorls fusiform in section, and sutures with dorsal, and ventral lobes, and angular lateral saddles as in adults of Eudoceras, but the siphon shifts from the venter, where it is in the larva, to near the centre. Unfortunately the only figured species is the Edaph. (Tem.) niotense, M. et W. Geol. Ill. Vol. 5, pl. 19. This is selected as the type because it is figured, though in our opinion it is not a full grown shell but only the later adolescent stage of a species as yet undescribed in the collection of Mus. Comp. Zool. The adult in this is close coiled, with flattened sides, broad lateral saddles. An impressed zone appears on the dorsum due to close coiling altering the form in section from fusiform to kidney-shaped, and a V-shaped annular lobe appears in the middle of the broad dorsal lobe.

Endolobus, M. et W. Geol. Ill., Vol. 2, pl. 25, p. 307. End (Naut.) Avonensis, sp. Dawson, has all the young stages like the preceding genus, but inherits the annular lobes, shifts the position of the siphon to near the centre, acquires the impressed zone, and changes the form of the whorl to the kidney shape at an earliet stage of the growth. The young have broad ventral lobes, bur the adults develop saddles in the centre of these, and in the type, End., spectabilis, large folds or tubercles appear on the sides. The latest survivor of this series is the End. (Naut.) excavatum sp. D. Orb. of the Jura, Terr. Jurass. Ceph. pl. 30.

Gonioceratidae.

We interpolate this extraordinary group here because its nearest affines are the compressed, straight cones with equal dorsal and ventral sides. This relationship is fully appreciated by Professor Hall who considers his genus Eudoceras as very closely allied to Gonioceras.

Gonioceras, Hall, Nat, Hist. N. Y. Vol. 1, p. 54 has a broad winged shell, which in form and structure, as indicated by the septa and striae of growth, closely resembles the internal shells of Sepia. We think, the facts are sufficient to warrant our assuming this, as probably one of the passage forms from the compressed Orthoceratites, above described, to the true Sepioidea, and possibly a more or less remote ally of Paleoteuthis Dunensis Roem. of the Devonian.

[1] Ἔδαφος, a seat.

Apsidoceratidae.

The whorls in section are some form of the sub-triangular, and throughout all the genera there is a constant tendency to sulcate the abdomen and retain the gibbous character of the dorsum. The genera have transverse costae, but no longitudinal ridges. The marked characteristic of the group is, however, the persistence of the large dorsal saddles, which enable us to see, that the dorsal lobe is produced only in the impressed dorsal zone and in this group appears to be due solely to involution. Even when it is replaced by a dorsal lobe in the nautilian species, this dorsal lobe becomes, as in Ephippioceras. subdivided by a small dorsal saddle.

Tripleuroceras,[1] nobis, includes straight cones, whorl in section triangular, or if elliptical, having flattened abdomen. Siphon is near the venter, nummuloidal, large and usually, but not invariably, partly filled with deposits more or less radiatory in structure. Sutures have ventral lobe on the flat abdomen, saddles at the angles, lateral lobes, and dorsal saddles or comparatively straight sutures around the dorsum. One species, Trip. explorator, sp. Bill., has an additional pair of lateral saddles. Silurian and Devonian. Type, Trip. (Orth.) Archiaci, sp. Barr. Syst. Sil., Vol. 2, pl. 251, 480. The dorsal saddles separate this genus from the Eudoceran group and show them to be the radicals of the following series.

Apsidoceras,[2] nobis, includes loosely coiled, smooth, costated or tuberculated gyroceran shells, with flattened abdomens. The whorls in section are triangular, the dorsum forming the internal apex of the outline; siphons near the venter and nummuloidal. The sutures have broad ventral lobes, saddles at the lateral angles, broad lobes on the sides, and dorsal saddles. There is frequently a line of heavy tubercles on each of the lateral angles of the whorls. They are all large shells and the abdomen is frequently hollow or fluted along the centre. They occur from Silurian to the Carboniferous inclusive. Type, Aps. (Lit.) magnificum, sp. Bill. Geol. Surv. Can. Rep. 1853–56, p. 307. Mus. Geol. Surv. Can.

Titanoceras, nobis, includes Silurian and Carboniferous nau-

1 Τρίπλευρος, three sided.

2 Αψìς, the felloe of a wheel.

tilian shells similar to the above, but of larger size with a narrow impressed zone on the dorsum, and a corresponding undivided, narrow, dorsal lobe. The sutures have similar ventral, and lateral lobes, but there are a pair of slight lateral saddles near the shoulders. The whorl in section has a narrower abdomen than in Apsidoceras, and longer abdomino-dorsal diameter, and is more compressed or shield-shaped, rather than depressed or triangular in section. Type, Titan.[1] (Naut.) ponderosum, sp. White, U. S. Geol. Surv. Final. Rep. on Nebr. Hayden, p. 236, pl. 3. Nat. Mus.

Ephippioceras,[2] nobis, includes Carboniferous forms with sub-acute prominent ventral saddles, broad lateral lobes, sub-acute lateral saddles near the shoulders, and broad, shallow dorsal lobes. In the American species, and perhaps in all, there is a slight dorsal saddle in the centre of this lobe. The septa in all species are creased, or raised into a median ridge between the two saddles. The aperture of Ephip. clitellarium reminds us of Pteronautilus in its shallow, acute ventral sinus. Type is Ephip. ferratum, sp. Owen, Geol. Kent., Vol. 3, p. 574, pl. 10, fig. 2, a species closely allied to Ephip. (Naut.) bilobatum Sow., De Kon. Calc. Carb., pl. 9 but is less involute. The siphon is below the centre in the late adolescent stages, and above the centre, or central in adults of the type species.

Pteronautilus, Meek, Pal. Up. Missouri, Smith. Contr., Vol. 14, p. 64, includes but one Dyassic species. This has completely involute whorls, and an aperture extended laterally into wings. The ventral sinus of the aperture is singularly acute resembling in this respect that of Ephip. clittellarium. This slight indication of affinity enables us to place the genus provisionally in this series. Type, Pter. (Naut.) Sebachianus, sp. Gein. Dyas, p. 43, pl. 11.

Trigonoceratidae.

The adults of the radical species, and early stages of descendent forms have whorls similar to those of the Apsidoceratidae. There are, however, longitudinal ridges along the edges of the sulcated abdomens in the adults of the radicals, and in the young of descendent forms these are repeated and then followed in

[1] **Τιτάν**, Titan. [2] **'Εφίππιον**, a saddle.

adults by quadragonal whorls. The dorsal saddles are retained, and though dorsal lobes are formed in the nautilian species, these are often subdivided by a minute saddle. Siphon is above the centre.

Trigonoceras,[1] McCoy, Carb. Foss. Ireland, 1844, p. 9, Nautiloceras D'Orb., Prod. Pal. p. 110, is a synonym. Trig. (Gyr.) paradoxicum, DeKon. Anim. Foss., and Gyr. aigoceras, ibid., D'Orbigny's type are the same species, the latter being the young of the former. The young have lateral costae until a late stage of growth. The abdomen is hollow, the junction with the sides angular, the sides themselves gibbous, and the whorl in section consequently shield-shaped, the dorsum forming the acute apex. The adults retain the form, but lose the costae. The siphon is above the centre. The sutures have broad dorsal lobes, saddles at the angles of the abdomen and sides, lateral lobes and dorsal saddles. This genus seems to be directly transitional to Apsidoceras, but we have not yet seen the young. The similarities of this genus and the hollow abdomened forms of the Triboloceratidae have been frequently noticed by authors, but we do not regard them as indicating a close genetic connection.[2]

Stroboceras, nobis, includes Carboniferous species which are similar to Trigonoceras in their larvae, but elevate the abdomen develop two pairs of lateral ridges, and have gibbous inner umbilical shoulders so that the dorsum becomes broader than the abdomen, and decidedly gibbous. The sutures have broad abdominal saddles, small acute saddles at the lateral ridges, narrow lobes on either side, broad lateral saddles on the swollen or gibbous part of the whorl, and small, sub-acute, dorsal lobes. Apertures are contracted laterally, and dumb-bell shaped. Siphon is half way from the centre to the venter. Type, Strob. (Discites) Hartii. sp. Daws. Acad. Geol. Ed. 3, p. 311, fig. 125, Mus. McGill College.

Trematodiscus,[3] Meek, was finally established by this author in his Invert. Pal. U. S. Geol. Surv. Hayden, Vol. 9, p. 491, with Trem. (Naut.) stygialis of the Carboniferous, DeKon. Anim. Foss., pl. 45, fig. 11 as th^ type. The larvae are at first stage observed

1 Στρόβος, a vortex.

2 See p. 293, Triboloceratidae.

3 We propose to change this name to Trematoceras since it was used by Häckel in 1860, for the Radiolaria, and by Eichwald for Bactrites.

similar in form to the larva of Trem. subsulcatum, and later take on the ridges and abdomen as in Strob. Hartii, but develop a broad furrow between the two ventral ridges. This furrow with the two lateral furrows form a trisulcated abdomen, and together with the ventral lobes in the sutures enable us to separate the species from the adults of Strob. Hartii. The siphon is near the venter The small dorsal lobe is first formed in the centre of the dorsal saddle, simple as in Stroboceras. Then a minute saddle arises dividing it into two V-shaped lobes. This genus also includes species with young more evidently similar to the adults of Trigonoceras, as is shown in Gaudry's figure of Trem. (Naut.) subsulcatum, Ench. du Monde Anim. Foss. Prim. p. 174, but which speedily in course of growth elevate the abdomen and develop ridges. In successive stages the ridges disappear, and the abdomen and sides become flattened, forming a whorl which in section is typically tetragonal and similar to Discitoceras. The siphon is near the venter in the young, and shifts to midway between the centre and the venter in the full grown.

Discitoceras, nobis, is equivalent to the genus Discites, McCoy, Synop. Carb. Foss. Ireland, p. 17. It includes species with quadragonal whorls having the abdomen slightly convex, sides flattened, the dorsum very gibbous. There is also a slight impressed, dorsal zone. The young are ridged longitudinally with prominent transverse striae, but though these cross and roughen the ridges, they do not render them subspinous. The sutures have ventral, and lateral lobes, aud broad dorsal saddles with small annular lobes. The siphon is above the centre. The living chambers vary from one-fourth to three-fourths of a volution in length. The aperture has a very deep ventral sinus, with large lateral saddles near the dorsum, and small lateral sinuses The type, Dis. costellatum, McCoy, Op. Cit. pl. 2, fig. 4, was apparently the young of a species similar to his Dis. discors. The name Discites has been used by DeHaan, Walch and Schlotheim for genera of Mollusca, and we, therefore, substitute another name for that first announced by McCoy.

Phacoceras,[1] nobis, has whorls compressed and acute in the adults, but with young similar to the adults of Discitoceras. The

[1] Φάκος, a lentil.

whorls are very involute, and there is a deep, impressed zone of involution on the dorsum. The young sutures are probably similar in outline to those of Discitoceras, but in the adults there are ventral saddles, according to DeKoninck. Type, Phac. (Naut.) oxystomum, sp. DeKon. Calc. Carb. pl. 17.

Aphelaeceras,[1] nobis, includes Carboniferous species allied to Discitoceras until a late stage, but the whorls are more compressed laterally, have hollow abdomens in later stages and adults, and sides more convergent. The forms are gyroceran, and have no impressed zone on the dorsum, which is gibbous, and sometimes projecting along the centre. Sutures, and living chambers and apertures similar to those of Discitoceras. The young appear to have median dorsal saddles, which become divided by slight dorsal lobes during growth. In the adults there is a dorsal lobe, but the median saddle appears to have been absent in the adolescent stage of the single species we have examined. This genus also includes nautilian species, which differ from the typical Aphelaeceras in being involute and in having an impressed zone on the dorsum, but the dorsal lobe similar. Aph. (Naut.) difficile sp. DeKon. Calc. Carb. and disciforme, sp. M. et W., Geol. Ill., Vol. 5, pl. 18, are members of this subdivision.

Subclymenia, D'Orb. Prod. de Pal., Vol. 1, p. 114, differs from Discitoceras in the sutures, and position of the siphon. The sutures have a deep V-shaped ventral, and acute, linguiform first pair of saddles, first pair of lateral lobes narrow, a second pair of small, lateral saddles near the umbilical shoulders, and dorsal saddles, divided by shallow annular lobes with a minute median saddle. The abdomens are hollow and the dorsal region gibbous, as in the adults of Aphelaeceras. The siphon is near the venter, but the funnels do not approach near enough to interrupt the sutures, or affect the depth of the ventral lobes. But one Carboniferous species is known, Subcly. evoluta, sp. Phil., De Kon. Calc. Carb., pl. 45.

Triboloceratidae.

This family includes shells, which at some stage have longitudinal ridges rendered subspinous by the transverse striae. The whorls in section tend to become depressed, and in the higher

[1] 'Αφελτ̀ς, smooth.

species have fluted, and often hollow abdomens. The siphon is above the centre in all except radical forms. The sutures acquire ventral, lateral, and dorsal lobes, and annular lobes in the higher nautilian species of Vestinautilus. The radical of this family is Thoracoceras among the Orthoceratidae, and this genus could be very appropriately included in this family. The type is the Thor. Vestitum Eichw. Bull. Soc. Imp. de Mosc. 1844, p. 761, pl. 17. It includes Thor. (Cyrt.) corbulum, sp. Barr. pl. 125 of the Silurian, and several Devonian species, besides the Carboniferous spinous ridged species like Thor. (Cyrt.) canaliculatum, sp. DeKon. Calc. Carb. pl. 33, and also the frequently smooth ridged arcuate forms, like Thor. (Cyrt.) Puzosianum, sp. DeKoninck, which have similar transverse striae though less prominent. The connection between this genus, and Triboloceras is too close to need discussion. A connection with the Trigonoceratidae can also be inferred from the resemblance of the adults of such species as Thor. Puzosianum, and the young of some forms of Trematoceras and Discitoceras. But the connection with Trigonoceras is made very doubtful by the transverse costae of that genus, the form, and the modifications of the dorsal sutures. We incline, therefore, to separate the group at least provisionally from the Trigonoceratidae.

Triboloceras,[1] nobis, includes the remarkable series of gyroceran, Carboniferous species described by De Koninck in his Calc. Carb., which have subspinous ridges in the young until a late stage of growth, and otherwise resemble the adults of Thoracoceras. The whorl in section is more or less depressed, and either biangular with convex abdomen and gibbous dorsum, or approximately triangular with concave abdomen. The siphon is above the centre. The sutures have broad, ventral, and lateral lobes, and dorsal saddles without annular lobes. Type, Tribo. (Gyr.) serratum, sp. DeKonnick, Calc. Carb. pl. 32, fig. 5. Mus. Comp. Zool. The forms range from Tribo. (Gyr.) propinquum, ibid., pl. 33, to Tribo. (Naut.) Meyerianum, ibid., pl. 29.

Vestinautilus, Ryckholt, includes nautilian species of the Carboniferous with depressed subtriangular, or trapezoidal whorls, the abdomens very broad, and the dorsum with an impressed

1 Τρίβολος, a burr.

zone in the adults of most species. The young in the adolescent stages have a hollow abdomen with keels, or longitudinal ridges on the abdomen, and forms as in the Triboloceras, but the full grown shells usually become convex on the abdomen with fewer ridges, and in old age are rounded and smooth. Vest. multicarinatus, DeKon. Calc. Carb. pl. 30, remains until late in the adolescent stage similar to the adult of Trib. Meyerianum. The genus also contains more involute species. In these the carinations tend to disappear, and the whorls become rounded as in Vestin. globatus and Coyanus, DeKon. Calc. Carb. pl. 31. The development is much concentrated in the last, the ridges being suppressed at an early stage. Vest. (Naut,) Koninckii, DeKon. ibid, p. 139, pl. 30, is cited as the type of Ryckholt's genus.

Koninckioceras,[1] nobis, includes nautilian Carboniferous species with whorls, having a depressed but broad convex abdomen, trapezoidal in section in the adolescent stages, and similar in form to some species of Triboloceras until a late stage of growth. Sutures have slight lobes on the venter or straight, and broad dorsal lobes, but no annular lobes. There is an impressed zone on the dorsum, but the umbilical perforation is very large. Type, Kon. (Naut.) ingens sp. De Kon. Calc. Carbon. pl. 23, Mus. Comp. Zool. Camb. Kon. (Naut.) implicatum, ibid, pl. 13, shows the adolescent stages. The form of whorl and dorsal lobe appears to place the species in the same series with Triboloceras.

Aipoceratidae.

This family is remarkable for the rotund form of the adolescent and adult whorls, and most species have a trumpet-like or flaring aperture. The peculiar heavy ridge of the umbilical shoulders in the nautilian forms is also a marked peculiarity. The siphon is in most forms close to the venter, but in some between the centre and the venter. The Sactoceran peculiarities of the radical species separate the group from any series to which it might have been otherwise referred.

Aploceras D'Orb. Prod. Pal. Vol. 1, p. 112, includes a series of arcuate Carboniferous forms described by DeKoninck, Calc. Carb. These have a brevicone aspect in most species, the shell

[1] Dedicated to Prof. L. DeKoninck.

is striated longitudinally with fine closely set ridges even in full-grown shells. The siphon is nummuloidal, and above the centre. The whorls vary in section from rounded to elliptical, and even depressed elliptical outlines. The living chamber in Apl. (Cyrt.) rostratum, sp. DeKoninck, ibid, pl. 35, is contracted slightly at the aperture. The type is Apl. Verneuillianum. sp. DeKon., Calc. Carb., pl. 34. The nearest affines of this genus seem to be in the genus Sactoceras.

Aipoceras,[1] nobis, includes the Carboniferous gyroceran forms of which we know but one species, Aip. (Gyr.) gibberosum, described by DeKoninck, Calc. Carb. pl. 32. This has a similar whorl and is evidently a close affine of Aploceras, but the siphon is tubular, and close to the venter as in Asymptoceras. The smoothness of the shell, also, is transitional to this last named genus, as well as the more compressed outline of the whorl in section. The sutures retain the simple outlines of the arcuate radicals, having slight ventral and dorsal saddles, or nearly straight outlines. Mus. Comp. Zool.

Asymptoceras, Ryckholt, Not. sur Asymp. et Vest. 1852, has for its type, according to DeKon., Calc. Carb. p. 112, Phillips' species of Naut. cyclostomus. Solenocheilus, Meek, is a synonym, having for its type Asympt. (Naut.) Springeri W. & St. J., Tran. Chic. Acad. Vol. 1, p. 124. The whorls increase very rapidly in size, the living chambers are short with flaring, or slightly contracted apertures. The venter is flattened, or slightly hollow along the centre. The sides are more or less gibbous, and the umbilical shoulders project in heavy ridges, or a large pair of tubercles. Upon each side of these are flutes which are specially characteristic. The dorsum is also remarkable for having the centre gibbous as in gyroceran forms, indicating the recent derivation of the genus from more loosely coiled forms. The sutures have broad ventral lobes, saddles at the abdominal ridges, broad lateral lobes, saddles at the umbilical shoulders and dorsal lobes, with small annular lobes. Siphon is near the venter.

The elliptical form of the young whorl, the large umbilical perforation, the simple, fine, smooth, longitudinal ridges, evenly distributed around the whorl, indicate derivation from Aipoceras.

[1] Αἰπύς, lofty or high.

The presence of a pair of large tubercles on the chambers of habitation in some of the species unites them with such forms as Asypm. (Naut.) bifrons sp. DeKon. Calc. Carb. pl. 16. Even the contracted chamber of this species and of Asypm. (Naut.) conspicuum ibid, pl. 19, does not enable us to separate these species.[1]

Nautilidae.

The species of this family have the typical nautilian whorls, ridged in the young, but smooth usually in adults. The sutures, though lobed on the venter in one genus, have generally broad saddles and sutures like those of the recent Nautilus. In several series we traced the appearance of the annular lobe in the sutures, and an internal septal depression, which we have called the cone. The sutural lobe appears in the Devonian, and is inherited in the Triassic genus, Cenoceras, with the cone better developed, and becoming separated from the sutural lobe. In different genera springing from this common type there is a tendency towards concentration in the young, the cones being confined to the earlier stages. Thus in the Jura the cones are still occasionally found in adults, but in the Cretaceous probably very rarely, if at all, and in the Tertiary and present no case of this kind was observed, though they are characteristic of the young. The lobes in the sutures are not exclusively confined to the larval and earlier adolescent stages of growth of recent species, as are the cones, but may be present in adults of the existing Nautilus. In consequence, however, of their separation from the cones, they become easily obliterated in fossils, and are apt to escape observation.[2]

[1] Asympt. (Naut.) dorsale is usually considered the type of D'Orbigny's genus Cryptoceras, Prod. de Pal. p. 114, but the species first mentioned by that author on p. 58, Tem. subtuberculatus, should be considered as the type.

[2] This is also the history of the same part in other series besides this family and is applicable to all the families of Nautiloids in which the annular lobes appear. The annular lobe of the suture, and the accompanying depression of the septa are almost invariably united in the Paleozoic forms, and the appearance of the cone is very rare. The separation of the two is, however, the rule in the Mesozoic, as detailed above in the Nautilidae. In the Ammonoidea, on the contrary, the lobes and cones appear though very rarely, in Silurian species, and are fully developed in the Devonian Goniatites.

Sphyradoceras,[1] nobis, includes a series of Silurian and Devonian, annulated, costated, and longitudinally ridged species whose close affinity to, and probable derivation from, Spyroceras, will hardly be disputed. Ridges and costae are both present in the young, but in succeeding stages one or the other, or both may disappear. The species are more or less trochoceran in mode of growth, with arcuate and gyroceran forms.[2] They have straighter sutures than in Hercoceras besides the differences of the shell markings, and the position of the siphon varies from near the centre to near the venter. The sutures have either straight sutures, or saddles on the venter, and also saddles on the dorsum. In some species there is a lateral line of tubercles similar to those of Heroceras, but smaller; and the inner lip of the aperture may also occasionally bend upwards as in Hercoceras. Notwithstanding these peculiarities the flattened sides and abdomen of adults and their apertures, which are similar to those of Barrandeoceras; and the compressed elliptical whorls of the young of arcuate species like Sphy. (Troch.) debile sp. Barr. pl. 18, and their central siphon, leads one to associate this genus in the same general series with Barrandeoceras. This group may possibly help us to explain the presence of the longitudinal ridges and annular costae in Barrandeoceras, when more perfect records are available. They may be at present considered a series of shells with slight trochoceran deformation, which is an offshoot of Spyroceras, and possibly nearly related to the ancestral forms of the Nautilidae. Type, Sphy. (Troch.) Clio. sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 59, 111. Mus. Geol. Surv. Albany.

Uranoceras, nobis, includes arcuate and gyroceran forms of the Silurian with large, stout, elliptical, or laterally compressed whorls, abdomen and dorsum convex and about equal in breadth. Siphon is near but above the centre. The sutures have very broad ventral saddles, slight, lateral lobes, and broad dorsal saddles in the early adolescent stages, and acquire very slight ventral and dorsal lobes in the adults of the American species. The siphon is large and nummuloidal, and the peculiar gibbous whorls,

1 Σφύρας, a cake of dung.

2 One species, Sphy. (Troch.) nodosum, sp. Barr. pl. 20, fig. 20, appears in only one variety to have had a very faint impressed zone, and may possibly come within our definition of the nautilian shell.

and sutures can be more or less closely compared with the young of Barrandeoceras, the adults of Nephriticeras, and the adolescent of the large Carboniferous forms, like Naut. eximius, and prægravis, DeKon., Calc. Carb. Type, Uran. (Cyrt.) Uranum, sp. Barr. pl. 196.[1] I have met with several specimens of this, or a closely allied species, from Anticosti, Mus. McGill. Coll., Bost. Soc. Nat. Hist., and Mus. Can. Geol. Surv. The exact radicals of this genus are unknown, but it has close relations with Spyroceras in its sutures; and the form of the whorl in U. Uranum is very similar to the laterally compressed and flat abdomened forms of Spyroceras.

Barrandeoceras,[2] nobis, includes gyroceran and nautilian shells with very large umbilical perforations, and compressed, slightly costated or smooth whorls, generally without an impressed zone, though this is sometimes present. The venter is narrower than the dorsum, the siphon near but above the centre, septa deeply concave, and sutures with ventral saddles, lateral lobes and dorsal saddles, without annular lobes. Type, Barr. (Naut.) natator, sp. Bill. Can. Nat. n. s. Vol. 4, Mus. Geol. Surv. Can., The genus also includes the Bohemian forms Barr. (Naut.) Bohemicum, sp. Barr. Vol. 2, Syst. Sil. pl. 32, 33, Sternbergi, ibid, pl. 36, 37, tyrannus, ibid., pl. 38, Sacheri, ibid, pl. 39. Living chamber is about one-half of a volution in length; it is about three-fourths of a volution in length in the type species.

Pselioceras,[3] nobis, includes the series of Dyassic Ophionei, traced by Waagen in his fossils of the Salt Range, Pal. Ind, Ser. 13, pt. 1, Pisces and Cephalopoda. The large umbilical perforation of the type, Psel. (Naut.) ophioneum, sp. Waagen, ibid, pl. 5, fig. 2, shows that it must have been cyrtoceran in the earlier stages for a prolonged period. There is a slight dorsal impressed zone formed, according to Waagen's figures, after the close coiled stage begins, on the first whorl. The resemblance of this genus to the adults of Barrandeoceras natator is very close in the sutures, and form of the larval and adolescent stages. We place it provisionally in the same series, noting, however, that the forms

[1] Barrande has also noted the Nautilius-like aspect of this species.

[2] This genus was dedicated to M. Joachim Barrande, before his death, as a token of respect and admiration for his work upon the fossil Cephalopods.

[3] **Ψέλιον**, a bracelet.

also resemble the genus Discitoceras in general aspect during the later adolescent and adult stages.

Nephriticeras,[1] nobis, includes Devonian forms with elliptical or broad kidney-shaped whorls. There is an impressed zone on the dorsum at a late stage in the elliptical forms, and in the kidney-shaped whorls this appears at earlier stages. The umbilical perforations are large, and the whorls arcuate until a comparatively late stage of growth in all except the highest smooth forms. Siphon is nummuloidal, and near, but above the centre. The sutures have broad ventral saddles in the adolescent usually with slight ventral lobes in the adults. The lateral lobes are also slight and broad, the dorsal lobes are similar, and have large V-shaped annular lobes in the impressed zone, the last often being very large, and cones are partially formed. The living chambers are from one fourth to half a volution in length and very broad, the increase of the whorl by growth being very rapid. The longitudinal ridges in the radical species, such as Neph. (Naut.) cornulum, sp. Hall, and their arcuate later larval stages, and adolescent gyroceran forms without impressed zones, and central nummuloidal siphons and sutures lead to the conclusion, that the genus sprang from some unknown ridged and probably Devonian form similar to Uranoceras, and Aploceras. Type, Neph. (Naut.) bucinum, sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 60, 109. Mus. Geol. Surv. Albany.

Cenoceras,[2] nobis, includes forms appearing in the Trias, Jura, and Cretaceous, with nummuloidal siphons, flattened abdomens, sides but slightly convex and convergent, the abdomen narrower than the dorsum. The siphon is nummuloidal, and, though near the centre, may be either above or below it. This again in the young occupies a position on the ventral side of the centre in the few forms known. The shells are nautilian from an early stage with decided impressed zones in the adults. The septal cone becomes in this genus separable from the sutural lobe with which it was combined in Nephriticeras. The transitional Triassic species, like Cen. (Naut.) carolinum, and Tintoretti sp. Mojsis. Med. Trias Prov., may have either ventral saddles or lobes in adults, and siphon central or below centre except in the young, and whorls which are not very involute. Jurassic species, though

1 **Νεφρίτης**, kidney shaped. 2 **Καινός**, modern.

with saddles in the young, have almost universally ventral lobes in adults siphon above centre and more involute whorls. The dorsal cones are in some species confined to the larval and adolescent stages, disappearing in adults, whether the annular sutural lobes disappear in adults is difficult to determine in fossils. Type, Cen. (Naut.) intermedium, sp. Sow. D'Orb. Terr. Jurass. Ceph. pl. 27. The resemblance of the Triassic forms to Barrandeoceras is decisive for association in the same series, but there is as yet no evidence that Cenoceras was directly derived from Barrandeoceras. The frequent presence of longitudinal ridges in the young and in some adults, the appearance of the annular lobes at comparatively early stages, and the kidney-shaped whorls of the larvae, also indicate derivation from Nephriticeras rather than Barrandeoceras. We have, however, not yet found the intermediate Carboniferous forms, and these, it must be remembered, may prove to be gyroceran and arcuate shells belonging to the common trunk or stock, but not necessarily to either of the genera mentioned. Some Jurassic species have ridges and transverse striae in the adult shells exactly as in the young of the existing Nautilus.

Cymatoceras,[1] nobis, includes Cretaceous species of the Radiati, remarkable for their transverse costae. The abdomens are rounded and the sides gibbous, though the whorls become compressed in adults of some species. The sutures have large ventral saddles, shallow lateral and dorsal lobes. The siphons are usually sub-central. Annular lobes and cones are present in the larval and adolescent stages, but disappear in adults. The young, as noted first by D'Orbigny, are devoid of costae, these appearing on the second, or even third whorl in some species. The ventral sutures are distinctly lobed in the later larval stages, the saddles developed later in the adolescent and adult stages. Doubtless at still earlier stages than those observed by us, the suture presented the usual larval ventral saddles. Type, Cym. (Naut.) pseudo-elegans, sp. D'Orb. Terr. Cretac. Ceph. pl. 8.

Nautilus,[2] includes forms of the Jura, Cretaceous, Tertiary

[1] Κῦμα, a wave.

[2] Reexaminations of the young of this genus have satisfied the author of errors in former views with regard to the funnels. The funnel of the second septum extends to the opening of the coecum of the first septum on the ventral, but not on the dorsal

and Present, which have tubular siphons, rounded abdomens precisely as in the more radical or lower species of Cymatoceras, and are separable from this genus only by the absence of tranverse costae at all stages. The young sutures in some Cretaceous species, Naut. Dekayi, for example, have first ventral saddles, then in later stages ventral lobes, and in the adults ventral saddles are developed. We have, also, not yet seen a full grown shell among Jurassic species, which had the annular lobes though they are sometimes retained until the latest adolescent stages. The abdomen is sometimes flattened, as in Cenoceras, but the young even in such species have gibbous, or kidney-shaped whorls, they also invariably present longitudinal ridges, which in some species, may even be said to be slightly subspinous. The sipon in the young is between the centre and the ventral side, and in the Jurassic species retains this position in the adults. In Cretaceous species it appears nearer the centre. In the Tertiary species there seems to have been no lobe developed on the venter at any stage, and in the recent species, all three of which we have examined, there is, also, no abdominal lobe at any stage. The adult lobed stage of the Jurassic progenitors is skipped in accordance with the law of concentration of development in descendent forms, and the larval saddles are perpetuated without change throughout life. The young of the modern Nautili do not resemble the adults of Cymatoceras or of Cenoceras, and in our opinion have only one nearly related form, the ridged adults of Nephriticeras. We have to go back to the later larval and adolescent stages of the transition forms of the Jura in order to see that there may have been direct connection between the genera Cenoceras and Nautilus, and some of the facts indicate that the separation of the two genera may have taken place in the Trias. Thus, Naut. striatus, sp D'Orb. and inflatus, ibid, Terr. Jurass. both have the typical form of this genus and ventral saddles. Though the siphons are above the centre, and the annular lobes are retained until a late stage, as in Cenoceras of the same period, they do not resemble them so closely in their aspect as they do the lower forms of the Triassic Ceno-

side. The funnel at this stage is, therefore, macrochoanitic, bnt not holochoanoidal as formerly supposed. The funnel of the third septum is much shorter. The microchoanitic characteristic appears to be due to the length of the chamber and not to any great difference between the length of these first two funnels.

ceratites, like C. carolinum sp. Mojsis. Med. Tr. Prov. pl. 83. N. elegans, Meek, and N. laevigatus are, however, transitional between this genus and Cymatoceras, and connect them closely. Thus we are obliged to regard the last as an offshoot of the genus Nautilus or of Cenoceras.

MACROCHOANITES.

(Transitiones.)

This group necessarily includes forms which belong to both Nautiloidea and Ammonoidea so far as their embryonic stages are concerned. Thus Bactrites, so far as we know, is a true Nautiloid shedding the protoconch and presenting the cicatrix on the apex of the conch or true shell, as figured by Barrande. Syst. Sil. pl. 490, from drawings made by the author. The ventral sutures are interrupted by the funnels as in Ammonoids, and the sutures are otherwise similar to those of Mimoceras and Anarcestes in some forms. These resemblances are precisely similar to those habitually occuring only between closely allied, parallel series in the two orders, which have been traced to a common radical. The inference is unavoidable, therefore, that we are here dealing with forms which have all sprung at no very remote period from an ancestor with a slender whorl, and striae of growth and sutures like those of the simpler and purely orthoceratitic forms of Bactrites. Having found it impracticable to introduce the curious aberrant forms of the Clymeninae in any other way, we have placed them in the form of a note.[1]

Bactritidae.

Bactrites, Sandb. Leonh. et. Bron. Jahrb. 1841, p. 240, is really a synonym for Trematodiscus, Eichw., Bull. Soc. Imp. Nat. de Moscow, p. 200, but it seems inexpedient to try now to restore the original applications of these names. One cannot compare Bactrites and Mimoceras compressum without being struck by the close affinities of the two forms, and feeling disposed to join Quenstedt in his, at that time, daring thought, that these two forms were closely allied, and bore to each other the same relation as the straight Baculites and the associated coiled Ammoni-

[1] See "Note" p. 312.

tes, Die Ceph. p. 64 pl. 1, 3. We, however, necessarily include in Bactrites, such transitional forms as Bact. (Orth.) pleurotomum, sp. Barr. pl. 296, Xanthus, Endymion, and caduceus, pl. 297, and many other similar Silurian and Devonian forms. These have the striae of growth raised into a saddle on the dorsal side, and the siphon central, or when near the side, ventral as in Bactrites. These forms, also, either have straight sutures or inclined sutures, Bact. (Orth.) fasciolatum pl. 319, and Bact. (Orth.) obliqueseptatum, sp. Sand. Verst. Nass. pl. 18; but they do not have ventral and dorsal saddles as in the compressed forms of Bactrites. Compare for example Bact. (Orth) Paris and eximium, sp. Barr. pl. 412, with the similar compressed Bact. carinatus, sp. Munst. Sand. Verst. Nass. pl. 17. Sandberger and Barrande agree in their observations and in their opinion, that the ventral lobe is due to the approximation of the funnels to the side in Bactrites, and the facts support this conclusion. The Silurian forms we have mentioned are evidently the radicals of Bactrites, and we can only account for their affinities in form, in the transverse striae, and sutures with Mim. compressum by referring both to the common stock and imagining them as the more direct descendants of that stock, which must have had banded shells similar to those of Geisonoceras. The aspect of the apex in two specimens of Bactrites Hyatti, in the Museum of Munich, show that Bactrites is probably a true Nautiloid in the earliest stages, but this distinction has lost much of its value since the discovery of the protoconch in some of the straight cones. It leaves us still at liberty to give due weight to the transitional characteristics of the later stages. And we must, also, in this connection call attention to the important transitional character of the cicatrix, which is shown in our figure of Bactrites on M. Barrande's pl. 490. The cicatrix is unusually large and indicates a protoconch with a larger neck than is usual among Nautiloids. We have seen some, perhaps, even larger in proportion, but they are exceptional as M. Barrande shows in his figures. These facts show, that the ventral lobe of Bactrites is an independent production in this series of straight cones. At the same time we should not forget that such parallelisms occur only in nearly related series, which are descended from the same common stock. At least this has been our experience in all the series we have traced, and we are, therefore, disposed to translate this case in the same way. The artificial line between Ammonoidea and Nautiloidea can be placed between this group and Geisonoceras, with which the shells and characteristics of the transitional forms blend, or between Bactrites and Mimoceras according to the weight one is disposed to give to the characteristics of the apex.

AMMONOIDEA.

We have already noted the characteristics of this order, but we find it necessary to add the following remarks.

In each group of Goniatitinae there are forms, with whorls depressed and with outlines semilunar in section, which are similar to Parodiceras and Anarcestes and resemble these genera also in having undivided ventral lobes. There are also in these radical genera and in other genera, either in the adults or in the larvae, forms having simple sutural outlines like those of Parodiceras with slight rounded saddles, and broad, shallow, angular lobes. There can be but little risk of error, therefore, in assuming that the genus Parodiceras is the organic centre of the Devonian forms, and the immediate radical of all Goniatitinae except the Primordialidae. The Primordialidae appear to be directly derived from Nautilinidae, and we have not been able to trace any descendants. This result shows that the genus Anarcestes is probably the genetic centre of distribution, the stock form in the phylum of the Ammonoidea, or the first with undeniably Ammonoidean form and characteristics, the immediate radical, while, as we have noted above, the group of Bactrites and Geisonoceras are the distal radicals.

Dr. Branco has worked out very valuable results with regard to the law of concentration of development among Cephalopods, but has failed to appreciate their meaning or to note the fact that others had tried to explain similar results. He confirms views first published by the author, that the larvae of the Goniatites and Ammonites have simple sutures, and the ventral lobes undivided in the early stages, and that these lobes become divided only in later stages, and farther, that the more ancient forms remain longer in the simple or goniatitic stage with undivided ventrals, than the later forms. He alludes also (Paleontogr. Vol. 3, 1880–81, p. 29) to the well known and frequently described increase of complication in the sutures which takes place during growth in every individual, and then shows that the earlier or goniatitic stages are abbreviated in the young of the mesozoic Ammonitinae. He is thus able to compare this process of the abbreviation in later species of the earlier ancestral characters and correlate its progress with the similar progressive complication, which takes place in the adult forms in time. He then inquires if this progress in the sutures in adults is an accident, "ein reiner Zufall," or if it stands in definite or causal hereditary relation to the concentration or shortening of the simpler or Goniatitic stages of the sutures in the more recent forms.

We think that it would have been no injury to his thorough and remarkable embryological contributions, if he had noted more fully our remarks on the nautilian character of the first septum in the Goniatites and Ammonites, and of the additional fact that every Goniatite passed through a nautilinian stage, and every Ammonite through a goniatitic stage. Dr. Branco was perhaps misled by our figure (Embryol. of Cephalopods, pl. 3, fig. 3) which has an accidental ventral fissure in the first septum. We distinctly state on page 86, however, that this was due to the "violent removal of the shell," and describe the first septum as having an entire ventral saddle in both Goniatites and Ammonites on pages 61, 64. These and other facts such as the earlier inheritance of siphonal coecum in the protoconch of the Ammonoidea, which Dr. Branco erroneously rejects, are due to the law of concentration and acceleration in development, or the shortening of the earlier stages of development in more complicated and later occuring species. The same author's supposition that the degenerate forms cannot be distinguished as such, but may be cited as facts against this theory shows that he has not understood the close coiled embryos of these forms, and is either not acquainted with the researches of Quenstedt, or has failed to consider then worthy of his attention. When an author takes high ground in favor of any special method one has a right to expect unusual freedom from error. Dr. Branco's method, however, has not enabled him to escape the usual fate of authors, whether fact-worshippers or theorists. He has misinterpreted the most important fact of the embryology of the Nautiloids, the cicatrix, and failed in correlating the resemblances between the embryos of Nautiloids and Ammonoids, and in correctly distinguishing their differences.

We appreciate his work very highly, and we gladly acknowledge discoveries properly belonging to him, and these are, the distinctions of the Asellate, Latisellate, and Angustisellate types of embryo among Ammonoids. The progression of the embryo through the concentrated and accelerated inheritance of ancestral characters was previously stated by ourselves, and his remarks on this point are simply confirmatory, though more fully stated, more completely worked out, and more richly illustrated.

Goniatitinae.

This sub-order may be characterized by the possesion of smooth shells marked principally by transverse striae, and open apertures similar to those of Nautiloidea. The large ventral sinuses of the apertures of nearly all the species show, that they must have possesed powerful hyponomes, or fleshy ambulatory funnels, and were animals which had similar habits to those of Nautiloids, capable of crawling efficiently on the bottom or of swimming by the use of the hyponome. The sutures are entire, with a few notable exceptions, in the later forms. The funnels change from the macrochoanitic form to a short transitional form, and in some species in later formations acquire the true ammonitoid collar, or in other words, become completely cloiochoanitic.

The ventral lobes are undivided, and similar to simple funnel lobes only in the Nautilinidae and Magnosellaridae. In the remaining families genera may have undivided or divided ventrals in the same family, or exclusively divided ventrals as in the Primordialidae. The dorsal or inner sides are occupied by saddles only in the gyroceran form, Mimoceras, and the uncoiled or gyroceran larvae of higher forms. The Nautilinidae have a broad dorsal lobe in the impressed zone, but no annular lobes except in one genus, Agoniatites. All the remaining genera have annular lobes, so far as known, except the transitional species from Anarcestes to the Magnosellaridae included in the genus Parodiceras. The annular lobes are undivided so far as known, the true siphonal saddles having no corresponding dorsal saddles as among the Ammonitinae. Silurian forms are notable as having sutures with undivided ventrals of the simplest type, shallow primitive outlines to the first pair of saddles, primitive first lateral lobes and dorsal sutures with broad lobes or saddles, but no annular lobes, and the funnels are machrochoanitic. There are exceptional genera, but these are very rare. Devonian forms have the large magnosellarian lateral saddles, and transitional characters in the forms, septa, and outlines of the sutures, which are advances towards the Ammonitinae. The ventral lobes when divided are apt to be very broad and the siphonal saddles large. In the Upper Devonian and Carboniferous there is a tendency to narrow the ventral lobe and produce smaller siphonal saddles, and divide the first pair of saddles and also the magnosellarian saddles into smaller lobes and saddles. Forms having marginal lobes and saddles, which make near approaches to the Ammonitinae occur only in the Carboniferous.

The abrupt appearance of the Goniatitinae in the later Devonian and earlier Carboniferous formations of North America, and the absence of radical forms of the group of Nautilinidae in the Silurian indicate that they were migrants from European sources and not autocthonous.

Nautilinidae.[1]

This family includes forms with gyroceran and nautilian whorls, and sutures with simple lateral lobes either throughout life or until a late stage of growth. There is a dorsal lobe in the impressed zone, which is due to the involution of the dorsal saddle suture, which is present in the larva. There is no annular lobe except in the more aberrant forms. The ventral lobe is a true funnel lobe in the lower species, becoming a wider ventral lobe in the higher species, as in Pinnacites. The funnels are long and tapering, and in species with approximate septa seem to be continuous, though really ellipochoanoidal. The shells are banded with transverse striae, but otherwise smooth, and the apertures have a ventral sinus, which may be in exceptional transitional forms like Mimoceras quite small, but are usually large.

[1] On p. 256 mention of the Magnosellaridae as having undivided ventrals and of the fact that the dorsal saddles were confined to the lower forms of Nautilinidae was accidentally omitted.

The young are asellate, the first suture having no ventral saddle, according to Branco. The larvae in some forms are cylindrical and open whorled, but in all the higher forms closed, and, though still asellate, have the broad form of the ammonitic embryo.

Mimoceras[1] includes two well known species of true Goniatites, but these are separable from Bactrites in no essential characteristic, except the presence of a permanent protoconch upon the apex. The septa have simple concave lateral sutures, and dorsal saddles without annular lobes, the whorls have no impressed zone, and the shells are, therefore, not really truly nautilian in form, but gyroceran; and even the compressed whorls are similar to those of some Bactrites. The ventral lobe is a simple funnel lobe, as in Bactrites, and it divides the ventral saddles in the same way. Their characteristics, and the protoconch ally them, however, even more closely with Anarcestes and oblige us to place them in the Nautilinidae. This evidence appears to need but one more link, the finding of a Bactrites with a globular protoconch. Type, Mimoc. (Gon.) compressum, sp. Beyr. Sandb. Verst. Nass. pl. 11, fig. 4; also, Mim. (Gon.) ambigena, sp. Barr. Syst. Sil. pl. 3, 12, and possibly Gon. Dannenbergi, Beyr. Verst. d. Bay. Rheins, Ueberg. pl. 1, fig. 5.

Anarcestes, Mojsis. Mediterr. Trias Prov. p. 181, was pointed out by that author but insufficiently defined, and a list of species given in a note, the only characteristic cited being the living chambers, which are said to be long. The genus is also characterizable by the broad semilunar whorl, the abdomen broader than the dorsum, this peculiar form is present in the later larval stages, and is maintained even in excess in some very involute species in which the abdomen in consequence becomes excessively broad, the sides very narrow, and the umbilicus very deep. There are some discoidal species, like Anar. crispus sp. Barr. pl. 9, fig. 31, with rounded whorls until a late stage of growth, but most of the species depart from the tubular outline at a very early age. Sandberger shows that in one variety of Anar. subnautilinus the first whorl is gyroceran, and Branco, in the same species, demonstrates, that variety vittiger is close coiled. Compressed whorls occur in some Silurian species, such as Anar. neglectus,

[1] **Μῖμος**, a mimic.

sp. Barr., but the compressed forms are more numerous in the Devonian than in the Silurian, like Anar. circumflexifer, and subnautilinus Sandb. Verst. Nass. pl. 11. The closest affinites exist between the young of Anar. subnautilinus, and the adults of Mimoceras, and it seems probable that this genus is directly derived from the gyrocean Mimoceratites, whether through the intermedium of Silurian or protozoic, transitional forms, we do not yet know.

Heminautilinus, nobis, includes species with whorls similar to those of Anarcestes, but with angular lateral lobes in the adults. The species figured by Munster as Gon. hybridus, Ueber Clym. pl. 3, fig. 6, is the type. This figure enables us to see that the species was a form having the sutures of Mimoceras and Anarcestes until far advanced in the adolescent stages of growth.

Agoniatites, Meek, Paleont. Explor. 40th, Paral. Vol. 4, p. 99, equals Aphyllites, Mojsis. Med. Trias Prov. p. 181. The last author designates the living chambers as shorter than in Anarcestes. Agon Vanuxemi, sp. Hall, Nat. Hist. N. Y. Vol. 5, pt. 2, pl. 59, has this part of whorl fully two-thirds of a volution in length. Agon. bicaniliculatus, sp. Sandb. Verst. Nass. pl. 11, in the least involute variety fig. 5, has it about the same length, and in the involute variety fig. 5, c-g, it is about one half of a volution. In this last variety the septa are so closely set, that the funnels of the siphon appear to be holochoanoidal, but close inspection brings out the thin connective wall of the siphon which distinguishes the ellipochoanoidal siphon of these groups. This connective wall is hard to demonstrate, both from its closeness to the shell, and the small size of the posterior ends of the funnels. The sutures have deep lateral lobes, and more prominent saddles than in Anarcestes; internally the septa are deeper than in Anarcestes, and rise to a shallow concavity near the venter. The dorsal lobe is to be found in the zone of impression, but is very shallow has an elevated suture, and is entire, without annular lobes. Comparison between Mimoceras and Anarcestes, and the larva of Agon. Vanuxemi show that the dorsal lobe, as in Nautiloids, is correlative with the closer coiling of the shell, and is really a sutural depression dividing the large dorsal saddles of the larva. The umbilical saddles of the sutures, are formed by the increase in breadth of the zone and the accompanying dorsal lobes, and increase in proportion to the deeper involution of the whorls, as in some Nautiloids. Agon. fecundus, sp. Barr. Syst. Sil. pl. 11, is less involute, and shows how closely the larval shells repeat the adult peculiarities of the parent gyroceran form, Mimoceras. In fig. 4, occurs the extraordinary variety with straight larval apex, which leaves us in no doubt, that these shells must have had a remote ancestor with a straight cone in the adult stage. Agon. fidelis and verna sp. Barr. pls. 8, 9 and Vanuxemi, Hall, exhibit species with the highly concentrated development common in the more involute, and compressed shells which generally terminate the series we have studied. They have skipped the larval peculiarities of the gyroceran stage, and become close coiled and even involute on the first or second whorl. Agon. tabuloides, sp. Barr. pls. 4, 244, exhibits in the section figured a decided annular lobe, showing that this may occur in some Silurian species of the Ammonoids, though usually a Devonian characteristic of both Ammonoids and Nautiloids. Another curious fact is that it has the internal depression we have called the cone, which among the Nautiloidea is not in our experience fully developed until after the Carboniferous, and certainly must have been rare, if it occurred in other forms in the Paleozoic.

Pinnacites, Mojsis. Med. Trias Prov. p. 181, was merely mentioned by that author and the type given, as the Pin. emaciatus sp. Barr. of the Silurian. We have not examined the type, but in the Mus. Comp. Zool. there exist fine specimens of the Devonian form which does not differ apparently from its Silurian ally. The highly compressed and acute whorl becomes excessively involute at an early age, and we were able to follow the sutures far enough to see, that in the larva the natural decrease of involution must bring about the disappearance of the umbilical lobes, and reduce the sutures to the outlines of Agoniatites. The abdomen is also broader in the young and the whorl in section is identical with the adults of Agoniatites, and these facts indicate direct derivation from the latter. The septa of the adults are double concave in correspondence with the lateral lobes, the internal surface being divided by ridges corresponding to the lateral saddles. There is a broad dorsal lobe, with two small, widely separated dorsal saddles, the impressed zone is very deep, and there is no annular lobe, unless the broad median lobe may be so considered

Celaeceras[1], nobis, includes only Cel. (Gon.) praematurum, sp. Barr. Syst. Sil. pl. 522. It is unique among Silurian forms in the sutures, which possess outlines similar to those of the more complicated Devonian and Carboniferous forms. There is in Barrande's figures, though not described by him, ventral saddles, similar to the saddles of Pinnacites and on either side are two deep lateral lobes similar to those of Glyphioceras. The first pair of lateral saddles are large and hastate, and the second pair of lateral saddles broad and rising rapidly to the umbilicus. The shell is not very involute, showing that it is a member of a larger series, which probably had both less involute and also possibly some more involute members. The inner lateral saddles associate it with the Agoniatites rather than Anarcestes. We regard it as having probably the same relations to Agoniatites, that Heminautilinus has to Anarcestes. The young, as in Heminautilinus, will probably be found to repeat the parent form until a late larval stage in some species. M. Barrande repeatedly alludes to this species as one of his best illustrations of anachronic species, or species which are out of place in time; which more closely resemble succeeding forms of more complicated structure than those of the fauna in which they occur. To us they are simply highly specialized forms, which have adopted habits similar to those of the species they resemble, and have been accordingly modified in their adolescent and adult stages, but still retain in their larval and adolescent stages the marks of their recent origin from the lower forms with which they are associated. We have accordingly named this form, the racer

[Note.]

CLYMENINAE

This group has characteristics which are so evenly balanced that we should have found it difficult to decide whether it was Nautiloid or Ammonoid, if it had not been for the protoconch, and the young sutures, which are shown by Branco in the Paleontogr. Vol. 3, 1880, pl. 8, fig. 1. The sutures in the young have ventral lobes, and the broad ventral saddles of the group are developed later. It is, therefore, an Ammonoid, but we cannot say that the young resemble the lower Goniatites; since the first suture of the only species known, in place of being asellate, or straight, has a broad saddle as in the higher Goniatites. A still more remarkable peculiarity, if general, is, as stated by Branco the absence of depressions on either side of the neck of

[1] **Κέλης**, a racer.

Cloiochoanites.

[Transitiones.]

The transitional forms of the Goniatitinae, which have the short type, or partly cloiochoanitic funnel elevated upon a median

the ovisac. These are the remants of the umbilical perforation, which are present in the young of all other close coiled Ammonoids. These characteristics, and the dorsal position of the siphon, and the presence of deep annular lobes, are differences of great importance and show that we must place the series above the Nautilinidae. The forms are evidently highly concentrated in development, but descendants probably of the same stock as Anarcestes. The adult forms and the sutures of Cyrtoclymenia are very similar to those of Anarcestes and indicate this derivation. The group appears to have had a very narrow distribution chronologically and geographically, and was probably a highly specialized series with exceptionally rapid evolution in some open fields of the Devonian. So far as I know, not a species of this group has yet been found in North America, those described heretofore are now known to be Goniatites. The author has spent considerable time in the study of this group and divided them into genera, but these can only now serve as the basis of appreciative criticism for the elaborate work of Dr. Gumbel, Ueber Clym. Paleontog. Vol. 11, p. 83, 1863. This author's sub-groups are equal to our genera, and most of his varieties are what we should call species. We, therefore, use his names in this value without making any claim to the credit of having originated them. This extraordinary series shows the phenomena of quick evolution in three series of forms. Cyrtoclymenidae with a series beginning with an Anarcestes-like form and passing through discoidal and compressed to quadragonal costated forms. Cymaclymenidae, a similar parallel series but with more complex sutures, and Gonioclymenidae also a similar series, but with more involute forms than the last, and the sutures becoming ammonitic with median ventral lobes and saddles divided by a pair of marginal lobes. The whole range of the transformations of the Goniatitinae are paralleled in this short series, whose principal differential characteristic is the dorsal position of the siphon. We have had no opportunity of studying the siphon but Dr. Gumbel's group of Euclymenia with imperfect siphons appear to us like the imperfect siphons which occur not infrequently among Nautiloids, the connective wall being destroyed by maceration. The Nothoclymeniae are apparently those with longer, larger funnels and thicker connective walls. Dr. Gumbel's figure of Cly. speciosa gives the funnels as if terminated by a darker colored connective wall.

CYRTOCLYMENIDAE.

The sutures are simple with broad undivided ventral saddles, rounded or incomplete shallow lateral lobes and only rarely internal saddles on the sides. The siphon is tubular and small.

Cyrtoclymenia includes species with depressed semilunar whorls in section, similar to those of Anarcestes. The sutures are similar, but the ventral saddles of the Clymeninae are present, though rounded, and the lateral lobes are also rounded. Type, Cyrt. angustiseptata, Gumb. pl. 15.

Oxyclymenia includes forms with discoidal shells, compressed and more or less involute whorls. The larval depressed whorls of Cyrtoclymenia have disappeared from the adult stages. The sutures have ventral saddles more prominent than in that genus, and in some species the angular lateral lobes are deeper, but there are no large lateral saddles. Type, Oxy. laevigata, ibid, pl. 16, also undulata, pl. 17, and Dunkeri, pl. 16.

siphonal saddle are not separable from congeneric forms having undivided ventral lobes. The Primordialidae have very large siphonal saddles carrying short, collarless funnels, and the Magnosellaridae have undivided ventral lobes. The funnels are small and elevated upon the first pair of saddles in most of the Magnosellaridae and these so closely simulate siphonal saddles as to deceive the most accurate observer.

Platyclymenia, nobis, includes species with similar sutures to Cyrtoclymenia, but the whorl is discoidal as in the Oxyclymenia and it differs from both of these in having costated whorls, which are in section sub-quadragonal Platy. annulata, ibid, pl. 15, fig. 11, and includes, also pl. 18, fig. 12, spinosa, pl. 16, fig. 1, and binodosa, pl. 19, fig. 1, though the latter has an internal lateral saddle.

CYMACLYMENIDAE.

The forms have undivided ventral saddles, and two pairs of lateral lobes, the first pair angular and the second pair in the umbilicus and rounded. The siphon is transitional to the large siphoned species of the next family.

Cymaclymenia includes species with forms similar to those of Cyrtoclymenia, but more compressed and involute. The sutures have prominent ventral saddles, and two lateral lobes with two umbilical or dorsal lobes on either side of the annular lobe. Type, Cym, striata, ibid, pl. 18, and bilobata, pl. 19. These forms in their siphons and their sutures connect Cyrtoclymenia with the larger siphoned groups, the Nothoclymeniae of Gumbel, which begin with the next genus.

Sellacymenia includes species with whorls compressed, sub-quadragonal and precisely similar to Platyclymenia but the sutures are similar to those of Cymaclymenia and the siphon also according to Dr. Gumbel is large and complete. Type, Sel. angulosa, pl. 19.

GONIOCLYMENIDAE.

The ventral saddles are divided by median lobes, and by a pair of marginal lateral lobes. There are also two lateral lobes on either side. The siphon is large, and the funnels conical.

Cryptoclymenia, nobis, includes but one species. This has the form of Cyrtoclymenia and enables us to connect the series of genera having ventral lobes, with this radical genus. The sutures have median lobes dividing the large ventral saddles, and two pairs of lateral lobes. Type, Crypt. Beaumonti ibid, pl. 20, fig. 5.

Cycloclymenia includes an extraordinary discoidal species with numerous, slowly growing whorls. The sutures have the ventral saddles divided by median lobes.

Gonioclymenia includes species with quadragonal whorls, sometimes costated as in Sellaclymenia and Oxyclymenia but they have median ventral lobes, and two pairs of lateral lobes and large siphons. Type, Gonio. speciosa, ibid, pl. 20, and also subarmata and intermedia ibid, pl. 21. The Gon. pessoides V. Buch, and biimpressus, ibid, Gon. et Clym. pl. 1, probably are true Clymeninae as stated by Gumbel, and may be species of this genus.

Discoclymenia includes Clymenia Haueri, which has sutures very similar to those of the preceding, but the lobes are more numerous, and the annular lobes broad. The whorls are much involved and compressed in the adult with a deep impressed zone.

The similarity of the funnels and funnel lobes to those of the Nautilinidae, may be seen in Sandberger's figures in Jahrb. d. Nass. Ver. f. Naturk. Vol. 7, 1851, pl. 2. The Glyphioceratidae and Proleceanitidae have undivided ventral lobes in the lower or transitional genera, and divided ventral lobes and cloiochoanitic funnels in the higher and later occurring forms. Triainoceras and Pronorites, have transitional ventral lobes which may be considered as undivided, and all the remaining genera have the short, collarless type of funnel. The excessively short, rapidly narrowing funnels, and the similar character of the breaks which they make in the sutures of the ventral side, is a marked, and highly interesting peculiarity, and led to our designating the whole group at first as Epichoanites.[1] We supposed that all the following genera could be included in this group, and farther characterized as having simple funnels without collars.

Dr. Branco, however, in Zeit. Deutsch. Geol. Gesell. 1880, p. 607, note, made us aware that Beyrich's observation on Glyph. (Gon.) sphaericum, and Sandberger's figure of Glyph. (Gon.) crenistria Verst. Nass. pl. 5, fig. 1, showed that the siphonal collar was present in both of these species. Branco's statement that our definition of a collar may be regarded as a mere question of opinion cannot be sustained. The microscope makes it evident that the fore-reaching part of the septum is not like the posterior part. The fore-part is an open collar around the siphon, while the hinder part is a true funnel, interrupting the siphon as in our figure, Embryo. Ceph. Bull. Mus. Comp. Zool. 3, No. 5, pl. 2, fig. 15. Sometimes also as in the cases above cited, and in the type of Schistoceras described farther on, it is easy to see with unassisted eyes, that the true funnels below and the collars above are distinct from each other.

Primordialidae.

This group which is closely allied to the Nautilinidae, possese remarkable interest as the most primitive series in which many of the essential differentials of the Ammonitinae first make their appearance. The ventral lobes are very large, and are divided by

[1] We are not yet satisfied that this would not be a convenient descriptive designation for the whole of the Cloiochoanites [Transitiones] or all the Goniatitinae, except the Nautilinidae.

median siphonal saddles which carry the funnel lobes. The development of the sutures has been followed out by Branco, Sandberger, and the author, and all agree that these median saddles arise in the centre of the primitive ventral lobes. The two arms of the primitive ventral lobe become widely separated, and appear in the later stages of growth, like true lateral lobes. The first pair of saddles are large and rounded, though in the higher and more involute species, often angular. The ridges from these cross the septa and have corresponding dorsal saddles on either side of the annular lobe. The young are assellate, as first stated by Dr. Branco, and the first sutures and radical forms indicate direct derivation from the same stock as Anarcestes. While still in the broad whorled anarcestian stage, the septa are nautiloidian or concave, but when the deep ventral lobes and large lateral saddles are formed, the septa become ammonitoid or convex along the median line. The funnels, which are also anarcestian in the young, become shortened as the siphonal saddles arise and assume the ammonitoidal aspect, though no collars are developed. The funnel lobes are variable in size, and may be absent in some specimens, as in two of Gephuroceras lamed in Coll. Mus. Comp. Zool. This variation has been also observed by Sandberger in this same species and in same variety with one of the above cited instances namely, lamed Var. cordatus, Jahrb. d. Nass. Ver. f. Naturk. Vol. 7, 1851, pl. 3, fig. 21, 22. The early larval sutures have broad dorsal lobes, which become narrowed into annular lobes in later stages correllatively with the development of the ammonitoid septa, and especially with the development of the first pair of lateral saddles. We adopt Beyrich's name of Primordialidae as more significant than that subsequently given by Sandberger.

Gephuroceras,[1] nobis, includes species with discoidal young, whorls with broad and more or less flattened abdomens in the adolescent stages, and the sides divergent as in Manticoceras. There is a decided resemblance to the adults of this genus especially to Man. latidorsatum, but the larval and adolescent stages in the radical species are separable by means of their flattened abdomen and less rapidly growing whorls. The adult whorls become

[1] Γέφυρα, a bridge.

compressed and subacute in several species, but retain their open umbilici except in the most involute species. In these, however, the larvae remain sufficiently constant to enable us to recognize the genus. The serrated or costated abdomens of the young of several forms, is also in marked contrast with Manticoceras. The depth of the ventral lobes causes the septa to assume a convex aspect, but the median line remains concave until a late stage of growth. The large lateral saddles when first formed, and until a comparatively late stage in radical species, have no corresponding dorsal saddles, these arise later as two minute saddles in the dorsal lobe, on either side of the annular lobe. The species are Geph. (Gon.) calculiforme, Beyr. Sandb. Verst. Nass. pl. 8, fig. 9–9a (not 9c–d), aequabile, Beyr. Gon. Mont. Rhen. pl. 2, fig. 1, and also Sandb. pl. 8, fig. 10, to which last also belong Sandberger's figures 9c–d mentioned in brackets above, Hoeninghausi, D'Arch. et Vern. Trans. Geol. Soc. Vol. 6, n. s. pl. 25, and Buchii, ibid, pl. 26, fig. 1, serratum, sp. Sandb. pl. 9, fig. 8, planorbe; sp. Sandb. pl. 9, fig. 3, forcipifer, sp. Sandb. pl. 6, fig. 3, discum, Roem. Nordw. Hartz. Paleontogr. Vol. 6. pl. 13, fig. 35 (not pl. 6, fig. 7) and bisulcatum ibid, pl. 6, fig. 8, acutum, Keyser, Dom. Schief. Verh. Mimneral. Gesell. St. Petersb. 1844, pl. A fig. 6. In America we have seen only Geph. (Gon.) complanatum, sp. Hall, Nat. Hist. N. Y. Vol. 5, pl. 70, fig. 6–12, and the Type, Geph. sinuosum, ibid, pl. 70, fig. 73–75, Mus. Geol. Surv. Albany.

Manticoceras,[1] nobis, includes species with compressed and often very involute whorls, which are, however, directly traceable by the closest gradations into forms with broad whorls, open umbilici, and an aspect similar to that of Anarcestes. The young are invariably less discoidal than in Gephuroceras, the abdomens rounded, and the sides divergent outwardly. A close resemblance to Agoniatites bicaniliculatus, or tuberculosocostatus [2] occurs in the costated young and in the sutures and form of Mant. tripartitum until a late larval stage. The adult sutures have the same general aspect as those of Gephuroceras, but the septa in the compressed involute forms become more decidedly convex. The

[1] **Μαντικός**, prophetic.

[2] This is a costated species of Agoniatitites, which we have supposed to be equivalent to Sandberger's figure Verst. Nass. pl. 2, fig. 3. It also resembles costulatus D'Arch. et Vern. Trans. Geol. Soc., pl. 26, fig. 8.

lobes remain rounded until later stages of the growth, the funnel lobes are generally smaller, the larger lateral saddles are also more persistent and retain their forms unchanged even in the extreme old stages of the largest specimens. The species are as follows, Manti. (Gon.) latidorsatum, Sandb. Verst. Nass. pl. 8, fig. 8, tripartitum, ibid, fig. 7, lamed, fig. 4, 6, are all regarded by Sandberger as varieties of lamed, but they can be distinguished by their development from each other. Manti. (Gon.) intumescens, Beyr. Rheins. Ueberg. pl. 2, fig. 4, Sandb. ibid, pl. 7, Manti. (Gon.) complanatum, pl. 8, fig. 5, the latter a variety of lamed Sand. both have in adults excessively acute, and involute whorls. Manti. (Gon.) bisulcatum, sp. Keyser, Dom. Schief, Verh. Min. Gesell. St. Petersb. pl. A, fig. 7, seems to be in this genus. In America we have found, Manti. (Gon.) simulator, sp. Hall, Nat. Hist. N. Y. Vol. 5, pt. 2, pl. 69, fig. 1,2, Pattersoni, ibid, pl. 72, fig. 1–5, Gon. Goniolobus, Meek, Geol. Expl. 40 Parall. Vol. 4, pl. 9, fig. 5, may possbly be a greatly modified Carboniferous form of this genus with closely approximated septa. Type, Manti. simulator, sp. Hall, Mus. Geol. Surv. Albany.

Magnosellaridae.

This family is distinguished by the early development and undivided outlines of the magnosellarian saddles, which induced Sandberger to designate the group as the Magnosellares. The ventral lobes are primitive and undivided, and in the lower forms are small, and really mere funnel lobes breaking the outlines of the ventral suture. This is a purely nautilinian character and the first pair of saddles also retain a similar primitive aspect, but in the higher forms tend to split up and form a first pair of lateral lobes and a second pair of saddles. The first pair of saddles have no correspondent on the dorsum but the second pair have corresponding dorsal saddles when they are present, as in Maenoceras and Sporadoceras. These facts justify the opinions of Mojsisovics, and others that the sutures of this genus are approximate to those of the Nautilini, and our own observations indicate closer affinity for Anarcestes, than for any other genus. The figures given by Sandberger in Jahrb. d. Nass. Ver. f. Naturk. Vol. 7, 1851, pl. 2, of Parodiceras biarcuatum, and amblylobum illustrate this affinity for Anarcestes, especially since these two have no annular lobes on the dorsum. The septa are concave as in the Nautilini in the larvae, but become convex internally after the rise of the magnosellarian saddles. The magnosellarian saddles, besides their prevalence in the Devonian species and in the larvae of later forms, are notable as resembling the similar large saddles of some of the Nautiloids, as in the young of Enclimatoceras, and the rise of the septa dorsally in some of the Anarcestes group.

Parodiceras,[1] nobis, includes species with whorls in section semilunar, sutures with very broad, generally flattened, and primitive forms of the first pair of saddles, lateral lobes shallow and mostly angular, the magnosellarian saddles, often rising, as in the young of Tornoceras above the level of the first pair on the venter. Our opportunities for study in this genus have been limited but we have been able to see that some species have very small annular lobes and others, as figured by Sandberger in Jahrb. d. Nass. Ver. Naturk. above quoted, had probably no annular lobes. These characteristics of the septa and the general aspect of the adults are transitional from Anarcestes to Tornoceras. In Branc. umbilicatum according to Sandberger's figure, in Jahrb. Nass. Ver. Vol. 7, 1851, pl. 2, fig. 9, there are slight saddles on the dorsum corresponding to the first pair on the venter, while in biarcuatum and amblylobum there are none. The first named species is directly transitional from Parodiceras to the genus Brancoceras.

The young are stouter than in Torn. auris and they also inherit the semilunar and involute whorls at early larval stages. Parod. curvispina is discoidal and biarcuatum, planilobum, angulatum are all more involute species figured by Sandb. Verst. Nass. pl. 10, but the last is laterally compressed. Parod. amblylobum, ibid, pl. 10, fig. 8, and pl. 4, fig. 5, has a compressed whorl in the later larval stages. Parod. oxycantha Sandb. pl. 10, fig. 3, in some specimens shows a decided tendency to division of the ventral saddles as in Maenoceras bifer. Parod. (Gon.) sublineare Munst. Ueb. Clym. et Gon. pl. 4, fig. 5, according to Munster's figure is transitional to the simpler sutures of Parod. (Gon.) undulosum, sublaevis, and globosum, sp. Munst. Ueber Clym. et Gon. pl. 4. We have found but one species in this country, the

1 Πάροδυς, transition.

type of our genus, Parod. (Gon.) discoideum, sp. Hall, 13, Rep. on State Cabinet and also Nat. Hist. N. Y. Vol. 5, pt. 2, pl. 71, fig. 1–13.

Tornoceras,[1] nobis, includes species which are similar to Parodiceras, but have compressed whorls, and annular lobes. The sutures have rounded saddles on the venter and rounded lateral lobes with the typical magnosellarian saddles of the family. The first pair of saddles have no corresponding saddles on the dorsum, and the annular lobes are situated immediately between the large dorsal saddles corresponding to the magnosellarian saddles. The ventral lobes and sutures in the larval stages are similar to the adults of Anarcestes. The stage at which the ventral saddles are in a primitive condition has close resemblance to the older stages of Parodiceras. Sandberger's figures of Torn. (Gon.) circumflexum, Verst. Nass. pl. 10, fig. 9, and auris, pl. 10 a, fig. 19, and Hall's figure of the young of uniangulare show this very well. The effect of the lateral saddles in elevating the internal parts of the septa and the concavity of the outer parts of the same sutures, which remain concave throughout life, are well shown in Sandberger's figures of Torn. auris, pl. 10, a, fig. 4, 5. Torn. (Gon.) discum, sp. Roem. Nordw. Hartz. Paleontogr. Vol. 3–pl. 6, fig. 7, and auris, ibid, pl. 6, fig. 11, both have sutures even in late stages, perhaps adults, very similar to those of Anarcestes, according to Roemer's figures. Torn. auris, sp. Sandb. pl. 10 a, fig. 12, and Var. pl. 10, fig. 11–12, together with Var. pl. 10 a, fig. 18, 19, make together a series which we include under the same name. Var. undulatus, pl. 10, fig. 17–19, also belongs to this species. Torn. (Gon.) retrorsum, sp. Von Buch, has a stout variety similar to auris, the typical variety undulatus Sandb. pl. 10 a, fig. 7, has morecompressed whorls than auris even in larval stages. The young in both of these varieties are smooth, and exhibit no signs of the raised and costated abdomen of auris, though here and there, specimens with reversionary characteristics occur. Var. typus. Sandb. pl. 10, cannot be separated in the larva or adults from the above. Torn. acutum, sp. Sandb. pl. 10, fig. 10, pl. 10 a, fig. 2, can be separated by the sub-acute whorl of the adolescent stage and the breadth of the later lobes and narrow

1 Τόρνος, circular or rounded.

ventral saddles. In America we find Torn. (Gon.) Mithrax, sp. Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, pl. 69, bicostatum, ibid, pl. 72, fig. 8–10, and the type, Torn (Gon.) uniangulare ibid, pl. 71, 72.

Maeneceras,[1] nobis, includes forms in which the first pair of saddles are broad, somewhat flattened, and during growth tend to become subdivided. The inner angles become subacute, and small marginal lobes appear between the outer angles and the ventral lobes. These changes may take place late in the life of theanimal or be inherited at comparatively early stages in accordance with the lawof concentration of development in the more complicated species. The dorsal sutures change correllatively, and acquire a pair of subacute dorsal saddles on either side of the annular lobe as in Sandberger's Maen. terebratum, Verst. Nass. pl. 5, fig. 3 d. Sandberger's figure 4 of Maen. bifer, and his figure 5 c of Maen. (Gon.) delphinum show, that as in Sporadoceras the dorsal saddles were connected with a second pair of saddles, and not probably with the primitive saddles. The larval stages, are identical in form and sutures with Parodiceras. Maen. (Gon.) bifer, sp. Sandb. ibid, pl. 9, fig. 4, is closely allied to Parod. oxycantha but has the genetic characters of this genus in the later larval stages. Maen. (Gon.) terebratum, sp. Sandb. ibid, pl. 5, fig. 3, exhibits all these characteristics, and the changes in the first pair of saddles described above at still earlier stages. The adult form of this species is the Maen. (Gon.) acuto-laterale Sandb., pl. 6, fig. 1b. The whorl in this stage is no longer rounded, but subacute, and the first pair of saddles are completely divided by rounded lobes. We have studied the intermediate adolescent stages of this species, and have been able to connect the two figures quoted by a fine specimen precisely intermediate in size and all its characteristics. Coll. Mus. Comp. Zool., type Maen. acuto-laterale, sp. Sandb.

Sporadoceras,[2] nobis, includes species which like Maeneceras have additional saddles developed from the division of the first or primitive pair of saddles, but these are generally pointed in adults and the first and second pairs of lobes hastate. The forms of the shells still remain similar to those of Parodiceras and Maeneceras and the magnosellarian saddles are undivided. A

[1] Μήνη, a crescent. [2] Σποραδός, scattered.

specimen in the Col. Mus. Comp. Zool. either identical or closely allied to Spor. bidens exhibits primitive saddles incompletely divided although the shell is about 4.3 cent. in diameter. The ventral lobes, and the first pair of marginal lobes are still comparatively small and are elevated upon the large primitive, larval saddles. This genus also as in the preceding shows two dorsal saddles which arise in correlation with the formation of the additional second pair of saddles, and are connected with them by ridges traversing the septa. The first pair of saddles have no correspondents on the dorsum. Sandberger's figure of Spor. bidens, pl. 8, fig. 11, illustrates these observations completely. The annular lobe is deep and undivided. Spor. (Gon.) bidens, sp., Sandb., pl. 8, fig. 11, bilanceolatum, ibid., pl. 9, fig. 7, and Spor. (Gon.) contiguum, sp. Munst. Clym. et. Gon. pl. 3, fig. 8, orbiculare, ibid, pl. 5, fig. 4, cucullatum, sp. Von Buch, Gon. et Clym. pl. 1, fig. 4, Hoeninghausi, sp. Von Buch. Ueber Amm. et Gon. and Munsteri, ibid, pl. 2; fig. 4, 5, also Sand. pl. 5, fig. 2, are examples of this genus. Type, Spor. bidens, sp. Sandb.

Glyphioceratidae.

This family includes forms having whorls semilunar in section and discoidal shells, with some more compressed and involute forms. The ventral lobes are undivided in the lower transitional forms which connect the family directly with Parodiceras, among the Magnosellaridae, but in the higher genera they are divided by siphonal saddles with cloiochoanitic funnel lobes. The first or primitive saddles are on the venter, the first or primitive lateral lobes are contracted in breadth, deep, and often angular, the magnosellarian saddles are undivided in some genera and divided in others by a single pair of wide, shallow, angular lobes. The primitive, or first pair of saddles have corresponding saddles on the dorsum, on either side of the deep, undivided, annular lobes. The development and outlines of the sutures, and the ventral lobes exhibit the close affinities of this family for the Magnosellaridae, and the still younger stages, as described by Branco, show their affinities for the Nautilinidae, especially Anarcestes.

The septa are convex along the median line, in all the genera except in the transitional genus Brancoceras. The development of the siphonal saddles is similar to that of the Primordialidae, but the gradations of the forms and sutures are unmistakable and connect them genetically with the genus Parodiceras. The siphonal saddles are evidently in this and other families purely representative characteristics arising from the tendency to divide the primitive ventral lobes. Within the families, however, it is evident that the siphonal saddles are inheritable after they have been introduced, and become fixed in the organization. In each of the three sub-families, the siphonal saddles are in accordance with this law first independently generated, and then become fixed.

The essentially representative character of the division of the lobes and saddles when first introduced in each series is especially well exhibited in the Dimorphocerae. In this tribe the ordinary outlines of the sutures of this family are modified by the introduction of marginal saddles, which sub-divide the lobes, as among the more recent Ammonitinae. After careful investigation, we can find no evidence for the supposition that the recent Ammonitinae acquired their similar modes of dividing the lobes by direct inheritance from such highly involute Carboniferous species. On the contrary there is strong evidence that the Triassic Ammonitinae sprang from discoidal shells with forms of whorl more closely resembling the primary radical Anarcestes.

If we analyze the forms of Triassic species, as they have been published by Mojsisovics in his classic work Med. Trias., Prov. we are at once struck by the prevalence in every series of a certain proportion of discoidal forms, and by the fact that these are repeated in the young of the more involute forms of the same series, as is not infrequently noted by Mojsisovics himself in his descriptions. Some genera like the Sphingites among Arcestidae and Tirolites, and Xenodiscus may have all, or nearly all the species discoidal, but as a rule the variation from these forms to much more involute, or completely involute forms takes place in the same genus, and is useful only in distinguishing the species. The discoidal or less involute forms are always the simplest in the structure of the sutures, as well as larval in their own series; witness again Sphingites and Xenodiscus, also such single species as are found in the group of Trach. furcosa, and Monophyllites.

Arcestes, Dyas, and Trias, so far as we know, is the only group as a whole, which possesses in the adults the depressed larval form of the Silurian Anarcestes, which we also recorded as occuring in nearly every group of the Goniatitinae and at the morphological base of the groups of the Clymeninae. This form of whorl has almost disappeared in the Trias and its place is taken by quadragonal derivatives, like Xenodiscus, and the compressed helmet shape, which we have designated as the secondary larval forms. Whatever form we may admit into the category of secondary larval radicals, they must in all cases be discoidal, with open umbilici; and either themselves, or their immediate ancestral forms must be shells, without spines or prominent outgrowths, though they may be costated, as in Sandbergeoceras, the immediate radical of the Prolecanitidae. The exact agreement between the sutures and forms, and their development both in the series and in the individual is not in the Trias substantiated by the observed geological positions of many species, in fact the occurence of Monophyllites, Sphingites, and Ceratites Sturii and the secondary radical, Dinarites Mohammedanus and other instances are directly against these views. This, however, does not at all alarm us, if there is any truth in the theory of descent, we feel sure that the clue lies in the development of the individuals which occupy the lower morphological borders of each series, and exhibit in their forms, sutures, and shells, the nearest approach to the primary radicals of the Silurian or Cambrian.

The Paleozoic or primary radical is Anarcestes, and its depressed whorl becomes larval in the more involute forms of all the genetic series with which we are acquainted among the Paleozoic Goniatitinae, being absent from the early stages only in forms with gyroceran young, and it is inherited by all forms above the Carboniferous, at the earliest stage of the formation of the apex or conch.

The discoidal secondary radicals are unquestionably the nearest allies of this primary radical, which occur in the Devonian, and these in their turn have a similar relationship with the Dyassic and Triassic species having similar discoidal forms and simpler sutures than other more involute shells of their several groups. We can, therefore, with the reservation, that the connections have not been actually made, state that a great change takes place in the Dyas, and that here or about the time of the end of the Paleozoic the secondary larval radicals, or Mezosoic helmet-shaped with more complicated lobes and saddles like Monophyllites, Ceratites Sturii, Dinarites Mohammedanus, and the less involute, smooth, similar, forms of Gymnites, Ptychites, perhaps also Pinacoceras, and Ophiceras begin to be more numerous and to replace the Paleozoic radicals as generators of distinct genetic series. Psiloceras, though in the Jura, belongs, we think to this class of radical forms.

The tertiary radical forms of the Jura and Cretaceous are often highly ornamented and complex in their sutures, but they are also discoidal, like all other larval radicals and they give rise to progressive series of more involute forms as we have tried to demonstrate in several families, and numerous genera. Following out Häckel's nomenclature which we regard as truthful and expressive, these categories of radicals can be very appropriately designated as the Epacmatic, and Acmatic radicals, and when as is often the case, the Acmatic forms become the radicals of degenerative series of uncoiled forms, we propose to call them Paracmatic radicals.

[Gastriocerae.]

Brancoceras,[1] nobis, includes species of the Devonian and Carboniferous with undivided, ventral lobes, rounded or spatulate first pair of saddles, broad, abrupt, magnosellarian saddles, and only one pair of often hastate lateral lobes. The spheroidal form of the shell, the deeply involute, and semilunar whorls show close affinities for Parodiceras. The adult stages still continue to have the septa concave along the centre, and only convex in the region of the magnosellarian saddles. The annular lobes are large and undivided, and the first pair of saddles have corresponding saddles on the dorsum. The dorsal sutures have also large saddles corresponding to the magnosellarian saddles as in the Magnosellaridae and three lobes. The internal sutures are, therefore, precisely similar to those of Sporadoceras, but the external sutures have one pair less of lobes and saddles, and in that genus the first pair of saddles on the venter have no correspondents on the dorsum. The closest connection evidently exists between this genus and Munsteroceras, which have similar outlines in the sutures, and rounded first lateral lobes as in this

[1] Dedicated to Dr. W. Branco.

genus. Bran. (Gon.) sulcatum, sp. Munst. Ueber Clym. et Gon. pl. 3, fig. 9, ovatum, ibid, pl. 4, fig. 1, lineare, ibid, pl. 5, fig. 1, subsulcatum, ibid, pl. 5, fig. 2, and Ungeri, Munst. Beitr. are all good examples of this genus. The type, Bran. (Gon.) Ixion sp. Hall, Nat. Hist. N. Y., Vol. 5, pl. 78, which is a close ally, if not identical, with Bran. (Gon.) rotatorium, DeKon. Calc. Carb. pl. 47, fig. 12, has young, ibid, pl. 73, fig. 12, which are similar in their globular shells, and in their sutures to the adults of the more spherical species of this genus. Branc. umbilicatum, sp. Sandb., has external sutures very similar to those of Parodiceras and is mentioned in the description of that genus.

Munsteroceras,[1] nobis, includes species of the Upper Devonian or Lower Carboniferous which resemble Brancoceras closely in form but are more discoidal. The siphonal saddle is small or larval in shape and is developed in the centre of a deep, often straight-sided ventral lobe. The first or primitive saddles are on the venter and spatulate in outline. The magnosellarian saddles are undivided on the sides in the lower species of this group, but a curious and instructive variation takes place in American forms. Munst. parrallelum has the outer suture of the magnosellarian saddle depressed posteriorly below the level of the inner suture of the corresponding dorsal saddle. An acute lobe is thus formed on the edge of the umbilicus, and a small saddle rises inwardly from this towards the zone of compression, and is visible near the edge of the umbilicus in Munst. Oweni. In Gastrioceras this lobe becomes more important, and in Paralegoceras it is a lateral lobe, and plainly visible on the sides. In the upper Devonian, according to Hall, we find Munst. parallelum, nobis, equals Oweni var. parallela, Hall, Nat. Hist. N. Y., Vol. 5, pt. 2, fig. 1, 2, pl. 73, the members of this genus are Munst. (Gon.) Whitei, nobis, equal Oweni, sp. White, Geol. Ind. Ann. Rep. 2, 1880, Pal. pl. 7, fig. 3, 4 (Gon.) tumidum, sp. Roem. Paleontogr. Vol. 3, pl. 13, fig. 3, 4 (Gon.) implicatum, sp. Phill. Geol. York. pt. 2, pl. 19, fig. 24, 25, reticulatum, ibid, fig. 26–32, excavatum, ibid, fig. 33–35, complanatum, DeKon. Calc. Carb. pl. 46, fig. 4, inconstans, ibid, pl. 48, fig. 4–9, truncatum, ibid, pl. 48, fig. 2, 3, implicatum, ibid, pl. 50, fig. 2. The forms are all more involute than Munst. Whitei,

[1] Dedicated to the memory of Georg, Graf zu Münster.

which is a discoidal shell. Type, Munst. parallelum, sp. Hall, Mus. Geol. Surv. Albany.

Gastrioceras,[1] nobis, includes species with open umbilici and whorls in section semilunar or trapezoidal. The abdomen is wider than the dorsum and the sides often costated. The larvae always have whorls semilunar in section, and similar in form and sutures to the larvae of Brancoceras during the stage before the generation of the siphonal saddles. The siphonal saddle is developed as in the Primordialidae, but is not usually so large or broad as demonstrated by Branco and confirmed by our own observations. The sutures at earlier stages and the whorls have the usual similarity to those of the adults of Anarcestes. The adolescent and adult stages have deep, straight-sided ventral lobes and siphonal saddles which are often more or less prominent and angular. The first pair or primitive saddles are on the venter and often spatulate making the sutures similar to those of Munsteroceras, while the general aspect of the shells is representative of Glyphioceras. The magnosellarian saddles are divided at the shoulders of the whorls with acute lobes, and internally are flanked by saddles rising rapidly to the zone of impression as in Munsteroceras. Gast. (Gon.) Listeri, sp. Phill. Geol. York. pl. 20, fig. 1, of the Carboniferous and Marianus, ibid, pl. 27, fig 2, and Jossae, sp. M. V. K. Russ. and Ural Mts. pl. 26, fig. 2, both from the Dyas are European examples of this genus, and in this country we find Gast. (Gon.) Kingii, sp. H. W., U. S. Geol. Surv. Expl. 40th Parall. Vol. 4, pl. 6, fig. 8, and (Gon.) globulosus, sp. M. W., Geol. Surv. Ill., Vol. 2, pl. 30, fig. 2.

Paralegoceras,[2] nobis, is similar to Gastrioceras in its sutures, but the whorls are compressed, and the sides smooth in the cast. The sutures are similar also to our genus Schistoceras, but the broad, shallow, angular second lobes, and the peculiar internal saddles show closer affinities for Gastrioceras and Munsteroceras. It is apparently a compressed Carboniferous form directly connected with Gastrioceras. The only species known to us is the Paral. (Gon.) Iowense, M. et W. Geol. Ill, Vol. 2, pl. 30, fig. 3, from the coal measures.

[1] Γάστρις, a pot-belly.

[2] Παραλέγω, I lie by the side of.

[Prionocerae.]

Prionoceras,[1] nobis, includes species with broad, acute, straight-sided, undivided, ventral lobes similar in outline to the first pair of saddles, and the first pair of lobes. The magnosellarian saddles are undivided. The young of these shells, if they had the same mode of development as other Goniatites must have had more rounded first pair of saddles at some stage of growth, and this would render the sutures at this stage similar to those of some forms of Parodiceras. The immediate affinities, however, connect them with Brancoceras, from which genus we should not have dared to separate Prionoceras, but for the artificial necessity of showing clearly the genetic relations of this genus and Glyphioceras. The species differ from Brancoceras only in the acuteness of the first pairs of saddles and lobes, and their peculiar pyramidal shape. The type is Pri. (Gon.) divisum Munst. Ueber Clym. et Gon. pl. 4, fig. 6, of the Devonian. This species and Pri. Belvalianum, De Kon. Anim. Foss. pl. 49, fig. 5, and Calc. Carb. pl. 50, figs. 8–10, have sutures similar, in their undivided ventral lobes, and lateral outlines, but the first pair of saddles on the venter are pyramidal in shape, like those of Glyphioceras, and are evidently transitions to this last genus.

Glyphioceras,[2] nobis, includes species with whorls in section semilunar, trapezoidal or compressed, the abdomens broad and convex, the sides divergent outwardly, and frequently costated. The sutures are remarkable for the acute, angular outlines of the lobes and saddles in the adolescent and adult stages, and the large size and frequently bottle-shaped siphonal saddle. There are exceptions to the angularity of the lobes in some species, which retain the early larval form of the outlines of the sutures in their later stages of growth, but in these, the rapidly narrowing ventral lobes, and the large size of the linguiform first lateral saddles enables one to refer the species to their proper genus. In their later larval stages the sutures are not distinguishable from those of Munsteroceras, with which also the forms of the whorl agree equally closely. The siphonal saddles are small, and occupy only the apex of the straight-sided, deep ventral lobes, and the first pair of saddles are spatulate, and the lateral lobes and magnosellarian saddles are precisely as in that genus.

[1] Πρίων, a saw.

[2] Γλύφις, the notch in an arrow.

Notwithstanding the extraordinary development of the siphonal saddles, there is no corresponding division in the annular lobe, which is subacute and entire in outline. The first pair of saddles have corresponding but smaller and less acute saddles on the dorsum, and the magnosellarian saddle is also nearly as prominent as on the venter. The umbilical shoulders are occupied by rounded lobes. All the known species are found in the Carboniferous and have the pyramidal form of siphonal saddle. The funnels are surmounted by collars which can be seen on good casts of Glyph. sphaericum and which closely simulate the collars of Schistoceras.[1]

It seems evident that Prionoceras is the intermedium between this genus and the common family radical, Brancoceras. The young of Glyp. obtusum, as figured by DeKon. Calc. Carb. pl. 47, shows the relation of the group to the more remote radical Parodiceras with which the sutures agree quite closely except in the siphonal saddle.

Glyph. (Gon.) crenistria, sp. Phill. Foss. Corn. Devon. pl. 50, fig. 234, spiralis, Rom. Nordwest–Harzegeb. Paleontoger. Vol. 3, pl. 8, fig. 15, carbonarium, Buch. Ueber Goniat. pl. 2, fig. 9, sphaericum, Calc. Carbon., pl. 47, fig. 3–5, striatum, Sow. Min. Conch., trans., pl. 53, fig. 1, striolatum, Phill. Geol. York. pt. 2, pl. 19, fig. 14–19, truncatum, Rom., Nordwest–Harzegeb. Paleontogr. Vol. 3, pl. 13, fig. 30. The shells in this section of the genus are involute but the umbilici open, and the whorl semilunar in section. The ventral lobe has a distinct siphonal saddle, which divides it into two acute terminations, the first pair of lateral saddles are inclined towards the umbilicus, and often acute, first pair of lateral lobes also acute, the magnosellarian saddles are undivided.

The second section includes the following, Glyph. (Gon.) obtusum, sp. Phill. Geol. York. pt. 2, pl. 19, fig. 10–13, micronotum, ibid, pl. 19, fig. 22, 23, platylobum, ibid, pl, 20, fig. 5, 6, stenolobum, ibid, pl. 20, fig. 7–9, Barbotanum. M. V. K., Russ. and Ural, pl. 27, fig. 3, diadema, ibid, pl. 27, fig. 1, complicatum, Kon. Calc. Carbon. pl. 50, fig. 4, nitidum Phill. ibid. pl. 20, fig. 10–12. These shells have similar sutures, but the saddles are often slightly rounded or linguiform, and the whorls compressed. The siphonal saddles are smaller, and larval in shape and proportion. All of the first list except spiralis occur in the lowest beds of the Carboniferous, and

1 See also p. 315, and p. 336.

those of the second list in the formations, up to the Lower Coal Measures of Bigsby and Etheridge.

[Dimerocerae.]

Dimeroceras,[1] nobis, includes a single species, Dim. (Gon.) mamilifer, sp. Sandb. Verst. Nass. pl. 5, fig. 5, which has rounded first pair of saddles on the venter, rounded first lateral lobes, and an additional pair of shallow, broad, angular, lateral lobes near the umbilical shoulders, generated by the division of the magnosellarian saddles. The ventral lobes are undivided and this species is evidently a transitional from Brancoceras to Pericyclus.

Pericyclus, Mojsis. Mediter. Trias. Prov. p. 141, includes two Carboniferous species which were designated by that author without description. The spatulate first pair of saddles and the additional, broad, angular, lateral lobes, which arise from division of the magnosellarian saddle give the sutures exactly the aspect of those of Dimeroceras. The genus can be separated only by the divided ventral lobes, and costations. Type, Peri. (Gon.) princeps, DeKon. Anim. Foss. and Calc. Carbon. pl. 49, fig. 1.

[Dimorphocerae.]

Homoceras,[2] includes only the curious species (Gon.) calyx, sp. Phill. Geol. York. pl. 20, fig. 22, 23. This has trapezoidal whorls, like those of Gastrioceras, and sutures which are quite similar to those of Glyphioceras. The form is, however, dwarfed with sutures still more like those of Nomismoceras, which has similar dwarfed forms. The siphonal saddles are small, the ventral lobes broad, and open, the first saddles and lobes rounded, and the magnosellarian saddles short, undivided, and rounded. The sutures show the species to be in the same series as Nomismoceras, but the highly depressed, trapezoidal form of the whorl obliges us to separate it from that genus. Gon. mutabilis Phill. ibid, pl. 20, fig. 24, 25, not fig. 26, may also belong to this genus, but there are no sutures as yet known.

Nomismoceras,[2] nobis, includes a series of dwarfed forms with compressed whorls, open umbilici, resembling in minature the larger forms of the Prolecanites but differing from these

1 Διμερτ's, in two parts. 3 Νόμισμος a coin.
2 ʽΟμός, like,

decidedly in their sutures. The ventral lobes are divided, and very broad and large, the lateral sutures generally are very like those of the second section of the genus Glyphioceras with which the forms are evidently closely allied, but the small siphonal saddles, and the larger size, and rounded outlines of the first pair of saddles, and the aspect of the magnosellarian saddles are differences of some importance. Nomismoceras (Goniatites) spirorbis Phil. Geol. York., pl. 20, fig. 51–55, rotiformis Phil. ibid, pl. 20, fig. 56–58, paucilobus Phill. ibid, pl. 20, fig. 36–38, platylobus Rom. Nordwest. Harzge. Paleontogr. Vol. 3, pl. 13, fig. 32. The whorls are discoidal, compressed, and helmet shaped in section in the first two species, and involute, compressed, and subtrigonal in the last two. Nom. paucilobus in form and sutures, is intermediate between the discoidal forms of this genus and Dimorphoceras.

Dimorphoceras,[1] nobis, includes Carboniferous species with involute compressed whorls, and sutures quite distinct from those of Nomismoceras on account of their peculiar siphonal saddles, narrow first pair of saddles and divided lobes, but resembling them closely in their magnosellarian saddles, and general aspect. They are in fact, only more complicated and modified examples of the same style of sutures, the lobes having ammonitic marginal saddles in place of entire outlines. They have a narrow, prominent, siphonal saddle, and minute funnel lobe, the arms of the ventral lobe on either side of this, are divided by one or two minute marginal saddles, the first lateral saddle prominent spatulate, the second lateral lobe divided like the arms of the ventral, the magnosellarian saddle broad and undivided. But two species are known to us, Dim. (Gon.) Gilbertsoni, Phil. Geol. York., pl. 20 fig. 27–31, Looneyl. Phil., ibid, pl. 20, fig. 32–35.

Prolecanitidae.

This family can be distinguished by the absence of the great magnosellarian saddles, which are so completely divided as to be more or less unnoticeable in adults, though visible as an underlying outline in some radical species, and in some larval forms such as Sand. Chemungense. The number of lobes and saddles varies greatly, but there are never less than two pairs of large, lateral

[1] Δίμορφος, double formed.

lobes in adults exclusive of the inner series of auxiliary lobes and saddles. One pair of lateral lobes, the outer pair of the adult stages, arises out of the division of the first pair of saddles in Prolecanites, and several pairs in Beloceras, but whether this may be considered exclusively the method of generation cannot be stated now. The primitive pair of lateral lobes are generally deepest and may be distinguished by this character. The general form of the matured lobes is hastate and the saddles club-shaped, but the Belocerae, the lowest or radical sub-family, and the lower or radical species of Triainoceras have simple flexuous outlines in the sutures. The ventral lobes are, as in other families, undivided in radical genera and species; and divided in higher forms of each tribe or sub-family group. The first pair of saddles have corresponding saddles on the dorsum, and there are deep, undivided, annular lobes. The dorsal suture is divided not only by this pair of saddles, but has additional pairs corresponding closely to the number of saddles and lobes on the exterior in all the broad whorled genera; except the umbilical lobes, which as in all the Goniatitinae have no correspondents. The radical genera appear to approximate to Sandbergeoceras and this genus is not traceable to Parodiceras, so far as we know. The other radical forms, however, like Sandbergeoceras Cnemungense and Phar. tridens have lobes and saddles, which indicate derivation from Magnosellaridae, and we have accordingly referred the group provisionally to this radical. This family is very interesting also, because we can directly trace a connection with Jurassic forms, and see that the phylliform marginal saddles of Lytoceras and Phylloceras are probably derived through Monophyllites of the Trias from Prolecanitidae. The line is evidently an unbroken one to Ptychites and we think these and the Phylloceratidae can be distinguished by the excessive division of the lobes, the attenuated and deeply cut saddles and the peculiar form of the siphonal saddles and their close relations to the first pair of saddles taken in connection with the phylliform marginal saddles, and the tendency to produce additional external saddles, and lobes, and numerous auxiliary lobes and saddles. We shall probably in forthcoming publications separate this whole series, including Arcestes from the Ammonitinae and Goniatitinae, under the name of Prolecanitinae.

[Belocerae.]

Sandbergeoceras,[1] includes species with peculiar saddles and obes, which are variable in number and larval in their outlines. The shells are discoidal, the form of the whorl in section is depressed, semilunar, the abdomen broadest, and there are costae from an early stage of growth. The ventral is undivided according to Sandberger's figures, and the funnel lobes break the suture with a peculiar tubular prolongation of the tips of the lobes, and with slight shoulders or minute incipient saddles on either side, like those in the undivided ventrals of Brancoceras. These are transitional to the minute siphonal saddles observed in the ventral lobes of Triainoceras, present in the lower Devonian forms. The species are Sandb. (Gon.) tuberculosocostatum, sp. Sand. Verst. Nass., pl. 4, fig. 1; and Sandb. (Gon.) Chemungense, sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pls. 69 and 74. The last species has sutures which show it to be closely allied to Prolecanites. Though very simple in outline, they would not have been sufficient to separate it from Prolecanites but for the presence of costaticns on the whorls.

Beloceras,[2] nobis, includes only one species but the most remarkable and in many characteristics the most instructive of Devonian forms. The additional lobes and saddles are very numerous and have entire margins and are apparently only limited in number by the breadth of the whorl. They are partly derived from division of the ventral or primitive ventral saddles, and partly from the division of the magnosellarian or umbilical saddles. It must also be observed that here as in other forms the primitive pair of lateral lobes are marked by their greater size, and their earlier development.

Sandberger has traced the mode of genesis of the lobes and saddles in his text and in figure of Beloc. (Gon.) multilobatum, sp. Beyr., and Branco, Paleontogr., Vol. 27, ser. 3, pl. 6, fig. 6, has shown the process in its earlier stages. His figures and statements, however, do not make it perfectly clear, that the first pair of saddles are true primitive saddles, though they certainly seem to have a close resemblance to those of Maenoc. bifer. Mojsisovics in his "Gebirge um Hallstatt, p. 43 and 69 refers the type of

1 Dedicated to Prof. Guido Sandberger. 2 Βελος, an arrow.

this genus to his genus Pinacoceras, from which, however, it is separable by the characteristics given above, and by the very simple flexuous lobes and saddles of the adolescent stage, which resemble those of Sandbergeoceras.

[Sagecerae.]

Medlicottia, Waagen, Paleontol. Indica., ser. 13, pt. 1, p. 39, and p. 83, equals part of Sageceras as formerly defined by Mojsisovics. The lobes are divided by single linguiform marginal saddles, and the second species named below has trifoliate, or divided saddles, though the first pair and the marginal lobes have the same form as in Orbignyanum. The ventral lobes are deep and apparently undivided, the first pair of saddles are narrow long, and the margins cut by several lobes and saddles growing progressively longer internally. The numerous auxiliary lobes are generated apparently as in Beloceras from the marginal divisions in the outlines of the first pair of saddles, and from the division of large magnosellarian saddles near the umbilicus. We only know of two species which can be properly included in the genus. They are Medlic. (Gon.) Orbignyianum, sp. M. V. K. Russ and Ural Mts., pl. 26, fig. 6, and Medlic. primas, Waagen, Pal. Indica., ser. 13, pt. 1, p. 39 and 83, pl. 2, fig. 7, both Dyassic forms. Mojsisovics has pointed out the probable connection of this group with Beloceras and Sageceras in his Med. Trias. Prov. p. 183, and in this we also concur. There is no proof in support of Branco's opinion, that forms like these with divided lateral lobes can be separated from true Goniatitinae, but the contrary appears to be evident in all forms of the Carboniferous, Dyas, and Trias.

Sageceras, Mojsisovics, Mediterr. Trias. Prov. p. 187, Das Gebir. um Hallst. p. 69, is a Triassic genus, which, as shown by this author's admirable figures, has the closest relations of affinity with both Beloceras and Medlicottia. The lobes are more numerous than in Medlicottia and are divided by small saddles, which are themselves slightly denticulated, showing a nearer approximation to the marginal saddles and lobes of Ammonitinae than any other Goniatite except Cyclololus. Of the three species mentioned by Mojsisovics, two S. Haidingeri, sp. Hauer, and S. Walteri, sp. Mojsis. are European. In America Sag. Gabbi, Mojsis., equals Sag. Haidingeri, Gabb. Geol. Calif. Pal. Vol. 1, pl. 5, fig. 8–10. This genus is separable from Medlicottia by the flattened outlines of the first pair of saddles, and from Beloceras by its divided lateral lobes. We do not feel sure that the ventral lobes are undivided, though here as in Beloceras the generation of the auxiliary lobes and saddles on the venter is similar to the same process in Maeneceras, which takes place in the outlines of the first pair of saddles. These saddles and the sutures generally are similar to Beloceras. while the form of the whorl and abdomen show close affinity for Medlicottia.

Lobites, Mojsisovics, Das. Gebir. um Hallst. pt. 1, p. 155 and Med. Trias. Prov. p. 176 are apparently distorted or retrograde forms with sutures similar to those of this family. Whether they are really members of this family and can be traced to an origin in genera like Popanoceras or Sageceras or some allied groups, we have no proper means of ascertaining. Mojsisovics regards them as genetically connected with Maeneceras delphinum in which the living chamber is similar, having a contracted shape which appears at first sight to justify this opinion. We, however, can regard such resemblances as genetically important only when species are similar in the sutures, and also found in closer relations in time.

[Prolecanites.]

Prolecanites, Mojsisovics, Med. Trias. Prov. p. 199, includes species with more or less discoidal forms, smooth, compressed whorls and a variable number of lobes and saddles. The ventral lobes are undivided. The lobes are hastate and the saddles club-shaped. The first pair of saddles become divided to form an additional pair of lobes and saddles and the auxilliary lobes and saddles are formed by division of the magnosellarian saddles. According to this author the type is Prol. (Gon.) mixolobum, sp. Sandb. Verst. Nass. pl. 3, fig. 13, not pl. 9, fig. 6, which is a Pronorites. Besides the species enumerated by Mojsisovics we include in the same genus also Prol. (Gon.) lunulicosta, sp. Sandb. ibid., pl. 3, fig. 14 with five pairs of lateral lobes and saddles. As we have remarked above on p. 333, Sandb. Chemungense, sp. Hall, Nat. Hist., N. Y., Vol. 5, pt. 2, pl. 69, makes a very near approach to this genus.[1]

[1] Lecanites, Mojsisovics, Mediter. Trias. Prov. p. 200, which has for its type Lec. glaucus, ibid. pl. 30, is described by the author as genetically connected with Pro-

Pharciceras,[1] nobis, this genus can be readily separated from Sandbergeoceras which it very closely resembles in form, and in the general aspect of the sutures, by means of the divided ventral lobes and the smoothness of the whorls. Phar. (Gon.) tridens sp. Sandb. Verst. Nass. pl. 4, fig. 2, is discoidal, and (Gon.) clavilobum ibid. pl. 8, fig. 3, is very involute. There are two pairs of lateral lobes in tridens and a small umbilical lobe, and two pairs of dorsal lobes, and in clavilobum Sandberger figures four pairs of lateral lobes. Phar. (Gon.) multiseptatum, as figured by Quenstedt, Die Ceph. pl. 3, fig. 3, is a member of this genus.

Schistoceras,[2] nobis, includes a single species which is not figured or described, but can be readily distinguished by its large, bottle-shaped, siphonal saddle. This is the only characteristic by which it differs from Prolecanites. The two arms of the ventral lobe are widely separated, and there are only three pairs of lateral lobes and a small umbilical lobe with two pairs of dorsal lobes. The lobes are hastate, and the saddles more rounded and club-shaped, as in Prolecanites. The first pair of saddles have dorsal correspondents and the annular lobe is deep [and acute. The young is costated and the sutures closely resemble those of Pharciceras tridens, from which this form is apparently directly derived.

[Triainocerae.]

Triainoceras,[3] nobis, includes but one species which can be separated from Sandbergeoceras only by reason of the transitional condition of the ventral lobe. This has a trident shaped division caused, as in other forms and especially as in Pronorites, by the development of two small pointed saddles on either side of the large funnel lobe, in place of the development of a large median saddle carrying up with it the funnel lobe as in most other genera of Goniatitinae. This genus shows that Pronorites was derived directly from the radical Sandbergeoceras, and that its resemblances to Prolecanites were due to parallelism and, therefore,

lecanites, but we find this connection doubtful. Undoubtedly the sutures have quite similar outlines, but if we compare them with those of Celtites, pl. 28, fig. 5, there is a very close agreement, indicating the same stock rather than the more remote one of Prolecanites.

1 **Φαρκίς**, a wrinkle.

2 **Σχιστός**, cleft.

3 **Τρίαινα**, a trident.

could not have been inherited directly from that genus. The only species known to us is the Triai. (Gon.) costatum, D'Arch. et Vern., Geol. Trans. Lond., 2 ser. Vol. 6, pl. 31, fig. 1. This has sinuous outlines in the sutures with undivided rounded lobes and saddles, and costated whorls very similar to those of Sandb. tuberculoso-costatum. It can be separated from Pronorites by these same characteristics.

Pronorites,[1] described by Mojsisovics in Mediter. Trias. Prov. p. 200, includes an exceedingly interesting series of dwarfed forms, which present the marginal divisions of the lobes and saddles subsequently characteristic of the Ammonitinae. Genetic connection with the Prolecanitidae seems to be assured by the aspect of the sutures. The form of the whorl, and the later larval sutures have the aspect, number of lobes and saddles, and apparently the same mode of developing the outer first pair of saddles from the first pair of saddles, as in the Prolecanitidae. The lobes are hastate, the saddles linguiform, the ventral is not fully divided by a siphonal saddle. The divisions are, in their incipient stages, like minute points or saddles on either side of the large funnel lobes. Thus the apex of the ventral is trilobate. The saddles are rounded, but the first lateral lobes are subdivided by two incipient saddles in Pron. mixolobus, according to DeKoninck, a fact not verifiable in our specimens of this species. There is only one marginal saddle in the first lateral lobe of Pron. cyclolobus. The species, so far as known, are Pron. (Gon.) cyclolobus, sp. Phill. Geol. York. pl. 20, fig. 40–43, mixolobus, ibid, pl. 20, fig. 43–47.

Popanoceras,[2] nobis, includes species of the Dyas, which are very closely allied to Pronorites, but have more complicated sutures, and approximate more closely to the Ammonitinae. The whorls are more involute and compressed, and are also costated,

[1] *Norites*, Mojsis., Med. Trias. Prov., p. 201, is described by that author as genetically connected with Pronorites. We are forced to differ again from this able authority, since the affinities between these forms are due to larval stages of the sutures, which are equally characteristic of Carnites, and some other genera. The form of whorl of Norites and the outlines of the sutures appear to us, as to Griesbach, to be closer to those of Sageceras. Norites is not very remote from Longobardites, which in our opinion is in the young similar to the genus Prolecanites both in form of whorls, and in modes of generating lobes and saddles. It seems to us prossible that the derivation of the group may have been from the lower forms of the Prolecanitidae but not from Pronorites.

[2] Πόπανον, a round, flat cake.

or marked by furrows. The lobes and saddles are numerous and club-shaped. The ventral lobes are divided by prominent narrow, siphonal saddles, carrying small funnel lobes. Three or more pairs of lobes are divided by marginal saddles, either single or double, the terminations of the lobes being either bifid or trifid.

Popan. (Gon.) Kingianum, M., V., K., Russia and Ural, pl. 27, fig. 5, Koninckianum, ibid, pl. 26, fig. 4, Soboleskyanum, ibid, pl. 26, fig. 5. The extreme form is the Popan. (Arcestes) antiquum, sp. Waagen, Foss. of Salt. Range, Pal. Ind. ser. 13, 1, pl. 1, fig. 10, and this is a close ally of Waagen's Cyclolobus Oldhami.[1]

[Remarks.]

Xenodiscus Waagen, is discoidal and similar to Ophiceras, Griesbach, Rec. Geol. Surv. India, Vol. 13, pt. 2, pl. 3, and this is transitional to Otoceras, ibid, pl. 2, which is highly involute. These Dyassic forms are the immediate radicals of the Triassic Ceratitinae. The annular lobes are divided by minute saddles, and the sutures are distinctly ceratitic and cannot be closely compared with any of the Goniatitinae. The Ceratitinae also in our opinion include, Hungarites, Ceratites, Dinarites, Tirolites, Arpadites, Beneckia, Meekoceras, Kipsteinia, Balatonites, Trachyceras, Celtites, Badiotites, Proceltites, Lecanites, Carnites, Tropites, Acrochordiceras, Helictites, and Choristoceras. The larvae of these, and many adults, show sutures similar to those of Nannites, Mojsis. pl. 39, and to the Dimerocerae among Goniatitinae. If this view is admitted, the Magnosellaridae and Glyphioceratidae will become the distal Paleozoic radicals of the Ceratitinae of the Dyas and Trias, and the Ammonitinae be confined to Psiloceras and Aegoceras, and their descendants in the Jura. These two genera must be regarded as offshoots of the Prolecanitidae, with either Gymnites or Monophyllites as the immediate radicals.

[1] Cyclolobus, Waagen, Pal. Ind. ser. 13, 1, p. 21, has for the type Cycl. Oldhami ibid., pl. 1, fig. 9. This genus is very important since it enables us to show the gradations by which the Prolecanitidae approximate to Arcestes, Ptychites, and Monophyllites. Cyclolobus is a true Ammonite and cannot be separated from the Triassic groups we have mentioned either by its form or sutures; and the phylliform marginal saddles, which are so persistent in the succeeding forms begin to make their appearance in this species. They enable us to connect Cyclolobus with Monophyllites, and the last with the groups of Lytoceras and Phylloceras. Mojsisovics regards the phylliform saddles as having no genetic significance. We think the facts are against him in this opinion, and that, on the contrary, there are strong evidences of the direct descent of the Phylloceratidae from the Prolecanitidae.

General Meeting, April 18, 1883.

Vice-President, Mr. F. W. Putnam, in the chair. Nineteen persons present.

Mr. Wm. M. Davis read a paper on the causation of gorges and waterfalls in glaciated regions. Mr. Davis also spoke of the results of an excursion to Becrafts Mountain, on the Hudson. The Helderberg limestones were supposed to overlie unconformably the older sandstones, although the evidence was unsatisfactory and not nearly as clear as would be supposed from the diagram given by Mather, in 1843, in the Geology of New York.

Annual Meeting, May 2, 1883.

The President, Mr. S. H. Scudder, in the chair. Thirty persons present.

The following reports were presented: —

Report of Alpheus Hyatt, Curator.

It was rightfully imagined when the present plan of arrangement was adopted, that the greatest obstacle in the path of any attempt to show the natural relations of the products of the earth would be the department of Mineralogy. It has been found, however, that though the separation of minerals from the mother rocks on account of their purer composition and definite forms, is artificial, still this separation has its logical uses.

It enables us to explain with directness and precision the relations of all the elements, and their strictly inorganic compounds, and prepares the mind for the consideration of the more complicated aspects of the Geological and Biological collections. Mineralogy acts as the vehicle for the conveyance of all the preparatory facts in Physics and Chemistry, which are essential for our purposes.

While we cannot find such definite marks of gradations in minerals as among animals and plants there are in nearly every division of minerals, even with their present entirely artificial and probably unnatural classification, such distinctions as those of Anhydrous and Hydrous groups, the simple Sulphides and double

Sulphides, the binary compounds, and the ternary compounds.

Notwithstanding these difficulties the facts all imply gradation. It makes no difference to us whether gradation leads up or down or mingles both of these tendencies; whatever direction the true classification may eventually take is immaterial. The indications of what is already known show that gradation of some sort must be the marked characteristic, and this alone would enable us to harmonize the whole provisionally with the other departments of the Museum.

Independently of this, however, we have found important support in an opinion with which all chemists and mineralogists whom we have consulted, agree. Both the chemical and the molecular constitution of the elements may be considered as less complicated than that of the purely inorganic and probably derivative compounds, and these in turn simpler than the Hydro-carbons. Theoretically also we are safe in assuming that the latter, which are the products of organic bodies, composed wholly of their fossil remains, oils, gums, etc., more or less altered by the physical and chemical conditions to which they have been subjected, are of later origin in time than the strictly inorganic compounds, and that these in turn are more recent, as a rule, than the elements of which they are made up.

These fundamental facts are quite sufficient for our present purposes and enable us to demonstrate that the same principles of classification apply in this department as in all others. We are already in receipt of letters from eminent teachers and others expressing their gratification at the results of our work in this department, and some of them strongly urge the immediate publication of a proper catalogue.

While we congratulate the Society upon the successful arrangement of the most difficult department with which we shall have to deal, it is also incumbent upon us to remember our obligations to our former President, Mr. T. T. Bouvé, to whose constant labors in years past the Society owes the preservation and good condition of the collection, and a large proportion of the specimens. Next to him comes Dr. C. T. Jackson, who while living was identified with us and whose name appears upon many of the tablets. We are also indebted to Mr. Thomas Gaffield for valuable gifts this year and in former years.

It may be well for us to remember also that we are actually against the wall which we have been approaching for the past ten years. The treasurer's report states that the finishing of the single department which we have brought forward as a necessary illustration of the quality of the work we proposed to do for the benefit of the people of Boston, was made possible only through an unusual accident in our finances.[1] We are, therefore, at the present time entirely without the means of completing any other department.

We cannot progress in the path we have chosen without serious injury to all the other interests of this society. We support a library, publications, and meetings, and these are necessarily far more important to the members than our Museum. The Museum must, therefore, not become a greater burden than it already is, or it will defeat the main object of its founders, and what should be one of the main objects of its existence. It must not only earn its own support from the public whom it strives to benefit, but be capable of assisting the less attractive though essentially important purpose of the Society's organization, the encouragement of original research from which all knowledge flows.

While we have conclusively shown the need of a Museum such as is contemplated for the instruction of the teachers, general students, and the public of this city, and also that it was possible to answer the requirements of these three classes, we have at the same time demonstrated other facts.

What we have been and are striving to do is as revolutionary in the management of Museums as was the first attempt to open a circulating library for the public. If we answered to-day the demands already continually made by teachers of the best class, and students (and I mean by this, specific requests which we should like to satisfy but which are perpetually and necessarily refused by us) we should have to arrange and keep on hand reference collections under the charge of attendants, and have a consulting room set apart for their use.

Our supplies are in every way behind the demands of the times; there is no question at all except the financial one, which

[1] The money for this purpose was obtained by the sale of stock from our general fund, which, however, had been increased to this amount in the previous year by a fortunate stock dividend.

has to be seriously considered. We advocate, therefore, in this report, the free use of specimens in the same guarded way as books, and we hope most fervently that the Boston Society of Natural History may be the first institution in the world to place proper reference collections with properly instructed attendants at the command of every person who wishes to study or consult them.

Mr. W. O. Crosby, assisted by Miss Carter, has finished the mineralogical collection, but in order to make it a complete exposition of our mode of arrangement, and of the objects of the Museum it is still necessary to publish a catalogue.

By careful and systematic work Mr. Crosby has been able to illustrate quite fully all the principal topics of interest in the study of Mineralogy and to him belongs the credit of the details of arrangement and classification. The collection on exhibition is divided into three parts.

I. Comparative Mineralogy.
II. Synopsis of Classification.
III. Systematic Collection.

The Comparative Mineralogy (I) occupies the two floor cases in room A, and covers 128 square feet, the Synoptical (II) is contained in one wall case and does not fill out the space allotted to it, which is over 26 square feet, the Systematic collection (III) occupies the wall cases. There are 5–9 flat or inclined shelves in these, with an outside movable bench for the spectator to stand upon in order to view to advantage the specimens placed above the eye line. There are 1000 square feet used for the Systematic collection and this space is well covered. The size of the room is 28×33 by 16 ft. in height, with a gallery, and is large enough not only for the collections as they now stand, but probably for all future expansion, if in accordance with the present plan.

(I). In the Comparative Mineralogy the elements are naturally placed first, and these are arranged in a pyramidal form so as to exhibit at the same time both the relative number and also the character of the mineral species contained in Basic, Acidic, and Acidific divisions, and their various relations to each other as given in Professor Dana's classification.

Comparative Mineralogy is divided into three topics.
1*st*. *Composition and chemical relations of Minerals.*
2*nd*. *Form and structure of Minerals ; crystallography.*
3*rd*. *Physical properties of Minerals.*

The first and second topics are fully dealt with in one of the floor cases, the pyramidal end of which is occupied by the elements, and the third in another of the same size, which stands parallel with it.

In this general account we can, of course, only allude to a few series which may be used as examples of the mode of arrangement. We have, however, added a fuller account in an appendix, since we have reason to believe that this mode of arrangement is in some respects unique in its design and execution.

The following are some of the examples of the mode of treatment of the sub-topics of the 1st, 2nd, and 3rd subdivisions of comparative mineralogy marked by the letters of the alphabet to distinguish them from the grouping indicated by the Arabic numerals.

(*a*). Variations due to chemical substitution are shown by a series of seven minerals among which are three principal varieties of Amphibole, and three of Garnet exhibiting the variations in color, and aspect due to changes in the composition of the varieties.

(*b*). Variations due to alteration and decomposition of minerals by a series of five minerals, among which are Orthoclase and Wernerite, two distinct minerals undergoing change to the same mineral, Kaolinite, by decomposition.

(*c*). Only one substance is devoted to the exposition of the great differencies which may exist between the constituents of a mineral and the compound resulting from their union; Pyrrhotite and its elements, sulphur and iron, are placed together upon one tablet.

d). A difficult subject to deal with in an exhibition of this kind which is wholly addressed to the eye is magnetism, this is shown by arranging a series as follows: —

(*Label.*)

Magnetism Series.

Showing that the magnetism of the few magnetic minerals is proportional to the percentage of iron they contain.

Limonite, iron 60 pr. ct., never magnetic.

Hemstite, iron 70 pr. ct., sometimes magnetic.

Magnetic, iron 72.4 pr. ct., always magnetic.

(*e*). The relations of water in the composition of minerals are dealt with in a series running from a strictly anhydrous Hematite to Natron (Hydr. Carb. Sodium) having 55 per ct. of water. There are twelve specimens in this series, and behind each specimen a tube shows the relative proportion of water in each.

(2*nd*). Form and structure, or crystallography, presented no very serious difficulties beyond the need of finding persons capable of making the special models which were required. This was finally satisfactorily accomplished.

(3*rd*). As an example of the methods pursued in illustrating the Physical Properties of Minerals, we give the following

(*Label.*)

Density Series.

Showing the range of minerals in specific gravity.

(*a*). This series consists of twenty-seven minerals, from Gold which is twenty times heavier than water, to Petroleum, which is lighter than that standard liquid. This gradation is made apparent to the eye by means of glass tubes containing equal weights of each of the substances, the solids being reduced to a fine powder. Thus Gold, with Sp. Gr. 19. 5, the heaviest substance, has necessarily the shortest tube, and Petroleum with Sp.Gr. 0.75, the longest tube, and the intermediate tubes show the gradations between these two. A series is formed in this way, which exhibits clearly that the volume of minerals is inversely proportional to their specific gravity, or weight.

There are a number of series showing the relation of minerals to light, among which we may select by way of illustration that of the color test or streak of minerals.

(*Label* 1.)

Streak Series.

Lustre metallic, and color mainly essential.

(*Label* 2.)

Streak Series.

Lustre non-metallic, and color non-essential except when white.

(*b*). Label No. 1, stands at the head of nine specimens, each mounted upon the same block, with a piece of Novaculite of uniform size, such as is used to try the streak of the minerals, partly covered with a band of the powdered mineral. Label No. 2 is at the head of a precisely similar series, but consisting of eighteen minerals with their accompanying stones, exhibiting the great contrast between the color of minerals themselves, and of their streaks upon the white surfaces of the Novaculite.

(*c*). There are series of specimens, showing the principal minerals which exhibit electrical properties either in their natural conditions or only when acted upon by friction or heat.

(*d*). Even the taste, feel, and odor of minerals are dealt with by similar series.

Though any one cannot imagine how a mineral may taste, simply from the sight of it, or what its feel is, or how it smells, every one knows some of the common minerals of the same series with which it is placed on exhibition. One can also, with the guidance of the collection, more easily duplicate the specimens and understand their relations.

Part II. The Synopsis of classification is arranged upon narrow shelves attached to a wooden backing of boards. The objects are by this means brought forward in the case and are closer to the glass doors than in the usual rows of broad shelves. The more important and abundant elements are here repeated, and each shelf is devoted to one of the grand divisions of the compound minerals. Each division of minerals is represented by its most characteristic species, and the subdivisions of the groups are indicated on the labels wherever these occur.

Part III. The systematic collection begins with the Native Elements, which occupy one wall case next to the synoptical collection. This is followed by the compounds; these fill the wall cases on the remaining sides of the room, and part of the gallery. Here we exhibit the different species of minerals, arranged in their proper order as classified by Prof. Dana, with some slight changes in the succession of some of the larger divisions.

Models of the principal, or most characteristic crystalline forms of each important species have been made out of plaster, and the surface hardened with paraffine in order to give a smooth finish. These are mounted upon wood, or tablets painted blue, in the same manner as the substances whose structure they are used to illustrate. It was found by experiment, that the best results were obtained by leaving these models of crystals uncolored.

The following is the report made upon the number of species and specimens in each part of the collections, and also serves to show the order of arrangement.

MINERALS.

COMPARATIVE COLLECTION.

202 species. 792 specimens. 136 models.

SYNOPTICAL COLLECTION.

164 species. 180 specimens.

SYSTEMATIC COLLECTION.

Native elements	21 species.	156 specimens.	14 models.
Sulphides, Arsenides, etc.	44 "	279 "	46 "
Sulpharsenites, Sulphantimonites etc.	17 "	37 "	6 "
Chlorides, Bromides and Iodides	10 "	26 "	7 "
Fluorides	5 "	86 "	5 "
Oxides	45 "	701 "	13 "
Chromates, Columbates, Tantalates, etc.	12 "	21 "	9 "
Arsenates, Vanadates, Phosphates, etc.	47 "	121 "	28 "
Nitrates, Borates, Tungstates, etc.	10 "	32 "	14 "
Sulphates	24 "	197 "	25 "
Carbonates	23 "	300 "	44 "
Silicates	146 "	1046 "	123 "
Hydrocarbons	8 "	20 "	1 "
Sum total of Systematic Collection	412 species.	3022 specimens	.335 models.

Geology.

This collection could not be finished for a final report as was anticipated; time failed us, and during the coming year it is probable that there will be a still greater and more substantial obstacle.

Mr. Crosby assisted by Miss Carter has, however, worked over and rearranged a considerable portion of the collections, and they have been greatly improved.

The collection of Lithology has been considerably enlarged and extended, and that of Petrology also. The latter is in part completed, and placed in one of the large floor cases built for this purpose last year.

The Dynamical Geology has been enriched by the purchase of three models, one of the topography of the Grand Cañon of the Colorado (6 ft.x 6 ft.) and two of the Henry Mountains of Utah, of smaller size. The Historical collection has been worked over, and the labelling and mounting of the whole finished. Much more might be written, but we prefer to wait until it is is ascertained whether it is possible to finish the arrangement as it has been begun.

Botany.

This department, which is still generously taken care of by Mr. John Cummings, has not received as much attention as usual this year, on account of the occupation of Miss Carter in the work on the Mineralogical and Geological collection.

The New England Collection of Algae has been greatly increased, through the kindness of Mr. F. S. Collins. It is now very nearly complete, containing 202 specimens representing 91 genera and 172 species. The algae in the systematic, or general collection have been thoroughly revised, and the synonymy corrected to correspond with the latest works, printed generic labels have also been supplied. This collection contains 2528 specimens, representing 250 genera, and 866 species. The blanks are now being filled out from the duplicates, this work being about one third completed.

Synoptical Collection.

This department has received a few additions in the shape of glass models of the invertebrates.

Miss Martin has been employed upon the collection, and has completed preparations of the exoskeletons of a Myriapod, Scorpion, and Limulus which have been mounted, and are on exhibition. Mr. Henshaw assisted by Miss Martin has nearly completed the selection of the types of Invertebrata which are to be represented in this collection.

Corals and Echinoderms.

The Halcyonoids, consisting of fifty species, have been identified and arranged by Mr. Henshaw.

Mollusca.

The land, and fresh-water shells of New England have been picked out and labelled by Mr. Henshaw. The work on the Cephalopods has been completed, and they are now on exhibition. The New England Cephalopods have been rearranged and placed on exhibition and labelled as far as practicable by Mr. Henshaw. Work has been begun by Mr. Henshaw upon the large mass of unarranged materials, which has accumulated in this collection, and which has never been worked over.

Crustacea.

Prof. Walter Faxon has identified and labelled our collection of Astacidae, which contains twenty-five species and one hundred specimens, all from North America except two from Europe. The balance of Mr. Kingsley's collections, a valuable donation of which we gave notice in our report of May, 1881, has been received. The whole has been transferred to four hundred bottles, and is now safe from evaporation. We are not yet able, however, to state the number of species, or give other particulars until the part just received has been looked over and reported upon by Mr. Kingsley himself.

Insects.

Mr. Henshaw has worked out a large part of the biological collections of the Lepidoptera, Coleoptera, and Neuroptera, and also the systematic collections of the Cicadidae and Chernetidae. The work of identifying the Anopleura, and that on the Myriapoda and Scorpions is about half completed. Accessions have been received from Dr. Hagen, Dr. Waters, and Messrs. Scudder, Sherriff, and Thaxter.

Fishes.

The Systematic collection in this department has been completed by Mr. Henshaw, so far as can be done at present. The additions which are essential to finish it, and exhibit the types of the families which are not represented, will be difficult to obtain, and our progress slow.

There are now on the shelves types of seventy-five families, and two hundred and forty genera, four hundred species, and nine hundred specimens. The number of families of fishes described in Günther's British Museum Catalogue is one hundred and sixteen, so that we still need the representatives of about forty-one families.

Dr. H. E. Davidson still continues to work for the benefit of the Society in this direction, and has presented us during the year with thirty more of his beautiful preparations of fishes.

Progress has been made with the New England Collection, but it is not yet completed as was anticipated. It contains at present 150 species, and 800 specimens.

Birds.

Mr. William Brewster, who is in charge of our Ornithological Department, assisted by Mr. Henshaw, has thoroughly overhauled the New England Collection, and materially improved its condition. The specimens have been carefully re-identified and relabelled, a task rendered necessary by the lack of uniformity, and occasional erroneous nomenclature of the old labels; moth-eaten and worthless birds, have been replaced by perfect ones; and those whose origin was doubtful or unknown have been removed to the general collection.

This has occasioned many gaps, which may have excited the surprise of those who have examined the list of desiderata issued early in the year, but it was unavoidable in dealing with a collection intended to represent the fauna of New England by specimens obtained, wherever possible, actually from within its limits. Fortunately most of these vacancies can be easily filled, and the present state of the collection is not discreditable to the Society.

There are about 370 species and varieties accredited to New England; the collection posseses 279 species represented by 634 specimens. This apparently leaves us about one hundred species short, but it must be remembered that this hundred includes a very large proportion of unique specimens, stragglers, and rare species which we shall acquire with great difficulty and very slowly.

The accessions to the New England Collection during 1882 include specimens presented by Messrs C. A. Houghton, F. J. C.

Swift, and William Brewster, with a number obtained by purchase. Two birds of great rarity have also been discovered in the general collection, and placed in the New England room. These are a fine immature male Labrador Duck (Camptolaemus labradoricus), and an immature black-throated Diver (Colymbus arcticus). The original labels of these specimens bear no record of locality, but both have been recognized by their donor, the Hon. Theodore Lyman, as specimens which came into his possession, in the flesh, in the year 1850. He distinctly remembers that the duck was received in the flesh with a lot of Eiders, from a gunner who shot them in or near Boston Harbor; while the Diver was purchased in the Boston Market. Hence there would seem to be no reasonable doubt that both are veritable Massachusetts specimens. It may be added that the Labrador Duck is now supposed to be extinct, while the Diver is the first authentic example known to have occurred in Massachusetts.

An important addition to the general collection has been received from Mrs. Henry Greenough, who has presented 37 mounted birds collected in the Philippine Islands by her son, the late Henry Greenough, Jr.

Mammals.

The collection contains now about thirty-five species and seventy specimens. Mr. Brewster has very kindly taken an interest in this department also, and we owe most of our opportunities for obtaining specimens to his efforts.

There are said to be fifty-seven species of Mammalia in New England, exclusive of the Cetacea, and we have, therefore, still many species to obtain.[1]

Teachers' School of Science.

The liberality of the Trustees of the Lowell Fund in permitting the Teachers' School of Science the use of Huntington Hall, has enabled the Society to extend the benefit of its labor in this department to teachers living in the neighboring towns, as well as in Boston itself. Agents were obtained by correspondence, and through the kindness of Mr. Dickinson, Secretary of the State Board of Education, in forty-four of the neighboring towns. All of

[1] The collections do not remain in the same condition as when last referred to in the preceding annual reports.

these were teachers, and volunteered their aid, and all faithfully formed the duty of sending out blank applications, and receiving and distributing our tickets to the applicants whom we had selected. In Boston, and many of the towns, the utility of the school was recognized so fully by the Superintendents of the Public Schools, that they themselves acted as our agents, and the tickets were distributed from their offices. There were two courses, one of ten lessons by Prof. W. H. Niles on Physical Geography, and one of five lessons on Physiology, by Dr. H. P. Bowditch. The courses began Nov. 4th, and the audiences at first averaged five hundred, but the interruptions of the Christmas holidays, as in former years, caused a falling off in the average of 100 to 150. In Dr. Bowditch's course which deals with a special subject, the average attendance was at first about 400, diminished after the April holidays by about 100 to 150. The diminution of the average caused by holidays has been noted more or less every winter, but the fact that it should have occurred this year was especially noteworthy. Both the courses were unusually attractive and popular, and had a large attendance; nevertheless the holidays were followed by the usual effect.

The average attendance of teachers in Prof. Niles course was estimated at about forty-four per cent. of the whole number of tickets issued for that course, and in Dr. Bowditch's course it was about forty per cent.

The following is an abstract of the statistics taken from our files of applications and records: —

NUMBER OF APPLICATIONS RECEIVED.

Physical Geography	988
Physiology	834
Both courses	1,822

NUMBER OF TICKETS DISTRIBUTED.

TO TEACHERS.

Physical Geography	953
Physiology	812
Both courses	1,765

TO PRIVATE ADDRESSES.

Physical Geography	145
Physiology	131
Both courses	276

LIST BY TOWNS.	GEOG.	PHYS.	LIST BY TOWNS.	GEOG.	PHYS.
Abington	3			651	568
Andover	1	2	Medway	1	1
Arlington	17	17	Melrose	14	12
Ashland	1		Milton	5	4
Belmont	2	2	Natick	1	1
Boston	365	302	Newton	64	50
Bridgewater	7	5	Norwood	5	4
Brockton	2	4	Quincy	42	23
Brookline	33	32	Reading	1	
Cambridge	57	59	Revere	2	
Canton	3		Rockland	1	
Chelsea	58	58	Salem	6	4
Concord	7	5	Saugus	1	1
Dedham	21	17	Somerville	50	48
Framingham	7	7	Stoneham	21	18
Hingham	9	9	Wakefield	18	8
Hyde Park	28	27	Walnut Hill	1	1
Kingston	1	1	Waltham	19	18
Lawrence	2	2	Watertown	1	1
Lowell	1	1	Weston	1	
Malden	16	12	Weymouth	1	1
Medford	10	6	Wilmington	2	2
			Woburn	45	47
	651	568		953	812

Total Geography, 953; Physiology, 812.

GRADE OF TEACHERS.

BOSTON PUBLIC SCHOOLS.

Tickets distributed to Superintendent	1
" " " Masters	32
" " " Sub-Masters	20
" " " Assistants	353

OUT OF TOWN SCHOOLS.

Tickets distributed to Superintendents	9
" " " Masters and Principals	125
" " " Sub-Masters	4
" " " Assistants	494

Winter Laboratory.

This laboratory has been used by the following classes, one in Zoology and Paleontology from the Mass. Inst. of Technology, one in Zoology from the Boston University, both of these under the charge of Curator; also one in Botany, and one in Physiology, both of these have been under the charge of Mr. B. H. Van Vleck. This department has been considerably improved, and its teaching power augmented during the past year with specimens contributed by Mr. Van Vleck, and diagrams painted by Miss Martin.

Annisquam Laboratory.

The laboratory, as was announced in the last annual report, was opened and supported by the Woman's Education Association. The windmill which was alluded to also in the same report as a donation from the same Association, was erected in the spring and was in use all summer. Mr. Van Vleck carefully attended to the details of its erection, putting up himself all of the more delicate portions of the apparatus inside of the building. Our janitor was also employed for several days in assisting with the necessary carpenter's work. Mr. Van Vleck, who gives his time gratuitously for the benefit of the laboratory and the teaching of the pupils, reports that he had fourteen students, of whom eight were women and six were men. The average time of attendance of women was three weeks and one day each, average time of men six weeks each. Of these students, eleven were teachers of Natural History, two were special students in this department, and one was an investigator. About half a dozen applicants were unable to come on account of the expense of board, etc., at the sea side, and in fact this obstacle is by far the most important in the path of our success. As soon as our laboratory courses are again started in the Teachers' School of Science we may expect to see the number of students increase in the Annisquam Laboratory, but until this is done there is no doubt that this department will not be so well attended as it has been.

Expeditions.

Mr. W. O. Crosby visited Baracoa in the Island of Cuba, and brought back a miscellaneous collection, of which, on account of Mr. Crosby's absence in Europe, we cannot give a more definite account. Mr. Van Vleck made a flying trip to Key West, Nassau and Cuba, and brought back a large collection which has benefited the Laboratory, and the Teachers' School of Science, and added some specimens of value and interest to our Museum.

The Curator made a few dredging trips during the last summer off Cape Ann, but in one case only were these at all noteworthy; on that occasion specimens of Octopus, and other interesting forms were brought up from a depth of about forty fathoms.

Report of Edward Burgess, Secretary.

The Secretary respectfully submits the following report.—

Membership.

The printed list of members issued last March is the first published for fifteen years, or since 1868, when the Society's first and only "Annual" appeared. The roll in the Annual numbered 492 Resident Members, 31 Honorary, and 222 Corresponding Members. The present list contains 421 names in the classes of Corporate and Associate Membership (which together correspond to the old Resident Membership), 20 Honorary, and 140 Corresponding Members.

During the year two Honorary, nine Corresponding and eighteen Associate Members have been elected. The Society has lost by death one Honorary Member, the late Prof. William B. Rogers, two Corresponding, one Associate, and six Corporate Members, and two of each of the latter classes have resigned.

Meetings.

At the sixteen general meetings of the year the average attendance has been thirty-three, or exactly the same as for two preceding years. The largest attendance at any one meeting was seventy-eight, and the smallest eleven.

The Section of Entomology has held seven meetings, with an average attendance of seven.

At the General Meeings thirty-five communications were made, and at the meetings of the Entomological section, seven.

Library.

The total number of additions to the Library reaches 2069; this includes,

	800	4 to.	Fol.	Total.
Volumes,	264	66	9	339
Parts,	1086	213	174	1473
Pamphlets,	226	10		236
Maps, etc.,				21
			Total:	2069

The Musée Royal d' Histoire Naturelle de Belgique has presented us a complete set of its magnificent Annales.

An appropriation of 300 dollars made by the Council has enabled the Librarian to make some progress in the much needed work of binding. With this sum, and what could be spared for the same purpose from the income of the Wolcott Fund, three hundred and sixty-seven books have been bound; at this rate it will, however, take a long time to put the Library in suitable condition. Eight hundred and sixty-four books have been borrowed from the Library by one hundred and nineteen persons.

Publications.

The twenty-first volume of Proceedings has been completed by the issue of Parts 3 and 4; and Part 1 of Vol. XXII will be issued in a few days.

Of the Memoirs one article on Archipolypoda by Mr. Scudder, has been issued, and two more articles are just printed viz: on the Embryology of Teleosts, by Messrs. Kingsley and Conn, and a revision of the Carboniferous Hexapods of Great Britain by Mr. Scudder.

Walker Prizes.

The wide scope of the subject selected for the Walker Prize 1883 — Original unpublished investigation on the life history of any animal, — has had its desired effect of calling forth a number of essays, the first offered for several years. Seven essays have been received in competition, and the award of the prizes will be announced by the Committee this evening.

REPORT OF CHARLES W. SCUDDER, TREASURER.

ANNUAL STATEMENT OF RECEIPTS AND EXPENDITURES, MAY 1, 1883.

1882, May 1, to May 1, 1883.

Admission Fees	$75.00
Annual Assessments	1175.00
Life Memberships	100.00
Dividends and Income from General Fund	4263.73
Walker Fund Income	2067.50
Walker Prize Fund Income	300.00
Walker Grand Prize Fund Income	92.00
Bulfinch St. Estate Fund Income (Cash)	1823.22
Courtis Fund Income	558.84
S. P. Pratt Fund Income	638.50
Huntington Frothingham Wolcott Fund Income	657.06
Dale Fund Income	25.00
Laboratory, Boston University, and Students' Fees	1727.60
Proceeds of sale of stock dividend from Invested Funds by vote of Council to defray expense of rearranging the Mineralogical and Geological Departments	1500.00
Balance	769.85
	$15,753.30

Teachers' School of Science.

Balance from last year	526.72
Donation from Augustus Lowell, Trustee	800.00
	$1,326.72

1882, May 1, to May 1, 1883.

Museum		2078.99
Publication and Printing	1472.32	
Less Receipts on this account	380.61	1091.71
Library		587.52
Salaries and Wages		6793.57
Repairs of Building		63.21
Fuel		324.00
Gas		75.22
General Expenses		1206.27
Laboratory, Instruction and Expenses		1819.36
Rearranging the Mineralogical and Geological Departments		1713.45
		$15,753.30
Excess of Expenditures, over Receipts		769.85

Teachers' School of Science.

Expended to date for Lectures, etc.	1310.65
Unexpended balance on hand	16.07
	$1326.72

BOSTON, MAY 1, 1883.

CHAS. W. SCUDDER,
Treasurer.

The Auditing Committee, Messrs. Cummings and Greenleaf, reported that they had examined the Treasurer's accounts, and found them correctly cast and properly vouched.

The three reports were accepted, and the Society proceeded to ballot for officers; Messrs. Moore and Blake were requested to collect and count the votes, and they announced the election of the following officers for 1883-84:—

PRESIDENT,

SAMUEL H. SCUDDER.

VICE-PRESIDENTS,

JOHN CUMMINGS, F. W. PUTNAM.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

S. L. ABBOT, M. D.

SECRETARY,

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

J. A. Allen,
Henry P. Bowditch, M. D.,
Samuel Cabot, M. D.,
W. G. Farlow, M. D.,
Samuel Garman,
George L. Goodale, M. D.,
H. A. Hagen, M. D.,
Henry W. Haynes,
B. Joy Jeffries, M. D.,
Augustus Lowell,
Theodore Lyman,
Charles S. Minot,
Edward S. Morse,
William H. Niles,
R. H. Richards,
N. S. Shaler,
Charles J. Sprague,
M. E. Wadsworth,
Samuel Wells,
William F. Whitney, M. D.

MEMBERS OF THE COUNCIL, EX OFFICIO,

Ex-President, Thomas T. Bouvé,
Ex-Vice-President, Richard C. Greenleaf,
Ex-Vice-President, D. Humphreys Storer, M. D.

Mr. George C. Currier was elected an Associate Member.

The report of the Walker Committee was read, awarding the first prize to an essay on the development of Oecanthus and Teleas,[1] and asking for further time to consider the award of the second prize. The report was accepted and the envelope containing the author's name being opened, Mr. Howard Ayers, of Fort Smith, Ark., was announced to be the winner of the first prize for 1883.

Mr. F. W. Putnam occupied the rest of of the evening with an account of a group of mounds enclosed by earthworks in the Little Miami Valley, Ohio. This group was of particular interest from the character of the mounds, several of which contained altars. Upon two of the altars many burnt offerings were found, among which were over 50,000 pearls, thousands of shell beads, and hundreds of objects cut from mica and native copper. Ornaments made of copper overlaid with silver, gold, and native or meteoric iron were also found, and also several ornaments made entirely of meteoric iron. This is the first time that native iron and native gold have been found in the mounds. In addition to the large collection of ornaments of various kinds, there were two stone dishes very elaborately carved, and a number of small terra-cotta figures representing men and women. Mr. Putnam illustrated his remarks by diagrams showing the structure of the mounds and by numerous photographs of the specimens found on the altars, as well as by exhibiting some of the most interesting of the ornaments made of the native iron.

General Meeting, May, 16, 1883.

The President, Mr. Scudder, in the chair. Fifty-four persons present.

The President introduced Major Hotchkiss, of Virginia, who read a memoir of the late Professor William B. Rogers.

The following paper was presented by title: —

[1] This essay appears in the Society's Memoirs, vol. III, art. VIII.

THE SPECIFIC GRAVITY, ASH AND APPEARANCE OF THE WOOD OF CERTAIN SHRUBS AND EXOTIC TREES FOUND GROWING IN THE UNITED STATES.

BY S. P. SHARPLES.

In making the collection of woods for the United States Census, upon which Professor C. S. Sargent has been engaged for the three years, a number of specimens were collected that the Professor has decided do not properly belong among the trees of this country, either from the fact that they are rarely more than shrubs, or else they are exotics and are only found where they have been introduced. These specimens have been placed at my disposal by Professor Sargent.

The specific gravity and ash were determined as follows:—

Specific gravity. Specimens were dressed out of a convenient size generally about two inches square and five inches long, when the stick was large enough; these were then thoroughly dried. From these specimens other smaller specimens were prepared; these specimens were exactly a decimeter in length, and were generally about thirty-five millimeters square, the latter dimension depending to a great extent upon the dimensions of the original stick. These specimens were placed in an oven and maintained at a temperature of 100°C. for a week, at the end of this time they were carefully weighed and measured; from the data thus obtained the specific gravity was calculated.

Ash. This was determined by igniting fragments of the wood weighing from ten to twenty grams, in a muffle furnace, until the carbon was completely burned. Care was taken to keep the temperature as low as possible. So far as could be done, the determinations were made in duplicate. The species in this list are largely southern.

Æsculus parviflora. Received from E. A. Smith, Alabama. Shrub one to three meters high, wood white, compact, soft, specific gravity 0.5265, 05311, 0.4911; av. 0.5162. Ash, 0.80, 0.71; av. 0.750770.

Staphylea trifolia. Sent by G. W. Letterman from Allenton, Mo. Shrub three meters high, wood light brown, sap wood yellow, compact, hard. Sp. Gr. 0.7330. Ash, 0.51, 0.58 ; av. 0.55 per cent.

Rhamnus lanceolata. Received from A. Gattinger, Nashville, Tenn. A tall shrub, wood light brown, sap wood yellow. Sp. Gr 0.7059, 0.6980; av. 0.7020. Ash, 1.67, 1.69; av. 1.68.

Zizyphus obtusifolius. Received from Charles Mohr, New Braunfels, Texas. Shrub, wood light brown, sap wood pale yellow, close grained, hard. Sp. Gr. 0.9082, 1.0445, 0.9168; av. 0.9565 Ash, 1.94, 1.79; av. 1.87, per cent.

Rhus Toxicodendron. Poison Ivy. Received from John Robinson, Beverly, Mass. This specimen was extremely poisonous to two of the men employed in the shop where it was dressed; two others working by their side, and who actually dressed the wood, were not affected by it! The wood is handsomely striped brown and yellow, with light yellow sap. It is soft and easy to work. Sp. Gr. 0.4955, 0.4969; av. 0.4962. Ash, 0.67, 0.72; av. 0.70.

Erythrina herbacea var. arborea. Collected by A. H. Curtiss on Miami Key, on coral soil. Sp. Gr. 0.2643, 0.2396; av. 0.2520. Ash, 2.27, 2.23; av. 2.30. A second sample collected by Mr. Curtiss at Caximbas Pass, growing on a shell soil, gave Sp. Gr. 0.1802, 0.1922; av. 0.1862. Ash, 7.72, 4.93; av. 6.33. The average of both specimens was Sp. Gr. 0.2191. Ash, 4.32.

Acacia flexicaulis. From S. B. Buckley, Austin, Texas. Shrub, wood dark brown with a yellow sap, hard. Sp. Gr. 0.9042, 0.8840; av. 0.8941. Ash, 1.51, 1.28; av. 1.40.

Acacia constricta. C. G. Pringle, Santa Rita Mts., Arizona. Wood dark reddish brown, sap wood pale yellow. Sp. Gr. 1.1620, 1.1680; av. 1.1650. Ash, 4.16, 4.42; av. 4.29.

Parkinsonia florida. From S. B. Buckley, Austin, Texas. Wood light brown, hard. Sp. Gr. 0.5123, 0.5200; av. 0.5162. Ash, 2.02, 2.28; av. 2.15.

Pyrus malus. Apple. From G. W. Letterman, Allentown, Mo. Wood pale brown, fine grained, hard. Those having old apple trees to cut down will be well repaid if they have them sawed up and made into furniture, as the wood takes a handsome finish. Sp. Gr. 0.6735, 0.6530; av. 0.6633. Ash, 0.63, 0.70; av. 0.67.

Cowania Mexicana. From M. E. Jones, Lewiston, Utah. Grew on gravel, wood pale rosy brown, fine grained, hard, taking a beauful polish; the veining is very handsome; the specimen received was about 75 mm. in diameter. Sp. Gr. 0.5627, 0.5627; av. 0.5627. Ash, 0.78, 0.58; av. 0.69.

Suriana maritima. Received from A. H. Curtiss, collected on Ramrod Key, Florida, on coral soil. Wood dark reddish brown, hard, a low shrub. Sp. Gr. 0.9073, 0.9313, 0.8957; av. 0.9114. Ash, 0.34, 0.41; av. 0.38.

Hydrangea quercifolia. Seven Barks, Hydrangea. Collected by A. H. Curtiss at Aspalaga, Florida, on shaded cliffs. Shrub three to six feet high. Wood pale yellowish, soft. Sp. Gr. 0.6880, 0.6864, 0.6872. Ash, 1.06, 1.23; av. 1.14.

Sambucus canadensis. Elder. Collected by A. H. Curtiss at Gainsville, Florida. The specimen was 168 mm. in diameter. This was a very large specimen and had but little pith in it. Wood fine grained, soft, light yellow. Sp. Gr. 0.5252, 0.5485; av. 0.5368. Ash, 0.83, 1.00; av. 0.92.

Viburnum obvatum. Collected by A. H. Curtiss on the Ogeechee River, Florida. A small tree or shrub growing on low ground or river banks. Wood light brown, close grained. Sp. Gr. 0.6545, 0.6378; av. 0.6462. Ash, 0.53, 0.60; av. 0.57.

Guettarda ambigua. Collected by A. H. Curtiss on a small key south of Elliots Key, Florida. Wood yellowish brown, hard and close grained. Sp. Gr. 0.8762, 0.8900; av. 0.8831. Ash, 1.19, 1.21; av. 1.20.

Cephalanthus occidentalis. Button Bush. Collected by A. H. Curtiss on the Altamaha River, Ga. Shrub two to four meters high. Wood yellowish, fine grained, hard. Sp. Gr. 0.6852. Ash, 0.39.

Baccharis halimifolia. Collected by A. H. Curtiss on the Altamaha River, Ga. Shrub four meters high. Wood brown, sap wood very light brown, close grained. Sp. Gr. 0.6920, 0.6140; av. 0.6530. Ash, 1.04, 1.09; av. 1.07

Pisonia aculeata. Collected by A. H. Curtiss on Bay Biscayne, Fla., growing on coral. A low shrub. Wood light brown, soft, coarse grained. Sp. Gr. 0.4010, 0.4075, 0.4038; av. 0.4041. Ash, 4.40, 5.20; av. 4.80. A second specimen collected by Mr. Curtiss on No Name Key, gave Sp. Gr. 0.4711, 0.4984; av. 0.4846. Ash, 5.90, 6.11; av. 6.00. Average of the two specimens Sp. Gr. 0.4444. Ash, 5.40.

Rhododendron californicum. Collected by F. Skinner near Empire City, Oregon. Stick 300 mm. in diameter. Wood pink, dense close grained, hard. Sp. Gr. 0.6372, 0.6353; av. 0.6363. Ash, 0.39, 0.52; av. 0.46.

Solanum verbascifolium. Collected by A. H. Curtiss on Umbrella Key, Florida. A shrub one to two meters high. Wood yellow, close grained. Sp. Gr. 0.5490, 0.5344; av. 0.5417. Ash 0.58, 0.56; av. 0.57.

Stillingia sebifera. Tallow Berry. Collected by A. H. Curtiss near Charleston, S. C. A tree ten to twelve meters high introduced from China. Wood light yellowish white, close grained. Sp. Gr. 0.5783, 0.5994; av. 0.5889. Ash, 0.63, 0.64; av. 0.64.

Sponia macranthea. Collected by A. H. Curtiss at Bay Biscayne, Florida, growing on coral soil. Wood light brown. Sp. Gr. 0.3245, 0.3558; av. 0.3402. Ash, 0.79, 0.85; av. 0.82. A second specimen from the same locality gave Sp. Gr. 0.2934, 0.4162. Ash, 1.22, 0.99; av. of the two specimens Sp. Gr. 0.3475. Ash, 0.97.

Myrica inodora. Collected by Charles Mohr, near Cottage Hill, Alabama, growing in wet sand. Wood light reddish brown. Sp. Gr. 0.6402, 0.6270; av. 0.6336. Ash. 0.27, 0.39; av. 0.33.

Casuarina equisetifolia. Collected on the Florida Keys by A. H. Curtiss. This tree is probably an exotic. It is planted everywhere in the tropics as an ornamental tree, and it seems there to be regarded as a kind of pine. The wood is heavy, close grained and of a light brown color. Sp. Gr. 0.9150, 0.8979, 0.9255; av. 0.9128. Ash, 0.56, 0.57; av. 0.57.

Quercus ilicifolia. Bear Oak. Collected by J. Robinson in Boxford, Mass. A shrub occasionally growing two or three meters high, and fifty to eighty mm. in diameter. Wood light brown, close grained. Sp. Gr. 0.7869, 0.7370, 0.7642; av. 0.7627. Ash, 0.40, 0.54; av. 0.47. A second specimen gave Sp. Gr. 0.7777, 0.7284, 0.7759; av. 0.7607. Ash, 0.28, 0.32; av. 0.30. The average of the two specimens was Sp. Gr. 0.7627. Ash, 0.39.

Quercus georgiana. Collected by A. H. Curtiss on Stone Mountain, Georgia. A shrub two to three meters high. Wood brown, close-grained. Sp. Gr. 0.7263, 0.6980; av. 0.7122. Ash, 0.71, 1.12; av. 0.92.

Salix lucida. Pussy Willow. Collected in Beverly, Mass., by John Robinson. A low shrub occasionally growing to the height of three meters. Wood light brown soft. Sp. Gr. 0.3441, 0.3641, 0.3330, 0.3502; av. 0.3478. Ash, 0.54, 0.50; av. 0.52.

Salix alba. Collected by Dr. Gattinger. Wood soft brownish. Sp. gr. 0.4234, 0.4212, 0.4085, 0.4154; av. 0.4171. Ash, 0.48, 0.55; av. 0.52

Salix cordata. Water Willow. Collected by T. F. Hathaway, South Paris, Maine. Wood light brown soft. Sp. Gr. 0.4597, 0.4752, 0.5730, 0.5310; av. 0.5097. Ash, 0.6657; av. 0.62.

Cocos nucifera. Cocoa Nut. Collected by A. H. Curtiss on the Everglades, Florida. The cocoa nut has been introduced into the south of Florida, where it is cultivated for its fruit. The wood is a light brown and resembles cork with copper wires run through it longitudinally, and is about as hard to work as such a compound would be; it rapidly removes the edge from a plane. Sp. Gr. 0.6036, 0.5661; av. 0.5849. Ash, 1.32, 2.02; av. 167.

Agave rigida var. sissalina. Sissal Hemp. Collected by A. H. Curtiss near Bay Biscayne, Florida, growing on rocks. The stem of this plant consists of two distinct parts, a large soft pith, surrounded by a hard rind. The hard portion has a specific gravity of 0.3604, 0.3943, 0.3686; av. 0.3744. Ash, 1.53, 1.39; av. 1.46. The Sp. Gr. of the pith is 0.0500, this was the lightest substance met with during the investigation.

All the above specific gravities are referred to water as unity. The ash in every case being stated in per cents.

The work done for the census, and which will appear in the forthcoming volume of the report on forestry includes determinations of the specific gravity and ash of all the trees of the United States, and also, many determinations of strength, elasticity, &c., the report being the most complete that has ever been published on the woods of any region covering so large an area as the United States.

General Meeting, October 3, 1883.

The President, Mr. S. H. Scudder, in the chair. Thirty-five persons present.

A letter from the chairman of the Committee on Walker Prizes was read announcing the award of the second prize for 1883 to H. W. Conn, of Baltimore, for an essay on the development of Thalassema, and to Wm. Patten, of Watertown, Mass., for an essay on the embryology of a Phryganid — the amount of the prize to be divided equally between the two authors.

The following papers were read: —

NOTES ON THE BIRDS OBSERVED DURING A SUMMER CRUISE IN THE GULF OF ST. LAWRENCE.

BY WILLIAM BREWSTER.

In the spring of 1881 I was invited by Professor Hyatt to join an expedition then organizing for a trip to the Gulf of St. Lawrence and also, if circumstances should allow, to Labrador and Newfoundland. This expedition was undertaken partly for pleasure, but chiefly for scientific exploration and the collection of fossils, birds, insects, and plants, as well as to obtain a series of photographs illustrating terraces, and other geological formations. Although the expenses were largely borne by Professor Hyatt and the gentlemen who accompanied him, the scientific work was done in the interest of the Boston Society of Natural History, to which almost all of the specimens were afterwards given. The plan of the expedition, the places which it visited, and the material results which it achieved have been already announced by our Curator in his last Annual Report, but for the benefit of those who may not see that publication, I will repeat such of them as have a direct bearing on my subject.

Our party, as finally arranged, consisted of Professor Hyatt, Curator of the Society; Mr. Samuel Henshaw, Assistant in the Museum; Messrs. E. G. Gardiner, W. H. Kerr, and E. R. Warren of the Institute of Technology; and the writer of the present paper.

We sailed from Annisquam, Mass., on the morning of June 17, in the "Arethusa," a schooner-rigged yacht of seventeen tons belonging to Professor Hyatt. Our course was laid directly for Cape Sable, Nova Scotia, which was passed on the evening of the 18th, and thence to the Gut of Canso where we arrived about sunset on the 20th.

The three succeeding days were passed in the vicinity of Port Hawkesbury, Cape Breton, and we entered the Gulf of St. Lawrence the morning of the 24th; anchoring that night at Port Hood, and reaching Grand Entry Island the evening of the following day.

The Magdalens proved a profitable, as well as interesting, collecting ground, and nine days were spent there; the places visited being Grand Entry Island, Amherst Harbor, Grand Entry Harbor, Bryon (according to some writers, Byron) Island; and finally Bird Rocks, where we landed the morning of July 4, and remained a few hours until forced to put to sea by a threatening change in the weather.

During the afternoon and night of the 4th the "Arethusa" ran through a heavy easterly gale, making for East Point, Anticosti, which was sighted early next morning, but the direction and force of the wind prevented us from rounding this cape, and the vessel being headed to the westward two more days were spent at sea before we succeeded in returning and casting anchor at Wreck Bay, a shallow indentation near the extreme end of the Point. Here we had several hours on shore during the forenoon of the 7th, but the anchorage proved unsafe, and indications of another storm induced us to seek a more secure shelter at Fox Bay, a harbor about ten miles to the northward, on the eastern end of the Island.

Near Fox Bay a wood road, cut by the inhabitants through the matted forest, affords easy access to the interior which was explored for a distance of eight or ten miles, There is also a large salt water lagoon connected with the bay by a beautiful river swarming with sea-trout and salmon. In many respects this locality was the most attractive and productive one that we visited. It was especially rich in birds, as the frequency with which it is mentioned in the following pages will attest; and the four days spent there are filled with associations of the pleasantest character.

We sailed from Fox Bay on the morning of July 12, our next objective point being Gaspé where our mail was to be sent. Nothing of importance, at least as regards ornithology transpired on this trip which, owing to light and baffling winds, consumed rather more time than we had expected. In fact we did not finally get clear of Gaspé Bay until the morning of July 16, when the course was laid for Ellis Bay, Anticosti. Head winds still attended us, and failing to enter this harbor we kept on past West Point reaching the Mingan Islands the night of the 17th.

Four days passed very quickly and pleasantly among the Mingans where we explored many beautiful bays and islands, finding water birds of several species breeding in abundance.

Returning to the western end of Anticosti on July 22, we spent the 23d and 24th at Ellis Bay, a lonely little harbor abounding with seals and birds of several kinds not previously met with, but on the whole, less rich in animal life than either Fox Bay or the North Shore.

We left Ellis Bay the evening of July 24, where our homeward voyage may be said to have fairly begun. After this no field work of any consequence was attempted, although we made some interesting observations and obtained a few specimens at Percé Rock, a wonderful place on the western shore of the gulf, near which our vessel was weather-bound for a few days. At this point I was obliged to leave the expedition and return directly to Boston, a fortunate necessity as it transpired, for the subsequent experience of the party, delayed nearly two weeks on the coast of Nova Scotia by head winds and fog, proved anything but agreeable.

The trip as a whole was attended by about the usual mixture of pleasure and hardship, success and disappointment. Its drawbacks and failures were mainly unavoidable, for our plans had been laid with care and forethought, and the vessel equipped to a fault; while the social composition of our party proved exceptionally pleasant and harmonious. But we started too late in the season and the weather during most of the summer, was simply abominable. Our log book records only eighteen moderately fair days out of the total sixty-two, and some of these were more or less interrupted by showers. The temperature in our cabin rarely reached 60° Fahr., while it often fell below 40°, and once reached 34°; add to this the fact that, excepting during dead calms, the wind usually blew half a gale, and it becomes apparent why much of the time was wasted at safe, but otherwise unprofitable anchorage. Indeed it was by no means uncommon to spend several days waiting for an opportunity to land on some tempting shore, and when the opportunity came it was often too brief for anything like thorough work.

In my own department there were further hinderances. Our vessel was so small, and her cabin so crowded, that it was usually impossible to prepare specimens at sea. Thus it frequently happened that when we came to anchor in smooth water and the rest of the party hastened on shore, I was forced to deny myself that pleasure and use the opportunity for skinning birds shot days before at our last stopping place. The drying and subsequent care of bird-skins in such a climate was also a matter demanding constant attention. They had to be spread out in the sun whenever the weather permitted, and in other ways guarded against injury from dampness. These duties consumed so much time that but little was left for field-work.

One of the bitterest disappointments was that attending our search for nests. I had hoped to find eggs of the Black-poll Warbler, Lincoln's Finch, Fox Sparrow, and similar desirable species, but the only land birds' nests actually seen were one each of the Robin and Downy Woodpecker, both containing young. This ill-luck was due partly to the lateness of the season, partly to the character of the forests — which in many places were postively impenetrable — but chiefly to the lack of opportunities for search.

As has been already explained the majority of these difficulties could not have been foreseen, or if foreseen, avoided; I take pleasure in adding that my catalogue of personal grievances includes none which in any way reflect upon the management of the expedition. On the contrary I was furnished with every facility, possible under the circumstances, for the collection, preservation, and storage of specimens, while there is not a member of the party to whom I am not indebted for acts of assistance or self-sacrifice. My obligations to its leader are especially great, not only for material aid in the furtherance of my work, but also for a large-hearted sympathy with, and appreciation of, its difficulties, which lightened many an irksome task and encouraged me to further exertions. Nor should I omit special acknowledgment of Mr Warren's kind help in preparing specimens, as well as Mr. Gardiner's unceasing efforts to procure for me rare or desirable birds.

Although the expedition resulted in a reconnoisance rather than a thorough exploration, a fairly large number of specimens was collected and some important notes made on the habits and distribution of several species as yet imperfectly known. A nearly full series of the specimens has been mounted for the New England Collection of the Society, while the notes are embodied in the following paper. With few exceptions it includes only such species as were actually observed by our party, and no attempt has been made to swell the list of names by citing species found by previous explorers, the design being to record our personal experience rather than to make a complete list of the birds known to inhabit the region traversed. In narrating this experience ground already covered has been as far as possible avoided; but in a few cases, especially those of exceptionally interesting birds, and of questions not definitely settled, I have disregarded such restrictions, trusting that there may be still room for original observations and impressions, even if they offer little that is positively new.

As regards nomenclature, no particular authority has been followed. On the contrary, believing as I do that neither of the systems at present accepted is founded on sound principles and that many of the changes which they include have been made on insufficient, and often wholly indefensible grounds, I have ventured in certain cases to indulge personal preferences especially in the matter of reviving an occasional familiar name that has done duty too long and too honorably to be lightly discarded. Possibly such conservatism is not always warranted; but it is at least legitimate in the present unsettled state of our nomenclature.[1]

1. **Turdus migratorius**, Linn. — Robin.

At almost every point where our vessel touched, the Robin was a common bird. As at home it seemed to prefer the vicinity of houses and settlements, but it frequently occurred in the depths of the loneliest forests. On Amherst Island I found a pair breeding among some stunted spruces, and at Ellis Bay, Anticosti, fully-fledged young were seen July 24.

2. **Turdus fuscescens**, Steph. — Wilson's Thrush.

Rather to my surprise I came upon a pair of these Thrushes at Ellis Bay, Anticosti, on July 24. They were in a thicket of mountain maples (Acer spicatum) where they apparently had a brood of young, for they showed much concern at my presence, approaching within a yard or two and uttering their characteristic *pheu* in an anxious tone. I did not shoot either of them (chiefly because they kept so near me that I could not fire without the certainity of mutilating the specimen), but they were seen so dis-

[1] Since the above was written a committee has been appointed by the American Ornithologists' Union to revise the nomenclature of North American birds. Their work, although well advanced towards completion, is not as yet available.

tinctly that there can be no doubt as to the correctness of the identification. Audubon states that he met with Wilson's Thrush in Labrador, as well as Newfoundland;[1] but it does not seem to have been since detected much to to the northward of Halifax (N. S.), on the Atlantic coast.

3. **Turdus pallasi**, Cab. — Hermit Thrush.

Owing probably to the superficial character of our investigations we failed to detect the Hermit Thrush at any point south of Anticosti. On that island, as well as every where along the North Shore, it was an abundant species, although one which was oftener heard than seen. When after a long day's buffeting with the rough seas of the gulf, our vessel came to anchor in some quiet cove, the song of this Thrush was sure to be prominent in the chorus of bird-music wafted to our ears by the soft land breeze. And long after the others had ceased, its rapt soliloquy would continue until twilight deepened into night and the streamers of the aurora began chasing one another from the horizon to the zenith. Heard under such conditions the performance was unusually impressive.

4. **Turdus swainsoni**, Cab. — Olive-backed Thrush.

Generally distributed, but nowhere so numerous as in portions of northern New England. It was exceedingly shy everywhere, and although I made repeated efforts to secure specimens only one was taken. This bird, an adult female shot at Fox Bay, Anticosti, July 11, does not differ from more southern examples. I noticed little variation in the songs or notes of different individuals, and have no reason to suspect that any of them were T. aliciae; although it will not be surprising if the latter species occurs on Anticosti, for Coues found it breeding abundantly in Labrador in 1860.

5. **Regulus calendula**, Linn. — Ruby-crowned Kinglet.

A female seen at Fox Bay, Anticosti, July 11, was the only individual observed during the trip.

6. **Mniotilta varia**, Linn. — Black-and-white Creeper.

On July 9 a male was heard singing at Fox Bay, Anticosti, and two days later another was met with and secured, about a

[1] Since writing the above I learn from Mr. George O. Welch that he found Wilson's Thrush common, and generally distributed along the southern coast of Newfoundland during the summer of 1883.

mile inland in the depth of a spruce forest. This specimen is the darkest and handsomest that I have ever seen.

7. **Parula americana**, Linn. — Blue Yellow-backed Warbler.

Seen near Port Hawkesbury, Cape Breton, June 23, and at Fox Bay, Anticosti, July 11, a single male being observed on each occasion.

8. **Helminthophila ruficapilla**, Wils. — Nashville Warbler.

On July 15, during a brief excursion into the woods that line the north shore of Gaspé Bay, I heard the unmistakable song of a Nashville Warbler; the species was not noted elsewhere.

9. **Helminthophila peregrina**, Wils. — Tennessee Warbler.

The only specimen met with was shot near Fox Bay, Anticosti, July 11. I had penetrated a mile or more inland, following a wood road, when the familiar song came faintly to my ears. Noting the direction of the sound I left the path and descending a slope entered a swamp where spruces (Abies alba) and larches (Larix americana) grew in matted and often impenetrable thickets with narrow openings between. Under the evergreens nearly every ray of light was excluded, and even the openings were too small to admit much sunshine; but they were enlivened in places by beds of beautiful lady's slippers, some of which were of a rich golden color, others rose shading into white, and the ground everywhere was deeply carpeted with moss.

This lonely place contained apparently only two birds, a Maryland Yellow-throat, and the Tennessee Warbler. The latter was flitting about in the upper branches of a larch busily searching for insects, but every now and then suspending this occupation to give utterance to his shrill, hurried song. It seemed a pity to rob the spot of his cheery presence.

10. **Dendrœca æstiva**, Gm. — Yellow Warbler.

The Yellow Warbler was one of the most abundant members of its family at Fox Bay, Anticosti, where, however, it was apparently confined to the vicinity of the settlers' clearings along the shore. About these it frequented wood edges and outlying thickets of spruces, intermixed with mountain ashes and cornels (Cornus alternifolia). In several such places it fairly swarmed, being actually more numerous than I have ever found it in New England. We also saw a few specimens in the village gardens at Gaspé.

11. **Dendrœca virens**, Gm. — Black-throated Green Warbler.

Met with only about Port Hawkesbury, Cape Breton, and at Fox and Ellis Bays, Anticosti. At the former place it was common but only two or three were seen on Anticosti.

12. **Dendrœca striata**, Forst. — Black-poll Warbler.

Decidedly the most numerous of the Warblers on the Magdalens, and fairly common at Anticosti, as well as along the North Shore. It was not detected at either Gaspé or Port Hawkesbury, although it *should* occur, of course, everywhere near the coast from Maine to Labrador. Among some remarkable stunted spruces which cover the sand-hills near Amherst Harbor (Magdalen Islands) these Warblers were in great force, and six or seven males could be often heard singing at once. I searched closely for nests, but although they must have been breeding at the time (June 26), none were discovered.

13. **Dendrœca maculosa**, Gm. — Black-and-yellow Warbler.

At both Fox and Ellis Bays, Anticosti, this beautiful Warbler was more abundant than any other species of its family, outnumbering even the Black-poll in the proportion of two to one. It was also ascertained to be a common bird about Port Hawkesbury, at Gaspé, and along the North Shore. Among the Magdalens, however, it was apparently rare; a specimen observed at Amherst Harbor, June 26, being the only one met with. Its habits throughout this region are essentially the same as in New England. It frequents thickets of young evergreens along wood edges or in clearings, and is not often seen in the depths of the forest.

14. **Siurus auricapillus**, Linn. — Oven Bird.

A single pair observed at Ellis Bay, Anticosti, on July 24.

15. **Geothlypis trichas**, Linn. — Maryland Yellow-throat.

The Maryland Yellow-throat was met with only at Fox Bay, Anticosti, where two specimens were seen. The note of one of them, a male shot July 11, was so shrill, wiry, and altogether unlike the bird's normal song that up to the moment of taking him in hand I felt sure I had stumbled upon a prize or, at least, something that I had never heard before.

16. **Myiodioctes pusillus**, Wils. — Wilson's Black-cap.

Although I had expected to find this species common it was observed only twice, near Gaspé and at Ellis Bay, Anticosti. On both occasions adults were seen feeding newly-fledged young; in the first instance among alders bordering a brook; in the second, on high ground in an opening grown up to mountain maples (Acer spicatum).

17. **Setophaga ruticilla**, Linn. — American Redstart.

Several were seen at Fox Bay and others near Mingan. At Ellis Bay they were really common in the hardwood timber and mixed growth a little back from the shore. The species was not noted to the southward of Anticosti.

18. **Tachycineta bicolor**, Linn. — White-bellied Swallow.

On July 9 two were seen near Fox Bay flying over the surface of a salt water lagoon.

19. **Petrochelidon lunifrons**, Say. — Cliff Swallow.

We found a small colony nesting under the eaves of a shed at Port Hawkesbury, but the species was not observed elsewhere. Verrill describes[1] a nesting place on the face of some limestone cliffs on the eastern side of the entrance to Ellis Bay. Owing to lack of time I was unable to visit this spot, but as none of the birds were seen about the bay I suspect that the colony had deserted the locality.

20. **Cotile riparia**, Linn. — Bank Swallow.

Bank Swallows were observed rather frequently, but we met with only two breeding colonies; one at Grand Entry Island, the other near Gaspé. In the latter locality the birds had drilled their holes in the face of a soft limestone cliff, but at Grand Entry they were nesting in the usual manner in a layer of sandy earth near the top of a bank.

21. **Progne subis**, Linn. — Purple Martin.

Observed at Point du Chêne where a colony occupied a Martin box in the village.

22. **Vireo solitarius**, Vieill. — Solitary Vireo.

On June 23 I heard a male singing in some spruce woods that crowned a hill behind the little village of Macnair Cove. Rather curiously, this was the only Vireo of any species observed during the expedition.

23. **Carpodacus purpureus**, Gm. — Purple Finch.

An abundant species of general distribution about the shores

[1] Proc. Bost. Soc. Nat. Hist., vol. IX, Dec. 1862, p. 137.

and islands of the gulf. We heard its rich song at Port Hawkesbury, among the spruces that lined the streets of Gaspé, in the lonely forests of Anticosti, and at various points along the North Shore. Throughout this region its voice was prominent in the chorus of songsters that add so much to the attractiveness of the brief, semi-Arctic summer.

24. **Loxia leucoptera**, Gm. — White-winged Crossbill.

On July 24 I observed a flock of eight or ten individuals at Ellis Bay, Anticosti. They were flying about a tract of burnt ground, occasionally alighting on some dead spruces. I got sufficiently near them to ascertain that the flock consisted of two pairs of adult birds with their young still in the streaked first plumage, but they were so restless that I could not obtain a shot. The old males occasionally uttered a feeble, trilling song very like that of the Snowbird (Junco hiemalis), and I also heard the metallic *chink* and chattering cry given by the species in winter. This was the only occasion on which Crossbills of either species were met with.

25. **Chrysomitris pinus**, Bartr. — Pine Linnet.

Pine Linnets were abundant at Gaspé, where they were apparently nesting in the spruces and balsams that lined the village streets. At all hours of the day the males could be seen circling or floating in the air, singing on wing in the manner of the Goldfinch (Chrysomitris tristis). This was on July 14. Later (July 24) we found them in flocks among the evergreen forests about Ellis Bay, Anticosti, where their restless, wandering movements indicated that the breeding season was at an end.

Despite the fact that all the authentic nests of this species have been taken in early spring, I am convinced that many individuals breed in June and July. In northern Maine and New Hampshire I have taken young in first plumage as late as the first week of August, while I have never found them on wing before July 10. It may be objected that such cases merely indicate a second laying ; but my experience earlier in the season, in the region just referred to, affords abundant proofs that the species never breeds there before the middle of June. The truth of the matter probably is that, like the Crossbills, it nests irregularly and at different times in different places. The song of the Pine Linnet is closely similar to that of Chrysomitris tristis.

26. **Chrysomitris tristis**, Linn. — American Goldfinch.

Common at Gaspé, but seen nowhere else.

27. **Passerculus savanna**, Wils. — Savanna Sparrow.

An abundant species on all the grassy islands and shores of the Gulf. Among the Magdalens there was a marked variation in the songs of individuals inhabiting different islands, although the notes of different individuals on the same island were usually identical. Being on the watch for the Ipswich Sparrow (P. princeps), I took pains to shoot every bird whose song was in any wise peculiar; but none of the numerous specimens examined showed any considerable variation from the typical style. I shall always regret, however, that no opportunity occurred for exploring the extensive sand-dunes of the larger islands. These wastes of shifting sand, covered in places with patches of beach-grass, were in every way suited to the peculiar requirements of the Ipswich Sparrow; and on several occasions, as our vessel passed near them, I caught the faint notes of Passerculi, some, if not all of which, may have belonged to this interesting species whose summer home is still unknown.

28. **Melospiza lincolni**, Aud. — Lincoln's Finch.

Shortly after our arrival in the Gut of Canso the "Arethusa" came to anchor one fine morning off Macnair Cove, a little fishing hamlet nearly opposite Port Hawkesbury. While our men were attending to the purchase of some supplies the rest of us improved the opportunity for a run on shore, and each choosing his own course the party soon became separated. I made directly for the nearest woods, and crossing a hilly pasture entered an extensive tract of young spruces and balsams which grew for the most part in clusters or thickets with circular openings between. These openings were more or less springy, and the wetter places sustained a rank growth of a peculiar dark-green reed,[1] slender and round-stemmed and similar to, if not identical with, a species which is found about brackish ponds along the coast of Massachusetts.

Here Lincoln's Finch was apparently numerous. At least, in the brief time that elapsed before we were recalled by a signal from the vessel, I shot three specimens, all of which were evidently breeding. The first was a solitary male, but as it came

[1] Probably Scirpus validus.

directly to me and chirped anxiously it probably had a mate and nest not far away. The other two were a mated pair. The male appeared first, and upon my shooting him the female started almost under my feet. There was no mistaking her extreme solicitude, but a search for the nest, although long and careful, proved fruitless.

Late in the afternoon of the same day (June 23) we landed again; this time at Plaster Cove, a picturesque spot on the opposite (Cape Breton) side of the Gut, about ten miles to the westward. The country here was drier and more rocky, but near the source of a brook that emptied into the cove I found a small tract of springy spruce openings, and in it another Lincoln's Finch. This bird acted precisely like the other three, and I was convinced that she also had eggs or young.

Rather curiously, I did not hear any of the males sing, although the day was favorable for bird music, and other species were particularly noisy. The notes of alarm or anxiety used by both sexes were a sharp *tchip* common to nearly all Sparrows, and a soft *tsup* indistinguishable from that of the Snowbird. These Sparrows impressed me as being rather more active and animated than are most of their allies. They are trim and graceful in form, and the feathers of the crown are habitually raised in a loose crest. I had no difficulty in distinguishing them from the numerous Song Sparrows which occurred with them; the Song Sparrows being much bolder and less skulking in their movements, as well as appreciably larger and stouter in build.

The positive determination of four individuals, probably representing three pairs, during so hurried and limited an exploration renders it probable that Lincoln's Finch breeds rather commonly over more or less of this region. Still it may be locally distributed there, especially if it is confined to the peculiar kind of ground where my specimens were obtained. On the Atlantic seaboard it has not, to my knowledge, been previously found breeding south of Labrador.[1] I fully expected to meet with it on the North Shore, if not at Anticosti, but it was not again seen.

29. **Melospiza palustris**, Wils. — Swamp Sparrow.

[1] Since writing the above Mr. George O. Welch has informed me that he found it numerous and apparently breeding within thirty miles of Halifax, N. S., during August, 1883.

An abundant species on Anticosti where the numerous fresh-water marshes and reed-fringed brooks afford haunts in every way suited to its peculiar habits. In all such places the pleasing mellow trill of the male was one of the characteristic bird voices, while it was often the only sound that broke the dreary silence, or rose above the rustle of the reeds stirred by the chill sea breezes.

I cannot help suspecting that Verrill mistook this species for the Tree Sparrow (Spizella monticola), for he does not include it in his list, while he characterizes the Tree Sparrow as "common" and breeding.[1] I failed to find the latter at all, although I searched for it closely.

30 **Melospiza meloda**, Wils. — Song Sparrow.

This ubiquitous species was abundant along the shores of the Gut of Canso and a few occurred about Gaspé, but we saw none either at Anticosti or on the North Shore. Dr. Merriam, however, has found it "tolerably common" near the mouth of the Godbout River.[2]

31. **Junco hiemalis**, Linn. — Common Snowbird.

Of general and very uniform distribution on the shores and islands of the Gulf, but nowhere as numerous as in northern New England.

32. **Spizella socialis**, Wils. — Chipping Sparrow.

Seen only at Gaspé where it was common.

33. **Zonotrichia albicollis**, Gm. — White-throated Sparrow.

Everywhere about the Gulf, save on the wind-swept Magdalens, this Sparrow was an abundant and familiar species. Along the Gut of Canso, in the fertile country about Gaspé, among the shaggy forests of Anticosti, and on the fir-clad coast of the North Shore, we heard its clear *pee-pee-peabody-peabody-peabody*, ringing incessantly along the wood edges, or breaking the silence of some lonely glen where the wandering summer breezes rarely rustled a leaf or stirred the Usnea moss that draped the branches of the grim spruces. Like the Fox Sparrow it is an untiring songster, and its voice is perhaps even more in keeping with the beautiful solitudes which it chooses for its summer home. This

[1] Proc. Bos. Soc. Nat. Hist., vol. IX, Dec. 1862, p. 138.

[2] Bull. Nutt. Orn. Club, vol. VII, p. 235.

voice is such a marked feature of the northern woods that it is sure to attract the attention of every one who hears it there, although only an occasional listener may know its author by his true name.

34. **Passerella iliaca**, Merr. — Fox Sparrow.

We found the Fox Sparrow among the Magdalens, on Anticosti, and everywhere along the North Shore. It was not detected at the Gut of Canso, nor at either Port Hood, or Gaspé. In fact, I doubt if it breeds, at least regularly, anywhere south of the St. Lawrence except on the Magdalens, for it is a species which could not be overlooked, even by the most superficial observer. It was particularly abundant at Fox Bay, Anticosti, where its favorite haunts were the impenetrable thickets of stunted firs and spruces near the coast; although it also occurred plentifully in the heavier forests of the interior, especially about openings. At Ellis Bay, as well as along the North Shore, it was much less numerous. No nests were found, but young in first plumage (similar to those which formed the types of Verrill's "Passerella obscura"[1]) and still under the care of their parents were taken at Fox Bay on July 9.

What the Mockingbird is to the South, the Meadow Lark to the plains of the West, the Robin and Song Sparrow to Massachusetts, and the White-throated Sparrow to northern New England, the Fox Sparrow is to the bleak regions bordering the Gulf of St. Lawrence. At all hours of the day, in every kind of weather late into the brief summer, its voice rises among the evergreen woods filling the air with quivering, delicious melody, which at length dies softly, mingling with the soughing of the wind in the spruces, or drowned by the muffled roar of the surf beating against neighboring cliffs. To my ear the prominent characteristic of its voice is richness. It expresses careless joy and exultant masculine vigor, rather than delicate shades of sentiment, and on this account is perhaps of a lower order than the pure, passionless hymn of the Hermit Thrush; but it is such a fervent, sensuous, and withal perfectly-rounded carol that it affects the ear much as sweetmeats do the palate, and for the moment renders all other bird music dull and uninteresting by comparison.

[1] See Proc. Bos. Soc. Nat. Hist., vol. IX, Oct. 1862, pp. 143–145

35. **Corvus corax carnivorus**, Bartr. — American Raven.

The Raven was evenly distributed throughout the region under consideration, but it was nowhere really abundant. Thus while a day rarely passed when several were not observed, I cannot recall ever seeing more than two or three together or even in the same vicinity. A number of empty nests were found (the young had all taken wing before our arrival), most of which were inaccessible; but one at Perroquet Island was built on a ledge less than ten feet above the beach.

At Grand Entry Harbor a Raven used to make frequent visits to some sand-hills near our anchorage where numerous Terns were breeding. He would course to and fro over the ground much in the manner of a Marsh Hawk, alighting whenever he discovered a nest with eggs. During these raids he was followed by a long train of Terns, whose distracted cries and threatening swoops were treated with perfect indifference.

The usual note of the Raven is a hoarse rolling *cr-r-r-cruck*, but he has other cries. At Ellis Bay I noticed a noisy mob of Crows dashing about the top of a tall spruce growing near the shore. Curious to learn the cause of the excitement I paddled towards the spot, when suddenly a deep, long-drawn moan came from the middle of the throng. Approaching still nearer the sound was repeated, and finally a Raven started from the tree hotly pursued by his tormentors. As he flew away he uttered the peculiar note at each dash which the Crows made at him, thus settling all doubts as to its origin.

The occasion just referred to was by no means the only one where we saw Crows mobbing a Raven. In fact they invariably gave their big relative a warm reception; and rather curiously, he appeared to be quite as helpless under their attacks as the Crow of New England is when pursued by the Kingbird.

Despite their difference in size and habits, I must confess that I often had difficulty in distinguishing Ravens from Crows. Every one must have noticed how the apparent size of a Crow will vary under different conditions of the atmosphere; it is the same with the Raven. At times he looks as big as an Eagle; at others scarcely larger than a Fish Crow. But when actually in company with Crows he cannot be possibly mistaken, for he then appears, as he is, nearly double the size of any of them. His flight did not seem to me as characteristic as it has been described. True, he sails more than does the Crow, and there is something peculiar in his wing strokes, but the difference is not always appreciable unless there is an opportunity for direct comparison.

36. **Corvus americanus**, Aud. — American Crow.

Nothing connected with the ornithology of the Gulf surprised me more than the habits of the Crows which we found there. They were abundant, and in many places as tame and familiar as street Pigeons. They fed largely on fish, crustaceans, and other animal matter cast up by the sea, and about the fishing stations congregated in large numbers to devour the offal that escaped the equally hungry dogs. Among the Magdalens we frequently saw them sitting on the roofs of the fishermen's huts, or stalking sedately among the boats drawn up on the beaches, often within a few yards of men at work. Even in the woods they would usually permit an approach to within ten or twelve yards, and at times seemed wholly devoid of fear. Mr. Henshaw was collecting insects one day on Grand Entry Island, when a pair, which probably had a nest in the vicinity, followed him for nearly an hour, poising directly overhead and frequently coming so near that he was tempted to strike at them with his net handle. The cause of this fearlessness is evident. The inhabitants cultivate no crops excepting a few potatoes, and the Crows being harmless, are tolerated, if not positively encouraged, as scavengers. The cunning birds are not slow to recognize the situation, and finding that they have nothing to fear from man quickly establish a relation which is more or less advantageous to both parties, but chiefly so, of course, to the Crows.

At Anticosti, as well as among the Magdalens, we were assured that all the Crows migrate southward on the approach of winter. Some of these migrants are doubtless the birds whose peculiar habits, as observed at Mace's Bay, were commented on by Mr. Chamberlain in his "Catalogue of the Birds of New Brunswick."[1] I cannot find, however, that either a specimen which he sent me, or those collected by our party, differ in respect to technical characters from the typical Corvus americanus.

37. **Cyanocitta cristata**, Linn. — Blue Jay.

[1] Bulletin of the Natural History Society of New Brunswick, No. 1, pp. 42, 43.

A small flock was met with at Plaster Cove near Port Hawkesbury, but none were seen elsewhere.

38. **Perisoreus canadensis**, Linn. — Canada Jay.

We found the Canada Jay abundant on Anticosti where, of course, it is resident. Several adults, and one young in the peculiar plumbeous first plumage, were obtained. The former do not agree with Mr. Ridgway's new race, nigricapillus, of Labrador, but are essentially similar to Maine birds.

39. **Tyrannus carolinensis**, Linn. — Kingbird.

Observed only at Point du Chêne, opposite Prince Edward's Island.

40. **Contopus borealis**, Swains. — Olive-sided Flycatcher.

A single specimen noted at Plaster Cove, Cape Breton, on June 23. I had fully expected to find the species at Anticosti where the woods are perfectly suited to its habits, but none were detected there.

41. **Empidonax flaviventris**, Baird. — Yellow-bellied Flycatcher.

At Ellis Bay, Anticosti, this Flycatcher was rather common in thickets of mountain maples (Acer spicatum), about the edges and openings of the woods. We did not meet with it either at Fox Bay or on the North Shore, but it doubtless occurs in both localities.

42. **Chordeiles popetue**, Vieill. — Nighthawk.

On the evening of June 27, as our vessel lay at anchor under the lee of Grand Entry Island, a Nighthawk mounted into the sky and repeatedly "boomed" overhead. Every now and then it would alight on a gravelly spit near by, where its mate was probably sitting. This individual was the only one observed during the summer. Verrill does not include the species in his list of the birds of Anticosti, but Dr. Merriam found it "a common summer resident"[1] at the mouth of Godbout River.

43. **Ceryle alcyon**, Linn. — Belted Kingfisher.

Observed at Gaspé and Mingan Harbor. In the latter locality it was rather common, frequenting the shores of the bay as well as the retired reaches of Mingan River.

44. **Picus pubescens**, Linn. — Downy Woodpecker.

[1] Bull. N. O. C., vol. VII, p. 236.

The only individuals seen were a pair whose nest, containing young nearly large enough to fly, was found near Fox Bay, July 11. Woodpeckers of whatever kind were very scarce throughout the regions which we visited, although many of the forests, especially on Anticosti, seemed to be perfectly suited to their requirements.

45. **Picoides arcticus**, Swains. — Black-backed Three-toed Woodpecker.

A single specimen seen near Gaspé and another heard at the mouth of Mingan River.

46. **Picoides americanus**, Brehm. — Banded-backed Three-toed Woodpecker.

This rare Woodpecker was met with on only one occasion — at Ellis Bay, Anticosti, July 24. I had penetrated into the depths of a sombre spruce forest when I suddenly came upon an adult female accompanied by a brood of young. The latter were full-grown and evidently getting their own living, for they climbed the tree trunks in the usual business-like way, tapping energetically at the softer places. This occupation was frequently interrupted by a merry game of hide-and-seek, when they would chase one another from tree to tree and around the stems, dislodging showers of loose bark in their ascent, and making a great racket, but always obedient to the call of their parent who led them in a nearly direct course through the woods. I found it impossible to count them, but although there seemed to be at least a dozen, I suspect that the number did not really exceed five or six. Their progress was so rapid and their movements so active that I had great difficulty in getting a fair shot at any of them; but by following the party for nearly half-a-mile I managed to kill the old female and one of the young. The former fell in a thicket where it could not be found, but the young bird was secured. It proved to be a female in first plumage and, like another of the same sex, and about the same age, which I have from northern New Hampshire, its crown is ornamented with a patch of yellow nearly as extended and conspicuous as in the adult male. This condition is by no means peculiar among Woodpeckers, however, for it is now known that with many, if not most species, the females in first plumage regularly possess markings which, with adults, are characteristic of the males.

The only note that I have heard the Banded-backed Woodpecker utter is a short *chuck* similar to that of P. arcticus, but rather softer and less loud. It closely resembles the sound of a distant axe-stroke on the resonant trunk of a dead tree.

47. **Colaptes auratus**, Linn. — Golden-winged Woodpecker.

A few seen near Gaspé, and one or two in the clearings about the fishermen's houses at Fox Bay, Anticosti.

48. **Asio accipitrinus**, Pall. — Short-eared Owl.

On July 22 two were seen by Mr. Gardiner on Niapisca Island, one of the Mingan group. They were shy and restless (although the day was clear), flying from place to place over the mossy barrens and uttering a barking note that reminded him of the cry of the Night Heron. He shot one of them, which proved to be an adult in worn breeding plumage. These were the only Owls of any species seen or heard during the summer.

49. **Pandion haliaetus carolinensis**, Gm. — American Osprey.

At both Fox and Ellis Bays, Anticosti, as well as along the North Shore, a few Ospreys were usually seen daily, but they were not numerous anywhere. The general scarcity — it might be almost styled absence — of raptorial birds in this region is surprising when the abundance of many forms of life upon which they are accustomed to prey is considered. I had expected to find several interesting species, especially the Peregrine Falcon, but, strange as it may seem, the only Hawk of any kind (excepting the Osprey) observed by our party was a large Buteo seen by Mr. Henshaw but not identified. Bryant had a similar experience in 1860.

50. **Canace canadensis**, Linn. — Spruce Grouse.

According to the inhabitants, this Grouse is the most abundant of its family throughout the wooded region bordering the North Shore.

51. **Bonasa umbella**, Linn. — Ruffed Grouse.

The Ruffed Grouse was not met with by our party, but I obtained some information affecting its northern range which, if true, is important. While at Mingan Harbor we were told, by the agent in charge of the Hudson Bay Company's trading post there, that three distinct species of Grouse inhabited the neighboring region. Of these the "White Partridge" was unmistakably the Ptarmigan (probably both L. albus and L. rupestris), while the "Gray Partridge" was equally clearly the Spruce Grouse. Of the "Birch Partridge" I give my informant's description in his own words as nearly as I can remember them: "It is larger than either of the others, brown in color, and has conspicuous tufts of shiny, black feathers on the sides of the neck. It has a habit of drumming on a rock or fallen tree. We call it the Birch Partridge[1] because it is usually found in hard-wood growth." He further said that he had shot specimens at various places to the eastward of Mingan, and on a certain occasion, when ashore near the entrance to Hudson's Straits, at the northern extremity of Labrador, had heard one drumming in the woods and following the sound, killed it.

Of course I made every effort to verify these statements and the result was highly satisfactory. The Indians about the post knew the bird well and had killed it at various points a hundred miles or more to the northward in the interior. The "guardian" of Mingan River was also familiar with it, and frequently heard it drumming in the neighboring woods. But the strongest evidence of all was furnished by a man who for several days acted as our pilot. This person had spent many years on the North Shore and had hunted extensively in the interior, as well as over, most of Labrador. He assured me that the "Birch Partridge" (of which he gave a good description) ranges over the entire region between the Gulf of St. Lawrence and Hudson Straits. In common with my other informants, however, he stated that it is nowhere numerous; but, on the contrary, occurs locally and sparingly in places suited to its peculiar requirements.

I have every reason to believe the above testimony reliable. If accepted it will, of course, extend the northward range of the Ruffed Grouse near the Atlantic coast, far beyond any point from which it has been previously reported.[2]

52. **Lagopus albus**, Gmel. — Willow Ptarmigan.

An adult female in summer plumage with a chick about ten days old were taken by Mr. Gardiner near Fox Bay, Anticosti,

[1] The Ruffed Grouse is called by the same name throughout most of northern New England.

[2] Dr. Merriam has recorded its occurence at Point de Monts, north of the mouth of St. Lawrence River. (See Bull. N. O. C., vol. VII, p. 238.)

on July 10. He found them about four miles inland on a ridge densely timbered with spruce and larch. The old bird was sitting on a log and when approached rose with a heavy whirr, clucking like a Ruffed Grouse. The chick started about ten yards away and flew well until stopped by the charge. No other young could be found, although Mr. Gardiner beat the ground over very carefully.

We were assured by the inhabitants of Anticosti that the Ptarmigan is the only Grouse which occurs on the island. It is said to be plentiful throughout the wooded portions and is, of course, resident. At Mingan it was formerly abundant, but of late years has been unaccountably scarce. It breeds in the interior, visiting the coast only in winter when hundreds have been killed about the trading post in the course of a few days.

53. **Ægialites semipalmatus**, Bonap. — Ring-necked Plover.

We saw the Ring-neck at Amherst Harbor, among the Magdalens, and on Mingan Island on the North Shore. It was evidently breeding at both places, but neither eggs nor young could be found.

54. **Phalaropus hyperboreus**, Linn. — Northern Phalarope.

Some Phalaropes seen near Bonaventure Island, July 12, and others met with on the 17th about midway between Anticosti and the North Shore, were undoubtedly of this species, although we were unable at the time to positively identify them. On July 25, however, while the "Arethusa" lay becalmed about thirty miles to the northward of Cape Rosier and perhaps half that distance from land, I had an opportunity of obtaining specimens, as well as of becoming better acquainted with their interesting habits.

I had gone in pursuit of some Petrels when my attention was suddenly attracted by a flock of Phalaropes in the act of alighting on the water a few hundred yards away. Upon sculling towards them I was surprised to find that they were by no means as unsophisticated as I had previously supposed. Long before I was within range they took wing; not all together, but in a straggling manner, one individual following another until all had left the water, when they closed into a compact bunch and rising high in the air whirled about a few times overhead, finally alighting several gunshots away. These tactics were repeated until I nearly despaired of getting a shot when at length, actuated by one of those unaccountable freaks occasionally shown by even the shyest birds, the flock dashed by within close range and I secured nine specimens with my two barrels. Several other flocks which afterwards appeared were equally wary, but I managed to get two or three long flying shots, adding four more birds to the bag.

The attraction at this particular spot was evidently a quantity of drift-weed in or near which the birds always alighted. Their motions on the water were peculiar. They usually settled close together, but the flock soon became scattered over a wide area, for each individual chose its own course without reference to that of its neighbor. They swam rapidly and invariably in zig-zag lines, accompanying each stroke of the feet with a graceful nodding motion of the head. As they hurried about among the floating sea-weed, visiting clump after clump in quick succession, their movements resembled those of a colony of excited ants. Occasionally one would alight or climb on a detached mass of weed and spend a few moments in pluming its feathers; but, as a rule, they were too nervous and active to remain long at rest. They floated very lightly on the water, nearly the whole body being exposed, and when suspicious of danger stretched up their slender necks to a surprising length. This attitude may have suggested the seemingly inappropriate name "Sea Geese," by which they are almost universally known among the fishermen.

While on the wing they uttered a short *quet* exactly like that of the Sanderling. Their flight was swift, erratic, and in every way like that of the smaller Tringae. When about to alight they often pitched down from a considerable height with closed wings, much as Snipe will do under similar circumstances. One that I wounded swam swiftly and dodged with such address that I had great difficulty in catching it, but it did not attempt to dive.

All the specimens taken were adults. They still wore the breeding plumage, but it was ragged and faded, and with the majority the autumnal moult had begun, more or less gray feathers appearing among the brown or chestnut ones. Twelve of the total thirteen were females. Dissection indicated that most of them had laid earlier in the season, but none showed any signs of having *incubated.* These facts suggest that the domestic relations of this species may be similar to those of Wilson's Phalarope, the male of which is known to assume — either by choice or necessity — the entire duties of incubation and subsequent charge of the young, while his mate, joining other equally recreant ones, throws aside all care and wanders abroad in search of selfish pleasures and diversions. In the present instance the nests of these birds may have been many hundred miles to the northward. If this inference be correct the occurence of the Northern Phalarope during early summer off the coast of New England is sufficiently explained.

55. **Philohela minor**, Gm. — American Woodcock.

The only specimen satisfactorily identified was one seen near Gaspé. Mr. Gardiner thought that he flushed another in a springy place at Fox Bay, Anticosti, but the foliage was so dense that he did not get a clear sight at it.

56. **Tringa minutilla**, Vieill. — Least Sandpiper.

A few were observed daily along the beaches at Fox Bay, Anicosti. Verrill found them breeding numerously in the interior of the island.

57. **Totanus melanoleucus**, Gm. — Greater Yellow-leg.

We found this species abundant on Anticosti and by no means uncommon about the mouth of Mingan River, where the fish-warden assured me that they nest regularly. Of the breeding of the species on Anticosti I have the strongest circumstantial evidence, as the following extracts from my note-book will show:

"Fox Bay, *July* 8. Explored a salt-water lagoon connected with the bay by a short, winding river. It proved a beautiful sheet of water, crescentic in shape, and perhaps three-quarters of a mile long. It was entirely surrounded by woods, the trees in many places overhanging the water. There were several small, grassy islands and some larger wooded ones. On the former we found at least a dozen pairs of Greater Yellow-legs which were apparently breeding, for they circled over our heads keeping up a deafening clamor. Neither eggs nor young could be found however."

"Fox Bay, *July* 10. Gardiner returned late this evening from an all day's trip into the interior, which he describes as a vast, treeless expanse of rolling ground covered with tall grass. In the hollows between the ridges are long, shallow ponds of clear water around which Greater Yellow-legs were breeding abundantly. They darted about his head and often followed him for a considerable distance. He brought me three specimens, all adult females. Two of them had each four incubating spots arranged in pairs, one pair on the sides of the breast, the other on the abdomen. The third bird had only one pair of spots, on the abdomen."

"ELLIS BAY, *July* 24. The Greater Yellow-legs are even more numerous here than at Fox Bay. At sunset last evening they were calling all around the shores, and I came upon one this morning which evidently had young. I had landed on a grassy point when she flew directly at me, darting down with set wings and passing within a few feet of my head, all the while uttering an incessant *clack-clack-clack-clack*, which sounded very like the clatter of a mowing-machine. Once or twice she alighted on the limestone flats and tumbled about as if wounded. I failed to find the young which must have hidden in the tall grass."

Previous to the experiences just related I had supposed myself well-acquainted with these birds, but I am free to confess that when I first met them at Anticosti I had to shoot several before I could believe that they were really Greater Yellow-legs. Not only were their flight and actions peculiar, but all their notes differed from any that I had ever heard them produce. In addition to the cry already described, they uttered a rolling *pheu-pheu-phé*, *pheu-pheu-phé*, repeated a dozen times or more in quick succession ; a mellow *pheu*, *pheu*, *pheu*, resembling the whistle of the Fish Hawk ; and a soft, hollow *hoo*, *whoo*, *whoo*, very like the cooing of a Dove. The latter note was given only when the bird perched on the top of some tall spruce, a habit by no means uncommon here, but one which I think has never been previously reported for this species, although the Willet, Wilson's Snipe, and several other waders are known to act in a similarly unorthodox manner during the breeding season. The shrill, descending whistle so familiar to the ears of sportsman was rarely heard at Anticosti.

As nearly as I can learn from a somewhat hurried examination of the literature of the subject, the Greater Yellow-leg has not been previously found breeding on the Atlantic Coast, while its eggs are still a desideratum in most collections, if, indeed, authentic specimens have ever been found. At the proper season, and with favorable opportunities for search, they could be unquestionably collected in considerable numbers on Anticosti.

58. **Tringoides macularius**, Linn. — Spotted Sandpiper.

An abundant species about all the rocky shores and islands of the Gulf.

59. **Numenius hudsonicus ?** Lath. — Hudsonian Curlew.

Several large flocks of Curlews which I took to be of this species were seen at East Point, Anticosti, on July 7. It is barely possible that they breed on Anticosti, but the inhabitants are probably right in asserting that only barren birds summer there.

60. **Nyctiardea grisea nævia**, Bodd. — American Night Heron.

On the evening of July 14 several of these Herons were observed on the flats in Gaspé Basin.

61. **Bernicla canadensis**, Linn. — Canada Goose.

The Canada Goose still breeds abundantly in the interior of Anticosti but we were unable to penetrate to its haunts. The inhabitants regularly kill large numbers in August when the adults are moulting, and the young not sufficiently feathered to be able to fly. Owing to this persecution the birds are fast diminishing in number.

62. **Bernicla brenta**, Pall. — Brant Goose.

At Mingan Harbor we were told that Brant bred abundantly about a hundred miles northward in the interior, but that the straggling individuals which were found not infrequently along the coast at that season were barren birds. Dr. Merriam gives[1] the species as breeding at Point de Monts, at the mouth of the St. Lawrence River, but as I understand that this record was based simply on the presence of adult birds there throughout the summer, I cannot help thinking that it needs confirmation.

63. **Anas obscura**, Gm. — Dusky Duck.

A common species in the Gulf, where, rather curiously, it seems to be confined to the immediate vicinity of the sea. At least at the Magdalens, Anticosti, and along the North Shore we were assured by the fishermen, Indians, and others that it breeds exclusively on or very near the coast, and is never seen in the fresh-water ponds or rivers of the interior. Our personal experience, as far as it went, confirmed this statement, for we did not once find the bird away from salt water, although it was met with almost daily about the shores of the more retired bays and coves.

[1] Bull. Nutt. Orn. Club, vol. VII, p. 239.

At Wreck Bay, Anticosti, I came upon a brood of young, which could not have been more than three or four days old, swimming in the sea at the base of a beetling cliff. They were accompanied by their mother who adopted the usual tactics to entice us away from the spot. We refused to be deceived, of course, and after a long chase captured one of the young by driving it ashore on a narrow, pebbly beach. Upon reaching the vessel it was carelessly tossed on deck when, to the surprise of every one, it scrambled nimbly down the companion-way and concealed itself so successfully in the cabin that at the time we were unable to find it. In the dead of the following night, however, after our lamp had been extinguished and all was quiet below, I distinctly heard the pattering of its webbed feet as it scuttled about over the bare floor. A few days afterwards it was found dead under one of the berths.

64. **Querquedula discors**, Linn. — Blue-winged Teal.

According to the fishermen at Fox Bay, Anticosti, this species occurs in small numbers during the migration.

65. **Clangula glaucium americana ?** Bp. — American Golden-eye.

A large brood of young, accompanied by a female which I did not have the heart to shoot, but which I took to be of this species, was seen in Mingan River near its mouth, July 20.

66. **Harelda glacialis**, Linn. — Old Squaw.

The "Cock-a-wee," as this Duck is everywhere called in the Gulf, was seen only once during our trip — on July 7, when a few individuals, doubtless barren birds, were observed at East Point, Anticosti. The fishermen and Indians of the North Shore all agree that it does not breed on that coast much to the westward of Labrador, although stragglers are always to be found throughout the summer. It is said to be one of the most abundant of the water-fowl in winter, when numbers are killed at tide openings in the ice.

67. **Histrionicus minutus**, Linn. — Harlequin Duck.

The fishermen and gunners at Fox Bay, Anticosti, were all familiar with this Duck, the sexes of which they distinguish by the usual coastwise names, "Lords" and "Ladies." The species is said to occur there only in winter when hundreds sometimes collect in the tide openings off East Point.

68. **Somateria mollissima dresseri**, Sharpe. — American Eider Duck.

The Eider is still common along the North Shore, but its numbers are rapidly diminishing there. This is due largely to the depredations of the Indians of the region who, during the summer, subsist largely on the birds and their eggs. Their manner of taking them is peculiar. They skirt the shore in canoes, keeping as close to land as the depth of water will permit. Meanwhile their dogs range about among the trees quartering the grounds like trained setters, and when a nest is discovered announce the fact by loud barking. The nests are usually within a few rods of the water, and the scent of the dogs is so keen that they rarely pass one. If the sitting bird can be caught or shot the opportunity is seldom neglected, for the half-starved Indian neither knows nor respects considerations of mercy — or, perhaps we should call it policy — which restrain more enlightened sportsmen on such occasions. Proceeding thus, two men in a canoe will frequently ransack twenty miles of coast-line in a single day and find, probably, nearly every Eider's nest. The result of this systematic persecution cannot be doubtful or long-delayed.

Our personal experience with the Eider was not extensive. We saw them frequently from Mingan Harbor eastward, but the Indians had been before us everywhere, and we could find neither eggs nor young. The birds were usually observed in flocks of from five to twenty individuals, all of which seemed to be adults and the majority females. Our pilot called them "Mooyaks," an Eskimo name he said, but one which we found in general use among the fishermen-gunners of this region. The Eider winters abundantly in the Gulf wherever it can find open water.

69. **Somateria spectabilis**, Linn. — King Eider.

One of the inhabitants at English Head Bay, Anticosti, gave me an accurate description of this Eider, which he said was nearly as common in winter as the "Mooyak." He called it by an Indian or Eskimo name which I neglected to note, and dwelt with much unction on the edible qualities of the peculiar fatty protuberance found on the forehead of the adult male. The bird was also known to the people at Fox Bay, but it was not considered common there.

70. **Melanetta velvetina**, Cass. — American Velvet Scoter.

This Scoter was observed near Port Hood, among the Magdalens, at East Point (Anticosti), and along the North Shore. It sometimes occurred singly, but oftener in flocks of from four or five to thirty individuals. We obtained no proofs of its breeding at any of the places visited by the expedition, but on the contrary were assured everywhere that it does not nest to the westward of Labrador proper.

71. **Mergus serrator**, Linn.—Red-breasted Merganser.

An abundant species of general distribution throughout the Gulf. We were told that it breeds chiefly in the interior, in fresh-water ponds and rivers, but I saw very young ducklings on salt-water. The following paragraph taken from the notes which I made at Ellis Bay, Anticosti, furnishes an instance of this, as well as gives a glimpse at the bird in its summer home:—

"The evening was delightful, and Gardiner and I improved it by taking one of the boats and sailing about the bay. A soft land breeze stole over the quiet water bringing the scent of flowers and spruces, the rich music of the Fox Sparrow, the clamor of Yellow-legs, the barking notes of Herring and Black-backed Gulls, and the occasional mournful cry of a Loon. Around us great numbers of seals were playing; some of them huge fellows who breathed heavily like a man in pain as they thrust their grizzled heads above the surface to take in air for another dive. But most interesting of all was a female Sheldrake brooding her swarm of ducklings on an isolated rock near the middle of the bay. We actually sailed within arm's length of her before she took the alarm. There then was great commotion; the young scattering in all directions and diving like Grebes; the parent fluttering along in front of the boat, half-running, half-flying, and croaking incessantly. But after we had withdrawn from the spot and all was quiet again, she quickly called the brood together; and a little later we saw them crossing the bay—a cluster of dusky specks throwing out silvery ripples on the smooth, black water."

72. **Sula bassana**, Linn.—Gannet.

A few Gannets were seen off the eastern shore of Nova Scotia and others in the Gulf near Port Hood, but they did not become really numerous until we reached the Magdalens. The shallow bays and channels among these islands afford extensive, and in every way favorable fishing-grounds, and hundreds of the birds were constantly in sight, mingling with the still more numerous Terns and Kittiwakes. Although a few Gannets are said to breed on Shag

Rock, near Grindstone Island, most of those seen at the Magdalens evidently came from Bird Rocks. This famous rookery was visited by our party on July 4. Its wonders have been so well described already by Dr. Bryant[1] and Mr. Maynard[2] that I shall confine the present narrative to a brief account of the changes which have taken place since their respective visits. In 1860 the number of Gannets breeding on the *top* of Great Bird (then uninhabited) was estimated by Bryant at about "fifty thousand pairs," or one hundred thousand birds. In 1872 Maynard found this portion of the colony reduced to about five thousand birds (a lighthouse had been erected on the summit of the rock and several men were living there). When we landed in 1881 the top of the rock was practically abandoned, although there were some fifty nests at the northern end which had been robbed a few days before and about which the birds still lingered. The shelving places and ledges around the face of the cliffs, however, were still densely populated, and the colony on Little Bird was probably as large as the available nesting places there would allow; but the total number of Gannets breeding on both islands did not, as nearly as I could estimate it, exceed fifty thousand. This number, although sufficiently astonishing and impressive when the limited area of the islands is considered, is, of course, insignificant in comparison with that of the legions which Bryant found twenty-one years before. The decrease is easily explained; for the stringent laws framed for the protection of these and other sea birds breeding on the rock, are — or were in 1881 — but loosely enforced, and a day rarely passed when parties did not land on both islands to collect the eggs and shoot the sitting birds. The eggs are eaten, and the flesh of the birds is used, in preference to anything else, as bait in the cod fishery. The negligence on the part of the Canadian government, which tolerates such open violation of its statutes, cannot be too strongly condemned.

After leaving Bird Rocks our party visited two other breeding places of the Gannet: the first, on Perroquet Island near Mingan Harbor; the second, on Bonaventure Island, just north of Bay Chaleur. The latter colony was a large one, and we were assured

1 Proc. Bost. Soc. Nat. Hist., vol. VIII, May 1861, pp. 65–75.

2 "Town and Country," 1879, vol. I, nos. 4–8.

that it was rarely disturbed; a fact owing more to the inaccessibility of the stronghold than to any forbearance on the part of neighboring fishermen. The nesting place on Perroquet Island, however, was despoiled the day before we landed by Indians, who did their work so thoroughly that only empty nests and occasional broken eggs remained to mark the spot where less than a week before we had seen hundreds of birds sitting in fancied security.

Of the Gannet's habits and general manner of life I learned little, if anything new, although for several weeks the superb birds were almost constantly with us; — floating idly on the blue sea; skimming close to the waves in the teeth of a stiff breeze; hovering excitedly over schools of capelin among which they plunged with fierce energy; and at evening, stringing out in long lines against the sunset sky as they flapped their way homeward to the rookery. But most vivid of all is the recollection of their presence on a certain occasion when our vessel was overtaken by a squall in the middle of the Gulf. At the height of the confusion, when the voices of the men struggling to take in sail were drowned by the rush of the wind, and the sea, a moment before so calm, was furrowed by furious gusts, overhead, against the black storm clouds where lightning flashed and thunder rolled incessantly, a score of the majestic birds sailed; calm, impassive, emotionless, breasting the gale as easily as if it were the gentlest summer breeze. How often must such a group have been the sole witnesses of still wilder scenes, when vessels less fortunate than ours have foundered and sunk with all on board.

73. **Phalacrocorax carbo**, Linn. — Common Cormorant.

The Common Cormorant was observed on only two occasions: at Wreck Bay, Anticosti, where we found a small colony nesting, and near Point du Chêne, where a few were fishing in the harbor. The colony at Wreck Bay comprised only about twenty nests — bulky structures of sticks and sea-weed built on the projections of a vertical limestone cliff some fifteen feet below the summit and at least one hundred above the sea, and inaccessible to one unprovided with a rope. At the time of our visit (July 7) each nest contained from two to four nearly grown young. These sat erect in the nests vibrating their gular pouches incessantly with a quivering motion, as if panting. The adults came and went singly, or in small flocks. They were excessively shy and I had great difficulty in securing two specimens, both of which proved to be females. The males were distinguishable at some distance by the clearer white of their throats, but I saw none which showed the peculiar plumes of the neck or the white patches on the flanks. In flight and general appearance this Cormorant resembles G. dilophus, but it looks much larger, and its white throat is usually a conspicuous feature.

74. **Phalacrocorax dilophus**, Swains. — Double-crested Cormorant.

Although this species was seen at various places in the Gulf, we found only one breeding-station — Percé Rock near the village of the same name. This remarkable island rises from the sea to the height of about three hundred feet, with perpendicular, in places overhanging, walls on all sides. It is nearly a thousand feet long and about one-third as wide at the broadest point, which is near the middle. The top slopes irregularly from either end towards the middle, which is thus slightly lower than the extremities. The eastern end is pierced at the base by an arch about twenty feet in width and perhaps twenty-five feet high. Through this arch the sea flows and small boats may easily pass at high water. What was once the extreme eastern end of the rock is now an isolated turret separated from the main island by a narrow channel which was formerly spanned by an arch similar to the one just described. This turret has also an incipient arch, at present only about two feet in diameter, but said to be fast enlarging.

At the time of our visit thousands of Herring Gulls and Cormorants were breeding on the summit of Percé Rock, and a few Black Guillemots occupied the crevices near its base.[1] Viewed from the sea this colony was sufficiently interesting, for the air was filled with circling Gulls, and rows of Cormorants lined the edge of the cliffs, sitting erect in strong outline against the sky, or craning their long necks outward to get a better sight at the intruders below. But to fully appreciate their numbers it was necessary to ascend a headland on the neighboring shore that overlooked the rock. From this point the sight was most im-

[1] Verrill found a colony of Gannets there in 1861, but at present their nearest breeding place is Bonaventure Island.

pressive. The top of the rock appeared like a stretch of burnt ground covered with patches of snow, the black areas being Cormorants, the white ones, Gulls. Although over the greater part of the surface the two birds were pretty evenly intermingled, the Cormorants in places sat crowded together in sable masses of considerable extent, while in others the Gulls formed beds of shining white. So completely was the rock covered by birds that its own color was scarcely anywhere apparent.

On this elevated stronghold the Cormorants lay their eggs and rear their young in perfect security.[1] Shortly after sunrise thousands of the adults leave for their fishing grounds in Bay Chaleur and Gaspé Bay, the greater number departing in a few large flocks. Through the day single birds and small companies are continually passing to and fro, but the general return movement does not begin until nearly sunset when, for half an hour or more, there is a steady stream pouring in from two directions and meeting at the home rookery. The incoming flocks regularly skirt the entire southern edge of the island and make a half wheel on set wings before alighting, but single birds fly directly in from any direction and alight at once. At this time of the day the flocks comprise from twenty to one hundred individuals. They fly at a height of about fifty yards above the water, either in a broad extended front, or in v-shaped ranks like Geese.

While in Gaspé Bay we frequently observed these Cormorants fishing near our vessel. They reminded me of Loons both in their general appearance, as they swam with the body partially submerged, and in their manner of diving. They disappeared beneath the water like a flash of light, springing nearly clear of the surface and then cleaving it so deftly that they scarcely made a ripple.

75. **Stercorarius parasiticus**, Brünn.— Richardson's Jaëger.

A single specimen was seen, July 20, near Mingan Harbor.

76. **Larus marinus**, Linn. — Great Black-backed Gull.

A few Black-backed Gulls were obtained in Gaspé Bay, but none

[1] Many years ago there was a sloping place, long since fallen into the sea, by which a daring climber reached the top; but in returning laden with eggs, he missed his footing and perished. A statute, passed shortly after this accident and said to be still in force, forbids any one from attempting to climb the rock under a penalty of five pounds.

were noted either among the Magdalens or on the North Shore, where I had expected to find them common. On Anticosti, however, they were numerous and generally distributed, usually outnumbering the Herring Gulls. They appeared to be breeding in or among the stunted evergreens that clothed the shores and headlands, and many were also seen circling over the heavier forests a mile or more inland where, like the Herring Gulls, they frequently perched on the tops of the trees. They often fished with the Herring Gulls, and the two species seemed to meet on perfectly friendly terms. The Black-backs are exceedingly noisy birds, especially when their young are in danger, as well as towards evening. At Anticosti their clamor was one of the characteristic accompaniments of the long summer twilight. I identified four distinct cries: a braying *ha-ha-ha;* a deep *keow, keow;* a short barking note; and a long-drawn groan, very loud and decidedly impressive when heard, as was usually the case, in the gloomy recesses of some lonely bay.

Previous writers — Audubon especially — have dwelt on the extreme shyness of this Gull, but I cannot forbear adding a further tribute to its remarkable sagacity. At all times of the year, during the breeding season as well as in winter, it is by far the wariest bird that I have ever met. A friend, who has wasted much time and ingenuity in the attempt, assures me that the adults cannot be either poisoned or trapped, [1] and the obtaining of a fair shot at one, even under the most favorable conditions, is an achievement of which a deer-stalker might be proud. During our summer in the Gulf I made every effort to obtain specimens, but although they were numerous in places I do not think that I once got within a hundred yards of an old bird. At Wreck Bay we found three young, perhaps a week old, squatting on a gravelly point at the base of a cliff. Their parents were circling overhead making the usual outcry, and at first we had high hopes of getting them within range; but, despite their evident solicitude, they kept far beyond reach of anything but a rifle-bullet. Accordingly we had to content ourselves with the young which were carried to the vessel and placed in a box on deck. One of them escaped as we were weighing anchor, but the other two

[1] During the past season, while at Newfoundland, he succeeded in trapping some on their nests.

shared our fortunes for several weeks. They fed greedily on all kinds of fish and flesh, and rapidly grew into large, noisy, and very vicious birds, ready at all times to bite the hand that fed them. We finally put them overboard in Ellis Bay when they swam directly for the shore, the parting on both sides being apparently equally free from regrets.

77. **Larus argentatus,**[1] Brünn. — Herring Gull.

Abundant throughout the Gulf, breeding almost everywhere. Along the North Shore, as well as on Anticosti, they nested chiefly among the evergreen woods, sometimes in the branches of the trees, but oftener on the ground in openings. Their nests were rarely near together, and I do not remember ever finding more than two or three pairs occupying the same locality, while they were usually distributed at intervals of perhaps half-a-mile over the mossy plains and openings, both inland and along the coast. They spent much of their time sitting on the tops of the trees, where their snowy plumage showed in strong contrast against the dark background. As our vessel approached the shore we could often see these Gulls scattered along for miles; the nearest looking like patches of snow, the more distant like white specks among the evergreens. Every now and then one would fly out to meet us, circling warily about and finally returning to his post of observation. They seemed to be ever on the watch for danger, and doubtless with good reason, for the Indians and fishermen rob them of their eggs whenever they can find them. Their present policy of scattering over wide areas, however, probably preserves the majority of nests from discovery. The only considerable *colony* of Herring Gulls which we visited was at Percé Rock, where, as already stated, many thousands were breeding in company with Cormorants. The old birds and their eggs are safe there, but the fishermen take a heavy toll from the young which often leave the rock before they are able to fly well, and falling into the sea are easily shot or captured alive. Early every morning several boats visited the place for the purpose of procuring them. They are eaten, and if properly cooked are by no means unpalatable, in fact we found them among the best of the sea-birds which could be had at that season.

[1] Believing the variety Smithsonianus to be untenable, I follow Saunders in referring the American birds to argentatus.

78. **Rissa tridactyla**, Linn.—Kittiwake Gull.

The Kittiwake breeds in considerable numbers at Bird Rocks, but we found a still larger colony established on the limestone cliffs at Wreck Bay, Anticosti. In both places the nests were plastered all over the face of the cliffs, from near the top to within a few yards of the sea below. Usually they occupied slight projecting points from which they could be easily detached, but a few were more substantially built on ledges or in shallow crevices. They were composed wholly of sea-weed and were saucer-shaped, rather deeply hollowed. All that we examined (the greater number were inaccessible) contained young, most of which were in the down.

At Bird Rocks few Kittiwakes were seen flying about, the pair belonging to each nest being usually at home, one bird brooding the eggs or young while the other stood or squatted on the rim of the nest. At intervals their shrill *kitty-wake*, *kitty-wake*, rang along the cliffs, being taken up by one bird after another like a watchword passed among sentinels; nevertheless they showed little alarm at our presence, rarely starting even when a gun was fired near them.

The colony at Wreck Bay was more active and bustling. Many birds were continually passing to and fro between the cliffs and the fishing grounds well out in the bay, and the arrival of each successive party was greeted with a general outcry of welcome. They were catching live fish here, and I was astonished to see them accomplish this in the manner of Terns, plunging straight down into the water and often disappearing for a moment beneath its surface. I shot several in the act before I could believe that they were really Gulls.

At Grand Entry Harbor their habits differed considerably, as will appear from the following extract of some notes which I made there under date of July 1:—

"There is a spot near our anchorage where the refuse from the lobster canning works is dumped at frequent intervals. Here the Kittiwakes congregate by hundreds. It is a pretty sight—the cloud of white birds hovering over the blue water, dozens sweeping down at once to join in the feast, eager, animated, excited, but showing not the slightest jealousy or selfish greediness. Their motions are identical with those of other Gulls under similar conditions. When about to pick up a floating object they drop the feet and for an instant literally stand on the water, while the bill is thrust down and the morsel seized. The action is graceful and so rapid that it is often difficult to see just how it is done. They are tame and confiding, often coming within a few yards of us. Ordinarily they are silent, but when a number are together they sometimes utter a low *cree*, *cree*, very like the cry of a young Tern. When the tide begins to ebb they float past our vessel, singly or in little companies, paddling about irregularly like Phalaropes, and feeding busily as they swim. I threw some pieces of fat among them, but they would not take or even notice it. They sit lightly on the water and carry both head and tail high. When one is killed or wounded the others pay little attention to it, at the most circling once or twice over the spot before passing on. This is at variance with their alleged habits in winter."

At this place the immature birds were largely in excess of the adults, from which they could be easily distinguished by the black-tipped tail and dark cubital bar. None of the immature specimens which I shot were breeding, but two adults showed unmistakable incubating spots.

At Bird Rocks Professor Hyatt obtained two young Kittiwakes apparently not more than three or four days old. They were deposited in a pail on deck and fed upon fish, which they ate freely. We could not induce them to drink, however, and in spite of every attention that could be thought of they pined rapidly. On the second day one of them died. The survivor was failing fast when some one placed him in a basin filled with salt-water, hoping that a bath might prove beneficial. To our great surprise he instantly began to *drink*, swallowing draught after draught with evident satisfaction. After that there was no further trouble. He had a dish of sea-water constantly within reach and it was frequently resorted to; but we could never tempt him to take fresh water, although the experiment was tried repeatedly.

Various theories have been advanced to account for the way in which sea-birds satisfy their thirst, theories which, as nearly as I can remember, have always started with the assumption that these birds must get *fresh* water, provided they drink at all (which has been disputed); but no one, I believe, has ventured to assert that they drink *salt* water. Nevertheless the facts just related show that the Kittiwake does this; and furthermore that it cannot or will not take fresh water when actually suffering from thirst. In view of such a development it is highly probable that the same practice obtains with other oceanic birds, many of which doubtless drink sea water freely; while some, like the Kittiwake, may even perish of thirst if separated from it for any length of time.

To return to our pet. He grew apace, and at the end of the fourth week was able to fly; but although he was occasionally thrown overboard for a swim, he showed no disposition to leave us. His manners from the first were singularly affectionate and confiding, and he never objected to being handled, but, on the contrary, received all caresses with a gentle playfulness that quickly won the heart of everyone. After the return of the "Arethusa," he was allowed full liberty at Annisquam, but although he made daily flights down the harbor, he invariably returned to the vessel at sunset and spent the night in the pail in which he had been reared. I last saw him about the 25th of August. When I reached the shore he was sitting on the water several hundred yards away, but in response to a familiar call he rose and flew directly to me alighting near at hand and allowing me to take him up with every appearance of satisfaction. In his fresh fall plumage he was a beautiful bird, and his gentle ways were inexpressibly winning. A week or two later he failed to return from one of his trips down the harbor. Perhaps he wandered out to sea; more likely some idle gunner made him an easy victim. At all events he was never seen again by any of his really devoted friends.[1]

[1] I am indebted to Professor Hyatt for the following interesting notes on this Gull made during the return voyage, after I had left the "Arethusa":—

"The Kittiwake after a long probation in trying his wings, at last several times in calm weather flew as high as the after rail (about a foot) and lighted upon it, but made no effort to go overboard. Finally on a calm day off the Gut of Canso the bird was placed in the water for a swim, but he showed great terror, swimming close to the boat we had lowered, and was so evidently anxious to be taken in again that he was kept out a very short time. He did not seem to become accustomed to the water until he had reached Annisquam and had acquired considerable powers of flight; preferring evidently his bath in a bucket. He appeared to be terrified, also, when first bathed in a bucket; but when placed in a basin, where he could stand with his feet on the bottom, took evident pleasure in bathing. After he became more accustomed to the water, the bucket was again brought into use, and then it was successful. The wide expanse of the sea, or the absence of a foothold, seemed to inspire him with terror. He made no efforts towards prolonged flights until one day after our return to Annisquam I took him to the door and threw him gently from an elevation of about ten feet. Instead of flying slowly to the ground, as I had anticipated, the bird sailed off a hundred feet at

79. **Sterna hirundo**, Linn. — Wilson's Tern.

The shallow bays and channels among the Magdalens furnish favorable fishing grounds for Terns, and the extensive sand-hills which border many of the beaches are in every way adapted for nesting purposes — a combination of attractions that had not been overlooked, for we found the birds there by thousands. Only two species were represented, the Wilson's and the Arctic. They usually occurred together, but the Wilson's Tern was everywhere the more numerous. The largest colony visited was at the eastern end of Amherst Island where several thousand pairs were nesting. It was impossible to identify their eggs without trapping the sitting birds. The moment the place was invaded the whole colony became aroused, and in the general confusion the owner of any particular nest could not be distinguished among the dozens of sympathizing friends that hovered with her over our heads.

Poor Sea Swallows! they have nearly as hard a time among the Magdalens as at breeding stations along our own coast. Not that the birds themselves are as often molested, for the islanders are too chary of powder and shot to waste them at useless marks; but the eggs are duly appreciated, and parties of women and children visit the sand-hills daily taking every one that can be found. How the birds bear the drain to which they are almost everywhere subjected is a mystery. But unless steps are taken very soon to ensure them at least partial protection during the breeding season the days of their race are numbered.

After leaving the Magdalens we saw few Terns of either species, the shores in most places being too rocky, and the bays too deep, to afford the required conditions of environment.

least, turned, flew back over the house and through the trees, avoiding obstacles, and soaring with perfect ease and very swift motion round and round the area of the house. Very soon, however, he began to approach very close to me and scream as if in distress. It was evident that he was tired and wished to alight, but did not know how to stop. Finally I succeeded, by suddenly throwing up my arms as he came towards me in arresting him; and he literally tumbled against me and fell on the ground. His excitement was very great, and he would have started again very soon, of his own accord, if I had not held and quieted him. He was wild with delight. I started him again when rested, and precisely the same scene was reënacted; and he did not learn to alight by himself until after several flights. After this he flew as Mr. Brewster has described, but on account of the danger from lawless gunners I was obliged finally to clip his wings. Not enough, as it proved, since he succeeded in flying over to some marshes opposite the house and never reappeared; probably having been shot.

80. **Sterna macrura**, Naum. — Arctic Tern.

Although less numerous than Wilson's Tern the present species was everywhere common in favorable localities. It occurred in the greatest abundance at the eastern extremity of Amherst Island, where it represented at least twenty-five per cent of the total number of Terns breeding there. I had several excellent opportunities for comparing the notes and habits of the two species. Their notes are similar, but several of them can be distinguished. The usual cry of S. macrura corresponds to the *tearr* of S. hirundo, but is shriller, ending in a rising inflection and sounding very like the squeal of a pig. The bird also has a short, harsh note similar to that of Forster's Tern. At any distance within fair gun-range I could usually separate it from Wilson's Tern by its longer tail and by the uniform and deeper color of the bill. In flight and habits the two seemed to me identical.

A fine example of the immature condition, separated for a brief period under the name "S. portlandica," was taken at Amherst Island and two others seen near the eastern entrance to the Gut of Canso. The one killed had the sexual organs undeveloped and evidently was not breeding, although, like the specimen which I shot years ago at Muskegat Island, Mass., it occurred in a nesting colony.

81. **Cymochorea leucorrhoa**, Vieill. — Leach's Petrel.

A few Leach's Petrels were seen in the Gulf, but the species was not observed in any numbers. At Bird Rock I found seven specimens in the bottom of a deep but perfectly dry well. All were dead, and the majority more or less decomposed. They had evidently entered by a crevice between the boards which covered the top, probably mistaking this opening for the entrance to a burrow. The light-keeper had noticed them there several days previously when two of the number were alive. They were the first that he had seen on the rock, and he was confident that none ever breed there.

82. **Oceanites oceanicus**, Kuhl. — Wilson's Petrel.

From the time of leaving Annisquam to our return a day rarely passed at sea when more or less of these Petrels were not seen. We observed them everywhere between Annisquam and the Gut of Canso, and they were common and generally distributed in the Gulf of St. Lawrence. They occurred most numerously during the first two days of the voyage between Capes Ann and Sable. Over this extent of ocean they were constantly in sight, skimming close to the waves and pursuing no definite course, but wandering aimlessly in irregular lines, sometimes turning back and repassing once or twice over a particular spot, oftener gliding on until hidden in some fog wreath or lost in the distance. Every now and then one would make directly for our vessel and wheeling over her wake follow for a mile or two, keeping a sharp lookout for any chance scraps that might be thrown overboard. Occasionally numbers collected about some spot where food had been discovered, and where, for a few moments, the water would be crowded with their dusky forms. Their manner of picking up a floating object is peculiar. The bird does not actually alight, but simply drops its legs and *walks* on the surface with outstretched wings the bill meanwhile being busily employed. Ordinarily it takes only a few steps and the wings are not appreciably moved; but sometimes, especially when the feast proves abundant, it stands perfectly still for several minutes at a time, maintaining its position by a tremulous, butterfly-like flapping. On other occasions its flight is easy, graceful, and strongly suggestive of that of a Swallow, to which in general shape also it bears a striking resemblance. It feeds chiefly on the table refuse thrown overboard from steamers and sailing vessels; but one which I shot disgorged a perfect shrimp of large size, showing that the bird still avails itself of the natural products of the sea.

I was unable to discover when or where these Petrels sleep. We rarely saw one sitting on the water, and long after dark I have detected their shadowy forms flitting over the vessel's wake. The sailors say that they fly all night, and one of our men told me that he had known them strike against the rigging and fall helplessly on deck, an incident which did not happen, however, during our cruise.

But a still greater mystery is that which envelopes the breeding of Wilson's Petrel. I am not aware that any one has ever identified its egg or even certainly found it nesting; yet it spends the entire summer along our coast from the Gulf of St. Lawrence to Cape Henry, Virginia, and over much of this area is even more numerous than Leach's Petrel. Why then have its breeding grounds remained undiscovered while those of Leach's Petrel are so well known? Before attempting to answer this question I must again refer to the experience of our expedition.

A number of Wilson's Petrels, shot at various times and places between the dates June 17 and July 25, were carefully dissected with a view to ascertaining their time of breeding. With all the condition of the sexual organs was similar; viz., at the very lowest stage of erotic development. The testes of the males were scarcely larger than dust shot, while the ovaries of the females presented the appearance of whitish sacs in which the separate ovules could not be clearly seen without the aid of a glass. I examined the females for signs of recent ovulation or incubation, but could find none. Furthermore, a male, taken June 18, showed every indication of being a young bird about eight or ten weeks from the nest. Its plumage differed appreciably from that of some adults shot the same day, and its skull and bones were very soft, the skull having that flexible, skin-like character found only in young birds.

These facts confirm a suspicion which I have entertained for a long time; viz., that Wilson's Petrel breeds in winter or early spring in tropical or sub-tropical regions and visits the coast of the north-eastern United States *only in the interim between one breeding-season and the next.* In support of this theory are the following facts: (1) That although the bird literally swarms off our coast during June, July, and August no one has ever found it breeding on the neighboring shores. (2) That the sexual organs of numerous summer specimens which I have dissected have been invariably undeveloped. (3) That a specimen taken June 18, although apparently a young bird, was at least two months old, thus indicating a date of breeding when the species is not to be found in our waters. If the above conclusions prove correct the case, as far as we now know, will be unique. But there are reasons for suspecting that the same thing obtains with other North American Procellaridae, especially our two common species of Puffinus.

83. **Puffinus major**, Faber. – Greater Shearwater.

We saw no Shearwaters in the Gulf, but the present species was met with off the Nova Scotia coast on June 19 and 20, and again near Mt. Desert during the return voyage in August. It was nowhere very numerous, only a few individuals being seen in any one day and these at wide intervals. They were less familiar than the smaller Petrels, rarely coming near our vessel and never following her wake. Their flight, also, is wholly different. The long, narrow wings are set stiffly at right angles with the body and the bird frequently glides half a mile at a time without moving them perceptibly. It usually follows a direct course and invariably skims close over the waves. I know of no other sea-bird whose movements are as easy and graceful. Indeed at times, especially during a gale, its evolutions will compare in grace and spirit with those of the Mississippi or Swallow-tailed Kites.

The preceding speculations respecting the breeding of Wilson's Petrel will apply nearly as well to this and the following species, both of which occur during the entire summer on our off coast fishing grounds. The Sooty Shearwater is never very common, but P. major may be found in certain places by thousands, at any time from June to September. Nevertheless I cannot learn that an authentic egg of either species has ever been taken on our shores. Bryant inferred that they bred along the Straits of Belle Isle, because he found the birds numerous there in what he assumed must be their breeding season; but Mr. George O. Welch, who has spent the past season collecting along the coast of Newfoundland, assures me that no one there has ever seen the egg or young of a Shearwater, although both P. major and P. fuliginosus summer abundantly in the neighboring waters.

84. **Puffinus fuliginosus**, Strickl. — Sooty Shearwater.

This species was seen only off the coast of Nova Scotia where it was less common than P. major. Its flight and habits seem to be identical with those of major, but its uniform dark coloring gives it a very different appearance. At a distance it looks as black as a Crow.

85. **Colymbus torquatus**, Brünn. — Common Loon.

A species of general distribution in the Gulf, but especially numerous along the North Shore, where we often heard its mournful cries at night, or in the early morning saw the stately birds swimming on the smooth surface of the land-locked bays and channels among the islands. I did not learn much about its habits there, but was told that it breeds only in fresh water.

86. **Colymbus septentrionalis**, Linn. — Red-throated Loon.

We saw the Red-throated Diver among the Magdalens, at Anticosti, and everywhere along the North Shore. Like the Common Loon it frequented sheltered bays and channels along the coast, but we were assured that it breeds exclusively in fresh water; a statement which is probably true, for we often saw the birds passing over the woods between inland lakes and the sea. They usually flew in pairs and often at a considerable height, croaking hoarsely at intervals. This croak is by no means their only note. On calm mornings the male sometimes indulges in a prolonged outburst of harsh, discordant cries, which are uttered with such volubility and variety of intonation that one might imagine a dozen birds to be engaged. This performance reminded me of the clamor of a flock of Geese. It was evidently the Loon's masterpiece, for during its production he would sail proudly about on the water with erect head and swelling plumage. It was so loud that it could be heard at a distance of a mile or more.

The Red-throated Diver is a much tamer bird than the Common Loon, and we found no difficulty in obtaining good flying shots by stationing ourselves at places where they were in the habit of passing. The adult birds, however, cannot be easily approached when on the water.

87. **Fratercula arctica**, Linn. — Common Puffin.

We saw a few Puffins at sea off the Nova Scotia coast, but they were not met with in the Gulf until we reached the Magdalens, where a considerable colony was found breeding on Bryon Island, and a still larger one at Bird Rocks. Afterwards we observed them at Wreck Bay, Anticosti, and on Perroquet Island near Mingan Harbor, where many thousands were breeding after the usual manner in holes burrowed in the sandy loam. The breeding place on Bryon Island was of a different, and, as far as I can learn, exceptional character. The northern end of the island is bounded by cliffs of sandstone and stratified clay, pierced by innumerable pocket-shaped holes and narrow, horizontal fissures. In places the sea beats directly against the base of the precipice, but there is usually a sloping shore formed by huge blocks and crumbling piles of sandstone fallen from above. For a distance of a mile or more along this cliff Puffins were breeding in company with Razor-billed Auks and Black Guillemots. Many of the Puffins had dug their nesting holes in the piles of débris near the waters' edge, but by far the greater number occupied natural crevices in the face of the cliff, often a hundred feet or more above the water. As we approached the place only a few were visible, flying about over the sea or standing erect on the ledges. But the first report of our guns brought dozens tumbling from their nests. Their manner of descending from the higher portions of the cliff was peculiar. Launching into the air with heads depressed and wings held stiffly at a sharp angle above their backs they would shoot down like meteors, checking their speed by an upward turn just before reaching the water. In a few minutes scores had collected about us. They were perfectly silent and very tame, passing and repassing over and by us, often coming within ten or fifteen yards. On such occasions their flight has a curious resemblance to that of a Woodcock, but when coming in from the fishing-grounds they skim close to the waves, and the wings are moved more in the manner of a Duck.

The Puffin in life, or when freshly killed, is one of the handsomest of the Alcidae. Its sharply contrasted black and white plumage sets off the vivid coloring of the bill and legs to advantage, and its form is trim and shapely. The eye, however, is small, flat, and dull, expressing only what seems to be one of the bird's prominent characteristics: viz., *viciousness*. Not only will the wounded birds bite sharply if incautiously taken up, but when several are placed together they vent their rage freely on one another. This amiable trait seems to be developed at a very tender age. Three young, which I obtained at Perroquet Island, and which could not have been more than a few days old, were put in a box for safe keeping and carefully covered with some boards. A few hours afterwards I uncovered them when, to my surprise, I found one lifeless, but still bleeding from numerous wounds, while the other two were fighting on his prostrate body. They clung to each other with the tenacity of bull dogs, and I had great difficulty in separating them; when this was accomplished they proved to be nearly worthless as specimens, the downy covering of their bodies having been stripped off in patches and the skin torn in many places. Rather curiously I do not remember seeing these birds quarrel when at liberty. Perhaps, as with certain individuals of the human species, the disagreeable side of their nature is only shown under adversity.

Verrill, criticising Coues's statement[1] that "the flesh of the Puffin, though not ill-flavored, is so exceedingly tough as to be eatable only in cases of necessity," affirms that he "found them, like the different species of murres, excellent food and not at all tough if properly cooked."[2] Our experience agrees with Professor Verrill's. Indeed, we considered the Puffins more tender and palatable than any other birds (excepting possibly young Herring Gulls) which we were able to procure.

88. **Uria grylle**, Linn. — Black Guillemot.

If the Black Guillemots ever congregated in large colonies they have learned the greater safety of dispersion. At least about the Gulf it is rare to find more than a few dozen pairs breeding in the same locality; but, on the other hand, they are so generally distributed that there is scarcely a rocky shore or island off which more or less of their dark forms may not be seen drifting idly on the tide or skimming swiftly over the heaving surface. Being seldom molested they are usually very tame, and at the fishing stations I have seen them diving among the boats or floating within a few yards of men at work on shore. Nevertheless it takes but a slight hint to develop all their native wariness, and if one is shot at and missed further pursuit is almost invariably useless.

The normal breeding habits of the species are so well known that I shall not dwell on my personal experience at large, but the following extract from some notes made at Grand Entry Island, where we found these Guillemots breeding under rather peculiar conditions, is perhaps worth publishing: —

"*June* 27. Early this morning we started in boats to explore the coast of Grand Entry Island. Upon pulling in under the cliffs we found ourselves surrounded by scenery of a novel and imposing character. Vertical walls of red sandstone — nearly of the color of burnt bricks — towered above our heads to the height of a hundred feet or more and outlying turrets, fast disintegrating under the action of the weather, rose like watch towers from the water, their summits ending in slender, needle-like points. Both cliffs and turrets were pierced with innumerable holes and fissures of varying shapes and depths; and in places, at the water's edge, some dark rounded openings marked the entrances to caves into which the swells rolled at intervals, bursting with a dull choking sound in the recesses within.

1 Proc. Phila. Acad. 1861, p. 251.

2 Proc. Bost. Soc. Nat. Hist., vol. IX, Oct. 1862, p. 142.

"At first we saw only a few Guillemots flying about or bobbing like corks on the blue water seaward. But as we neared the base of the precipice the sound of the oars and of our voices brought many sitting birds from their nests in the lower crevices. They took wing rather clumsily, slanting down towards the surf with feet and tails wide spread, but they drew up their feet and closed their tails when they got fairly under way, and flew directly out to sea. In a short time, however, they would return and circle about us, occasionally dashing past within a few yards, but ordinarily taking care to keep beyond gun range. They were tamest when sitting on the lower ledges or shelves of the cliff, where they frequently alighted. A shelf only a few feet above the water was usually chosen, and the bird upon closing its wings would maintain an erect position for a moment or two and then lie quietly down. Often upon rounding a projection of the cliff we came upon two or three thus engaged. On such occasions they would cower close to the rock, apparently too much frightened to fly, but every now and then uttering a shrill *pee-e-ee*, that sounded remarkably like the alarm note of the Wood Duck. Once we ran the boat almost within arm's length of a pair before they took wing.

"These Guillemots seemed to be breeding in the greatest numbers in the caves already referred to. We entered one of these places at some risk of cru.hing our boat, for there was a heavy sea running. The interior was a long vault-like passage with an arched roof above and an uncertain depth of water beneath. The walls were smooth and slimy and fairly honey-combed with holes, some of which apparently connected with neighboring caves, for we could hear the water rushing through or catch an occasional gleam of distant light. In this grewsome place the 'Sea Pigeons' fairly swarmed, and every crevice seemed to have its occupant. A few scrambled from their holes and dashed past our heads making directly for the arch of light that marked the entrance, but the greater number remained quietly in their strongholds. Nor was such action ill-judged for, owing partly to the depth of the crevices, partly to the sea-slime that made it impossible to climb the walls, we did not succeed in reaching a single nest. The fate of these cave dwellers and their eggs during a storm is an interesting subject of speculation, for there must be times, even in summer, when the caves are entirely submerged. Probably the old birds escape without much trouble, but many eggs and young must be destroyed."

89. **Lomvia troile**, Linn. — Common Guillemot.

Although stragglers were seen in various parts of the gulf, we found this species breeding at only two localities, Bird Rocks and Perroquet Island. At Bird Rocks I had a good opportunity of studying its habits, but observed nothing that is not already known. The birds still breed there in amazing numbers, but they are said to be fast diminishing. This is due not so much to persecution (for the bait seekers slaughter Gannets chiefly, and most of the Murres breed where their eggs are inaccessible) as to the recent introduction of a cannon which is fired every half hour in foggy weather. At each discharge the frightened Murres fly from the rock in clouds, nearly every sitting bird taking its egg into the air between its thighs and dropping it after flying a few yards. This was repeatedly observed during our visit and more than once a perfect shower of eggs fell into the water around our boat. So seriously had the Murres suffered from this cause that many of the ledges on the side of the rock where the gun was fired had been swept almost clear of eggs. The Gannets and Kittiwakes did not seem to be similarly startled, and from their different manner of sitting no accident results to the eggs even if they take wing suddenly.

Of the colony at Perroquet Island I can say little. When we first saw the place the water was covered with Murres, and hundreds were sitting on their eggs along the ledges of the western end of the island. But a week later when we landed there the colony had been practically annihilated by Indians, and the few birds remaining were so shy that I could not get near any of them. All that I saw, however, seemed to belong to the present species.

In 1861 Verrill found Murres breeding in large numbers at the eastern end of Anticosti but we saw none there, although Razor-billed Auks were numerous at Wreck Bay.

90. **Lomvia ringvia**, Brünn.—Ringed Guillemot.

The Ringed Guillemot was met with only at Bird Rocks where we saw just six individuals. Two of these were single birds shot while flying in towards the rock; two others, a mated pair, were sitting side by side on one of the lower ledges where both were killed by one discharge; and the remaining two, also paired, occupied a narrow shelf about half-way up the cliff at a point where the bucket in which our party was hoisted passed so near them that I could almost touch the sitting female.

Although this limited experience comprises my personal knowledge of the bird in life I cannot help considering it a valid species. If, as has been so generally maintained, it is simply an exceptional or dichromatic condition of L. troile, it is difficult to account for the fact that two or three ringed individuals had selected mates of their own style among so many thousands of the common kind,[1] for it is well known that with other birds addicted to dichromatism, or great variability, the different varieties are quite as apt to be found paired with their opposite extremes as with individuals of similar coloring.

91. **Lomvia arra bruennichi**, Sch. — Brünnich's Guillemot.

We observed (or at least identified) this species only at Bird Rocks where it had been previously found by Bryant in 1860 but unaccountably overlooked by Maynard in 1872. At the time of our visit it actually outnumbered the Common Guillemot and represented, according to the best estimate that I could make, about seventy-five per cent of the total colony of Murres.[2] The two species were more or less indiscriminately mingled on most of the ledges and it was not unusual to see alternating pairs sitting so close together that they touched one another. Under these conditions it is of course difficult to identify any considerable number of eggs, although a few may be positively determined by using care and patience, for there is no trouble whatever in distinguishing the birds at any reasonable distance. The whitish tomiae of Brünnich's Guillemot afford a ready mark of distinction when the bird is flying, and on the ledges its black head and neck are conspicuous among the much lighter, chocolate-colored ones of the Common Murres. I observed no difference in the flight or habits of the two species, but more extended observations would probably reveal certain distinctive traits. Mr. Welch informs me that Brünnich's Guillemot breeds sparingly at many places along the southern coast of Newfoundland, but he did not find the Common Guillemot there, although he looked for it carefully.

92. **Utamia torda**, Linn. — Razor-billed Auk.

The Razor-bill, although less ubiquitous in the Gulf than the Black Guillemot, is still more generally dispersed there than either the Murres or Puffins. The largest colony which we visited was at Bird Rocks, where there were probably several hundred pairs nesting in crevices, or in the deserted burrows of the Puffin; but

[1] Maynard's experience at Bird Rocks was identical with mine. He found the Ringed Murres invariably paired with individuals of their own kind.

[2] In 1860 Bryant estimated the comparative numbers of the three kinds of Murres at Bird Rocks as follows: Three of N. troille to two of N. lomvia [L. arra brünnichi], and one of U. ringvia. (See Proc. Bost. Soc. Nat. Hist., vol. VIII, 1861, p. 75.)

it was more common to find them in communities of from three or four to as many dozen pairs. Thus while the bird is nowhere very conspicuous it is really not uncommon, and if its scattered colonies could be collected about one or two small islands, as is the case with the Murres, the respective numbers of the two species would probably prove less unequal than they seem. The course adopted by the Razor-bill is by far the wiser one, however, for dispersion during the breeding season can alone save our sea-birds from ultimate extinction, although few of them as yet show any disposition to abandon the social instincts which bring them into so much trouble.

Of the habits of the Razor-bill I learned nothing new. It bears a strong resemblance in life to the Common Guillemot, but the peculiar shape of the bill will usually serve to distinguish it when within gunshot.

THE FORTIETH PARALLEL ROCKS.

BY M. E. WADSWORTH.

Two papers by Drs. Zirkel and Merrill, published late last spring in the Proceedings of this Society, call for some notice. Although these papers were read during the previous year, and were such that they could hardly be allowed to stand long unanswered, it seemed best to wait until they were published, and to reply after a reëxamination of the collection under discussion could be made. Accordingly the following note was sent by me, May 21, to Mr. Arnold Hague, custodian of the collections of the 40th Parallel Exploration: "The recent publication of papers by Messrs. Zirkel and Merrill renders it advisable that a reëxamination of the 40th Parallel rocks should be made by me; especially since they have now been permanently reärranged. This examination it is proper I should make since Dr. Merrill's paper bears internal evidence that we have written about different specimens. I, therefore, ask you as custodian of the collection for your permission to make such examination during the coming summer." The following reply was received from Mr. Hague dated May 31: "In reply to your letter asking for permission to examine the geological collection of the 40th Parallel Exploration, I regret to say that such permission cannot be granted at this time. We have been studying and working upon the collection for the past year and a half and had expected to have printed the results this coming summer, but as our work is still unfinished, publication must be deferred for the present. As our work covers a good deal of new as well as old ground, I cannot, in justice to myself, grant to any one the privilege of studying the collection during my absence in the west this summer. After the work is published the collection will, I hope, be open to examination by all who take the slightest interest in the study of crystalline rocks." While the summer was preferred, the examination of the specimens in question could have been made at any time in Mr. Hague's presence and under any restrictions he chose to impose consistent with my ascertaining the facts — but the denial appears to be absolute, for the present at least. It will at once be seen that this refusal to allow me to look over the specimens in question places me at a serious disadvantage in this discussion, especially since Dr. Merrill has been allowed not only the liberty of twice examining the collection, but also of having slides and chemical analyses made. I have not seen the collection since 1878, and since I was then[1] informed by Messrs. King and Bickmore that I should have access to it at any time, I did not deem it necessary to write out in detail my reasons for the opinions formed with the specimens in hand, although certain notes were taken.

Since I am denied all access to the collection which has been entirely overhauled and reärranged since my examination, I must deny the right of any one to assume that the slides and rocks now bearing the numbers given by me are the same ones that were designated by these numbers at the time of my examination in 1878. The condition of the collection at that time has been stated with sufficient fullness (W. 272[2]) and need not be discussed here.

[1] They, of course, have no control over it now.

[2] For convenience the following abbreviations will be employed in this paper:
B. — Bulletin Museum Comp. Zoöl., 1879, v, 275–287.
P. — Proceedings Boston Soc. Nat. Hist., 1881, xxi, 234–243.
W. — Proceedings Boston Soc. Nat. Hist., 1881, xxi, 243–274.
M. — Proceedings Boston Soc. Nat. Hist., 1882, xxi, 452–470.

I now propose to show that in this last paper of Professor Zirkel there is the same inaccuracy of statement as existed in his 40th Parallel work; and to give evidence that my main charges have been well sustained by the observations of other workers in the same field.

Dr. Zirkel gives us to understand that Richthofen's classification was and is generally accepted in Germany; also, that it was this classification which he (Zirkel) used in volume VI.; that it was literally the same as that published by him in 1873, and which he had used in his lectures since 1863, or four years before Richthofen published it. (Z. 110, 111.) If Zirkel had been publicly teaching this classification since 1863 how could he regard Richthofen's publication of it in 1867 "an extraordinary step in scientific progress," as he says he did?

It is safe to say that principles, not names (unless they are peculiar to the classification), are the most important points in any classification. Richthofen's classification is primarily based on the order of geological succession, and is restricted to the products of the massive eruptions in Tertiary and post-Tertiary times, while Zirkel's classification, to which he refers, is based mainly on the nature of the feldspars which the rocks contain. Again the classification in volume VI. is not Richthofen's, but a mongrel one; while Zirkel's positive assertion that it is literally the same as that published by him in 1873 is wrong; for it differs, among other points, in the addition of the distinction of younger (Tertiary and recent) and older (pre-Tertiary), as well as in the insertion of several new species; namely, augite-syenite, augite-trachyte, quartz-propylite, and the corner-stone of Richthofen's system, propylite.

Baron Richthofen states of such classifications of eruptive rocks as that upheld by Zirkel and taught by him since 1863:—"We are struck by the observation that, if they are based on any principles at all, these are usually artificial. . . . Even the most recent and elaborate systematical arrangements . . . are based on almost purely artificial principles. . . . The high value of miner-

Z. — Proceedings Boston Soc. Nat. Hist., 1882, XXII, 109–116.

VI. — Microscopical Petrography, or volume VI of the 40th Parallel Exploration. The figures in the text after the abbreviation refer to the pages of the publication mentioned.

alogy as a basis of classification cannot be denied. But its exclusive application has caused the combination into certain groups, of such rocks as from a geological point of view are widely separated, while it has given rise to distinctions in cases where the results of geological observation would demand close connection. . . . It can easily be demonstrated that when exclusively applied, it [chemical composition] leads to a systematical arrangement of rocks, which is in even greater contradiction with the natural mode of occurrence than when the same is based upon mineral composition alone. . . . The natural differs from the artificial system in this, that it starts from the application not of one only but of various principles, compares and weighs the results obtained by each of them, and accepts them as final only when perfectly harmonizing among each other. . . . The natural system of rocks should, therefore be based, not only upon the entire range of their petrographical characters, such as mineral composition, chemical composition, texture, and specific gravity, but also upon their mode of origin and geological occurrence. . . . Their recurrence in the most widely separated countries, with similar external character, identical chemical composition, and in analogous relative order of succession, is another distinguishing feature of eruptive rocks. For these reasons, as well as [others], . . . they appear to owe their present positions to the action of general planetary processes, and to reveal by their own nature that of the mineral matter participating in the original composition of the globe. . . . Bearing in their own character and system the imprint of their origin, the eruptive rocks will, by their nature itself, allow well-founded conjectures as to the interior structure and composition of the earth." (Mem. Cal. Acad. Sci., 1868, I, part II, pp. 5–9) These principles, so far as they go, are held by me, and constitute in part the basis of my classification; and in Richthofen's case they constituted "an extraordinary step in scientific progress," according to Zirkel. Having been informed that Richthofen's system was fully sustained by the 40th Parallel Exploration, it was naturally supposed that his principles would be followed and a natural system founded; instead of this I found, as I conceive, a mongrel system — a new garment patched with very old and tender cloth. This system appeared to me to be entirely artificial, and not even then to have any fixed principles.

Having, as I think, shown that Richthofen's and Zirkel's principles of classification were not in accord, I will proceed to show how Richthofen's system — or rather his species peculiar to it, propylite — has been received in Europe since Zirkel maintains that the system has met with warm sympathy. (Z. 111). In the lithological text books of Zirkel, Lasaulx, and Rosenbusch, published respectively in 1873, 1875, 1877, the name propylite does not occur in the indices, and I have never seen it in the text; but H. O. Lang, in his Elements, places it under hornblende-andesite. Justus Roth, in his Beiträge zur Petrographie der plutonischen Gesteine, 1879, does the same. Dr. C. Dölter while upholding the Transylvanian propylite, appears to class it as a variety of hornblende-andesite; while Judd and Koch claim that the Schemnitz propylite is a modification of andesite, the former even holding that both occur in the same eruptive mass. Szabó classes both this propylite and andesite as the same rock under trachyte, while vom Rath holds that this same propylite is a pre-Tertiary diabase. Dr. Hussak, however, agrees with Richthofen. Rosenbusch, in a general article on propylite published about the same time as mine, points to the little value of, and the inconsistencies in, Zirkel's diagnostic distinctions between propylite and andesite, and places the former as a simple modification under the latter. In his latest published classification Rosenbusch puts propylite with a question mark under andesite, quartz-propylite under dacite, and augite-propylite and quartz-augite-propylite under augite-andesite, thereby taking concordant ground with myself so far as our difference in nomenclature permits.[1] Zirkel even states in volume VI., page 10, "The vagueness of this diagnosis, founded upon geological properties alone, and wanting well-defined, characteristic lithological distinctions, has prevented the propylite of von Richthofen from receiving any considerable acknowledgment among European geologists, who doubted its specific independence or the necessity of separating it petrographically from hornblende-andesite."

Having I think proved the correctness of my statement, denied by Zirkel, that Richthofen's and King's classification was not ac-

[1] Verhandl. Geol. Reich., Wien, 1879, pp. 17–23, 27–29; 1880, pp. 309, 310; Min. Petrog. Mitth., Wien, 1879, pp. 1–16; Quart. Journ. Geol. Soc., 1876, XXXII, 292–325; Sitz. neider. Gesell., Bonn, 1878, XXXV, 33; Neues Jahrb. Min., 1879, pp. 648–652; 1882, II, 1–17.

cepted in Europe and was not adopted by Zirkel until his visit to New York, I proceed to show what grounds have been taken by the United States geologists and lithologists on the points discussed in my previous papers. In the second annual report of the Director of the United States Geological Survey, Dr. Becker, going even farther than I went in condemnation of Zirkel's work, states of the Washoe district, the rocks of which were studied by Richthofen, King, and Zirkel: "The reduction of rocks of originally different aspect to apparently uniform character by chloritic decomposition is strikingly evinced by a mere list of the species in the district, which have been grouped under the terms propylite and quartz-propylite. These are granular diorite, porphyritic diorite, diabase, quartz-porphyry, hornblende-andesite, and augite-andesite. . . . The 'green hornblendes' are simply pseudomorphs of chlorite after hornblende or augite as the case may be. . . . The description of propylite as a species arose from the erroneous determination of chlorite as green hornblende. . . . The microscopical characteristics of propylite are illusory. Finely disseminated hornblende in the groundmass of a Washoe rock is very rare, and far rarer is the presence of particles of hornblende in feldspars. . . . Base is rare in propylites; where it originally formed a constituent of the rock, it has for the most part undergone devitrification. . . . There is no proof yet known of the existence of a pre-andesitic Tertiary eruption in the United States. The term propylite should not be retained in the nomenclature of American geology even to express certain results of decomposition, for the equally loose term, greenstone, seems to cover the same ground and has priority." (*l. c.* pp. 297, 298.) Becker thus agrees with my earlier condemnation of propylite. It will be remembered that objections were offered by me (B. 285) to the quartz-propylites and dacites on the ground that most of them were old rhyolitic rocks, in which term I included felsite, quartz-porphyry, etc. Dr. Becker states of these: "The quartzose rock of the district which von Richthofen had determined as a pre-Tertiary quartz-porphyry, King regarded as quartz-propylite. . . . Zirkel . . . confirmed the independence of propylite and quartz-propylite as lithological species, regarded the quartzose rock as dacite . . . This rock [the above quartz-porphyry], which Baron v. Richthofen determined correctly, has since been called quartz-propylite, dacite, and its felsitic modification rhyolite." (*l. c.* pp. 294, 299.) Dr. Becker also states that the predominating feldspar is orthoclase in this rock. He further remarks that the porphyritic diorites, the diabases, the hornblende and augite andesites have all, when decomposed, been taken for propylites! (*l. c.* p. 300.)

My observations had led me to believe that many of the rocks described as trachyte by Zirkel were not properly so classed. Dr. Becker states that the rock of Mt. Rose which Zirkel regarded as trachyte, but which I had taken to be an andesite, is really an andesite. Further, he says that Dr. Hawes after separating the feldspars and having them analyzed found none "corresponding either physically or chemically to orthoclase. There is much reason to believe that trachyte occurs less often than had been supposed in the Great Basin area." (*l. c.* p. 300.)

Mr. S. F. Emmons, in like confirmation of my paper, states that the earlier classification of the western rocks as andesitic and trachytic is doubtful, and that "many facts already observed by us suggest a doubt whether von Richthofen's classification of volcanic rocks will be found to hold good everywhere in Colorado."[1] Nevadite I had considered to be a glassy rock, not crystalline as claimed by King, and I had assigned it to the trachytes (W. 269; Science, I, 128); Messrs. Hague and Iddings have now discovered that it is glassy, but they place it in dacite — the so-called quartz bearing andesite. They also state that their basalt, hypersthene (augite), and hornblende-andesites, and dacite show every intermediate grade between the types. (Am. Journ. Sci. 1883, XXVI, 222–235.) Since the publication of my paper, Professor Whitney has informed me that the mode of occurrence of the propylite about Aurora and elsewhere, which he visited in company with Richthofen, indicates that it is but a local modification of andesite, and that the results of his field studies are in accord in all essential points with those independently obtained by myself from a different mode of study.

It would appear to be now clearly shown that my previous papers have been well sustained by the later published studies (so far as they cover the same ground) of the United States Geological Survey, and as great mistakes pointed out by others in Zirkel's work as any that I have asserted existed in it.

[1] Bull. U. S. Geol. Survey, 1883, p. 17.

In objecting to the separation of rocks into distinct species according as they are pre-Tertiary or not, I am on common ground with Dana, Reyer, Allport, and many others, especially the English geologists; but since Zirkel refers to his classification published in 1873 as proof that he has always worked on this principle, a few extracts will be given from his work to which he refers.[1] He says in substance: "The common division of the eruptive rocks into older (pre-Tertiary) and younger (Tertiary and post-Tertiary) and the nomenclature dependent thereon appear to be of little value. Leaving out of account the variable microstructure of the quartz and the alteration of the feldspars, there is absolutely no distinction between the older quartz porphyries [felsites] and the younger liparites [rhyolites]. If we do not consider the more or less common molecular alteration, there exists no difference either in composition or structure between many old melaphyrs and younger basalts. The carboniferous diabase and miocene basalt of Scotland are microscopically undistinguishable from one another. It is to be hoped that those rocks which are identical in mineralogical composition and structural peculiarities will be designated by a single name. The age differences which are conditional upon certain small variations can be adjectively expressed. Why should not the same principle of nomenclature be adopted for the eruptive as for the sedimentary rocks. We have Carboniferous and Tertiary limestone and sandstone, why not Carboniferous and Tertiary basalt or diabase . . . Indeed, the combination of plagioclase and diallage with or without olivine is known as gabbro with an entire disregard of the principle of age, whether it belongs to the carboniferous; or, as in Italy, it is an eocene eruption; or, as in the Hebrides, it is only a geological dependence on the miocene basalt." I might continue quoting from Zirkel's writings similar remarks, but enough has been given to show that my views are but the logical application of that which he has admitted to be true.

To maintain, as most classifications must do to have any basis, that the products of fissure and volcanic eruptions entirely changed between the Cretaceous and Tertiary periods, and that no species previous to the Tertiary have ever been produced since, even if the rocks are absolutely identical in every particular, is in my

[1] Mikros. Beschaf. Min. Gest., pp. 291-93.

opinion to hold a most unphilosophical dogma. No matter if it does appear to hold good in Germany — the Wernerian hypothesis seemed to do so for Saxony — the question is what holds good for the world.

Dr. Lagorio at least seems to hold as I do, that there is no proper separation between the hornblende- and augite-andesites,[1] and while I understand why such a division is made I deny its validity (Z. 115).

If I can place any dependence upon the statements made to me by those conversant with the work of the 40th Parallel Exploration, comparatively few of the sections were made in this country, while the general views of Mr. King on the classification of these rocks were published in 1870, four years before Zirkel began his work. The general distinctions which Zirkel claims to have made without knowing Mr. King's views (Z. 111, 112) are those that every lithologist readily makes — the separation of an altered rock from an unaltered one, terms which approximate to the divisions older and younger. But Zirkel's statements here prove nothing regarding the chief portion of the work — especially that on the modern volcanic rocks. Again it seems evident from his own words that he was successful only in the majority of cases in this preliminary examination; but after Mr. King had acquainted him "with the geological distribution, relative age, and reciprocal connections of the rocks," Zirkel was able to do his work in such a manner that of some 2500 thin sections he tells Mr. King "that your original designations should almost never be altered or corrected." (W. 249, 271; Z. 113; VI, page 15.)

Concerning the question of the transportation of the rock specimens across the Atlantic I gave the name of my informant, Mr. King himself. The statement which I published from the French, I took from a paper whose complete title I gave, and no statement could be found then or can be found now about the paper indicating that it was not the direct production of Zirkel himself. It should have been stated to be a translation, instead of being published with all the marks of an original paper. I do not see but that Zirkel's remark in the paper to which he refers (Z. 112), "that he went to America to look over the collection and to pick

[1] Die Andesite des Kaukasus, Dorpat, 1878.

out the things to send to Europe," is entirely consistent with my statement.[1] However, since Zirkel denies the taking of hand specimens to Germany, I will cheerfully retract my former statement and believe that Mr. King misunderstood me when he repeatedly told me that Zirkel had the *missing hand specimens* I was inquiring about.

The statements that the augite-andesites are younger than the rhyolites, etc., appeared in volume VI. as Zirkel's own, and for them he is to be held responsible until they are denied by him, especially since his classification and arrangement of the rocks was based on such statements as these. However, the admissions of himself with those of King clearly show that the classification came from Mr. King and his colleagues.

Zirkel now claims (Z. 113) to have seen in 1875 one specimen of the Red Creek schist containing excellent large crystals of cyanite, but it seems they shrunk to minute ones while Mr. King was at work upon them, and finally had disappeared in 1878. (W. 251, 252.) In 1882 they seem to have reappeared in the form of quartz, since Dr. Merrill found an abundance of that mineral of which Zirkel makes no mention. (M. 445, 446.) The mica from the analysis is evidently a muscovite which is partially hydrated; for the character to which Dr. Merrill refers is not, as he says it is, stated by Rosenbusch to be *characteristic* of paragonite, and it is common in any micaceous mineral which has suffered alteration. If we compare the analyses given by Merrill with those given by Roth of mica schists from which the quartz and other minerals had been removed as far as possible, it will be seen that the latter contain 2.13, 4.81, 5.26, 2.49, 4.19, and 2.48 % of water. I claim that if Dr. Merrill's process was resorted to, almost every mica schist in New England would be found to be hydrous. Although technically he may have gained his point, I maintain from the experience obtained in passing a good many years in regions abounding in mica schists that the rock in question is nothing but an ordinary mica schist and is destitute of the physical characteristics, except color, which belong to the rocks to which the term hydrous mica schist pertains. That Zirkel was mistaken in his determination of this rock as a paragonite schist in which he observed all the characters of the St. Gothard rock, except microscopic disthene, I

1 Berichte Verhandl. k. sächs. Gesells. Wissen., Leipzig, 1877, II, 156.

think all will now admit, even if one specimen did bear cyanite; and further, that he either mistook the quartz as well as the mass of the mica for paragonite, or else the sections now in the collection are not the original ones.

I deny that I charged Zirkel, as he says I did, with being unable to determine the species to which a rock belonged without being informed of its field characters. (Z. 113.) I said that King's statement *implied* it (W. 271), but I will now say that if King's statement is correct he proved that in this case where Zirkel was not informed as to the geological age of the rock he was unable to correctly designate it in his own nomenclature, and Dr. Becker has shown the same thing. I also assert, without fear of contradiction, that those who adopt a nomenclature such as Zirkel and Rosenbusch now do, dependent on the geological age, cannot properly designate their rocks until they are informed of their field character; also, since many of the eruptive rocks are the latest in the field, that age can in a vast number of cases never be ascertained, and, therefore, the rock never properly determined in their system.

It may here be pointed out that Dr. Merrill's statement that I object to calling in field relations to aid lithological conclusions is wrong; for if I have ever insisted on any one point, it has been that the field and laboratory work should go hand in hand, and be performed by the same observer. Dr. Merrill then incorrectly quotes my statement of what Mr. King's remarks imply, as my belief. I do object to basing a lithological classification on geological age, because I believe such a classification to be unnatural. I object to assigning rocks which are identical to several distinct species, merely because they happen to be in overlying or underlying volcanic flows. It seems to me perfectly proper to collect field data to aid lithological classification but there is a chance for difference of opinion concerning what data to use; and it would seem that when the classification is perfected that we ought be able readily to infer the necessary field relations from the lithological characters and the reverse, except in the highly altered rocks.

Professor Zirkel states (Z. 115), "The members of a series of trachytes are held by Mr. Wadsworth to be basalts. This seems to render it proper to instruct him, that a rock in which sanidin prevails and which does not contain olivine never can be named a basalt." There is a horn to this dilemma which Dr. Zirkel does not seem desirous to take. If my paper of 1879 be turned to, it will be seen that basalt is essentially defined there as a rock which in the unaltered state is composed of plagioclase, magnetite, olivine, augite, a globulitic base and a little sanidin, while andesite is described as composed of a glassy or felsitic (felty) base with varying augite and hornblende, plagioclase, more sanidin than in the basalt, and magnetite. Trachyte is said to have a light gray glassy base with predominating sanidin, biotite, and hornblende, while rhyolite is stated to possess a clear glassy base holding crystals and fragments of quartz, sanidin, biotite, and hornblende. All these are said to have their old and altered states, since the key note of that paper is that the older rocks now given distinct names are really rocks that once were identical with modern forms — the present difference being due mainly, if not entirely, to alteration and crystallization. Now after giving these definitions it is stated that Zirkel has described rhyolites as trachytes, trachytes as andesites, and rhyolites and basalts as trachytes, etc. After the remark that most of the trachytes analyzed belong to the basalts and andesites it is said: "The basalts that have been described as trachytes are not doubtful ones, that might naturally have been classed with trachytes, but well-marked specimens, identical with some that have been described under the head of basalt in the same report." (B. 278–281, 285, 286.) Now is not my meaning clear that these rocks are not those in which sanidin predominates, but that Zirkel incorrectly determined the feldspars, and took plagioclase for orthoclase — a mistake which I found he had repeatedly made in both the older and younger rocks. Again some of these rocks contain olivine according to Zirkel's own statement (W. 267), and, therefore, ought to be basalts according to him.

I did not ask how the absence of olivine absolutely separates a rock from the basalts as Zirkel says I did (Z. 115); but I did ask how the absence of olivine in a rock absolutely separated it from the basalts in Zirkel's own work, as he said it did, when he described a number of rocks as basalts which contained no olivine according to to his own testimony! (W. 267.) His remarks now show that in his opinion he must have made serious mistakes in this work and in many of his former papers, since Rosenbusch appears to have been the first of microscopical lithologists to consider olivine essential to the basalts.[1]

My objection to Zirkel's method of establishing nephelite is that from the microscopical examination of a small portion of a rock he should assume that he knew how much olivine there was in the remainder, and that from this he could establish quantitative relations. His methods are strikingly in contrast with the accurate ones of Rosenbusch and many others. (Z. 115; W. 271.)

Since Dr. Merrill found in one section that the supposed haüyne grains were outside of the rock mass and in the balsam, while he is unable to say anything about the other two sections,[2] I trust Professor Zirkel will accept his determination. (M. 467; W. 267, 268; Z. 114; B. 286.) That such a mistake could have been made by Zirkel had been strenously denied both in this country and in Europe. The error would not have been so much like that caused by the traditional fly on the astronomer's object glass, if Zirkel's attention had not been so strongly called to these grains as being strange and remarkable forms. It is remarkable that in this discussion those three slides whose numbers were known from Zirkel's manuscript were not immediately examined on the publication of my paper in 1879. If I was wrong in this case it would have then completely overwhelmed my work, while if I had been found to be right it would have gone very far to establish the correctness of my statements regarding other errors. This long silence, coupled with Dr. Merrill's testimony, conclusively shows that my work was correct in this point. Since Professor Rosenbusch has suggested to me that the blue grains in my sections were from the emery, it is proper to state that this idea occurred to me at the very first, but microscopic examination then of the corundum and emery used in grinding showed that their grains were of a different character. The only explanation I could find of the included grains is the one I have already given, unless they were in the balsam before it reached the laboratory.

In the question of the formation of propylite from andesite Dr.

1 Mikros. Phys. 1877, II, 424.

2 It is interesting to observe that Zirkel's denial covers only the two sections that Dr. Merrill cannot say anything about, but is silent regarding the third, the supposed haüyne of which he (Merrill) admits is foreign.

Zirkel seems to confound the decomposition and surface weathering of a rock with the molecular changes that take place in all eruptive rocks after consolidation, with more or less rapidity, according to the chemical composition, conditions to which they are exposed, etc. (Z. 113.) Dr. Merrill seems to make a similar mistake. Dr. Zirkel asks of me the impossible: to find in a *fresh* rock the characters which I stated were to be found only in *altered* rocks. The reverse I have often done; as, for instance, finding the characters of andesites only partly obliterated in the so-called propylites. I have also found the minerals said to characterize propylite, but which I maintain are alteration products, in rocks which Zirkel himself determined to be andesites. Dr. Zirkel states that I demand that his work should conform with my later published principles (Z. 110), but such a demand is not to be found in my writings. I have not stated that Zirkel regarded the hornblende of the diorites as an alteration product, as he says I did, but that I [the writer] held that view. (W. 257; Z. 113.) The pronoun in English refers to the preceding noun, unless the context shows a different construction to be necessary.

Also in case of the two syenites (Z. 113) which I said were old andesites (W. 256, 257.), I hold that the feldspar prédominating is plagioclase, and not orthoclase, and Dr. Merrill agrees with me in one case. Zirkel observed plagioclase in both; and it is a question of judgment how much of the unstriated feldspar owes its present condition to decomposition, and how much to its being really orthoclase. (M. 459.)

The view that the peridotites were old, coarsely crystalline, somewhat altered basaltic rocks allied to the gabbros, I held in 1879, and at that time the specimens in the collection under my charge seemed to bear out that view. However the next year, with more material at my command, I abandoned it, accepting the peridotites as a distinct species; and I think I have since then taken sufficiently advanced ground in that direction.[1] But Zirkel incorrectly states that I *still hold* this particular view.

By the quartz found in the rhyolitic groundmass I refer to that forming a constituent part of the groundmass, and not to the glass-bearing quartzes porphyritically inclosed in it. My re-

[1] Bull. Mus. Comp. Zoöl. VII 60-66, 183–187; Proc. Bost. Soc. Nat. Hist., 1881, XXI 195-197; Science, 1883, I, 127–130; Mem. Mus. Comp. Zoöl., 1884, XI.

mark was intended as a general objection to basing specific distinctions on slight grounds and was not intended to be confined to any single section. (M. 469; W. 269; Z. 115.)

Concerning the greenish alteration spots that I claimed Zirkel mistook for olivine, but which he denies, it may be noticed that Dr. Merrill observed that the hand specimen now bearing the number 531 was not the one described by Zirkel — since it is a fresh rock. But he fails to observe that my language implies that the rock seen by me was old, altered, and much decomposed; and, therefore, probably the rock described by Zirkel, which is now missing. The section and hand specimen both agreed, and the collection was carefully examined by me to see if by any possible chance any other rock could have been described by him. No other one could be found and I must still hold that the rock I saw was the one Zirkel saw, and that he made the mistake pointed out; but the specimen now seems either to have vanished or is doing duty in another part of the collection. I make my statements, of course, on the supposition that the collection was fairly authentic at the time of my visit. (M. 469, 470; Z. 116; W. 270.)

My reasons for regarding No. 608 (2006) as a rhyolite instead of a basalt (tachylyte or hyalomelane) are the following: It contains feldspar crystals some of which are macroscopical, although Zirkel states that it contains no macroscopical secretions. These feldspars under the microscope prove to be sanidin. The glass shows fluidal structure and is composed of an irregular mixture of dark, light, and yellowish brown glass, filled with the common globules seen in rhyolitic glasses of this character. The structure of this glass is similar to that imperfectly represented in volume VI, plate VI, fig. 3, and closely like that in the sections which in 1878 bore the numbers 558, 1444, 1474, and 1676 (vol. VI, pp. 171, 185, 186, 191; Nos. 351, 417, 424, 450). It presents the characteristics that I, as well as Zirkel, have repeatedly observed in rhyolitic glasses; while it does not, to my mind, show a single character belonging to any basaltic glass that I have ever seen; therefore, I have no reason to doubt its being a rhyolite until it shall be proved by chemical analysis to be a basalt. Its want of solubility is certainly consonant with its rhyolitic character. (W. 271; M. 470.)

The three numbers in my earlier paper, which Dr. Merrill quotes as numbers of rocks (M. 455) are the numbers of three chemical analyses (B. 286) given by Mr. King! Again with all the complaint made that I gave no numbers in my abstract, it has been entirely overlooked that I gave data therein whereby my entire disagreement with some 140 different specimens as determined by Zirkel, and the numbers thereof could be readily ascertained.

Dr. Merrill's statements about the diorites do not, except in a few points, concern me; since I believe that the rocks called by that name are in every case, or nearly so, varieties of other species and generally produced by alteration.

The Kawsoh "diorite" (M. 457; W. 257), in which I found augite, had the augite well marked, but since Dr. Merrill could only find epidote in the section examined by him and since he states among other points that "quartz is pretty abundant in it, while Zirkel said it contained almost none, and also because Merrill's description does not at all accord with my language it is fair to presume that he had a different rock. It is possible he may be mistaken in his epidote, for that mineral occurs in such rocks not in fragments but as an alteration product. Where Dr. Merrill writes of No. 187 that it is "a very simple though beautiful diorite, it is moreover a pretty fresh rock" (M. 458), and I find in my notes written with the rock in my hand in 1878 that "the hand specimen is so weathered and dirty I can make nothing out of it," it would certainly seem that we are not discussing the same rock. I certainly found quartz and mica in the number 1389 of the year 1878. (W. 258; M. 459).

The same change in hand specimens and sections, if Dr. Merrill is correct in his statements, will probably account for Nos. 164, 167 and many others.

Concerning No. 77 (M. 460; W. 256) it is proper to assure Dr. Merrill that in 1878 no hand specimens in the collection bore numbers, therefore his informant is mistaken in the statement that it bore the No. 1488. Furthermore, I have already stated that I called attention "by writing [in pencil] upon the labels to certain errors in slides and to the misplacement of the hand specmens" (W. 273), and it is natural that these errors should have been corrected before he made his examination. If there is a "general similarity easily recognizable between the section and hand specimen" now, what could have been my object in denying it, if such resemblance then existed; especially when the correlation of the field, hand specimen, and section characters of rocks has been a special point with me. In the case of Nos. 280 and 281 it is clear to me that Dr. Merrill has either examined specimens of a common type of rhyolites, with which his description agrees, which now replace the specimens which I found in the collection in 1878, or else he has devoted his description entirely to the mud and other fragmental portions of the rocks, losing sight of the cementing silica. (M. 463, 464; W. 261, 262.)

Of the trachytes Nos. 289, 323, 324, 325, 327, 329, 330, 332 (M. 465, 466; W. 266, 267), which are regarded by me as basalts, except one or two which are allied to the andesites, it is necessary that I should have the specimens in hand in order to state what characters led me in each case to take the ground I did. Such apparent inclusions as those Dr. Merrill describes in the quartz are frequently penetrations of the groundmass, etc., and not inclusions in the proper sense; but without the sections I have no means of ascertaining that, and he may be correct. It is not uncommon for the western basalts to carry quartz, sanidin, and biotite, of course mainly as foreign or secondary, and it is well known that my decisions regarding a rock species are based on the characters of the rock as a whole, and not on a few artificial rules. It has to be remembered at every point that the principles of nomenclature employed by us are entirely different.

Section 612[1] (2699) contained in 1878 considerable well marked and unmistakable olivine; if the section has since been changed I cannot help it. (M. 466; W. 266.) My notes state that No. 473, which Zirkel said contained no biotite, has macroscopical and microscopical biotite, and I think the rock contained then very much more than Dr. Merrill states; but even if it did not, it shows a want of accurracy on Zirkel's part in saying that no biotite occurred. (M. 468; W. 269.)

It can be seen that even on Zirkel's principles Dr. Merrill agrees with me that Nos. 196, 197, 198, and 199 of Zirkel's diabases are basalts (M. 461; W. 258, 259); also that Zirkel's "beau-

[1] Since this paper was written I have been informed by a lithologist, who had seen the section, that it contains the olivine as stated by myself.

tiful trachyte" (303) and rhyolite (464) are nearly, if not quite, identical.

If Dr. Merrill's remark in his first paper (B. 236) be compared with mine (W. 258) regarding the diabases Nos. 191, 192, 193, 194, and 195, which I consider as old andesites and which he takes to be diabases (W. 461), it will be seen that we agree entirely as to our determination, but differ merely as to names. It is to be remembered, however, that Zirkel does not appear to use the term diabase in the same way. Concerning the melaphyr, No. 209 (M. 461), it can be seen that my remark about the so-called augites (W. 260) applies only to the forms which were surrounded "by a very distinct series of blackish brown grains" and to the heaps of grains. These characters are common to the andesitic hornblendes, but not to the augites. Usually associated with these are augites (or hypersthenes) having the planes given by Dr. Merrill, and such is probably the case here, for such association is one of the characters I rely upon in determining the old andesites; but my notes do not give the diagnostic points in this case, for I did not think it necessary to take them down, supposing the collection would always be accessible. The augite forms given by Dr. Merrill bear out my view that this is an old andesite, for such well developed forms are very common in the andesites, and very rare in the basaltic rocks of America whether new or old, so far as my observation has extended. Of the quartz propylites of Zirkel it may be said that Dr. Merrill agrees with me that No. 228 is a granite porphyry in the Zirkelian sense, and that the quartz of No. 230 on which Zirkel founded specific distinctions is an alteration product. (M. 462.)

In the case of No. 17 the quartzose material existed, as stated by me; but we may have had different sections, or we may differ in our judgment as to what to call the material, or as to what is a comparatively large amount, while even Dr. Merrill's description of this section shows that Zirkel's work is imperfect and erroneous, if both had the same slide. (M. 462, 463; W. 265.)

No. 386 Dr. Merrill states is of a light brownish tint on the weathered surface and of a light grayish white color, glistening all about with mica; also that it has not the faintest shadow of a resemblance to a basalt. Yet Mr. Wadsworth finds that the handpiece is "evidently a basalt." Not so fast. I said that a certain specimen bearing on the label 913 "is evidently a basalt," but my notes distinctly state that the rock is "dark gray." Here again we have evidence that we have not the same hand specimen. Zirkel had, indeed, stated that the rocks from that region were light gray, but I was unable to find any from the locality except this dark gray one, which otherwise appeared macroscopically to answer to his description; and I stated what I thought that hand specimen to be. (M. 468, 469; W. 269.)

APPENDIX.

Owing to my paper not being reached in the printing of these Proceedings until the present time, it has been permitted me to bring it up to date (March 1, 1884) by the addition of such evidence as has since been brought out by the United States Geological Survey.

Dr. Becker's completed work is now published and I have good reason to complain that although he professes to give a history of the propylite discussion in this country, he ignores my prior published views on the question completely; although he takes ground identical with them.[1]

In this work, besides the views previously quoted from his abstract, Dr. Becker writes, in confirmation of my previously published statements, that the quartz in some of the rocks determined by Zirkel as quartz-propylite appears to him to be secondary. (*l. c.* p. 85.) Again he says: "It was found that even where a high degree of decomposition and a thoroughly propylitic character prevailed, reasonably fresh rocks could be discovered by diligent search . . . [and] they always proved andesitic. Where andesite dikes or overflows had been recognized and had been supposed to succeed propylite, careful examination and excavation showed that the change was through a transition, not by contact." (*l. c.* p. 82.) In like manner their relations to other rocks were traced until all the so-called propylites were eliminated, but enough has previously been given from his earlier published summary to convey his idea. He further points out many errors in Zirkel's mineralogical determinations, but generally in such a way that no one would observe the fact who was not carefully comparing the two accounts. In order that the different views in the determination of the same rocks may be seen at a glance, I give below a table showing the names applied to the Washoe rocks by Zirkel, Becker, Merrill, and myself in the order of their determination and publication. Omitting the difference in nomenclature, owing to our diverse principles of classification, I do not see but that the determinations of Dr. Becker and myself are in accord in al-

[1] Becker, Geol. Comstock Lode, pp. 12–31, 33, 81-90.

most every particular except in the case of Nos. 227, 529. The difference in 529 seems to be owing to some very doubtful field evidence. It is to be remembered, however, that owing to the changes, etc., of the 40th Parallel Collection we may not be talking about the same rock, which may also account for No. 227.

WASHOE ROCKS.

Nos.	1876. Zirkel.	1879–1882. Wadsworth.	1882–1883. Merrill.	1883. Becker.
212	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
213	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
214	Propylite.	Andesite.	Propylite.	Augite Andesite.
215	Propylite.	Andesite.	Propylite.	Augite Andesite.
216	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
217	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
218	Propylite.	Andesite.	Propylite.	Diorite Porphyry.
219	Propylite.	Andesite.	Propylite.	Diorite Porphyry.
221	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
222	Propylite.	Andesite.	Propylite.	Diabase.
223	Propylite.	Andesite.	Propylite.	Diabase.
224	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
225	Propylite.	Andesite.	Propylite.	Hornblende Andesite.
226	Quartz Propylite.	Felsite.	Unable to determine.	Quartz Porphyry?
227	Quartz Propylite.	Old decom'd frag'l rock.	Unable to determine.	Quartz Porphyry?
228	Quartz Propylite.	Granite Porphyry of	229, Granite Porphyry	Porphyritic Diorite.
229	Quartz Propylite.	Zirkel.	of Zirkel.	Porphyritic Diorite.
230	Quartz Propylite.	Andesite.	No opinion.	Porphyritic Diorite.
231	Quartz Propylite.	Andesite.	Quartz Propylite.	Hornblende Andesite.
232	Quartz Propylite.	Mistake in slide.	— —	Diorite.
265	Dacite.	Felsite.	Dacite?	Quartz Porphyry.
266	Dacite.	Felsite.	Dacite?	Quartz Porphyry.
333	Rhyolite.	— —	— —	Quartz Porphyry.
529	Basalt.	Diabase.	Diabase.	Metamorphic Diorite.

The Third Annual Report of the Director of the United States Geological

Survey has been published and a few advance copies distributed. From this it can be seen that Professor Zirkel's work is looked upon by the Survey as so unsatisfactory that it is to be all done over again! Mr. Hague also fully sustains some of my points by stating that Zirkel frequently mistook triclinic feldspars for sanidin, and that the trachytes of Zirkel in the 40th Parallel Collection are in nearly all cases andesites. (*l. c.* pp. 11, 12.)

Mr. Hague further states, in like confirmation of my prior published views, in his "Abstract of Report on the Geology of the Eureka District, Nevada," that granite pophyry and granite are the same; the difference being purely one of structure, owing to conditions of cooling, rather than dependent upon geological age. (p. 275.) It is further stated by him that the hornblende andesite passes into a "rock which strongly resembles augite-andesite, not only in composition but in microscopic structure," and "judged simply from the hand specimen might properly be classed as augite-andesite." (pp. 281, 282.) Again: "Although olivine is absent from the augite-andesites of the district, it will not serve . . . as a mineralogical distinction to separate the two rocks, inasmuch as over wide areas of basalt it is wholly wanting. It occurs so irregularly scattered through the rock that any attempt to separate the basalts themselves into two divisions on a basis of olivine seems futile." (p. 285.)

It would seem to be now clearly shown that Professor Zirkel did mistake grains in the balsam for crystals in the feldspars, that he made repeated mistakes in the determination of his minerals and rocks, that his propylites are altered rocks, that most of his trachytes belong to other species and finally that his work on the 40th Parallel Collection is so poor that it has now to be done over again.

This certainly seems a complete vindication of most of the important points of my first paper so far as it relates to the 40th Parallel Exploration, while American lithology is now freed from the chains that were forged in 1875 to bind her.

Mr. F. W. Putnam gave an account of his summer's explorations of emblematic mounds in Wisconsin and Ohio. In the former state groups of these mounds on the Baraboo River, and at Madison, Lacrosse, and Eaton's Farm, Wisconsin River, were described in detail. Mr. Putnam then illustrated by photograph and map the "Great Serpent Mound," in Adams Co., Ohio. After careful study he thought that this was probably not a fortification, but that the resemblance to the form of a serpent might indicate some ancient rites of the builders. The speaker also referred to the famous Highbank Works on the Scioto River, Ohio.

The following papers were read by title: On the development of Hyla Pickeringii, by Miss Mary H. Hinckley;[1] and the development of Thalassema, by H. W. Conn (Walker Prize Essay).

General Meeting, October 17, 1883.

Vice-President, Mr. F. W. Putnam, in the chair. Twelve persons present.

Dr. C. S. Minot discussed the histology of the skin of insects, pointing out the homologies of the different layers in the arthropods and vertebrates.

Dr. G. F. Waters spoke of two observations he had made long ago showing that birds possess the sense of taste, and cautiously exercise it before swallowing anything new to them.

Thirty years ago whilst working one spring in my garden, in Waterville, Me., I observed a hen peck at something white upon the ground in such a halting way as to suggest the idea that she was in doubt as to what it was. She seemed to be tasting of it, taking a little of the substance in her mouth, then holding her head up would partly close her eyes and open and shut her mouth slowly at first then quite rapidly — this was repeated four or five times, when she began to eat ravenously as though she had been without food for a long time. My curiosity was aroused and I at once went to see what she had found. It was in a part of my garden where hens were not allowed to stray and generally at my approach she would have left for her permitted quarters, yet this time she did not stir but only eat the faster and as I took hold of her tried to get more. The substance proved to be part of a large potato which had remained in the ground during the winter, which had been open, and repeated freezings and thawings had turned the starch of the potato to sugar.

The same year I obtained some young hawks from the nest and brought them up by hand. They were in the habit of taking their food from my fingers. I bought fish, frogs, and beef-liver for them. The liver was cut into strips from three to five inches long which they always swallowed just as I gave it to them never breaking it up for convenience sake. I used to feed them early in the morning, and after I began my garden work. If no food, fish, frogs, or liver had been provided, I took my garden fork and dug a few earth worms for them. At first I gave the worms to them from my fingers, but in a little while they began to help themselves, picking them up quite fast, just as hens and chickens will. When they began to slacken in

[1] See Memoirs B. S. N. H., III, No. 10.

the work I stopped digging and began my tour of the garden for "cut worms." The garden had been left wild for a number of years, and was thoroughly infested with a large, hairless, cut worm of a dark sage green color. They lay just under the ground in the day time and came forth at night and ate every green thing that came in their way. I usually began with my peas to look for the pests and the smaller of the hawks would follow close at my heels to watch my movements or keep me company. I had begun killing the caterpillars with a stick, but upon the hawk coming and looking in my face just as I had found an unusually large one I handed it to her. She took it readily in her bill and dropped it upon the walk, then thrust one of the claws of her right foot through one end of the caterpillar and standing upon the left foot she held up the caterpillar and took a good look at it, wiping her eyes frequently with her nictitating membrane whilst doing so, and turning the caterpillar round so that she could see it from all sides. After she had thus viewed it for some time she put it down upon the ground keeping it still transfixed by the right foot, and raising the left foot carefully fixed the other end with a claw of that. Then with her bill she broke it in two in the middle. Then standing erect upon her left foot she raised the right with the half of the caterpillar on one of the claws, again looked it over very carefully, and daintily tried it with her bill evidently taking a little in her mouth, then wiping her eyes with her nictitating membrane; it was a long wipe during which her bill was opened a little and shut half a dozen times quite rapidly just as a person would do it tasting. This was repeated two or three times when she took the remainder from the claw and ate it. The same movements were gone through with the other half. Then without waiting for an invitation she proceeded to help herself to the pests. She would pick them up where I failed to see them, and so thoroughly cleared the ground of the pests that they gave me very little trouble thereafter. Most of her time was spent in the garden apparently looking for these caterpillars. I once saw her catch and eat a mouse, also a green snake ; and she ate up her brother when he was shot for eating young birds, but ordinarily she had a "diet of worms."

The following paper was read : —

ON THE CHASM CALLED "PURGATORY" IN SUTTON, MASS.

BY W. O. CROSBY.

Purgatory, in Sutton, Mass., like the places bearing the same trivial name in various other parts of New England, is a well defined chasm or gorge. It is situated in the southeastern part of the town, and is cut out of the southwestern flank of a broad, rocky, and wooded hill. This chasm is quite straight, about one-fourth of a mile long, fifty feet wide, and has a northeast and southwest trend. The walls are vertical, vary in height from ten to seventy feet, and are composed of a massive, micaceous gneiss, which is the prevailing rock of that region. The bottom or floor of the chasm is encumbered to an unknown depth with large, angular masses of the gneiss. The gneiss dips to the northeast about 25°, and is traversed by two well marked systems of joints; one system running northeast and southwest, or parallel with the chasm; and the other in a direction at right angles to this. The gneiss is also intersected by numerous veins of endogenous granite, holding beryl, garnet, and other minerals, which coincide in trend with the joint planes.

The only explanations of the origin of the Sutton purgatory which I have seen are the two suggested by Dr. Edward Hitchcock in his Report on the Geology of Massachusetts. The first, which he rejects as being too violent and as unsupported by the disposition of the gneiss, which does not dip away from the chasm, supposes the chasm to have been produced during a local uplift of the strata.

According to the second hypothesis, which Dr. Hitchcock was inclined to accept, this chasm is similar in its origin to the Purgatory at Newport, R. I.; *i. e.*, it is the product of marine erosion at a time when the sea occupied the surrounding valleys.

It appears to me, however, after an examination of the ground, that the second supposition is even more untenable than the first. At no point do the walls of the chasm show the slightest trace of water action; and the floor, instead of being bare and smooth, or covered only with rounded and water-worn boulders and pebbles, is piled with huge, angular blocks of gneiss. The same facts, as well as the situation of the chasm on a hill and not in a valley, are fatal to the notion that it is the channel of some ancient river. Glaciation, also, is entirely out of the question, for the chasm is transverse to the direction of glacial movement, and its walls are entirely unglaciated.

The only explanation commending itself to my mind is that referring the chasm to a local subsidence. In short, I conceive that during some disturbance of this portion of the earth's crust, such as a violent earthquake, the wedge-shaped mass of rock included between two master joints converging downwards has dropped, while the rocks were in a state of tension, to a depth of one hundred feet, more or less, thus giving rise to the chasm.

This explanation is in harmony with all the facts observed. The chasm, as previously stated, is parallel with a well defined system of joints, and its walls are evidently joint planes. No erosion is required and evidences of erosion are entirely wanting. The angular blocks with which the bottom of the chasm is filled are just such as would naturally be produced by such a catastrophe as is here conceived. Finally, there can be no doubt that parallel master joints frequently do converge downwards, that during the passage of an earthquake the rocks are thrown alternately into states of powerful tension and compression; and that, since earthquakes are of almost annual occurrence in New England, we may fairly suppose that they are sometimes sufficiently violent to accomplish results such as are here ascribed.

The dislocation here appealed to as a cause of the chasm is one that geologists will recognize as what might be called a normal form of geological accident. In Jukes' Manual of Geology it is regarded as the best explanation of normal faults. The fracture bounding each side of the wedge-shaped mass which slips down is necessarily a normal fault.

The facts observed also furnish a clue to the geological age of the chasm. However formed, it must be of post-glacial origin; for, lying across the path of the ice-sheet it would, if antedating the glacial epoch, have been scraped full of glacial detritus, whereas it is singularly free from such material. The ice-sheet swept the till from this elevation, leaving it bare and rocky, and then at some subsequent period the chasm was formed as explained. It is a common but evident error to refer all such geological events to some remote period; and I have seen nothing inconsistent with the view that Purgatory, in Sutton, is, geologically speaking, of very recent origin; being, perhaps, only a few centuries old.

General Meeting, November 7, 1883.

The President, Mr. S. H. Scudder, in the chair. Thirty persons present.

The President announced the deaths of Mr. Joachim Barrande, Prof. Oswald Heer, Honorary Members; and of Dr. J. Lawrence Smith, a Corresponding Member of the Society.

It was voted that the Honorary Secretary be requested to express to their families, the Society's sympathy.

Messrs. Frank O. Carpenter and George R. A. Hiss were elected Associate Members.

The following papers were read:—

AGRICULTURAL IMPLEMENTS OF THE NEW ENGLAND INDIANS.

BY HENRY W. HAYNES.

When the little band of sixteen Pilgrims "with every man his musket, sword, and corslet, under the conduct of Capt. Miles Standish" had set out upon their first exploration of the new country where their lot had been cast, upon the 15th day of November, 1620, we are told that very soon they "found much plain ground, about fifty acres, fit for plough, and some signs where the Indians had formerly planted their corn."[1] The account goes on to tell how shortly afterwards they came upon a large quantity of this same corn carefully stored in underground repositories, which they forthwith proceeded to "borrow," although they afterwards paid for it most conscientiously. In like manner we find all the earliest narratives of the first settlers filled with statements in regard to the large quantities of maize that the natives were in the habit of raising;[2] although Governor Bradford, it is true, has stated that "they have nothing so much corne as they have since ye English have stored them with hoes."[3] However that may have been, the latest investigator of the "Indian question," Rev. Dr. George E. Ellis, tells us that "the early European colonists in

1 Mourt's Relation (Young's Chronicles of the Pilgrims) pp. 125 and 130.

2 Wood's New England's Prospect, chap. v. (Prince Soc. ed. p. 75); Id. chap. xx (p. 116); Morton's New English Canaan., chap. XIII (Prince Soc. ed. p. 160).

3 History of Plymouth, p. 102 (Deane's ed.).

all their widely separated harboring-places in the whole stretch of our sea-coast, were indebted to the surplus maize, which the Indians had in store, to save them on one or another exigency from starvation." [1]

The question, therefore, naturally presents itself to our minds how, in the very low stage of civilization in which the natives are usually stated to have been found here, they were able to secure such large products of the soil, and what was the nature of the agricultural implements used by them? Dr. Palfrey has answered this question in a somewhat dogmatic fashion by stating that "one tool sufficed for their wretched husbandry; a hoe, made of a clam-shell, or a moose's shoulder-blade, fastened into a wooden handle." [2] He quotes no authorities for his statement, but I suppose he obtained his information about the clam-shells from Wood who praises the industry of the Indian women in cultivating maize, "keeping it so clear with their clam-shell hoes as if it were a garden rather than a corn-field." [3] Several writers have referred to the use of the shoulder-bones of deer for this purpose. Among them Loskiel, speaking of the Delawares and Iroquois, says they "used formerly the shoulder-blade of a deer, or a tortoise-shell sharpened upon a stone, and fastened to a thick stick instead of a hoe." [4] But, on the other hand, our associate, Mr. Lucien Carr, who has just published a most able and thorough study of all the authorities who have anything to tell us about "The Indian as an Agriculturist," quotes quite a number of writers to show that the natives commonly made use of "*wooden* hoes and spades." [5]

But in this instance, as in so many others, the *authorities* have not told us the whole story by any means, and archaeology comes in with the most irrefragable proofs that implements of a very different sort were largely employed by them. Who, for example, in reading the narrative of the first hostile en-

1 The Red Man and the White Man, p. 174.

2 History of New England, vol. I, p. 27.

3 New England's Prospect, chap. xx. (p. 106).

4 Mission among the Indians in North America, part I, p. 67. See also Le Moyne's "Brevis Narratio" in De Bry, ser. 1, part 2. pl. XXI, expl.

5 The Mounds of the Mississippi Valley historically considered, p. 9, note 12; and pp. 14, 20, 25.

counter between the Pilgrims and Indians, in which we are told that the former "took up eighteen of their arrows which we have sent to England by Master Jones; some were headed with brass, others with hart's horn, and others with eagle's claws;"[1] or Wood's statement that "their arrows were headed with brass in shape of a heart or triangle;"[2] or Higginson's, "For their weapons they have bows and arrows; some of them headed with bone, and some with brass"[3]—, who would receive the impression that the Indian arrow-heads were commonly made of stone? Yet archaeology points for her proof to the tens of thousands of such objects which are found all over our country, made of a great variety of stone, and some of them of exquisite workmanship; while of brass arrow-heads a few only have been discovered in graves, as at Revere beach; of course all of these must have been made since the coming of the white man.[4] Indeed in Underhill's "History of the Pequod War" we are told that a Dutch trader was prevented from bartering with the Pequods on the ground that they were to be supplied in part with "kettles, or the like, which make them arrow-heads;"[5] and Sir Ferdinando Gorges had previously complained about "disorderly persons" who sold the savages "arrow-heads and other arms."[6] In later times they seem to have substituted arrow-heads made of metal for those of stone.

To return from this digression, in addition to clam-shells, bones and wooden spades and hoes, we are informed by another writer that the Indians made use of implements of agriculture made of a still different material. Adair, speaking of the Catawbas, says that one of their corn-fields was seven miles in extent; and he argues that the tribe must have been "a numerous people to cultivate so much land with their dull stone axes."[7]

1 Mourt's Relation, p. 158.

2 New England's Prospect, chap. XII (p. 101).

3 New England's Plantation (Young's Chronicles of Massachusetts), p. 257.

4 Reports of the Peabody Museum, vol. II, p. 732. Reports of the Long Island Hist. Soc. (1878–1881), p. 40. Jones' Antiquities of the Southern Indians, p. 251. Abbott's Primitive Industry, p. 240.

5 Coll. of Mass. Hist. Soc. 3d ser., vol. VI, p. 17.

6 Description of New England, Id. ib. p. 70.

7 History of the American Indians, p. 225.

This is all that the early writers have to tell us upon this question, so far as I am aware, and we will now proceed to relate what light archaeology has been able to shed upon the subject.

Prof. Charles Rau, the learned archaeologist of the Smithsonian Institution, was the first to direct attention to a class of stone implements, remarkable alike for their large size and their superior workmanship, which in his judgment unquestionably were used by the Indians for purposes of agriculture.[1] They are found most frequently in the western states, are made out of flint of a very fine quality, and are of two quite different shapes. The first are *spades*, oval-shaped plates often more than a foot in length, by five inches or more in breadth, and about three-fourths of an inch thick, flat on one side and slightly convex on the other, and worked to quite a sharp edge all around. The second are *hoes*, semi-circular in shape, of which the largest are six inches, or a little more, long, by as many broad, and about an inch thick, and with the lower round end worked to a sharp edge. At the upper end near the top of this latter kind are two notches, one on each side, by which it was fastened to a handle. "If the shape of the implements described did not indicate their original use, the peculiar traces of wear which they exhibit would furnish almost conclusive evidence of the manner in which they have been employed; for that part with which the digging was done appears, notwithstanding the hardness of the material, perfectly smooth as if glazed, and slightly striated in the direction in which the implement penetrated the ground." Specimens of these interesting objects of both sorts are here for your examination. In a subsequent article Dr. Rau gives an account of several large deposits of such implements which have been met with in different localities.[2] One found in Illinois, just opposite the city of St. Louis, contained seventy-five; and another at Racine, Wis., about thirty. A remarkable one was discovered by Messrs. Squier and Davis in the course of their exploration of one of the so-called "sacrificial mounds" situated on Paint Creek, Rose Co., Ohio. "This mound contained, instead of the altar usually found in this class of earth-works, an enormous number of flint disks standing on their edges and arranged in two layers one above the other at

[1] Smithsonian Report, 1863, p. 379. [2] Smithsonian Report, 1868, p. 401.

the bottom of the mound. The whole extent of the layers has not been ascertained; but an excavation six feet long by four broad disclosed upwards of six hundred of these disks rudely blocked out of a superior kind of grayish, striped flint. They are on an average six inches long by four wide." But the most extraordinary find of this character, which I have ever seen recorded, is the one mentioned by Dr. Snyder as having been made in Schuyler Co., Illinois, when *thirty-five hundred* of such implements were unearthed without reaching the limits of the deposit.[1]

The only similar discovery I have ever heard of in New England occurred about fifty years ago. Mr. Lincoln, of Dennysville (near Eastport), Maine, while employed with an ox team in hauling gravel from a pit, broke into an Indian grave in which were found by the side of the skeleton a large number of flint implements of various kinds. Many of them were unfortunately broken at the time, but among them were several evidently intended for spades, two of which are here for your examination. They were all of the same rectangular shape as these, the largest measuring about six inches long by four broad.

It will be noticed that they are both colored with a red pigment made out of haematite ore, with which the Indians were in the habit of painting themselves. Such a use of red paint, made from the same material, for personal decoration was equally common among the primitive races of the old world, and pieces of the ore are often found in the European caves associated with stone implements. In both hemispheres alike it was a funeral custom to stain with it the bodies of the dead and the various objects interred with them. The famous "fossil man," of Mentone, now in the Jardin des Plantes at Paris, had his head thus colored, and also the chaplet of shells with which it had been adorned.[2] Carver, in his "Travels through North America," gave an account of an Indian burial in which it was so employed; and from this narrative Schiller drew the allusion which occurs in his famous "Indian Death-Dirge" which has been so admirably translated by Sir Edward Bulwer-Lytton: —

"The paints that warriors love to use
Place here within his hand,

1 Smithsonian Report, 1876, p. 437.

2 Rivière, Découverte d' un squelette humain dans les grottes de Menton, p. 26.

That he may shine with ruddy hues
Amidst the spirit-land."

All the objects found in the grave at Dennysville were colored in the same manner as these before you.

In his excellent work upon the Southern Indians Mr. Charles C. Jones has given a description, with a figure, of another pattern of stone *hoe*, resembling in appearance half of a grooved axe split in two longitudinally.[1] It is five inches, or more, in length by two and a half in breadth, slightly concave, and has a groove at the top by which it could be lashed securely to a handle. "For a distance of more than two inches and a half from the edge it exhibits on both sides that delicate polish which is engendered only by constant attrition and long-continued use." I have here for your examination a specimen, from a mound in Tennessee, that Mr. Putnam has kindly loaned me from the Peabody Museum, at Cambridge, resembling the one figured by Mr. Jones, but considerably longer.

Implements of a similar type, but smaller, are found in New England and throughout the middle and southern states. Two such are described and engraved by Dr. C. C. Abbott, in the chapter upon "Agricultural Implements" of his exhaustive treatise upon the varous articles of the handiwork of the native races of our sea-coast.[2] Such *hoes* are not uncommon in New Jersey, and they are made by having been first "pecked" into shape and subsequently ground down nearly smooth. Finally Dr. Abbott has given a figure of "a stone spade, such as is found in considerable numbers in Mercer Co., N. J., but which is not known in other localities. . . . All of those collected show distinctly the striae and polish, amounting in some to a glaze which characterize the western spades. . . . The material of which they are made varies. Slate, argillite, etc., have been used. . . . The narrowed handle and broad blade are well-marked features in all the specimens, and they merge into each other. . . . It is possible that they may be a local form, but the pattern is so simple in design and so well adapted for digging in loose, sandy soils that similar objects may be confidently looked for in other localities."[3]

Dr. Abbott's anticipation has been realized, and I have here

[1] Antiquities of the Southern Indians, p. 301. [2] Primitive Industry, pp. 222, 223.

[3] Id. ib., p. 225.

for your examination just such a stone *spade*, which I found last summer in a field in Squantum, North Quincy. It is the only one of this precise pattern that I have ever seen. The implements which, in my opinion, were more commonly used by our New England Indians were of much simpler and ruder types, but they may all readily be classed under the two designations of *spades* and *hoes*. I have brought several specimens of each type for your inspection out of a large number which I have at home. It is only quite recently that I have begun to search for them, but I have never failed to find them upon the sites of old Indian settlements. Most of them are from the immediate vicinity of Boston, but I have found the same classes of objects in different localities in New England. The *spade* is the larger, heavier implement, one remarkably well adapted to break up the ground and prepare it for planting. The *hoes* are smaller, generally not larger than the palm of the hand, and would be usefully employed for weeding. On several of them can be seen two little nicks, at the upper end on each side, by which they were fastened to handles. All the examples show upon the surface and especially on the lower edge evident marks of wear and use; but so simple is their form, and so little artificial shaping has been given to them that hitherto they have never attracted attention. That they must have been in common use I think is indicated by the number I have found after comparatively little search.

ORIGIN AND RELATIONS OF CONTINENTS AND OCEAN-BASINS.

BY W. O. CROSBY.

(Introduction.)

The reasoning of Thomson, Hopkins, and Darwin, and the very important consideration that pressure — except with a few bodies which, like water, expand on freezing — must raise the fusing point and thus favor solidification, leave but little room to doubt that the earth as a whole is a very rigid body. So convincing are the arguments, that this notion of an essentially solid earth has already supplanted, in the minds of the great majority of geologists, the view but recently almost universally held that below a comparatively thin solid crust the globe is yet wholly liquid.

While the reconstruction of dynamical geology on the basis of a solid earth undoubtedly marks a great advance in the science, yet it appears to me that some eminent writers have carried the new views too far, and made certain portions of the earth too solid. Thomson asks for an average rigidity equal to that of steel, and Darwin says that no considerable portion of the interior of the earth can even distantly approach the fluid state; but this is not necessarily inconsistent, as many appear to think, with the existence of a shallow, discontinuous, *plastic* zone between the rigid crust and a nucleus *more rigid than steel.*

One of the most important results reached by Thomson is that up to this time the refrigeration of the earth has been limited to the superficial portions, that below a depth not exceeding 300 miles the temperature ceases to increase downward at a sensible rate, and that the maximum terrestrial temperature is probably not above 7,000° to 10,000° Fah. In other words, the great interior portion of the earth, embracing five-sixths of its volume and probably seven-eighths of its mass, has a sensibly uniform temperature, which is not incomparably higher than temperatures with which we are familiar on the earth's surface. But the pressure to which materials in the interior of the earth are subjected increases steadily all the way to the centre. Therefore, since heat acts against, while pressure promotes, rigidity, if the earth-matter, as is generally believed, is solid at a depth of 300 miles in obedience to pressure (about 2,000,000 pounds per square inch) and in spite of its high temperature, it is to my mind quite conceivable that at greater depths, where the temperature is not sensibly, or at most not greatly, higher, a pressure ten times greater (or 20,000,000 pounds per square inch) may induce a degree of rigidity exceeding that of steel or any substance with which we are acquainted.

The extreme probability, if not the absolute certainty, of the existence of this high degree of rigidity in the central portions of the earth becomes apparent when we consider that, as Professor

Dana has correctly stated,[1] the rigidity of slowly solidified rock, at the earth's surface, is beyond that of glass or steel.

If we may assume that rigidity varies with varying temperature and pressure according to some simple and similar, though contrary, laws, then by the side of Thomson's temperature curve we may construct a curve for pressures, based on any probable law of the downward increase of specific gravity; and readily observe where the relations of temperature and pressure are most favorable for a plastic zone; *i. e.*, where the pressure is least relatively to the temperature. This region must be comparatively superficial, since the temperature increases downward rapidly at first and very slowly at greater depths; and I have found in this way that the ratio of temperature to pressure probably reaches its maximum between 40 and 80 miles below the earth's surface.

But the experiments of Daubrée have shown, contrary to the old idea, that the capillary absorption of water by the earth's crust, within certain limits at least, is facilitated, rather than hindered, by the high subterranean temperatures; and hence we are warranted in believing that the crust is hydrated to a very great depth. Now the principle is generally accepted that water reduces in a marked degree the fusing points of rocks, liquefaction resulting from aqueo-igneous fusion at temperatures far below those of purely igneous softening. Therefore, since the minimum ratio of pressure to temperature occurs so near the surface, water becomes an important element in locating the most probable position of a plastic zone. The maximum plasticity, other things being equal, will be determined, approximately at least, by the minimum ratio of the pressure to the product of moisture and temperature; and this probably exists nearer 40 miles than 80 miles below the surface. Several well established and entirely independent facts — such as the high specific gravity of the earth as a whole, the excess of basic elements in certain eruptive rocks, and the metallic nature of many meteorites — point unequivocally to the conclusion that the earth's interior consists chiefly or entirely of metals, among which iron must occupy a prominent position. Now it may very well be that, as Judd has suggested in his recent work on volcanoes, the access of water to the outer portions of this highly heated but only partially oxidized earth-

[1] Amer. Jour. Sci. (3), VI, p. 11.

matter is attended by farther oxidation and the evolution of considerable heat. So that it is conceivable that a higher temperature may reign in the lower portion of the hydrated crust than in the regions immediately below the limit reached by the water; and it will not escape observation that this higher temperature is developed at the point where the other conditions are most favorable to the formation of a plastic stratum. If we hold that in the anhydrous globe the pressure is everywhere more than a match for the temperature, it is yet difficult to believe that it can be so in the lower levels of the hydrated crust, where moisture coöperates with a temperature of from 2,000° to possibly 5,000° Fah. In other words, from these generally accepted principles the inference flows almost irresistibly that the earth possesses a plastic zone, and that this is near the surface; and, as already pointed out, this is in harmony with the conclusions of Thomson and Darwin, if we make the not unreasonable assumption that the central portions of the earth possess a degree of rigidity greater than the mean which they require.

One fact to which considerable weight has been attached by Le Conte [1] as an argument against a plastic zone is rapidly disappearing. I refer to the elliptical form of the earth's equatorial section. It is certainly true that the existence of such a zone would be extremely improbable, if the inequality of the equatorial radii was very marked. Now the values of these radii usually accepted are those determined by Col. A. R. Clark, of the British Ordnance Survey, according to whom the major exceeds the minor radius by 6,378 feet, the major axis intersecting the meridian of 15° 34′ E. But Colonel Clark has published a revision of his results, founded on new data; and he now finds the difference between the equatorial radii to be only 1524 feet; whilst the meridian of the major axis is 8° 15′ W.; and the polar radius is lengthened 1000 feet. Colonel Clark, himself, evidently regards the ellipsoidal form of the equator as doubtful. Thus, there is, at all events, no *proved* result of geodesy opposed to the hypothesis of a plastic zone in the earth.

On the other hand, there are many important and generally admitted geological facts which can be satisfactorily explained only on the supposition of a yielding stratum at a moderate dis-

[1] Amer. Jour. Sci. (3), IV, p. 351.

tance below the earth's surface. This stratum, however, in order to answer perfectly all the purposes of the geologist, need not be very extensive in the vertical direction. If we assign it a volume equal to one-hundredth that of the earth, I think there are few geologists who will not find it sufficient. Nor need the stratum be absolutely continuous, though it must be nearly so. Nor, again, do we require anything more than a very low degree of plasticity.

Babbage's theory that elevation and subsidence of the earth's crust are due to the expansion and contraction of rocks by heating and cooling is an adequate explanation of some local and limited movements, in volcanic districts. But it is no explanation at all of extensive movements affecting large areas. Let us observe the increase in temperature required in one hundred miles in thickness of the earth's crust to lift the great plateau of central Asia from the level of the sea to its present altitude of 16,000 feet — approximately, an expansion of three miles in one hundred. Taking Colonel Totten's highest coëfficient of expansion — .000,009,532, or say .000,01 — then to produce an expansion of .03 we must have an average increase of 3,000° Fah. The increase, evidently, cannot be so large near the surface, and consequently must be larger at considerable depths. But at a depth of one hundred miles, according to Thomson, the crust has nearly its original temperature, and cannot lose or gain heat in any such fashion. Therefore, a smaller thickness must be heated still higher. But at all depths not very near the surface we suppose the rocks to have temperatures near their fusing points; and an increase of from 3,000° to 5,000°, without increase of pressure, would surely fuse them. And, further, no explanation is offered as to where this heat comes from or goes to. A clear statement of this theory, as applied to really important instances of elevation and subsidence, is sufficient to refute it. It breaks down with its own weight. It also fails to explain local movements which are paroxysmal. Babbage appreciated some of these difficulties, and suggested that the elevation of extensive areas of the sea-floor, where sediments are accumulating, could be explained by expansion due to rising of the isogeotherms. But this would not account for subsidence any where, nor for the elevation of any old land-surface. Besides, it is a well established fact that areas where thick deposits of sediments are formed usually are, and, as a rule, *must* be, areas of *subsidence*.

Herschel started with this datum of the science, and added the following: the rising of the isogeotherms softens and weakens the hydrated crust; and the weight of increasing sediments bears it down. But it is now generally conceded by geologists that subsiding sea-floors are the *cause* and not the consequence of thick deposits of sediments.

Although the true theory of elevation and subsidence must be one recognizing a variety of causes; yet the mere thickening and thinning of the crust by expansion and contraction, and the softening of its lower portions, do not explain the grand facts of the rising and falling of continents and ocean-floors. In short, the magnitude of the phenomena compel us to suppose that, in many cases, elevation and subsidence are due to the bending of the crust through its entire thickness. But this supposition involves the farther supposition of a plastic zone beneath the crust. And, as a matter of fact, the great majority of geologists, in spite of the reaction from the hypothesis of a liquid globe, do admit the existence of a relatively soft and plastic layer as the only satisfactory explanation of the extensive vertical movements of the earth's surface. This point is even conceded by those who, like Professor Dana, stand most strongly, in their theories of continents, for a globe continuously solid from centre to circumference.

In the American Journal of Science (3), vol. 6, p. 7, Professor Dana says: "The Appalachian subsidence in the Alleghany region of 35,000 to 40,000 feet, going on through all the Paleozoic era, was due, as has been shown, to an actual sinking of the earth's crust through lateral pressure, and not to local contraction in the strata themselves or the terranes underneath. But such a subsidence is not possible, unless seven miles — that is, seven miles in maximum depth and over a hundred in total breadth — of something were removed, in its progress, from the region beneath." In other words, "there existed, underneath a crust of unascertained thickness, a sea or lake of mobile (viscous or plastic) rock, as large as the sinking region." And it is also stated that "this under-Appalachian fire-sea probably dated back to the era of the general fluidity of the earth."

have extended east beyond the existing border of the continent. And he further states that "the under-crust fire-sea on the Pacific border must have had great length from northwest to southeast; and, also, great breadth, for the border region is at least 1,000 miles wide; and great breadth and great length seem plainly its characteristics even till Tertiary times." Again, "It is further to be noted that, in the course of past time, the whole continent has had its surface, from one side to the other, criss-crossed with oscillations and lines of disturbance, from the lateral pressure acting against its opposite sides, whence it is clear that the continental subterranean areas were *once* continuous. The facts from the ocean seem to demand a vastly greater range for the under-crust mobile layer." And, finally, in conclusion, Professor Dana says there is a flexible crust and mobile rock beneath it.

Thus we find Professor Dana fully committed to the view that the earth contains a nearly continuous plastic zone; although his theory of continents, as will appear farther on, appears to require that the continents should be for the most part at least, rigidly connected with the earth's solid nucleus. We hardly seem warranted, however, in *assuming* — for it certainly has not been proved — that a nearly if not quite universal mobile layer, which we are compelled by the phenomena of elevation and subsidence to believe was in existence from the period when the entire globe was an incandescent liquid down to the later Tertiary times, suddenly became solid under the continents with the close of that epoch.

Besides, we have abundant evidence, not only that nearly all parts of the globe experienced extensive vertical movements during the Tertiary period, but also that the grand continental oscillations do not belong wholly to the past; for great changes in the elevation of the continental masses, and in the relative distribution of land and sea, are now in progress. Geologists are familiar with this evidence, and I will notice only a single example. Perhaps the most striking instance of change of continental level now in progress is that afforded by the western half of South America. It was long ago demonstrated, by the observations of Darwin and others, that this part of the earth's crust is *now* rising slowly, yet at a rate which is measurable from century to century, or even from decade to decade. And the evidence is very clear that this movement has been going on for a long time over the whole southern half of the continent, but especially on the west side. From Cape Horn northward, 1,200 miles on the east coast and nearly 2,500 miles on the west coast, old sea-beaches and terraces full of species of shells now living in the adjacent seas, are observed at heights ranging from 100 to 1,300 feet above the sea. These are the facts furnished by Darwin, but more recently Alexander Agassiz has traced the ancient shore line in Peru at an elevation of 3,000 feet by means of coral still sticking to the rocks. There is also evidence that points distant from the coast rise faster than the coast itself.

Here are indisputable facts which demand a plastic zone under a large section of South America at the present time. And, by presenting the similar facts observed in other continents, it would be easy to show that a very large part of the land of the globe is now moving up or down, and hence must be now underlaid by a plastic stratum. While, on the other hand, there is not a vestige of trustworthy, positive evidence to show that this plastic stratum is not as wide-spread and continuous to-day as it ever was ; and the probabilities certainly are that it is nearly so. That is, contrary to the ideas inculcated by some leading geologists, I venture to assert that we have no evidence that the continents are more stable now than they were during the Tertiary or Secondary periods.

Among recent geological writers of note, there are none who are more pronounced believers in a thoroughly solid earth than Archdeacon Pratt and Prof. Joseph Le Conte. They both appear to deny the existence of a plastic zone, considering the earth as entirely solid, with the exception of a few limited and isolated lakes of liquid rock situated in the crust and forming the sources of volcanic materials. Rejecting the idea of a plastic zone, Le Conte is, as he confesses (Amer. Jour. Sci. (3), vol. IV, p. 472), unable to explain the phenomena of elevation and subsidence. Le Conte is an able and prominent advocate, and in part the author, of the theory of the formation of mountains which has been developed during the last score of years — chiefly by Hall, Hunt, Dana, and Le Conte — and which is at present very generally accepted by geologists. The most prominent and essential feature of this theory is that mountains are due to a *horizontal* mashing up of the earth's crust along lines of weakness, the crushing force being simply the tangential thrust induced in the crust by the continued cooling and contraction of the earth's interior, after the crust has attained a constant temperature and volume. Now, according to Le Conte, this horizontal crushing of the crust, as evidenced by folds and slaty cleavage, is so great that on the average the breadth of the crushed area — the mountain-zone — is diminished in the ratio of 5 to 2; 10,000 feet becoming 4,000 feet, and 10 miles becoming 4 miles. In other words, the formation of a mountain-range is equivalent, in one sense, to closing a fissure several miles in width; and this requires a decided horizontal movement in a very large part of the earth's crust, the latitude and longitude of places being permanently changed.

This slipping of the crust over the nucleus could not take place without a plastic zone, which is thus seen to be essential to the generally accepted theory of the origin of mountains.

Therefore, to sum up, whether we consider the relative distribution of temperature, pressure and moisture in the earth's crust, the phenomena of elevation and subsidence, the formation of mountains, or the origin of volcanic products, to which I have scarcely alluded, we equally reach the conclusion that the earth must contain a nearly universal plastic stratum. Consequently, any theory of the origin and relations of continents and ocean-basins incompatible with the existence of this mobile layer must, in the present condition of the science, be considered as in so far inadequate. A yielding layer or bed, we are compelled to believe, underlies the continents and seas and must be regarded as fundamental in any true theory of these grandest of the earth's surface features.[1]

[1] Within a few months several prominent geologists have revived the old view that below a thin, solid shell the earth is wholly liquid. So far as the relations of continents and ocean-basins are concerned, the condition of the central portions of the earth is of little consequence to one who has accepted the view here insisted upon, that the crust rests upon a nearly continuous mobile layer; for the theory of a liquid globe merely extends the mobile layer to the centre. It does not appear to the writer, however, that any arguments yet advanced forbid us to believe in the essential solidity of the earth's great central nucleus. Hon. J. W. Powell, Director of the United States Geological Survey, holds (Science, III, 480) that the phenomena of faulting, plication and vulcanism are incompatible with a solid earth. But certainly a mobile layer ten to twenty miles thick would satisfy the dynamical geologist as well as one 4,000 miles

THEORIES OF THE ORIGIN OF CONTINENTS AND OCEAN-BASINS.

Taking a general view, the theories or explanations of the origin of continents and ocean-basins may be regarded as two in number. A brief statement of each of these will be first in order; and after that we will consider more in detail the arguments that oppose or support them.

1. We have, first, what may be called the old theory, the one taught by Lyell and all the older geologists and still very generally accepted. This is the theory held by the present writer; and hence the following statement of it on account of the personal coloring may not, as a whole, meet the views of those who would still indorse its main features: The mobile stratum between the solid nucleus and the solid exterior lies at the foundation of this theory; for the continents and ocean-basins are here regarded as broad upward and downward *bendings* of the crust. These great crust-flexures are produced and sustained by the tangential thrust arising from the contraction of the earth's interior. The final result of the increasing horizontal strain in the crust is that the crust is mashed up and a mountain-range formed. No crushing can take place, however, until the strain reaches a certain high maximum; for otherwise it would go on all the time, and we would recognize no distinct mountain-building epochs in the earth's history. But I hold that, until the crust can obtain final and permanent relief by crushing, it will accommodate itself to the shrinking nucleus by undergoing a grand distortion or warping, which will be slight in the vertical direction when the strain is small, but as the strain accumulates during the lapse of ages the deviation from the normal spheroidal form will *tend* to become greater — the continents higher and the oceans deeper —, though this may not actually occur in every case because denudation is constantly degrading the land and filling up the seas. It

thick; and on this basis we can reconcile the conclusions of the geologists and physicists. It is doubtful, however, if physicists will accept Major Powell's novel argument from the "flow of solids;" namely, "that pressure itself would reduce the interior of the earth to a fluid condition." Dr. M. E. Wadsworth (American Naturalist, XVIII, 587) points out the self evident fact that Thomson and Darwin necessarily assumed as the basis of their reasoning conditions different from those of the actual earth. But he has not shown that the difference is of such nature as to necessarily or even probably invalidate their conclusions.

is a principle generally accepted by geologists that the accumulation of sediments on the subsiding sea-floors along the margins of continents is attended by an elevation of the isogeotherms and a consequent softening of the crust. Thus are developed the weak zones which yield and are mashed up to mountain-ranges when the crust can no longer resist the growing tangential strain. And when this occurs the distortion or warping of the crust is lessened which means a diminution of the mean height of the continents; though their margins are elevated by the mountain-making. These periods of catastrophe and mountain-making are regarded as favorable to more or less extensive interchanges of land and sea, of areas of elevation and depression; for this theory does not require that the continents should be fixed.

2. The second theory is that developed during the last third of a century, chiefly by Professor Dana, and commonly known as Professor Dana's theory. The main points in this theory, as gathered from the latest expression of Professor Dana's views, are the following:[1] — The earth, superficially at least, is, and was originally, before it had a solid crust, of unlike composition on different sides. This heterogeneity caused a corresponding difference in heat conductivity. The more rapidly conducting areas cooled fastest and were the first to become covered with a solid crust. Solidification is attended by contraction; and therefore the newly formed crust must have been heavier than the liquid immediately beneath it. As a consequence it broke up and sank until it reached a liquid stratum of the same specific gravity as itself; and afterwards the process of crusting and sinking went on until a solid crust was built up from this point to the surface. Through the continued escape of heat this primitive crust is thickened and is still thickening by additions to its lower surface. These first formed portions of the crust became, and will always continue to be, the continents. The remainder of the earth's surface was still liquid, after the solidification of the continental areas was well advanced; and, of course, as long as it continued liquid its surface was level with that of the crust areas. Finally it became the theatre of a similar process of crusting and sinking, and at last permanently froze over. Now the main point is that the contraction of this inter-continental crust during its formation

[1] Amer. Jour. Sci. (3), vols. v and vi.

caused its surface to sink below that of the continents; and the depressions thus developed became the future ocean-basins, which, like the continents, are, according to this theory necessarily of a permanent character. Indeed, it is a plain deduction from Professor Dana's hypothesis that the existing continents and oceans are as old as the earth's crust. Although subject to extreme changes of level and frequently submerged, yet no portion of the continent has ever become the site of the deep central ocean; nor has any portion of the floor of the abyssal sea ever been elevated to form continental land. In the beginning, the continents were narrow and the oceans shallow; and during the course of geologic time the continents have become constantly wider and the oceans deeper.

Closely related to Professor Dana's theory is that held by Archdeacon Pratt and Professor Le Conte. The following statement of this theory is given in Le Conte's own words: [1] — "Continental surfaces and ocean-bottoms are due to *unequal* radial contraction of the earth in its secular cooling. It is evident that in such secular cooling and contraction, unless the earth were perfectly homogeneous, some parts being more conductive would cool and contract more rapidly in a radial direction than others. Thus some radii would become shorter than others. The more conductive, rapidly contracting portions, with the shorter radii would become sea-bottoms; and the less conductive, less rapidly contracting portions, with the longer radii, land-surfaces. In other words, the solid earth becomes slightly deformed and the water collects in the depressions." Le Conte and Pratt further hold that the quantity of matter along each of the terrestrial radii was not only originally, but is yet, essentially equal; the matter being denser along the shorter oceanic than along the longer continental radii."

Certain passages in Le Conte's writings lead one to infer that he regards his theory as essentially similar to Professor Dana's. Nevertheless, the language quoted above shows that the difference is fundemental. They agree in requiring a heterogeneous earth as a basis for unequal radial contraction and fixed continents; but beyond that they are diametrically opposed. For Professor Dana says that the more rapidly conducting and cooling

[1] Amer. Jour. Sci. (3), vol. IV, p 352.

areas form the continents; but Professor Le Conte says they form the ocean-bottoms. Professors Dana and Le Conte agree, however, upon the main point against which the principal arguments of this paper are advanced; namely, that the continents and ocean-basins are permanent, their present positions being those which they occupied at the beginning of geological time.

We pass now to a more detailed examination of the two main theories, with the view to determining which one, in the light of our present knowledge has the best claim to the title of the true theory of continents and ocean-basins.

1. Continents and ocean-basins are upward and downward bendings of the earth's crust.

This theory harmonizes perfectly with the known facts of elevation and subsidence; and it is the only theory that does offer an adequate explanation of this important class of phenomena. It permits the interchange of continents and seas; a relation which is supported by a vast mass of geological data, and against which no sound argument has yet been urged. The principal, and, so far as I am aware, the only serious objection to this theory is that brought forward or at least specially insisted upon by Le Conte.[1] He says that the great crust arches could not sustain themselves for a moment, even if the crust were several hundred miles thick; but the continental arches would break *down*, and the oceanic arches would break *up* and restore a level surface. But he goes still further and remarks: — "So great is this force tending to the general form of equilibrium that, even if the earth as a whole were rigid as a solid globe of glass (that is, had no plastic stratum), it could not resist it. Hence he is driven to the conclusion, already expressed in his theory of continents, that there is the same amount of matter along each of the terrestrial radii; since, if there were not, the continents, although they are parts of a globe continuously solid and as rigid as glass, would, according to his view, settle down after the manner of the inequalities of a mass of pitch. If, then, we can show that the masses of the terrestrial radii are not equal Professor Le Conte's continents are left absolutely without support. Now nothing could be easier than to demonstrate this. For, although we may readily grant that, leaving out of view the equatorial protuberance due

[1] Amer. Jour. Sci. (3), vol. IV, p. 346.

to the earth's rotation, this was the normal constitution of the liquid globe; yet, after solidification, this equal radial distribution of matter would very soon be spoiled by denudation; and now, after the continents have been repeatedly swept away and the débris piled upon the sea-floor, we may fairly claim that it has entirely ceased to exist. The horizontal movement of the crust during mountain-making also operates to the same end; for there is certainly, as Professor Le Conte himself insists, more matter along the radii terminating in the Sierra Nevada and other mountain ranges now than before the mountains were formed.

The notion, then, that the terristrial radii are now of equal weight is wholly untenable; but the continents, with their vast plateaus and mountain ranges are actual existences; proving that Le Conte has greatly over-estimated the levelling effect of gravitation upon the inequalities of the earth's surface.

Having shown that the well established facts of denudation and mountain-making are a sufficient refutation of the second part of Le Conte's objection to the theory here advocated, I turn now to the consideration of the first part where he states, in effect, that continental and oceanic arches resting on a plastic stratum could not sustain themselves even though the crust were several hundred miles thick. But, first, I will point out an apparent oversight in the only alternative which he allows those who believe in a plastic stratum. He says, "If there be, indeed, a solid crust on a liquid interior (or plastic zone), in order to sustain itself the inequalities of the upper surface in contact with the air *must be repeated on the lower surface;*" and his figures in illustration show inequalities on the under surface of the crust equal in form and size to those on the upper surface. This equality between the upward and downward protuberances of a floating crust could exist only in the case where the density of the crust is just half that of the supporting liquid; but we are obliged to suppose that the difference in specific gravity between the crust and liquid in the case of the earth would be very small. If we assume that the liquid is one-tenth heavier than the crust, then a protuberance of two miles on the upper surface of the crust would require a protuberance of twenty miles on the lower surface to sustain it. Hence Le Conte is quite right in saying that this theory "breaks down with its own weight;" and it becomes doubly important for those believing in a plastic stratum to show that an arched crust is a possibility.

In the first place I desire to direct attention to the *very slight* amount of distortion required in the crust to produce the existing continents and oceanic hollows. Le Conte's diagram gives a wrong impression, because the depressions are never concave. Taking the mean height of the land at 1,000 feet and the mean depth of the sea at 15,000 feet, we have a mean relief of 16,000 feet. So far as this argument is concerned, however, the oceans are not so deep; for the water helps to hold the depressed surfaces down and thus to maintain the distortion, being equivalent in this respect to a layer of rock equal in thickness to two-fifths of the depth of the ocean — 6,000 feet. This reduces the total effective relief to 10,000 feet, or say two miles, which is one-two thousandth of the earth's radius. In other words, the oceanic depressions, taking the average depth, are not deeper relatively than the varnish one-fiftieth of an inch thick on a globe eighty inches in diameter. On such a model of the earth the continents and ocean-basins would be produced by warping the film of varnish to the extent of its own thickness.

Le Conte denies the possibility of crust-arches, even if the crust is several hundred miles thick. But he admits, as all geologists must, that the tangential strain due to the cooling and shrinking of the earth's interior accumulates through long geological ages before the crust finally finds relief by crushing. Of course no one supposes now that this horizontal pressure ever even distantly approaches its highest conceivable maximum, which would result when an actual separation occurred between the earth's nucleus and crust. But the attainable maximum pressure is, nevertheless, very great; being sufficient to crush a more or less rigid crust at least twenty, and possibly fifty, miles in thickness. Now, the important question seems to be, has this enormous lateral thrust any visible effect upon the crust before the time when the crushing of the latter begins? Those who answer in the negative must be prepared to show that the crust is far more uniform in thickness, weight, and rigidity than most geologists would probably be willing to admit that it can be. The case is like this: by the shrinking of the nucleus, the crust is left unsupported to a certain extent; but it will continue to maintain its original form of fluid equilibrium, and the strain will be without visible effect until it becomes great enough to crush the crust; provided that the tendency to follow the contracting interior is equal in all parts of the crust; *i. e.*, provided that the thickness and rigidity of the crust are sensibly the same at all points. The accepted theory of mountain-formation, however, not to mention other considerations, forbids us to believe that the crust is thus homogeneous. But if it is not, then it must, in the case supposed, be in a state of unstable equilibrium; the thicker and heavier parts are pulled downwards most strongly; and the result is a grand distortion or warping of the crust whereby its interior capacity is diminished so that it can accommodate itself to the shrunken nucleus. The depressed areas become sea-floors and the elevated areas continents. It is not clear how those who admit the existence of a plastic stratum in the earth can consistently doubt that a condition of unstable equilibrium in, and consequent warping of, the crust would inevitably follow the shrinking of the nucleus.[1] Of course, if the earth is continuously rigid from centre to circumference, as Le Conte claims, there is an end at once of all extensive elevation and subsidence, and of all mountain-making too. For, although Le Conte has not said it, yet it seems to be a logical consequence of his theory that the crushing of the crust would not be limited to narrow zones since that implies a slipping of the crust over the nucleus which would be impossible if the two were everywhere rigidly connected; but the crushing would be, like the wrinkling of the skin of a withered apple, more or less uniformly distributed, producing many minor corrugations but no lofty, well-defined and dominant ranges.

As already stated the warping of the crust, unlike the crushing, does not require that the tangential pressure shall first accumulate through long periods of geological time; but we may fairly suppose that it begins soon after the development of the pressure

[1] This point is easily illustrated by experiment. If from the interior of a thin spherical shell of some flexible substance we remove a portion of the air so that the atmospheric pressure, which may be taken to represent gravity in the case of the earth, will be greatest on the external surface and thus develop a tangential pressure in the shell, it will be readily seen that it would be almost impossible to construct a model of such perfect uniformity and symmetry that a general distortion or flattening of its form would not be the immediate result.

and grows as that grows. Of course this distortion does not relieve the crust from the lateral thrust; but, after warping, the thrust is due, not to the *partial* action of gravity upon the whole crust, but to the *entire* weight of the continental masses, or those comparatively small portions of the crust lifted above the mean level of the ocean-floor.

The argument, then, shapes itself in this wise; granting that the earth contains a mobile layer, and that the crust is not equally thick, rigid, and convex in all parts, it follows that as the contraction of the nucleus goes on the crust experiences either a general distortion or continuous crushing; but we are obliged to reject the last supposition, because geologists recognize in the earth's history distinct mountain-forming epochs. A certain amount of distortion, therefore, is inevitable; and we have simply to consider whether the existing relief of the continents could probably be developed in this way before the strain would become great enough to crush the crust. According to Mallet, if the crust were completely separated from the nucleus, its sustaining power would not exceed one four-hundredth of its own weight. Now the continents, if we may estimate the thickness of the crust at fifty miles and the continental relief at two miles and make proper allowance for the higher specific gravity of the lower portions of the crust, embrace about one one-hundred and fiftieth of the mass of the earth's crust; or a load two to three times greater than the crust could sustain, if it were entirely unsupported. But it is proper to assume that mountain ranges, being due to the horizontal mashing of the crust, are in part sustained by corresponding inequalities of the under surface of the crust. And besides there is a vast difference between an arch supported only by its abutments and one resting at all points upon matter which is only imperfectly plastic, which is plastic perhaps only in comparison with the enormous pressure to which it is subjected, and which under some parts of the continents may be as rigid as the crust itself. In view of these considerations it seems probable that the continents approach, though they do not necessarily exceed, the maximum load which the crust can sustain; and it may be that in the limited sustaining power of the crust we have a correct explanation of the comparatively uniform and small depth of the oceanic hollows. This view with regard to the behavior of the earth's crust under the influence of the tangential thrust is indorsed by Professor Dana, althought it appears to be inconsistent with his theory of the origin of continents. As already shown, he admits the existence of a nearly universal mobile layer; but he also goes farther and insists that *all important movements of elevation and subsidence, except where mountains are formed, are due to the bending of the crust in consequence of the lateral pressure arising from the cooling and shrinking of the interior.* In other words, Professor Dana says that *the crust experiences a grand distortion before the strain becomes great enough to crush it.*

The argument for this theory may be summed up as follows: The earth either has or has not a plastic stratum. If it has not, it is impossible to explain the phenomena of elevation and subsidence and the formation of mountain systems; but if it has, the continents and ocean-basins can only exist as upward and downward bendings of the crust, and against this view of their constitution no insuperable objections have been urged.

2. **The continents and ocean-basins are due to the greater conductivity and more rapid cooling of the continental portions of the earth's crust; hence they are permanent, and the continents are wider and the seas deeper now than at any former period.**

This theory rests at the very outset upon an assumption which is not supported by a vestige of evidence; namely, that the earth was originally, and is now, of unlike composition along different radii or on different sides, the continental portions of the crust being composed of denser materials than the oceanic. If the liquid globe had possessed this constitution the ellipsoidal form of the equatorial section which, under the most refined measurements of geodesy almost disappears, would, in obedience to the laws of hydrostatic equilibrium, be strongly marked.

It seems strange that an assumption so vital to the theory should have been made without any attempt to demonstrate its validity. What are the facts that support it? Where are the analyses showing an essential unlikeness in composition between the different portions of the earth's crust? — showing, in other words, that the rocks exhibited on the continents are denser, *i. e.*, more basic on the average, than those forming the ocean floor?

We may safely say that the known facts and the probabilities are all against the supposition that such a difference exists. But without this unproved difference in composition there could be no difference in conductivity and radial contraction and the theory entirely fails. However, granting, for the sake of the argument, the possibility of this diversity of composition; it still fails as a foundation for the theory, since it could only have been a very transient characteristic of the crust. For, as Professor Dana admits, the elevation or subsidence of large areas of the crust must involve a horizontal displacement of liquid material beneath. Material under the Pacific, for example, being squeezed under the bordering continents. But this process mixes up the matter which by cooling forms continents and ocean-basins through unequal contraction; and the areas of high and low conductivity are no longer kept distinct.

But we may grant farther the possibility of a permanent difference in composition and still doubt the necessity of Professor Dana's inferences. As a rule dense bodies are not only good conductors of heat, but they also have low fusing points. This is eminently true of the main constituents of the earth's crust. The most favorable supposition that could be made for Professor Dana's theory would be that the continents have, or had originally, the composition of basalt and the sea-floors the composition of granite; and in any case the difference in composition must be regarded as similar to, but less rather than greater, than that between basalt and granite.

But if areas of liquid basalt and granite have the same initial temperature and cool under identical conditions, it does not necessarily follow that the basalt areas will solidify first. The basalt, on account of its greater conductivity, loses heat more rapidly than the granite; and yet, in view of the higher fusing point of the granite, the probabilities are that it would first assume the solid state, the two rocks being wider apart in their fusing points than in their power of conducting heat. This conclusion is abundantly sustained by the observations made on the relative liquidity of basic and acidic lavas. Rhyolite and trachyte solidify at a high temperature and so rapidly, when exposed to the air, that they are often left in the amorphous or glassy condition of obsidian; while basalt, congealing at a much lower temperature, usually remains fluent long enough to permit more or less crystallization and rarely retains the vitreous texture. Hence vitreous basalt or tachylite is a rare rock, although vitreous rhyolite or obsidian is abundant.

In short, this theory requires an unproved and improbable constitution of the earth's crust; but, if the existence of this indispensable condition were demonstrated, the known facts with regard to the solidification of basic and siliceous rocks would apparently lead us to a conclusion diametrically opposed to that reached by Professor Dana; namely, that the lighter and more slowly conducting areas would become solid first, forming the *continents*, while the denser and more rapidly conducting areas would be the last to solidify and would form the *ocean-floor.* In connection with his theory, Professor Dana offers the following explanation of the fact that the land is mainly in the northern hemisphere; the southern hemisphere is composed of heavier material than the northern, and consequently the ocean is attracted in the former direction. But it will not escape observation that this admission that the densest matter is under the sea sustains the point made in the last paragraph and is a direct contradiction of the most essential part of Professor Dana's theory of the origin of continents.

Professor Dana says that his theory accounts for the abrupt slopes of the continental borders, the ocean deepening rapidly and not gradually, after we cross the true edge of the continent. But it seems to the present writer that this is just what Professor Dana's theory does not account for. For, if we were to admit that the earth is of unlike composition on different sides, it would certainly be contrary to all analogy to suppose that the areas of unlike composition are sharply marked off from each other; and yet the steep slopes of the oceanic depressions, according to this theory, require an abrupt change in radial contraction and consequently in conductivity and composition.

The existence of a plastic zone beneath the crust is inconsistent not only with the supposition that there is a marked absence of uniformity in the composition of the crust, as has been pointed out; but it is also believed to be inconsistent with another essential feature of Professor Dana's theory; namely, that the existing relief of the crust has originated in the unequal radial contraction of the areas of dissimilar composition. To appreciate this point we have only to conceive separate blocks of the crust floating on the mobile layer, and to reflect that they must be of nearly the same density as the layer in which they are immersed. If we suppose the liquid to be one-tenth heavier than the blocks, it is clear that blocks forty miles thick would rise four miles, or one-tenth their thickness, out of the liquid; while blocks ten miles thick would project only one mile; a difference of thirty miles in the thickness of the blocks corresponding to a difference of three miles in their altitudes above the surface of the liquid. But, if the blocks are connected to form a continuous crust, the principle of flotation will hold just as truly, the upper surfaces of the thick and thin portions being much more nearly in one plane than the under surfaces. Therefore the development of the existing relief of the earth's surface in accordance with Professor Dana's theory would require an excess of contraction in the oceanic as compared with the continental areas of more nearly thirty miles than three miles as Professor Dana has estimated, and this enormous contraction would correspond to a continental crust nearly four hundred miles thick. In fact, this theory is entirely inconsistent with a floating crust; but it demands, on the contrary, that the earth should be solid from centre to circumference, at least under the continents; and yet Professor Dana admits that the Rocky Mountains have been elevated 8,000 to 10,000 feet since Cretaceous time, and that the eastern part of the continent subsided 40,000 feet during the Paleozoic era, and so on.

But, ignoring for the present the principle of flotation, let us assume that the theory in question is sound up to this point, and inquire whether unequal contraction of the continental and oceanic areas could produce the depressions of the earth's surface. We will suppose, with Professor Dana, that average rocks contract eight per cent between the liquid and solid states — much less than Bischof's experiments show, but more in harmony with the most recent determinations; and make the extremely favorable though improbable supposition that the oceanic areas remained liquid until the continents became entirely solid. Now Professor Dana says the average depth of the depressions is three miles, equal to the contraction resulting from the cooling and solidification of about thirty-eight miles of rock. There is one point of vital importance, however, which has been entirely overlooked; namely, the transferrence of material, as the result of denudation, from the continents to the sea-floors. If, as this theory requires, the continents and oceans are fixed, this action must have been always in the same direction. Now few geologists estimate the thickness of the stratified rocks at less than ten miles; but it will be claimed by those believing in the theory that the sediments must be much thinner over the floor of the central ocean; therefore we will assume five miles as the average thickness for the globe, and allow that they are three-fourths on the continents now. But to restore to the continents what they have lost according to this view would increase the height of the land and the general inequality of the surface at least five miles, which, added to the existing relief of three miles, gives eight miles as the excess of contraction of oceanic over continental areas, corresponding to a crust 100 miles thick. Remembering, however, that according to Professor Dana, the most of this detritus was derived from much smaller continents, say one-half as large, and it is seen that the excess of contraction of the oceanic areas corresponds to a crust over 200 miles thick. It seems no exaggeration, therefore, to say that a clear statement of this part of the theory is sufficient to refute it.

As already pointed out, Professor Dana's theory affords no adequate explanation of the known facts of elevation and subsidence. His writings often appear ambiguous and contradictory upon this point since, though generally admitting the existence of a plastic zone, he often argues as if the continents at least were solid to the earth's centre.

No proposition in geology is more firmly established than this: during the whole of geological time the earth's crust has been subject to extensive and wide-spread oscillations; and, as already pointed out, we know beyond a doubt that these movements are still in progress. Geologists do not now generally believe that the profound subsidences permitting the deposition of thick sedimentary formations are produced by these same sediments; but they rather agree with Professor Dana that the oscillations are due to lateral pressure and go on independently of the sedimentary process. But this view certainly does not harmonize well with the notion that these great vertical movements of the crust are merely local phenomena. On the contrary, all will concede that it is more reasonable to suppose that the area affected is, on the average, roughly proportional to the change of level. Now the subsidence of 40,000 feet in the Alleghany region during Paleozoic time did not make a deep ocean *there*, because deposition kept pace with the downward movement. But where is the evidence that the subsidence was limited to the eastern border of the great Paleozoic sea? Are we not, in accordance with the foregoing, at liberty to conclude that it affected, perhaps in equal measure, the central portions of the sea, where the deposition was only one-tenth as rapid as in the east? To answer in the affirmative is to admit that a large part of the present continent became the site of the abyssal ocean. If, as we believe, the great oscillations of the crust go on independently of deposition, it is certainly strange that they should be limited to the neighborhood of coast lines. Professor Dana admits that the important upward movements of the crust affect extensive areas, as witness the elevation of North America, Europe, and Asia in the Tertiary period, and the elevation of South America at the present time; and no good reason is apparent for denying that the same holds true with important downward movements. The evidence of elevation is, from the nature of the case, abundant and positive; while the evidence of subsidence is meagre and negative; except along the coast-lines where deposition measures the movement. But speculation is unnecessary here, because the coral-islands of the Pacific are monuments of a subsidence which is at once profound and wide-spread.

Professor Dana agrees with most American geologists that during Paleozoic time a considerable body of land lay to the eastward of the present Atlantic coast-line of the United States. But, if it extended very far in that direction — more than one hundred miles — it must be now in part under one to two miles of water. According to Professor Dana and the great majority of geologists, the important movements are necessarily reciprocal, one part of the crust rising as another part sinks; and Professor Dana says farther that the oceanic crust is more flexible and rests on more mobile material than the continental. Why, then, should he, with the certain knowledge of a Paleozoic subsidence of 40,000 feet in the Alleghany region, a Mesozoic subsidence of

50,000 feet in central Europe, and a subsidence in the Rocky Mountain region, according to King, of 60,000 feet, etc., hold that it is extremely improbable that any part of the floor of the deep sea ever has been or will be elevated to form dry land?

Again, what is the basis for the view that all extensive upward movements are confined to the land areas? It certainly is a strange doctrine that, while the stable continental crust is subject to repeated up and down movements of from *one to ten miles*, the (according to Professor Dana) comparatively flexible oceanic crust is only susceptible of slight oscillations, in addition to a slowly progressing subsidence covering the whole of geological time. As Professor Dana has shown, however, the coral islands testify that a large part of the floor of the Pacific has subsided from 3,000 to at least 10,000 feet in quite recent geological times. He also insists that this subsidence is a true downward *bending* of the crust, being due mainly to pressure and not to contraction, that the ocean-floor moves as a unit, and that the entire crust of the of the earth is involved in the movement. But 10,000 feet subtracted from the depth of the Pacific would make it a very shallow ocean; and its islands would be vastly more numerous and larger than they are now.

In fact, the Central Pacific, before the subsidence began, was probably as continental as the major portions of Europe and Asia during the early Tertiary epochs. Now, since this coral island-subsidence is not the result of contraction, what large element of improbability is there in the supposition that it may some day be reversed to the extent of 10,000 or even 20,000 feet? Nearly all the land bordering on the Pacific is rising, and rising probably (as Dana has suggested) as a joint and complementary effect of the same great cause that produces the oceanic subsidence. It is safe to assume, however, that these continental movements will, sooner or later, be reversed; and when that happens will not the Pacific subsidence be almost necessarily reversed too?

The formation of extensive deposits of sediments requires a continent as well as an ocean. So far as our present purpose is concerned we may say that the continents are composed entirely of stratified rocks, there being no igneous rocks except such as have come up through the stratified series. In other words, no part of the primitive or unstratified crust is any where exposed. Furthermore, the old crystalline or Eozoic formations which, according to Professor Dana, formed the first land and the nuclei about which the present continents have been developed, are of enormous thickness. The Eozoic rocks of the Rocky Mountains, Canada, New England, and the southern Appalachians have an average thickness of probably not less than 50,000 feet, and many geologists would say 100,000 feet. Where was the land whose waste afforded the material for building these tens of thousands of feet of strata? It must have existed somewhere. It was probably outside the borders of the modern continents; and it was certainly land whose site was subsequently occupied by the sea.

Thus it is clear that extensive bodies of land, in other words *continents*, were in existence before any part of the land of today had appeared above the sea.

But, without pressing farther the question as to how, if the theory in question is correct, the modern continents ever came to have a beginning, let us advance a step and look for the source of the materials composing the subsequent additions to the continents, including the Paleozoic and all later formations. According to Professor Dana, they were derived entirely from the comparatively small Eozoic areas. This, however, means not less than ten, and possibly twenty, miles of erosion, and necessarily implies either that this primitive land had originally an incredible height, or that during the course of geological time it has been constantly renewed by elevation as fast as worn away. But what are we to think of the original volume of formations which could suffer this enormous waste and still have a thickness measured by miles? We could not emphasize more strongly the absolute necessity of extensive pre-Eozoic continents to serve as a source of Eozoic sediments.

If the continents, since their first appearance, have been elevated ten to twenty miles and are still rising, they must rest on a plastic stratum. Thus Professor Dana's theory, when rigorously followed out, leads to the conclusion that the continents are essentially great upward bendings of the crust. A large part of this stupendous elevation must have occurred, if at all, since the early Paleozoic beds were deposited; and consequently they must *also* have suffered miles of erosion, and have been completely removed from large areas which they once covered; so that the Eozoic lands, according to this view, are much wider now than at the beginning of the Paleozoic era. But this only augments the difficulty of finding an adequate source for the post-Eozoic sediments; — a problem which would appear to be especially difficult for Professor Dana, since there are few geologists who now restrict the Eozoic rocks within such narrow limits as he does, extensive formations commonly regarded as Eozoic being referred by him to the Paleozoic.

It is said that all the stratified rocks exposed on the continents are shallow water deposits, and consequently that the floor of the deep sea has never been elevated to form land. This proposition is more easily stated than demonstrated. Among the crystalline sediments, especially, there are many kinds which, for aught that we can now determine, may very well have had a deep sea origin; but the subsequent development of crystalline characters has, in most cases, made it impracticable to trace their histories. There is nothing in our great formations of white crystalline limestone, such as that stretching along the western base of the Green Mountains, to indicate that they are shallow water deposits; and it is simply begging the question to set them down as such. Their purity and uniformity are favorable to the view that they have not been formed near the land.

Over considerable areas of the ocean-floor glauconite or greensand is now accumulating; and, so far as I am aware, the essential identity of this deposit with the great beds of greensand in the Cretaceous and other formations has not been questioned. It frequently happens that the siliceous organisms always present in the deep sea oozes predominate to such an extent as to give character to the deposit, which then becomes a Diatom or Radiolarian ooze; and it is difficult to understand why such a deposit is not fairly represented by the well known diatomaceous, or so-called infusorial, earths of Tertiary age, or even by the hornstones and cherts of the older formations. The Radiolarian ooze has been found in the deepest parts of the Pacific, and nowhere at a less depth than 2250 fathoms.

Mr. Wallace, in his "Island Life," contests the generally accepted view that the chalk is a deep sea deposit and that it is the ancient representative of the modern calcareous or Globigerina ooze found in all the great oceans at depths varying from 250 to nearly 3,000 fathoms. The chief objection which he raises is that the chalk and ooze differ widely in composition; and analyses are quoted to show that the ooze is, on the average, poorer in calcium carbonate, and richer in silica, alumina, and iron than the chalk. In these chalk analyses, however, no account has been taken of the flints, which may be fairly regarded as representing the silica in the ooze, the flints being due to the segregation of finely divided silica which was originally uniformly diffused through the chalk. The silica, therefore, may be at once stricken from the list of differences between the chalk and ooze.

The Cretaceous age closed several millions of years ago, a time long enough to permit considerable changes in the character of the deep sea oozes. The alumina and iron in the Globigerina ooze are chiefly the insoluble residue of the volcanic dust spread every where over the ocean-floor; they form a part of all marine formations, and the fact that they are conspicuous constituents of the calcareous ooze simply implies that the Foraminifera shells accumulate with extreme slowness at the present time. To make the ooze chemically identical with the chalk, we have only to increase the rate of the organic deposition. But Mr. Wallace has already done this for the Cretaceous period; for he shows, first, that the abundance of the pelagic Foraminifera, of the calcareous tests of which both the chalk and the ooze are mainly composed, is, other things being equal, proportional to the temperature of the water; and, secondly, that the Cretaceous seas of Europe were very warm. He conceives that a land barrier stretched from Scandinavia to Greenland, concentrating the Gulf stream and directing it across the site of modern Europe.

Mr. Wallace's explanation of the chalk of Europe embraces propositions that are not easily reconciled. For he insists, and rightly, upon the great purity of the chalk, and yet holds that it was deposited in a shallow and narrow sea, and consequently near large bodies of land. He derives the chalk in large part from the comminution of coral-rock, and yet names only two points in Europe (Maestricht in Belgium and Faxoe in Denmark) where coral-reefs of Cretaceous age may be observed, and refers to no modern coral-reefs where chalk is now forming in this way.

The Oahu deposit belongs to the past and is very small, twenty to thirty feet across and eight to ten feet thick and entirely destitute of Foraminifera. The chalk contains no corals, nor fragments of corals, nor does it shade off at the borders into coarser calcareous rocks composed of broken coral; and in no modern ocean are the coral-reefs entirely converted, as fast as formed, to an impalpable slime or ooze. If all this occurred, as Mr. Wallace imagines, in the Cretaceous Mediterranean of Europe, the force of the waves and currents must have been sufficient to transport the finer débris of the land long distances from shore, but this supposition is negatived by the great purity of the chalk.

Sir Wyville Thomson, from whose reports on the voyage of the "Challenger" Mr. Wallace quotes, and to whom the calcareous ooze analyses were known, evidently failed to discover the great disparity between the ooze and the chalk, for he says:[1] "I imagine, however, that the limestone which would be the result of the elevation and slight metamorphosis of a mass of Globigerina ooze would resemble very closely a bed of gray chalk;" perhaps as closely as it is reasonable to expect, considering the enormous lapse of time between the two deposits.

The truly abyssal deposit of the modern ocean is the red clay which is found at nearly all depths below 2,500 fathoms and, according to Sir Wyville Thomson, covers not less than ten million square miles of the ocean-floor. In the "Challenger" report Sir Wyville expresses the opinion that a deposit of this red clay might come to be very like one of the Paleozoic schists. But, apparently, he did not hold this view long; for at the meeting of the British Association for the Advancement of Science, in August, 1878, he concluded an account of the deep sea clay as follows:

"So far as we can judge, after a most careful comparative examination, the deposit which is at present being formed at extreme depths in the ocean does not correspond either in structure or in chemical composition, with any known geological formation; and, moreover, we are inclined to believe, from a consideration of their structure and of their imbedded organic remains, that none of the older formations were laid down at nearly so great depths — that, in fact, none of these have anything of an abyssal character. These late researches tend to show that during past geological changes abysssal beds have never been exposed, and it seems highly probable that

[1] Voyage of the "Challenger," vol. II, p. 256.

until comparatively recent geological periods such beds have not been formed."

It must have occurred to many of the readers of the paper just quoted that Sir Wyville has failed to exhibit any sufficient reason for abandoning his earlier view that the deep sea clay and ooze are not essentially unlike some of the argillaceous and calcareous rocks exposed on the continents. But it is not my purpose to further contest this point; for, although believing that the deep sea deposits are matched lithologically among the formations on the land, I do not claim that the chalk, for example, is, in consequence, *necessarily* a consolidated abyssal ooze. Although this conclusion is much strengthened by the fact that the chalk does not resemble any shallow water deposit of the present day half so much as it does the Globigerina ooze. Still, nothing is truer in geology than that very similar effects may flow from very dissimilar causes.

But the point that I wish to raise now is embodied in the following question: Are there any deep sea deposits? If, as I believe, this question may be fairly answered in the negative, at least as regards the truly abyssal portions of the sea, then the argument that these sediments are not represented on the continents ceases to have any weight, in fact, it no longer exists. Now nothing has been more clearly demonstrated by the deep sea explorations carried on during the last fifteen years than that the abyssal sediments, and especially the red clay, are accumulating with extreme slowness. Over the red clay areas the dredge brings up large numbers of nodules of very irregular forms varying in size from minute grains to masses weighing several pounds and consisting chiefly of the iron and manganese per-oxides arranged in concentric layers in the matrix of clay, around a nucleus formed by a shark's tooth, or a piece of bone, or an otolith, or a piece of siliceous sponge, or more frequently a fragment of pumice. Sir Wyville Thomson has shown that we have in these nodules, and in some of their nuclei, "ample evidence that this abyssal deposit is taking place with extreme slowness; for the nodules are evidently formed in the clay, and the formation of the larger ones and the segregation of the material must have required a very long time; while many of the shark's teeth forming the nuclei of the nodules and which are frequently brought up uncoated with foreign matter, belong to species which, we have every reason to believe, have been extinct since early Tertiary times. Some teeth of a species of Carcharodon are of enormous size, four inches across the base, and are indistinguishable from the huge teeth found in the Eocene beds." On this point Mr. John Murray, also of the "Challenger" scientific staff, says: "when there has been no reason to suppose that the trawl has sunk more than one or two inches in the clay, we have had in the bag over a hundred shark's teeth and between thirty and forty ear-bones of cetaceans; and we may conclude with great certainty that the clays of these oceanic basins have accumulated with great slowness." He also says: "It is indeed almost beyond question that the red clay regions of the Central Pacific contain accumulations belonging to geological ages different from our own." Again, "the shark's teeth, ear-bones, manganese-nodules, altered volcanic fragments, zeolites, and cosmic dust are met with in greatest abundance in the red clays of the Central Pacific, at that point on the earth's surface farthest removed from continental land. They are less abundant in the Radiolarian ooze, are rare in the Globigerina, Diatom, and Pteropod oozes, and they have been dredged in only a few instances in the terrigenous deposits close to the shore. These substances are present in all the deposits, but owing to the abundance of other matters in the more rapidly forming deposits their presence is masked, and the chance of dredging them is reduced. We may then regard the greater or less abundance of these materials, which are so characteristic of a true red clay, as being a measure of the relative rate of accumulation of the marine sediments in which they lie. The terrigenous deposits accumulate most rapidly, then follow in order Pteropod ooze, Globigerina ooze, Diatom ooze, Radiolarian ooze, and, slowest of all, red clay."

The time since the Eocene, when the large Carcharodons lived, is estimated by geologists at more than a million years, and yet enough clay has not been deposited during this immense period to bury the teeth of this giant shark beyond the reach of the dredge! the rate of increase of the sediment being probably less than one foot, and possibly not more than two or three inches, in a million years.

Now suppose that after a submergence of ten million years the floor of the deep ocean is slowly raised to form dry land. Is it surprising that a bed five or possibly ten feet thick of ferruginous clay containing organic remains similar to those found in shore deposits is not recognized as of abyssal origin, but is completely lost among the miles of marginal sediments composing the new continent? In the ordinary sense there are no abyssal sediments, but we find over these oceanic wastes merely the impalpable dust that slowly settles during the lapse of countless ages from the limpid water of the central sea. The land is the great theatre of erosion and the sea of deposition; but just as there are extensive rainless tracts on the continents where there is practically no erosion so there exist still larger areas of the ocean-floor over which the complementary process, or deposition, approaches the vanishing point. On both land and sea the main field of geological operations is marginal, following the shore line; but nowhere does the earth's crust experience such perfect rest as under the deep sea.

A large proportion of the volcanoes of the globe are in the central portions of the ocean, nearly all the oceanic islands being either volcanic, or consisting of coral-rock resting upon old submerged volcanoes; while of the submarine volcanoes which have never reached the surface we of course know nothing, but it is probable that such exist and possible that they out-number those whose craters are dry land. Now on the land we observe no important exception to the rule that volcanoes are situated upon, or in the immediate neighborhood of, thick deposits of recent sediments — Tertiary or Secondary. And we also observe that in the earlier periods of the earth's history the same law held good.

Are the oceanic volcanoes to be regarded as exceptions to this general law? If so, upon what ground? If not, then the inference is at least probable that the great volcanic archipelago of the Pacific, as well as the numerous volcanic islands in the Atlantic and Indian Oceans, rests upon extensive stratified formations of no great geological age. But the deep sea sediments, as we have seen, are of very trifling thickness, with the exception of the coral-limestone; and this rests upon, and is newer than, the volcanoes. Hence the inference is plain that the floor of the central ocean has been at one time a marginal sea-bottom and the theatre of active and extensive deposition. This means that a large part of the deep sea-bottom has formed not only the shoulders but the dry land of the continents.

If, as those believing in stable continents and oceans virtually claim, the oceanic portions of the earth's crust have been covered since the beginning of geological time with a sheet of cold water, the frigid zone extending, along the ocean-floor, through all latitudes to the equator; and if, during the whole of geological history, deposition has been almost entirely suspended over these vast areas, the sediments of probably not less than a million years being insufficient to cover the teeth of the Eocene shark; then, since the strength and thickness of the earth's crust are, in the main, due to, and are a measure of, the refrigeration which it has experienced, it must be admitted that the oceanic crust is probably very thick and very stiff. That sediments are in general a source of weakness rather than of strength in the crust is the testimony of the ablest students of structural geology; and this proposition forms the basis of the generally accepted explanation of the origin of mountains.

Now, if volcanoes are evidence of anything, they are evidence of weakness in the earth's crust. They prove the presence of fissures reaching down to the plastic zone beneath the crust; and, as we have already noticed, they are, on the land, intimately connected with thick deposits of sediments — with what are generally recognized as weak places in the crust. But it is a logical deduction from the hypothesis here combatted that the numerous oceanic volcanoes do not stand on thick accumulations of sediments — for no deposits of sensible thickness are formed in the deep sea, and that they occur on the strongest, rather than the weakest, portions of the earth's crust — for nowhere are the conditions more favorable for deep and permanent refrigeration of the crust than under the oceanic abysses and, according to Mr. Wallace and Professor Dana, the site of the deep sea has remained unchanged during all the changes of which geology furnishes a record.

Professor Dana says the oscillations of the sea-floor are slight compared with those of the land, the principal movement being a gradual subsidence running through the ages which may be reversed to the extent of a few thousand feet, but never sufficiently to convert the sea-bottom into dry land. Yet this cold, thick, stable oceanic crust, which has never been weakened by thick sedimentary deposits, is an area of wide spread and intense volcanic activity; while the continental interiors which, according to the theory in question, have experienced far greater oscillations of level and are covered by unknown but great thicknesses of stratified rocks, are almost entirely free from active volcanoes.

Volcanoes have burned, and poured out their floods of rock, over nearly all parts of the continents. But all volcanoes are, in a geological sense, short lived; and, ere the sediments through which they reach the surface have become old, their energy is exhausted and the wound in the earth's crust is permanently healed. And there can be little doubt that active, terrestrial volcanoes follow the sea-shore simply because it is there, chiefly, that thick deposits of recent sediments are found. It is a natural inference from these considerations that the volcanoes of Polynesia, for example, are piled upon thick sedimentary formations deposited, perhaps, during the slow subsidence of a great Pacific continent. But, according to Professor Dana, they are quite unlike terrestrial volcanoes, having no necessary connection with sediments and being as old as the earth's crust.

The submarine mountain-ranges are, equally with the oceanic volcanoes, an argument against the immutability of oceanic conditions. Few geological theories are now more generally accepted than the theory that mountains are formed by the horizontal mashing up of thick deposits of sediments. These stratified formations of immense thickness — five to ten miles for most important mountain-systems — can only be formed on a marginal sea-bottom. Hence it is impossible to avoid the conclusion that mountains are of sea-shore origin. But an application of this theory to the submarine mountain-ranges is fatal to the notion that the oceanic abysses are permanent. Yet what warrant have we for supposing that these grand corrugations of the ocean-floor are different in structure and origin from the continental mountain-systems? The supposition that they are composed entirely of volcanic ejectamenta is contrary to all analogy and extremely improbable. No well defined and important mountain-ranges on the land have this composition. While the idea that submarine mountains are original corrugations of the earth's crust, formed, perhaps, before the advent of oceans and stratified rocks, is equally gratuitous and baseless.

As an argument in favor of the permanence of continents and oceans, Mr. Wallace attaches great importance to the supposed fact, first mentioned by Darwin, that, with the exception of New Zealand, and the Seychelles Islands in the Indian Ocean, none of the truly oceanic islands contain either Paleozoic or Mesozoic rocks; the inference being that during the Paleozoic and Mesozoic eras neither continents nor continental islands existed where our oceans now extend, for had they existed Paleozoic and Mesozoic formations would in all probability have been accumulated from sediment derived from their wear and tear.

This argument is not so formidable as it at first appears. Mr. Wallace thinks it is doubtful if New Zealand can be properly called a true oceanic island. But it is difficult to see how it can be differently classified, since the ocean between it and Australia is one thousand miles broad and three miles deep. But there are other exceptions to the law which he formulates. New Caledonia is an oceanic island, over 700 miles of deep water separating it from Australia, while the sea in its near neighborhood has a depth of 15,000 to over 17,000 feet; and yet it is composed of stratified crystalline, Paleozoic and Mesozoic rocks. The Salomon Islands, 500 miles from New Guinea and nearly twice that distance from Australia, are, according to Garnier, composed of rocks similar to those found in New Caledonia. Kerguelen Island, in the southern part of the Indian Ocean, and 2,000 miles from the nearest continent, is certainly a true oceanic island; and yet it is composed, in a large part, of stratified rocks, both fossiliferous and crystalline. The Philippine Islands contain Secondary, if not Paleozoic, strata; and, although only 300 to 500 miles from Borneo and the continent of Asia, they are surrounded on all sides by water from two to three miles deep. Naturalists are generally agreed that the true borders of the continents are not the actural shore-lines, but the lines, sometimes 100 to 200 miles from shore, where the water commences to deepen rapidly and the abysses of the ocean begin. All land beyond this true continental edge is oceanic. Now, judged by this criterion, the Philippines are, apparently, oceanic islands. It is certainly unreasonable to say that all oceanic islands must be remote from the continents. As well might it be claimed that all the higher parts of the continents, or mountains, must be remote from the sea. I have been informed by Prof. Jules Marcou that the Marquesas Islands, lying on the eastern border of Polynesia and near the centre of the Pacific, contain representatives of the older stratified formations. And now we learn through Dr. C. Doetter of Graz that the Cape Verde Islands do not consist exclusively of volcanic rocks, but contain also gneiss, mica and clay slates, and limestones.[1] Paleozoic and Mesozoic rocks are well developed in Spitzbergen, which, it would seem, may be fairly classed as an oceanic island. Again, many oceanic islands have not been examined geologically with sufficient care to justify Mr. Wallace's sweeping and positive statement that, with two exceptions, none of them contain any traces of the older stratified formations.[2]

With the exceptions noted, the oceanic islands are nearly all small, and are composed of eruptive rocks or of coral reefs resting, presumably, upon a volcanic foundation. The oceanic islands are, of course, merely the tops of submerged mountains; and it is only with the highest points of the continents that they can be properly compared. Now, supposing the existing continents were submerged to an average depth of 15,000 feet, what would be the geological character of the land remaining above the sea? Paleozoic and Mesozoic rocks would probably be about as scarce in it as in modern oceanic islands. As a rule the loftiest mountains of the globe are composed of eruptive rocks, and in many cases they are distinct, or even active, volcanoes; although the main mass of every mountain system is formed of stratified, and often of fossiliferous, formations. The volcanic materials usually form but a small part of the whole; but they are the cap-sheaf.

1 Petermann's Mittheilungen, 1883, 72.

2 The report of the German Meteorological Expedition to South Georgia Islands contains the interesting information that the only rock observed on this ice-capped Antarctic land is clay-slate. Even the blocks brought down by the glaciers from the lofty mountains of the interior were all slate. (Nature, 29, 509.) And Mr. T. Mellard Reade (Geol. Mag. I, 225), in commenting on this report, directs attention to the fact that this large remnant of an undoubtedly ancient and extensive sedimentary formation is now a true oceanic island, standing in deep water remote from the continents.

Granting, however, for the sake of the argument, that the older fossiliferous formations would be left above the water in some cases ; if the islands of this class were large, they are fairly represented in the modern ocean by New Zealand, New Caledonia, and Spitzbergen, and, if small, by the Seychelles, Salomon, Marquesas and Cape Verde Islands, and Kerguelen Island. The smaller stratified islands, however, would usually be short-lived, being destroyed by erosion. Volcanic and coral islands, on the contrary, are constantly growing and making good the loss by erosion. Submarine volcanoes suffer no erosion until their summits reach the surface of the water ; and their growth is mainly vertical, since the water must ordinarily prevent the lava from flowing far from the outlet or crater. Consequently, if a continent, the stratified summits of which are high and the volcanoes low, is submerged, the former will be soon swept away by erosion, and the lavas ejected by the latter will be piled up, monument-like, until they reach the surface, when, although erosion checks the upward growth, its ravages are constantly made good by fresh outflows of lava.

In the opinion of the writer, these considerations materially diminish the surprise which one feels on first observing that the oceanic islands are mainly volcanoes or coral reefs. For in no other class of islands do we find those elements of growth which enable them to keep pace with the increasing subsidence and to make good the encroachments of the sea. An active volcano cannot be permanently submerged, and the same is true of a coral island, provided the subsidence goes on slowly enough. In short, nearly all the larger oceanic islands do embrace considerable masses of the older stratified formations; and the fact that the smaller ones do not as a rule is satisfactorily explained by a comparison with the highest points of existing continents, and a due consideration of the facts that small stratified islands would necessarily be short-lived, and if submerged only 100 feet might remain forever unknown, and that the volcanic and coral islands cannot usually be either submerged or worn away, possessing a power of growth which makes them eternal.

If the oceans are permanent, the vast archipelago of Polynesia is, beyond a doubt, one of the most inexplicable features of the earth's surface. As Professor Dana has shown, we know by the coral islands that the depth of the Polynesian sea has increased at least 10,000 feet, or two miles, in comparatively recent geological times. The present average depth of this part of the Pacific is probably not more than three miles. Consequently, when the great coral island subsidence began the average depth was about one mile. Now no one can doubt that the elevation of Polynesia by two miles would bring into existence hundreds, perhaps thousands, of new islands and greatly extend the area of those now existing, probably uniting whole groups into one or two large islands, and thus giving Polynesia the aspect of a larger Malaysia. Mr. Wallace has shown very clearly that the Malay Archipelago, like the West Indian Archipelago, is a vast area of half-submerged continental land. But probably its appearance is no more continental now than was that of Polynesia before the coral island subsidence began.

The western islands of Polynesia are the largest, and parallel with this we have the fact that the subsidence, as indicated by the coral monuments and the heights of the volcanic land, increases eastward; so that it seems entirely an arbitrary matter as to where we draw the line between the two great archipelagoes of Malaysia and Polynesia. Professor Dana has directed attention particularly to the fact that the trend of the whole of Polynesia, and of each of the Polynesian groups, is exactly parallel with the Malaysian trend, which is continued through Australia to New Zealand.

The largest and most western islands of Polynesia, like the still larger islands of the Malay Archipelago, include both the older and newer stratified formations, as well as volcanic rocks. But as we pass toward the east and north the islands not only become smaller, indicating a more profound subsidence in that direction; but the older stratified rocks disappear and the islands are composed entirely of volcanic materials and coral formations.

That Sumatra, Java, Borneo, etc., have been a part of the Asiatic continent in very recent geological times few will question. That Australia and New Guinea have, at an earlier period, been connected with this great Asiatic peninsula is almost equally certain. And that New Zealand, New Caledonia, the Salomon group and New Ireland were, in like manner, once joined to Australia hardly admits of doubt, in view of the fact that they are, in geological structure, essentially identical with the great island continent. Although comprising both the older and newer stratified formations, these islands are largely volcanic, and are bordered by extensive fringing coral reefs. But they are properly a part of the great Polynesian Archipelago, and differ from the equally high, volcanic and coral-girt New Hebrides and Feejee groups mainly in being larger and containing some Paleozoic and Secondary rocks. And beyond the last named groups the islands are still smaller and lower, and barrier reefs predominate, until the volcanic heights entirely disappear and their sites are marked only by atolls and coral islands. Still farther east and north the subsidence becomes too great for even these, and the blank sea alone remains. Thus the continental shade off insensibly into oceanic conditions; and the same argument which makes the larger islands of the Pacific portions of a submerged continent applies with nearly equal force to the multitude of smaller islands.

In this connection it is interesting to consider what would be the aspect of the continent of Asia after a subsidence of between two and three miles. The great plateau of Thibet would still have a considerable elevation above the sea, and, with its bordering mountain ranges, would compare in size with Australia. While stretching away from it in all directions, especially to the east and north, would appear long meandering lines of islands, becoming smaller and lower with the distance. If the sea were warm and the subsidence sufficiently gradual, the sites of the lower mountains and ridges would be marked by monuments of coral formation, and active volcanoes would also keep pace with the subsidence. In short, modern Australasia and Polynesia would be substantially reproduced. Hence it cannot be said that there is anything in the topography of the Pacific islands militating against the idea that they are remants of a submerged continent.

It is generally admitted that the West India islands are submerged portions of the American continent; in fact, the relations of the fauna and flora to those of South and Central America compel us to accept this conclusion. Yet these islands stand, for the most part, in very deep water; depths of from 10,000 to over 18,000 feet being common; and the deepest holes being actually within sight of the shore line. Is not this, then, an instance where continental land becomes the bottom of the deep sea?

Many writers on this subject seem to consider that the dawn of the Paleozoic era was near the beginning of geologic time, and that, if they can demonstrate that continents and oceans have not changed places since that period, the whole question is settled. But this is undoubtedly an erroneous view; and I think we may safely concede that the continents stand now where they did in Cambrian times without admitting their absolute permanence; and of course the latter is the real point in dispute. If we compare the thickness of the fossiliferous with that of the Eozoic formations, or the degree of metamorphism of the Cambrian with that of the Laurentian beds, or the amounts of organic evolution before and since the deposition of the earliest Cambrian sediments, it seems difficult to avoid the conclusion that a very large proportion of the time since the appearance of life upon the globe had elapsed before the dawn of the Paleozoic era. The oldest Eozoic rocks have probably never been seen, and below them come the vast thicknesses of Azoic stratified rocks which it is certain were formed after the appearance of the ocean on the globe and before the advent of life.

Now, if Professor Dana's theory means anything, it means that the continents stood where they now stand during the long Azoic and Eozoic eras as well as during the Paleozoic and later eras. One of the most striking and important facts in historical geology is the profound lithological, stratigraphical, and paleontological break observable almost every where between the oldest Paleozoic strata and the underlying Eozoic. What does this signify, if not that there was a general interchange of land and sea at that time? Before the deposition of the Potsdam sandstone nearly the entire continent of North America, so far as we know, was dry land, and had been dry land for long ages. How far this land extended beyond the present limits of the continent we have no means of knowing. The Potsdam beds rest every where upon old land surfaces.

At the beginning of the Cambrian the land subsided and nearly the whole of what is now North America was covered by the Paleozoic sea. How deep this sea became we are unable to determine with exactness. Along the eastern shore its bottom subsided to a depth of eight miles; and over the central portions the principal sediments were impalpable clays and limestones which might have been formed, so far as we can judge from their lithology and paleontology, in a sea two or three miles deep. This Paleozoic sea covered the major part of the continent till the Carboniferous age — a period estimated by geologists at from ten million to fifty million years, or three times as long as the Mesozoic and Cenozoic eras combined. It is not easy to see how North America, during these millions of years, was any more continental than Oceania is now.

One of the most important questions in American geology is that as to the source of the Paleozoic sediments in the Appalachian region. The volume of these sediments is enormous, measuring 30,000 to 40,000 feet in thickness for a breadth of probably 100 miles and a length several times greater. The Paleozoic shore line lay to the southeast and all this mass of material evidently came from that direction. But the only pre-Paleozoic land now visible between New York and North Carolina is a narrow belt of crystalline rocks varying in width from nothing to sixty or eighty miles. This has been broadened by the erosion of the Paleozoic sediments; though narrowed somewhat by the deposition upon it of the Mesozoic and Tertiary beds on the east. If it never extended beyond the present shore line, it certainly cannot be regarded as an adequate source of the vast piles of Appalachian sediments. Some geologists, appreciating this difficulty, have supposed that this narrow belt of Paleozoic land was renewed by elevation as fast as destroyed by erosion, the elevation required being not less than the thickness of the derived sediments, or eight miles. But eight miles of subsidence on one side of the shore line and eight miles of elevation on the other side implies a pretty flexible crust; and the advocacy of this violent hypothesis by eminent geologists shows how far some of the believers in stable continents are willing to go rather than disturb the ocean floor; although, according to this theory, the oceanic crust is newer and more flexible than the continental. Most American geologists, however, including Professor Dana, have solved this problem of the Appalachian sediments by broadening the belt of Paleozoic land. Professor Dana conceives that it extended as far east as the existing shore line, perhaps beyond it (although on his map showing the land at the beginning of Paleozoic time there appears in this part of the continent only a very narrow, broken strip, lying far within the present continental borders); while others have considered it as of continental extent. As I have before remarked, if it extended more than one hundred miles beyond the present coast line, a part of it now forms the floor of the deep sea.

There is another important consideration, besides the thickness of the Paleozoic sediments, demanding an extension of the Paleozoic land to or beyond the existing border of the continent, and that is the entire absence of Paleozoic rocks on the Atlantic seaboard south of New England. Very plainly, the Blue Ridge belt of crystalline rocks was not, during the Paleozoic era, a narrow strip of land washed by the ocean on both sides, but it formed the western border of the Paleozoic continent. And all analogy requires us to suppose that this Paleozoic land had breadth like the continents of to-day. But this is equivalent to saying that the greater part of it is now covered by the deep sea.

As I have elsewhere pointed out, the submarine contours of the Gulf of Maine show that it must have been once something like the modern Hudson Bay, land-bordered on the east as well as on the west; for a broad submarine ridge or plateau extends over nearly nine-tenths of the distance between Nova Scotia and Cape Cod, forming a nearly complete barrier between the comparatively deep water of the Gulf of Maine and the greater depths of the ocean beyond. If the sea bottom were elevated fifty fathoms, the Gulf of Maine, although still three hundred miles long, and having a maximum depth of 110 fathoms, would be changed from a broad-mouthed bay to an almost completely land-locked gulf. The Paleozoic rocks observable around the Gulf of Maine show that it was in existence in Paleozoic time, when its eastern border probably formed a part of a great Atlantic continent.

At the close of the Paleozoic era the Appalachian sediments yielded to the horizontal pressure in the crust and the Alleghany Mountains were formed. It is plain that when a zone of the earth's crust is thus plicated a subsidence of adjacent portions is a necessary consequence. Professor Dana, holding that the continents are stable and fixed, attributes the folding and crumpling of the strata in mountains in general, and in the Alleghanies in particular, to the subsidence of the sea bottom. But the continents are the portions of the crust lifted above the general level and held in unstable equilibrium, and their tendency to subside is so great as, according to Professor Le Conte, to be almost irresistible. While it would seem equally natural and necessary for the ocean bed to rise when the strain is relieved which holds it down.

Professor Dana regards the floor of the great interior Paleozoic sea between the Blue Ridge and the Rocky Mountains as having been essentially a part of the continent during all the millions of years when it was submerged, and not as having been the bottom of a true ocean. Therefore he could not attribute the Alleghanies to its subsidence. Besides, this sea-floor *rose* when the Alleghanies were made, and all geologists agree that the character of the Alleghany foldings shows conclusively that the pressure producing them came chiefly from the southeast. Hence, Professor Dana, believing that the Atlantic existed with nearly its present outlines during Paleozoic time, says that the Alleghanies were formed by the subsidence of the great arch of the Atlantic. But, as we have seen, he admits that the Appalachian sediments were separated from the Atlantic by at least one hundred and possibly several hundred miles of firm land. In other words, Professor Dana tells us that the sediments deposited in one ocean were plicated by the subsidence of the floor of another and entirely distinct ocean. This is very much the same as saying that the sediments now accumulating in the Gulf of Mexico will some day be compressed and folded by the subsidence of the bottom of the Pacific, Central America and Mexico remaining undisturbed as at present.

The Triassic and other Secondary deposits upon our Atlantic sea-board make it impossible to doubt that a very general and extensive subsidence of the land in this quarter did take place at the time of the Alleghany revolution. Here is positive proof of the subsidence of a very extensive land area, and of land, too, immediately adjoining the Alleghany sediments: but where is there a vestige of reliable evidence showing that the floor of the Atlantic subsided at this epoch, or even that the Atlantic was then in existence?

The Atlantic continent helps us over many difficult points in

American geology, and against it, so far as I am aware, no important arguments have ever been advanced. It provides, in the first place, an adequate source for the Appalachian sediments. It explains the absence of Paleozoic strata from the Atlantic seaboard; and renders intelligible the contours of the Gulf of Maine. Finally, in the subsidence of this continent we have a complete explanation of the structure of the Alleghany Mountains. The pressure was entirely adequate for the work, it came from the right direction, and was delivered at the right point, namely, upon the eastern edge of the new sediments.

If, as it seems necessary to believe, the folding and crushing of the Paleozoic deposits was attended by the subsidence of an adjacent portion of the crust, it is reasonable to suppose that the subsidence was proportional to the crushing. Now the Appalachian foldings and disturbance generally culminate in the Pennsylvania region; and it is both interesting and instructive to observe that the Appalachian belt of crystalline rocks — the Paleozoic land — is lowest and narrowest in eastern Pennsylvania and New Jersey; showing that the subsidence of the Atlantic continent was most profound and extensive in this latitude, submerging all but the actual shore line of the ancient land and producing the great concave curve of the Atlantic coast line between Cape Cod and Cape Hatteras.

NOTES ON THE LITHOLOGY OF THE ISLAND OF JURA, SCOTLAND.

BY M. E. WADSWORTH.

This island, situated to the west of Scotland and south of the Firth of Lorn, according to Macculloch, Murchison, Geikie, and others, is composed of quartz rock and schists traversed by basaltic dikes running northeast and southwest. The quartz rock occupies most of the island particularly the western and central portions, while the schists predominate on the eastern coast. The quartz rock rises in the elevations known as the Paps of Jura to the height of 2569 feet, and dips, according to Macculloch, E. S .E., at an average angle of about 27°.

It is not my purpose to discuss the general geology of this island which is regarded as belonging to the Lower Silurian, for the reader will find sufficient information for ordinary purposes in the Transactions of the Geological Society of London, 1814 (1), II, 450–457 ; Macculloch's Western Islands of Scotland, 1819, II, 205–222; Geikie's Scenery and Geology of Scotland, 1865, pp. 214–218; Quarterly Journal of the Geological Society, 1861, XVII, 221, etc.

Several years ago there were placed in my hands a number of specimens of the Jura rocks by Mr. A. H. Wheeler of San Francisco, Cal., who had collected them. Descriptions were then written and given to him, and it is a revision of these descriptions that it is proposed to present to this Society to-night.

The main rock of the island, as before stated, is a quartzite, varying in texture from fine to coarse and forming in places a conglomerate. One specimen has a fine-grained gray groundmass of quartz grains holding larger rounded grains of milky, vitreous, and pink quartz. The rock closely resembles some of the indurated portions of the Potsdam sandstone of Wisconsin, and under the microscope it is seen to be composed principally of rounded quartz and feldspar grains. The cementing material is partly silica, but chiefly a material composed of minute greenish micaceous scales, apparently formed from the mud and feldspathic material of the rock. The feldspar grains of the original sandstone in the metamorphosis of this rock to quartzite, have been likewise more or less transformed into a mass of like greenish scales. Some feldspars, however, retain evidence of their triclinic nature. Besides these there also occur orthoclase and plagioclase grains that are as clear and transparent as the quartz, which from their general characters I am inclined to regard as secondary products in the rock, probably replacing some of the original feldspar grains. The quartz grains are as a rule well rounded showing prolonged attrition. This according to Sorby would indicate rather a windblown than a waterworn sand.[1] Surrounding the quartz grains, between them and the matrix, are bands of exceedingly minute cavities appearing almost like black dust. These bands also exist in portions of the quartz and in the adjacent matrix and feldspars. They traverse the two latter without much regard for

[1] The Monthly Microscopical Journal, London, 1877, XVII, 113–136.

the micaceous scales, and from this it is probable that they are of later origin than the quartz grains, and were caused by the water action (hot?) which cemented the grains, altered the feldspars, and transformed the sandstone into a quartzite.[1] These cavities are apparently fluidal and sometimes have moving bubbles. Associated with these are larger fluid inclusions having rapidly moving bubbles. These latter inclusions are generally in the quartz and much resemble those seen in the quartz of granites, but they are not particularly abundant and may have a similar origin to those above mentioned. Indeed it would seem that if hot waters bearing silica in solution should deposit that silica in the minute fissures of the quartz it would produce the usual linear arrangement of cavities and bubbles, while the deposited silica would be so optically oriented that no trace of the "mending" process would be visible. Microlites, trichites, zircon, magnetite, etc., occur in the quartz. Some of the grains show the hair-like trichites so common in the quartz of granites. Some of the quartz appears to be of secondary origin, while part of the mica scales show the optical characters of muscovite.

The quartzite obtained at Red Cove is more compact, indurated, and of a more uniform character than the preceeding. It also contains trichites, secondary quartz, and fluid inclusions more abundantly. It has a slight reddish tinge owing to the iron oxides distributed through the section particularly in the decomposed feldspars.

No sections were made of the schists. One coming from the top of Cruib, near the center of the island, is a gray, fine-grained somewhat arenaceous rock. Another from the west side of the island is a bluish black argillaceous schist, almost an argillite, and contains cubes of pyrite. Schist like this is common in New England.

The only specimen, in the collection of the dikes, crossing the quartzites and schists is a dark gray rock with whitish and yellowish brown spots of decomposition products, opal, etc. The section is of a yellowish gray color, and under the microscope is seen to be composed of divergent ledge-formed feldspars, holding between them irregular grains and crystals of augite, olivine, and magnetite, while extending through most of the section is a dirty

[1] A. A. Julien, American Quarterly Microscopical Journal, January, 1879.

greenish viriditic product arising from the alteration of the various minerals of the rock and its presumed original base. There are also other secondary products which will be spoken of later. The feldspar as a rule shows the characters of basaltic plagioclase, but presents a whitish fibrous and granular alteration (kaolin) in places, as well as the viriditic product. The augite is cut by the plagioclase and has a reddish brown color. Its shades, owing to its dichroism, vary from a light brown to a yellowish brown. Its inclusions are principally magnetite and it is but little altered, the product in that case being generally viriditic.

The olivine is in irregular grains and crystals more or less fissured and altered. Some show mainly a clear olivine mass with little serpentinous alteration along the boundary and fissures, while others are entirely changed to serpentine pseudomorphs after the olivine. The serpentine is of a greenish, reddish brown, or orange-yellow color, the latter predominating. This is somewhat dichroic, the shade varying. The olivine shows the usual effect of the destructive action of the magma so commonly observed in the olivine of basalts. Some orthoclase occurs, but this appears to be entirely a secondary or alteration product in the rock. Many clear spots of transparent opal (hyalite) occur, while apatite needles are not uncommon.

The magnetite is in grains and crystals sometimes cut by the other minerals particularly the feldspar. It is also held in grains in the olivine as well as in the augite and feldspar. The general order of priority in the crystallization appears to be: magnetite, olivine, feldspar, augite, followed by the various secondary products.

This rock is regarded by me as having been originally identical with that forming modern basaltic dikes; the present difference being entirely owing to secondary changes brought about since the solidification of the rock. However in its present condition it would ordinarily be called a melaphyr, and closely resembles many of the melaphyrs of New England.

A boulder found on the east side of the island on the top of a hill at Lagg is a coarsely crystalline rock showing macroscopic hornblende, feldspar, biotite, and epidote.

Under the microscope it is seen to be composed of diallage, hornblende, feldspar, epidote, biotite, quartz, apatite, titaniferous iron, chlorite, etc. The diallage is of a colorless, yellowish, greenish, and reddish brown appearance. It remains only in remnants surrounded by the secondary hornblende. The cleavage is usually well marked although in one or two cases it is suggestive of the augitic variety. The hornblende is principally in needle-like fibers making up larger masses which optically have the same orientation. It is strongly pleochroic varying from a yellowish green to grass green and bluish green. The hornblende fibres extend out from the diallage through the adjacent feldspar and quartz in bundles and rods. The feldspar is chiefly triclinic, and is greatly altered, containing much epidote, chlorite, quartz, etc. The biotite shows dichroism from yellow to dark brown, occurs in masses and plates, not abundant, and generally is associated with the hornblende. The titaniferous iron is mainly altered to "leucoxene." The epidote is in nearly colorless granules scattered throughout the section, and in larger pale yellow masses, showing cleavage and twin structure. The quartz is in irregular masses in the feldspar and in the interspaces between the other minerals. It contains fluid cavities with moving bubbles and numerous granules, and needles of epidote, hornblende, etc. The apatite occurs in the usual elongated crystals, and is especially abundant in the chlorite. This mineral is in fibres and scales forming masses which sometimes show a dichroism varying from yellow to green, but at others are not dichroic. Some secondary feldspar was observed.

This rock I regard as once having possessed the characters of a gabbro or coarsely crystalline basalt (dolerite or diabase), but that it has since been subject to great alteration. So far as made out the feldspar, diallage (or augite), and titaniferous iron were the original minerals of the rock — if any olivine existed it has entirely disappeared — and that through their alteration by percolating waters (thermal?) has been produced the hornblende, chlorite, biotite, quartz, epidote, "leucoxene," the ferruginous products, and probably the apatite, etc.

In its present condition most lithologists would call this rock a quartz diorite, but I would prefer to class it under the species from which it appears to have been derived by alteration, that is under the basalts as a gabbro or diabase. This I would prefer in order to show its natural relations, since the term diorite now includes a great number of rocks produced by the alteration of different species running from basalt to granite.

General Meeting, November 21, 1883.

Prof. W. H. Niles in the chair. Twenty-four persons present.

Mr. E. Burgess showed a remarkable fabric spun by the larvae of a Tineid moth. These larvae had woven a complete lining to the top and sides of a bucket containing some corn on which they fed. The lining was easily removed whole from the bucket, and showed a wonderfully uniform texture, which, though extremely delicate, was found to be of considerable strength. Mr. Henshaw identified the species as Euphestia interpunctella Hübn.

General Meeting, December 5, 1883.

The President, Mr. S. H. Scudder, in the chair. Twenty persons present.

The President announced the death of Dr. John L. LeConte, for many years a Corresponding Member of the Society.

Mr. George H. Barton read a paper on the lava fields and streams of the Sandwich Islands, and presented one of two very curious worm-like laval concretions, quite different from any specimens before noticed. Mr. Barton showed other specimens and photographs in illustration of the subject.

Prof. Niles spoke of the causes of turns in lava streams, which often occur independently of the formation of the ground over which they flow, and which he believed were caused by sudden congelation of the lava at some point, resulting in a dam which would turn the course of the laval stream in another direction.

A vote of thanks to Mr. Barton for his gift was unanimously passed.

Mr. S. H. Scudder alluded to the fossil genus Kamptecaris from the Old Red Sandstone which Peach now shows is not a Crustacean, as formerly supposed, but a Myriapod much older than any previously described member of the group.

INDEX TO VOL. XXII.

The names of genera and species described as new are italicised.

ERRATA.

Page 191, 12th line, for "either overlie," read "either underlie."
Page 188, 6th line, for "Sackuest," read "Sachuest."
Page 255, note 3, for "Trematodiscus," read "Trematoceras."
Page 256, third paragragh, 9th line, after "Nautilinidae" add "and Magnosellaridae."
Page 256, fourth paragraph, 1st line, before "Nautilinidae" insert "lower forms of the."
Page 257, 4th line from bottom, read "lay" for "laid."
Page 261, 1st line, after "Nautilinidae" add "and Magnosellaridae."
Page 262, 2d line from top, for "Clymeninnae," read "Clymeninae."
Page 263, 6th line from bottom, after "Cretaceous" omit comma.
Page 268, fourth paragraph, 3d line, between "in" and "type" insert "the."
Page 272, 3d line from bottom, omit "strictly."
Page 278, Note 2 transpose to page 278.
Page 279, second paragraph, 1st line, after "generally have" add "an."
Page 281, third paragraph, 5th line, for "imprassed," read "impressed."
Page 281, Note 2, for "**Νὴευς**," read "**Νηδῦς**."
Page 285, Note 1, for "**Ρυιστ**," read "**'Ρυτὶς**."
Page 286, third paragraph, last line but one, for "Sutures," read "sutures."
Page 288, second paragraph, 5th line, for "earliest," read "earlier."
Page 288, second paragraph, 6th line, for "bur" read "but."
Page 289, first paragraph, last line but one, after "Ephippioceras" change period to comma.
Page 291, first paragraph, 1st line, transfer "1" to third paragraph, 1st line, first word.
Page 301, first paragraph, 6th line, for "(Naut.) intermedium, sp. Sow." read "inornatum."
Page 301, first paragraph, 7th line, for "pl. 27" read "pl. 28."
Page 321, Note 1, for "**Σποεας**" read "**Σποράδος**."
Page 324, second paragraph, 5th line, between "forms" and "above" insert "of Ammonitinae."
Page 333, first paragraph, 2d line, for "obes" read "lobes."
Page 335, for "Prolecanites" in brackets read "Prolecanitae."
Page 358, 20th line, for "dishes," read "dirks."
Plate 2, upper portion, the figure numbered "31," should be numbered "37."

CONSTITUTION

AND

BY-LAWS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY.

WITH A LIST OF

OFFICERS AND MEMBERS.

1883.

OFFICERS FOR 1882-83.

PRESIDENT,

SAMUEL H. SCUDDER.

VICE-PRESIDENTS,

JOHN CUMMINGS, F. W. PUTNAM.

CURATOR,

ALPHEUS HYATT.

HONORARY SECRETARY,

S. L. ABBOT, M.D.

SECRETARY.

EDWARD BURGESS.

TREASURER,

CHARLES W. SCUDDER.

LIBRARIAN,

EDWARD BURGESS.

COUNCILLORS,

J. A. Allen,
Henry P. Bowditch, M.D.,
Samuel Cabot, M.D.,
Thomas Dwight, M.D.,
W. G. Farlow, M.D.,
Samuel Garman,
Geo. L. Goodale, M.D.,
H. A. Hagen, M.D.,
B. Joy Jeffries, M.D.,
Augustus Lowell,
Theodore Lyman,
Edw. S. Morse,
Wm. H. Niles,
A. S. Packard, Jr., M.D.,
R. H. Richards,
N. S. Shaler,
Chas. J. Sprague,
M. E. Wadsworth,
Samuel Wells,
Wm. F. Whitney, M.D.

MEMBERS OF THE COUNCIL, EX OFFICIO,

Ex-President, Thomas T. Bouvé,

Ex-Vice-Presidents, Richard C. Greenleaf,

D. Humphreys Storer, M.D.

CONSTITUTION AND BY-LAWS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY.

CONSTITUTION.

ARTICLE I.

The Society shall be called the BOSTON SOCIETY OF NATURAL HISTORY.

ARTICLE II.

It shall consist of Associate, Corporate, Corresponding, and Honorary Members, and Patrons.

ARTICLE III.

All Members shall be chosen by ballot, after having been nominated at a preceding meeting; the affirmative votes of three-fourths of the Corporate Members present shall be necessary to a choice. The nomination of Corporate, Corresponding and Honorary Members shall proceed from the Council. Any person who shall contribute, at one time, to the funds of the Society, a sum not less than three hundred dollars, shall be a Patron.

ARTICLE IV.

Corporate Members only shall be entitled to vote, to hold any office except that of Treasurer, or to transact business; Corresponding and Honorary Members and Patrons may attend the meetings and take part in the scientific discussions of the Society; they may, however, on application, be transferred to the list of Corporate Members by a majority vote of the Council. Associate Members may attend such meetings as are designated by the Council, and take part in the scientific discussions at the same.

ARTICLE V.

The officers of the Society shall be a President; two Vice Presidents; a Curator; an Honorary Secretary; a Secretary; a Treasurer; a Librarian; and twenty Councillors; these officers, together with the past Presidents and Vice-Presidents, shall form a Board for the management of the concerns of the Society, and be called the Council, of which the Secretary shall be the clerk, *ex officio*.

ARTICLE VI.

Officers shall be chosen by ballot, after having been nominated at a preceding meeting, and a majority of votes of the Corporate Members present shall be sufficient for a choice.

ARTICLE VII.

By-Laws, for the more particular regulation of the Society, shall from time to time be made.

ARTICLE VIII.

This Constitution may be altered or amended in any of the preceding Articles, by a vote to that effect, of three-fourths of the Corporate Members present at any two consecutive meetings of the Society; the members having been first duly notified of any proposed alteration: but the Article which immediately follows this shall be unalterable.

ARTICLE IX.

The consent of every member shall be necessary to a dissolution of the Society. In case of a dissolution, the property of the Society shall not be distributed among the members, but donors may claim and receive such donations as they have made to the museum, and the remainder shall be given to some public institution, on such conditions as may then be agreed on; and the faithful performance of such conditions shall be secured by bonds, with sufficient penalties for the non-fulfilment thereof.

BY-LAWS.

SECTION I. OF MEMBERS.

ARTICLE 1. Elections for membership shall be held at the first meeting in the months of January, March, May and November. Any person of respectable character and attainments, residing in the City of Boston, or its immediate neighborhood, shall be eligible as an Associate Member of this Society. Nominations must be made in writing, by three members, at least one month previous to the time of elections; such nominations shall be made to a Committee consisting of the President, Secretary and Treasurer, who shall report upon the same at the meeting previous to that upon which elections are to be held. Every person elected shall, within six months from the date of election, pay into the Treasury an admission fee of five dollars, and subscribe an obligation, promising to conform to the Constitution and By-Laws of the Society; and until these conditions are fulfilled, shall possess none of the rights of membership, nor be enrolled upon the list of members.

Art. 2. Corporate Members may be chosen only from Associate Members of a year's standing, who are either professionally engaged in science, or have aided its advancement. Corresponding and Honorary Members may be selected from persons eminent for their attainments in science, on whom the Society may wish to confer a compliment of respect. Neither Corresponding nor Honorary Members shall be required to pay an admission fee or other contribution.

Art. 3. Persons who have been unsuccessful candidates for admission shall not be again proposed as members until after one year.

Art. 4. Members may withdraw from the Society, by giving written notice of their intention, and paying all arrearages due. Members who shall neglect to pay their regular assessments for two successive years, upon receiving due notification from the Treasurer, shall have their names erased from the roll of members.

Art. 5. Members may be expelled from the Society by a vote of three-fourths of the Corporate Members present, at a meeting specially called to consider the question by a notice given at least one month previous.

SECTION II. OF THE ELECTION OF OFFICERS.

Article 1. Whenever any existing or anticipated vacancy in the list of officers is to be filled by election, a Nominating

Committee shall be appointed by the Society at a stated meeting, to bring in at a subsequent meeting one or more nominations of persons to fill each such vacancy; but additional nominations may be made in any other way.

ARTICLE 2. No person shall be elected to any office until his nomination has been under consideration by the Society for at least two weeks.

SECTION III. OF OFFICERS AND THEIR DUTIES.

ARTICLE 1. The President shall preside at meetings of the Society and of the Council; shall preserve order, regulate debates, and conduct all business proceedings.

ART. 2. The Vice Presidents shall perform the duties of President in his absence, in the order of seniority in office.

ART. 3. The Curator shall be a person of acknowledged scientific attainments. Under direction of the Council he shall have general charge of the building and its contents ; and shall be responsible for the proper arrangement of the Collections. He shall prepare and read at the annual meeting a report upon the museum. He shall acknowledge all donations and record the same, with the date and name of donor. He shall also keep catalogues of the collections in his charge, and shall perform such other duties as may be prescribed by the Council and mutually assented to.

ART. 4. The Honorary Secretary shall keep the common seal; notify Corresponding and Honorary Members of their election; and receive and read to the Society all communications which may be addressed to him.

ART. 5. The Secretary shall take and preserve correct minutes of the proceedings of the Society and Council, in books to be kept for that purpose; shall have the charge of all records belonging to the Society; shall conduct the correspondence of the Society, and keep a record thereof; shall notify Corporate and Associate Members of their election, and committees of their appointment; shall call special meetings when directed by the President; and shall notify members residing in the vicinity of all meetings, and officers of all matters which shall occur at any meeting requiring their action.

ART. 6. The Treasurer shall have charge of all money and other property of the Society, excepting the building on Berkeley Street and its contents, and excepting also such property as may be placed by the Council in the hands of Trustees; shall collect all fees and assessments and receive all donations in money which may be made to it; shall pay all accounts against the Society, when the same shall be approved by a vote of the Council; shall keep a correct account of all receipts and expenditures in books belonging to the Society, and shall, at each annual meeting, and at other times when required by the Council, make a detailed report of the same.

ART. 7. The Librarian shall have charge of the books belonging to the Society, or deposited for its use, and of the publications of the Society. He shall observe and enforce such regulations as the Council shall from time to time make for the use of the books.

ART. 8. The Council shall control all expenditure of money, make rules for the use of the library and museum, and special rules for the direction of the Librarian and Custodian, and shall elect, annually, three committees of five members each, to take charge of the interests of the museum, library, and publications respectively. The Council shall have full power to act, for the interests of the Society, in any way not inconsistent with the Constitution and By-Laws.

ART. 9. The Council shall annually appoint three Trustees one of whom shall be the Treasurer *ex officio*, to whose charge shall be entrusted all the funded property of the Society, with power to sell and reinvest, according to their judgment.

SECTION IV. OF ASSESSMENTS.

ARTICLE 1. Every Corporate and Associate Member shall be subject to an annual assessment of five dollars, payable on the first day of October in each year; but no assessment shall be required of any Associate Member during the six months succeeding his election. Commutation may be purchased for fifty dollars.

ART. 2. The President and Treasurer shall be empowered to exempt (*sub silentio*) a member from assessment when, from peculiar circumstances, they may deem it for the interest of the Society so to do.

ART. 3. Members who are absent from New England during a whole year, commencing on the first day of October, shall be exempt from the annual assessment for such year provided they give notice of their intended absence to the Secretary.

SECTION V. OF THE LIBRARY.

ARTICLE 1. Members and Patrons of the Society may have access to, and take books from the Library; and the Library Committee may, by special vote, extend the use of books to others than members, specifying the conditions under which they may be taken.

ART. 2. The rules and regulations for the use of the Library shall be printed and exposed in the library rooms, and a digest of them affixed to each volume.

SECTION VI. OF THE MUSEUM.

ARTICLE 1. Members of all classes, and the public generally, shall have access to the museum at such times as the Council shall determine.

ART. 2. Specimens shall be removed from the museum only by leave of the Curator, who shall take a receipt for the same, and be responsible for their restoration in good order.

SECTION VII. OF COMMITTEES OF THE COUNCIL.

ARTICLE 1. The Museum Committee shall have general direction of the expenditure of Museum funds and appropriations, and shall act as an advisory board to the Curator, who shall submit to it any proposed changes in the administration or arrangement of the museum.

ART. 2. The Library Committee shall have general direction of the expenditure of library funds and appropriations, and make regulations for the use and care of the books.

ART. 3. The Publishing Committee shall, from time to time, cause to be published, and superintend the publication of, such papers read to the Society, and such portions of the records of the Proceedings, as may seem to them calculated to promote the interests of science, so far as the funds appropriated by the Council shall permit, it being understood that the Committee shall not be held responsible for any opinion expressed in said publications. The said Committee shall also have authority to effect exchanges for other scientific publications.

ART. 4. The Council shall, previous to every annual meeting, appoint a Committee, whose duty it shall be to audit the accounts of receipts and expenditures of the Corporation.

SECTION VIII. OF LECTURES.

ARTICLE 1. Public lectures, when judged expedient by the Council may be given under the auspices of the Society.

SECTION IX. OF MEETINGS.

ARTICLE 1. A meeting shall be held on the first Wednesday in May annually, for the choice of officers and other general purposes. At this meeting the Curator shall present a report upon the condition and progress of the museum, the lectures which he superintends, and any other matters of general interest; the Secretary upon the library, publications, meetings, and the lectures which he superintends; the Treasurer upon the receipts and expenditures of the year; and the Trustees upon the financial condition of the Society.

ART. 2. Stated meetings of the Society shall be held on the first and third Wednesday of every month; unless when suspended by a vote of the Society.

ART. 3. Ten members shall form a quorum for business.

ART. 4. The order of proceeding at meetings shall be as follows:—

1. Record of preceding meeting read.
2. Candidates for membership proposed.
3. Balloting for members.
4. Scientific communications.
5. Business called up by special resolutions, or otherwise.
6. Donations announced.
7. Adjournment.

SECTION X. OF SECTIONS.

Article 1. Sections of the Society, holding separate meetings of their own, may be formed on the written application of ten Corporate Members, by the consent of the Corporate Members present at two consecutive meetings of the general Society. As in the general Society, Corporate Members alone shall be entitled to vote, to hold office, or to transact business.

Art. 2. The requirements of membership shall be: —

1 Membership in the general Society.

2. Written nomination by two members at a regular meeting of the Section.

3. Election by a three fourths vote of the Corporate members present at the subsequent meeting.

4. Signature to the standing rules within six months from the date of election.

Art. 3. The records shall be entered in chronological order upon the book containing the records of the ordinary meetings of the Society.

Art. 4. Such notice of each meeting as shall be judged by the publishing committee suitable for publication in the Proceedings or Memoirs of the Society, may be announced by the Secretary at the next regular meeting of the Society.

Art. 5. Sections shall have the exclusive right to make additional regulations for the perfecting of their organizations subject to the approval of the Council.

SECTION XI. CHANGE OF BY-LAWS.

Article 1. The By-Laws of the Society may be altered or amended by a majority vote of the Corporate Members present at any meeting; provided that they shall have been duly notified, two weeks previous, of an intended change.

LIBRARY REGULATIONS.

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1. The library shall be open for the use of books and their delivery and return from 9 A. M. to 1 P. M., and from 2 P. M. to 5 P. M.

2. No books shall be taken from the library without the knowledge and record of the librarian or his assistant. Officers may, for purposes of study, remove any book from the library to other parts of the building, after recording them in a book kept for this purpose; but in taking books out of the museum they shall observe the same rules as other members.

3. The librarian shall have discretionary power to admit strangers who may desire to consult the library during his hours of attendance, and to allow of the examination of the books under his supervision.

4. No person shall be allowed to retain more than five volumes at any one time, except by permission of the library committee.

5. Books may be kept out one calendar month, unless sooner called in by the librarian; but no longer, without renewal, and renewal may not be granted more than twice; after which the book may not be taken out again by the same person until three days after its return. Any book can be recalled at any time by the librarian.

6. If books are not returned within the time specified, a written notice of delinquency shall be sent by the librarian. If not then returned within a week after the date of notice, a fine of five cents per day for every volume not returned shall be incurred, and a second notice then sent. If still further delinquent, the librarian shall notify the council of said delinquency.

7. Should any person desire to borrow a book which is lent out of the library, he may leave his name and the title of the book with the librarian. When the book shall be returned, the librarian shall reserve it for the person so applying, provided the latter call for it within three days.

8. When call is made for any book which is lent, the librarian may demand its return by regular printed form of notice after the expiration of ten days from the date of borrowing.

9. Each book shall be placed in one of three classes, designated by the council, viz.: (a) those which may be taken out only by special vote of the library committee; (b) those which may be removed only by the permission of the librarian and two members of the council; (c) those which may be lent without restriction. Books of the first two classes shall have a label attached to the inside of the cover, designating their class.

10. Every book shall be returned in good order, regard being had to its necessary wear with good usage. If any book shall be lost or injured, the person to whom it stands charged shall replace it by a new volume or set, if it belong to a set, or pay the value of the volume or set to the librarian; the value being fixed by the library committee. And thereupon the remainder of the set, if the volume belong to a set, shall be delivered to the person so paying for the same; — every book detained above a year being held to be lost.

11. Periodical publications, both literary and scientific, shall not be taken from the library until two weeks after they have been placed upon the shelves or table.

12. Books may be deposited in the library for the use of the society; but said books shall not be taken from the library without the consent of the owners.

HONORARY MEMBERS.

Spencer F. Baird,	Washington.
Joachim Barrande,	Paris.
George Bentham,	London.
Leonard Blomefield,	Belmont, Bath.
James D. Dana,	New Haven.
A. Daubrée,	Strasbourg.
J. W. Dawson,	Montreal.
Asa Gray,	Cambridge.
Oswald Heer,	Zurich.
Sir Joseph D. Hooker,	London.
Thomas H. Huxley,	London.
Joseph Hyrtl,	Vienna.
Albert v. Kölliker,	Würzburg.
Isaac Lea,	Philadelphia.
Henri Milne-Edwards,	Paris.
Richard Owen,	London.
C. U. Shepard,	Amherst.
J. J. S. Steenstrup,	Copenhagen.
Rudolph Virchow,	Berlin.
J. O. Westwood,	Oxford.

CORRESPONDING MEMBERS.

Harrison Allen, M. D.,	Philadelphia, Pa.
William Allen,	Boston.
Sir James Anderson,	Liverpool, Eng.
Francis Archer,	" "
Francesco Ardissone,	Milan, Italy.
Nathaniel E. Atwood,	Provincetown.
Wm. O. Ayres, M.D.,	New Haven, Conn
Dr. Edward Baldamus,	Halle, Germany.
A. S. Baldwin, M.D.,	Jacksonville, Fla.
Mariano Bárcena,	City of Mexico.
Rev. A. Constantine Barry,	Prairie du Sac, Wisc.
Hermann Behr, M.D.,	San Francisco, Cal.
E. van Beneden,	Liége, Belgium.
W. G. Binney,	Burlington, N. J.
N. H. Bishop,	Lake George, N. Y.
William P. Blake,	New Haven, Ct.
George A. Boardman,	Milltown, Me.
Wm. H. Brewer,	New Haven, Ct.
Wm. K. Brooks,	Baltimore, Md.
John Brown,	New York, N. Y.
John Capellini,	Bologna, Italy.
William B. Carpenter, M.D.,	London.
Henry John Carter,	London, Eng.

Antonio del Castillo,	City of Mexico.
Paul A. Chadbourne,	Amherst.
A. W. Chapman, M.D.,	Appalachicola, Fla.
Edward D. Cope,	Philadelphia, Pa.
Guido Cora,	Turin, Italy.
Elliott Coues, M.D.,	Washington, D. C.
Hermann Credner,	Leipzig, Germany.
Ezra T. Cresson,	Philadelphia, Pa.
Josiah Curtis, M.D.,	Washington, D. C.
Henry Davis,	McGregor, Iowa.
Wm. Boyd Dawkins,	Manchester, Eng.
Rev. William Dean,	Bangkok, Siam.
Dr. Anton Dohrn,	Naples, Italy.
Sanford B. Dole,	Honolulu. Hawaiian Islands.
Henry E. Dresser,	London, Eng.
Paul B. Du Chaillu,	New York, N. Y.
Arthur Mead Edwards,	Berkeley, Cal.
Wm. H. Edwards,	Coalburgh, W. Va.
D. G. Elliot,	New Brighton, N. Y.
Roswell Field,	Gill, Mass.
Wm. Henry Flower,	London, Eng.
Oscar Fraas,	Stuttgart, Germany.
John C. Frémont,	New York, N. Y.
M. Ganin,	Nizza, Italy.
J. T. Gardner,	Washington, D. C.
Albert Gaudry,	Paris, France.
Archibald Geikie,	Edinburgh, Scotland.
Lewis R. Gibbes, M. D.,	Charleston, S. C.
Theodore Gill, M.D.,	Washington, D. C.
Hans Bruno Geinitz,	Dresden, Germany.
Townend Glover,	Washington, D. C.

G. Brown Goode,	Washington, D. C.
Augustus R. Grote,	New Brighton, N. Y.
John T. Gulick,	Kalgan, China.
Dr. L. H. Gulick,	Honolulu, Hawaiian Is.
Dr. Juan Gundlach,	Bemba, Cuba.
James Hall,	Albany, N. Y.
Edwin Harrison,	St. Louis, Mo.
Franz Ritter von Hauer,	Vienna, Austria.
F. V. Hayden, M.D.,	Philadelphia, Pa.
James Hector,	Wellington, New Zealand.
Henry Y. Hind,	Windsor, Nova Scotia.
Charles H. Hitchcock,	Hanover, N. H.
Dr. John Hjaltalin,	Rejkyavik, Iceland.
Ferd. von Hochstetter,	Vienna, Austria.
Bernard A. Hoopes,	Philadelphia, Pa.
W. J. Hoffman, M. D.,	Reading, Pa.
Frithiof Holmgren,	Upsala, Sweden.
Oliver P. Hubbard,	Hanover, N. H.
Samuel Hubbard,	San Francisco, Cal.
Dr. J. C. Jay,	Rye, N. Y.
Dr. Christopher Johnson,	Baltimore, Md.
John King,	Boone, Ia.
Dr. Cornelius Kollock,	Cheraw, S. C.
L. de Koninck,	Bruxelles, Belgium.
A. Kowalewsky,	Kiew, Russia.
Thure Kumlein,	Busseyville, Wisc.
Carl Kupffer,	Kiel, Denmark.
George A. Lawrence,	New York, N. Y.
Dr. J. L. LeConte,	Philadelphia, Pa.
Joseph Leidy,	Philadelphia, Pa.
Leo Lesquereux,	Columbus, Ohio.
F. W. Lewis, M.D.,	Philadelphia, Pa.

Franz Leydig,	Bonn, Germany.
Dr. Christian F. Lütken,	Copenhagen, Den.
Thomas Macfarlane,	Acton Vale, Canada.
Oliver Marcy,	Evanston, Ill.
O. C. Marsh,	New Haven, Ct.
Joseph B. Meader,	Stoneham.
S. Weir Mitchell, M.D.,	Philadelphia, Pa.
Alphonse Milne-Edwards,	Paris.
Francis P. Nash,	Geneva, N. Y.
Dr. John S. Newberry,	New York, N. Y.
Edward Norton,	Farmington, Ct.
Dr. J. G. Norwood,	Columbia, Mo.
Baron C. R. von Osten Sacken,	Heidelberg, Germany.
Dr. George A. Perkins,	Salem, Mass.
Dr. Thomas F. Perley,	Portland, Me.
Felipe Poey,	Havana, Cuba,
John W. Powell, U. S. A.,	Washington, D. C.
Joseph Prestwich,	Oxford, Eng.
Temple Prime,	New York, N. Y.
Andrew C. Ramsay,	London, Eng.
Ferd. von Richtofen,	Berlin, Germany.
Robert E. Rogers,	Philadelphia, Pa.
Ludwig Rütimeyer,	Basle, Switzerland.
Marquis de Saporta,	Paris, Erance.
Henri de Saussure,	Geneva, Switzerland.
C. M. Scammon,	U. S. Rev. Marine.
William Sharswood,	Philadelphia, Pa.
Benjamin Silliman,	New Haven, Ct.
Hamilton L. Smith,	Gambier, Ohio.

J. Lawrence Smith, M.D.,	Louisville, Ky.
Isaac Sprague,	Grantville, Mass.
G. C. Swallow,	Columbia, Mo.
Dr. Armand Thielens,	Tirlemont, Belgium.
George W. Tryon,	Philadelphia, Pa.
Edward Tuckerman,	Amherst, Mass.
Philip R. Uhler,	Baltimore, Md.
A. E. Verrill,	New Haven, Ct.
W. Waagen,	Munich, Germany.
Henry A. Ward,	Rochester, N. Y.
R. H. Ward,	Troy, N. Y.
Carl Wedl,	Vienna, Austria.
Dr. Henry Wheatland,	Salem, Mass.
George M. Wheeler, U. S. A.,	Washington, D. C.
William T. White, M.D.,	New York, N. Y.
R. P. Whitfield,	" "
J. D. Whitney,	Cambridge, Mass.
Chas. Whittlesey,	Cleveland, Ohio.
Burt G. Wilder, M.D.,	Ithaca, N. Y.
Daniel Wilson.	Toronto, Canada.
Alexander Winchell,	Ann Arbor, Mich.
J. J. Woodward, M.D.,	Washington, D. C.
L. P. Yandell, M.D.,	Louisville, Ky.
Ferdinand Zirkel,	Leipzig, Germany.
Carl L. Zittel,	Munich, "

LIST OF CORPORATE AND ASSOCIATE MEMBERS.

[Names of Corporate Members are prefixed by a †.]

---

† Samuel L. Abbot, M.D.,	90 Mount Vernon St.
† Alexander Agassiz,	Cambridge.
John E. Alden,	595 E. Seventh St.
Jane Alexander,	Jamaica Plain.
† Henry Freeman Allen,	" "
† J. A. Allen,	Cambridge.
Wm. L. Allen,	15 Chester Square.
† Robert Amory, M.D.,	Brookline.
† Robert R. Andrews,	Cambridge.
Arthur C. Anthony,	285 Marlboro' St.
† Nathan Appleton,	10 Commonwealth Ave.
† William S. Appleton,	39 Beacon St.
Jennie M. Arms,	E. Cambridge.
† George J. Arnold, M.D.,	175 Warren St.
† Elisha Atkins,	37 Commonwealth Ave.
Grace E. Atkins,	" "
Edward Atkinson,	Brookline.
† Edward P. Austin,	Absent.
† Charles E. Avery,	19 Chester Park.

† Lucas Baker,	Cambridgeport.
† William E. Baker,	63 Chester Sq.
† A. C. Baldwin,	Hotel Vendome.
† James M. Barnard,	Hotel Pelham.
Walter B. Barrows,	Reading.
Charles F. Batchelder,	Cambridge.
† John M. Batchelder,	"
† Richard W. Bender,	Absent.
† Edward R. Benton,	"
† A. Graham Bell,	Washington, D. C.
† George A. Bethune, M.D.,	166 Tremont St.
† Henry J. Bigelow, M.D.,	52 Beacon St.
† Wm. Sturgis Bigelow, M.D.,	60 " "
† Edward A. Birge,	Absent.
† George H. Bixby, M.D.,	143 Boylston St.
† Clarence J. Blake, M.D.,	226 Marlboro' St.
† George B. Blake,	22 Beacon St.
† James H. Blake,	Cambridge.
Albert N. Blodgett, M.D.,	86 Boylston St.
Mrs. A. L. Boardman,	38 Kenilworth St.
Elizabeth D. Boardman,	120 Beacon St.
† George Wm. Bond,	Forest Hills.
† J. N. Borland, M.D.,	229 Beacon St.
† Edward T. Bouvé,	Hingham.
† Thomas T. Bouvé,	40 Newbury St.
† Frederic C. Bowditch,	Brookline.
† Henry I. Bowditch, M.D.,	113 Boylston St.
† H. P. Bowditch, M.D.,	Jamaica Plain.
† J. Ingersoll Bowditch,	" "
† William I. Bowditch,	Brookline.
† Rev. C. D. Bradlee,	57 W. Brookline St.
† N. J. Bradlee,	65 Highland St.
Charles R. Brainard,	13 Pemberton Sq.
† F. W. Brewer,	72 Commonwealth Ave.
† Willard S. Brewer,	" " "

† William Brewster,	Cambridge.
Edwin C. Brooks,	Mt. Auburn.
† Francis Brooks,	97 Beacon St.
† Henry C. Brooks,	Tremont House.
† Walter R. Brooks, D.D.,	Absent.
† J. Frank Brown,	Somerville.
† Jonathan Brown,	
† C. Allen Browne,	78 Boylston St.
† John Bryant,	Cohasset.
† Wm. S. Bryant,	61 Beacon St.
† Wm. N. Bullard,	127 Boylston St.
† Edward Burgess,	300 Beacon St.
† Edward C. Cabot,	Brookline.
† Louis Cabot,	Brookline.
† Samuel Cabot, M.D.,	11 Park Sq.
† Lucien Carr,	Beacon St.
† Charles Carruth,	79 Newbury St.
† T. P. Chandler,	Brookline.
† R. Stuart Chase,	Haverhill.
† W. S. Chase,	17 Beacon St.
Harold C. Childs,	Dorchester.
† I. Y. Chubbuck,	54 Roxbury St.
† S. E. Chubbuck,	509 Columbus Ave.
T. W. B. Clark,	413 W. Broadway.
Cora H. Clarke,	Jamaica Plain.
† Thomas W. Clarke,	31 Moreland St.
† B. S. Codman, M.D.,	347 Columbus Ave.
† Edward W. Codman,	53 Marlborough St.
Frank S. Collins,	Malden.
† Henry Colman, M.D.,	Lynn.
† Algernon Coolidge, M.D.,	81 Marlborough St.
† Isaac C. Cooper,	22 Highland St.
W. G. Corthell,	Hotel Boylston.
† Charles B. Cory,	8 Arlington St.
Grace G. Cowing,	Norfolk House.

† C. F. Crehore, M.D.,	Newton Lower Falls.
Lucretia Crocker,	40 Rutland Sq.
† Wm. O. Crosby,	Mt. Hope.
† Charles R. Cross,	Norfolk House.
† W. P. Cross, M.D.,	581 Broadway.
† John Cummings,	Woburn.
† Nathaniel Cummings,	501 Columbus Ave.
Augusta R. Curtis,	61 Studio Building.
† Elisha P. Cutler,	299 Marlboro' St.
† Edmund F. Cutter,	118 Boylston St.
† William H. Dall,	Absent.
Lorin L. Dame,	Medford.
John Dane,	Hotel Vendome.
F. Graef Darlington,	Pittsburgh, Pa.
Herman E. Davidson, M.D.,	329 Beacon St.
† William M. Davis,	Cambridge.
Stephen G. Deblois,	133 Newbury St.
† Henry G. Denny,	18 Lambert Ave.
† Quincy E. Dickerman,	Somerville.
† Charles K. Dillaway,	183 Roxbury St.
† J. S. Diller,	Absent.
† George Dimmock,	Cambridge.
† John H. Dix, M.D.,	Hotel Pelham.
John Dixwell, M.D.,	6 Pemberton Sq.
David Dodge,	Chelsea.
† Jonathan Dorr,	Dorchester.
Charles E. Dotey,	Stoneham.
† G. W. W. Dove,	Andover.
† Henry D. Dupee,	Dorchester.
† James A. Dupee,	14 Chestnut St.
† Thomas Dwight, M.D.,	70 Beacon St.
† Henry Edwards,	34 Commonwealth Ave.

† Henry Edwards,	New York.
† William Edwards,	So. Natick.
† Charles W. Eliot, LL.D.,	Cambridge.
† Calvin Ellis, M.D.,	114 Boylston St.
† James H. Emerton,	New Haven, Conn.
† William Endicott,	10 Mt. Vernon St.
† John A. Estabrooks,	Dorchester.
† Wm. G. Farlow, M.D.,	Cambridge.
† Isaac D. Farnsworth,	39 Commonwealth Ave.
† Charles E. Faxon,	Jamaica Plain.
† Walter Faxon,	Cambridge.
† Henry H. Fay,	328 Beacon St.
† Joseph S. Fay,	88 Mt. Vernon St.
† Joseph S. Fay, Jr.,	169 Commonwealth Ave.
† J. Brooks Fenno,	22 Louisburg Sq.
† Charles H. Fernald,	Orono, Me.
† J. Walter Fewkes,	Cambridge.
† Frank S. Fiske,	Longwood.
† Augustus Flagg,	Clarendon, cor. Marlboro' St.
† Charles L. Flint,	29 Newbury St.
† Daniel V. Folts, M.D.,	39 Maverick Sq., E. B.
† Edward J. Forster, M.D.,	Charlestown.
† John Foster,	25 Marlboro' St.
† William Foster,	Absent.
Nathaniel A. Francis,	Brookline.
Harriet E. Freeman,	37 Union Park.
Roscoe Frohock,	Malden.
† Donald McL. Frothingham,	
† Frederic G. Frothingham,	Absent.
† T. O. Fuller,	Needham.
† Thomas Gaffield,	54 Allen St.
† Charles W. Galloupe,	Swampscott.
† Edward G. Gardiner,	Absent.

Frederick Gardiner, Jr.,	Cambridge.
† Samuel Garman,	"
Phineas E. Gay,	589 Tremont St.
Herbert Gleason,	Malden.
† B. W. Gilbert,	Newton Lower Falls.
† George L. Goodale, M.D.,	Cambridge.
† Lester Goodwin,	Newton.
† Samuel H. Gookin,	Lexington.
Arthur C. Gould,	Longwood.
Arthur F. Gray,	Danversport.
† Asa Gray, M.D.,	Cambridge.
† R. C. Greenleaf,	28 Newbury St.
† Robert W. Greenleaf,	Charlestown.
† David S. Greenough,	Jamaica Plain.
Wm. O. Grover,	17 Arlington St.
† H. A. Hagen, M.D.,	Cambridge.
† Josiah L. Hale, M.D.,	
Mary L. Hall,	40 Rutland Sq.
† Byron D. Halsted,	Absent.
† Martin L. Ham,	752 Broadway.
† Charles E. Hamlin,	Cambridge.
† D. A. Hamlin,	"
George W. Hammond,	Hotel Hamilton.
† Ivory Harmon,	95 Moreland St.
† Edward D. Harris,	New York.
† Edward M. Hartwell,	Absent.
Edmund M. Haskell,	226 Beacon St.
Franklin Haven, Jr.,	97 Mt. Vermon St.
Henry C. Haven, M.D.,	Exeter St., cor. Commonwealth [Ave.
† Gustavus Hay, M.D.,	91 Charles St.
† Henry W. Haynes,	239 Beacon St.
Roland Hayward,	Cambridge.
† Charles D. Head,	Brookline.
† Augustus Hemenway,	95 Marlboro' St.

† Samuel Henshaw,	77 Newbury St.
† George Higginson,	39 Brimmer St.
† Thomas Wentworth Higginson,	Cambridge.
Louise M. Hill,	223 Newbury St.
Edgar R. Hills,	Providence, R. I.
Mary H. Hinckley,	Milton.
† Holmes Hinkley,	1 Fairfield St.
† John Hogg,	50 Commonwealth Ave.
† Henry A. Holden,	Hotel Berkeley.
† William Holden,	Absent.
† Oliver W. Holmes, M.D.,	296 Beacon St.
† Charles D. Homans, M.D.,	90 Boylston St.
† John Homans, M.D.,	161 Beacon St.
Charles R. Hooper,	264 Beacon St.
John F. Hooper,	" " "
Mrs. Marie A. Hooper,	" " "
† Nathaniel L. Hooper,	56 Chestnut St.
† R. W. Hooper, M.D.,	114 Beacon St.
Mrs. S. T. Hooper,	Westminster Ave.
Charles A. Houghton,	West Medway.
† Charles T. Hubbard,	2 Louisburg Sq.
† Gardiner G. Hubbard,	Washington, D. C.
† D. T. Huckins, M.D.,	Watertown.
† David Hunt, Jr., M.D.,	149 Boylston St.
† T. Sterry Hunt, LL.D.	Montreal.
† Alpheus Hyatt,	Cambridge.
Mrs. H. P. Hyde,	Everett.
† H. B. Inches, M.D.,	172 Tremont St.
† Martin B. Inches,	72 Boylston St.
† Ernest Ingersoll,	Absent.
Catharine I. Ireland,	9 Louisburg Sq.
† John C. Jackson,	Absent.
† Gustavus A. Jasper,	Dorchester.

† Benjamin Joy Jeffries, M.D.,	15 Chestnut St.
† John Jeffries,	126 Beacon St.
† John A. Jeffries,	126 Beacon St.
† William A. Jeffries,	" " "
† Samuel Johnson,	7 Commonwealth Ave.
Charles W. Kempton,	Absent.
† Charles S. Kendall,	453 Shawmut Ave.
Mrs. M. P. Kennard,	Brookline.
† George G. Kennedy, M.D.,	20 Chestnut St.
† H. P. Kidder,	2 Newbury St.
J. S. Kingsley,	Melrose.
† Samuel Kneeland, M.D.,	New York.
† John P. Knight,	284 Dartmouth St.
† W. J. Knowlton,	Brookline.
Wm. H. Ladd,	Lynn.
Amory A. Lawrence,	59 Commonwealth Ave.
† Amos A. Lawrence,	Longwood.
A. J. Lewis,	267 Newbury St.
† James L. Little, Jr.,	140 Marlboro' St.
† C. William Loring,	Beverly Farms.
† John A. Loring,	5 Hancock Ave.
† Rev. Samuel K. Lothrop,	12 Chestnut St.
† Augustus Lowell,	171 Commonwealth Ave.
† Arthur T. Lyman,	16 Mount Vernon St.
† Theodore Lyman,	191 Commonwealth Ave.
† B. Pickman Mann,	Washington, D. C.
Walter P. Manton,	Absent.
† Jules Marcou,	Cambridge.
† Edward L. Mark,	"
† G. F. H. Markoe,	1 Circuit St.
† John P. Marshall,	Medford.
† Stephen C. Martin, M.D.,	27 Dudley St.

† Lyman Mason,	164 W. Chester Park.
Wm. F. Matchett,	284 Beacon St.
† F. W. G. May,	Dorchester.
† John McCrady,	Absent.
† Thomas McHayes,	
N. Fred Merrill,	Salem.
James C. Merrill, M.D.,	Absent.
F. Lawrence Messenger,	Melrose Highlands.
Susannah Minns,	14 Louisburg Sq.
† Charles S. Minot,	Roslindale.
† Henry D. Minot,	"
† George Mixter,	219 Beacon St.
† George T. Moffat, M.D.,	132 Boylston St.
† Hugh Montgomery.	U. S. Hotel.
† Henry L. Moody,	Malden.
† Alexander Moore,	414 E. Third St.
Nina Moore,	W. Newton.
† Edward S. Morse,	Salem.
† Henry D. Morse,	Jamaica Plain.
† Samuel T. Morse,	12 Marlboro' St.
† N. C. Munson,	Shirley Village.
† John Murdoch,	Absent.
† Albert L. Murdock,	Jamaica Plain.
Mrs. H. P. Nichols,	12 Ashburton Pl.
† Wm. Ripley Nichols,	2 Billings Pl.
† Franklin Nickerson, M.D.,	Lowell.
† Sereno D. Nickerson,	3 Beacon Hill Pl.
† W. H. Niles,	Cambridge.
† Jacob Norton,	67 Carver St.
† Wm. E. Norton,	Absent.
Emily A. Nunn,	Absent.
† John T. Ogden,	520 Shawmut Ave.
† John M. Ordway,	Jamaica Plain.
† John Orne, Jr.,	Cambridge.

† Francis A. Osborn,	236 Marlborough St.
Charles H. Osgood,	Newton.
† A. S. Packard, Jr., M.D.,	Providence, R. I.
† D. M. Parker, M.D.,	132 Boylston St.
† William Parsons,	181 Beacon St.
Emerette O. Patch,	Lexington.
† F. H. Peabody,	247 Berkeley St.
† Oliver W. Peabody,	Milton.
D. P. Penhallow,	Absent.
† William Perkins,	83 Mt. Vernon St.
John C. Phillips,	Berkeley, cor. Marlboro' St.
† Avery Plumer,	130 Marlboro' St.
† C. B. Porter, M.D.,	5 Arlington St.
† Warren B. Potter,	Hotel Kempton.
Charles E. Pratt,	373 Warren St.
† Jonathan Preston,	204 Dartmouth St.
† William G. Preston,	6 Park Sq.
† Raphael Pumpelly,	Newport, R. I.
† C. P. Putnam, M.D.,	63 Marlborough St.
† Frederick W. Putnam,	Cambridge.
† James J. Putnam, M.D.,	63 Marlborough St.
† Henry P. Quincy, M.D.,	57 Mt. Vernon St.
† Edward S. Rand,	39 Fort Ave.
† John W. Randall, M.D.,	Boston Highlands.
† Richard Rathbun,	Washington.
† John P. Reynolds, M.D.,	236 Clarendon St.
Stephen H. Rhodes,	135 Highland St.
† Henry B. Rice,	American House.
Mary E. Rice,	Absent.
Mrs. Ellen H. Richards,	Jamaica Plain.
† George H. Richards,	85 Pinckney St.
† Robert H. Richards,	Jamaica Plain.
† William L. Richardson, M.D.,	76 Boy ston St.

C. E. Ridler,	Kingston.
† Edward S. Ritchie,	Brookline.
John Ritchie, Jr.,	57 Chester Park.
† Thomas P. Ritchie,	Brookline.
† Alfred P. Rockwell,	3 Fairfield St.
Edward W. Roper,	Revere.
† M. D. Ross,	Jamaica Plain.
Wm. H. Ruddick, M.D.,	502 Broadway.
† J. D. Runkle,	Brookline.
† Le Baron Russell, M.D.,	34 Mt. Vernon St.
† Francis G. Sanborn,	Andover.
Henry Savage,	431 Beacon St.
Wm. H. Sawtell,	6 Rutland Sq.
† Henry Sayles,	Chestnut Hill.
† Barthold Schlesinger,	Brookline.
Charles W. Scudder,	"
† Samuel H. Scudder,	Cambridge.
Lucy E. Sewall, M.D.,	151 Boylston St.
† Nathaniel S. Shaler,	Cambridge.
† J. C. Sharp, M.D.,	54 Commonwealth Ave.
† Stephen P. Sharples,	Cambridge.
† B. S. Shaw, M.D.,	28 Marlboro' St.
† Lemuel Shaw,	49 Mt. Vernon St.
† Luther D. Shepard, M.D.	Dorchester.
† Augustine Shurtleff, M.D.,	Brookline.
† A. D. Sinclair, M.D.,	35 Newbury St.
† Charles C. Smith,	286 Marlboro' St.
Jennie Smith,	Cambridge.
† S. G. Snelling,	24 Commonwealth Ave.
† A. W. Spencer,	Hotel Berkeley.
† Chas. Jas. Sprague,	380 Marlboro' St.
Frank F. Stanley,	Swampscott.
† Charles Stodder,	15 E. Canton St.
† George H. Stone,	Absent.

† Joseph Stone,	Lawrence.
† D. Humphreys Storer, M.D.,	182 Boylston St.
† William Stow,	Arlington.
Cordelia A. Studley,	Cambridge.
† Allen M. Sumner, M.D.,	76 Commonwealth Ave.
John O. Sumner,	Absent.
† Charles W. Swan, M.D.,	32 Worcester St.
† J. Brooks Taft,	Somerville.
† I. T. Talbot, M.D.,	66 Marlboro' St.
Lewis Wm. Tappan, Jr.,	Milton.
Ralph S. Tarr,	Absent.
† L. Lincoln Thaxter,	Charlestown.
† Nathaniel Thayer,	70 Mt. Vernon St.
† Chauncey Thomas,	14 Linwood Sq.
John H. Thurston,	Cambridge.
† Edward S. Tobey,	19 Chestnut St.
William Trelease,	Absent.
† William Tudor,	Absent.
† Warren Upham,	Absent.
† B. H. Van Vleck,	Boston.
† Joseph Vila,	Hotel Huntington.
† M. Edward Wadsworth,	Cambridge.
† O. F. Wadsworth, M.D.,	139 Boylston St.
† George W. Wales,	142 Beacon St.
† T. B. Wales,	23 Brimmer St.
† Charles H. Walker, M.D.,	Chelsea.
H. F. Walling,	Absent.
† Charles E. Ware, M.D.,	41 Brimmer St.
† G. Washington Warren,	16 Marlboro' St.
† Joseph H. Warren, M.D.,	51 Union Park.

Joseph W. Warren, M.D.,	107 Boylston St.
† G. F. Waters, M.D.,	8 Beacon St.
† Rev. R. C. Waterston,	71 Chester Sq.
† Sereno Watson,	Cambridge.
† S. G. Webber, M.D.,	47 Rutland St.
† Andrew G. Weeks,	14 Newbury St.
† Charles G. Weld,	6 Commonwealth Ave.
† Moses W. Weld, M.D.,	23 Worcester St.
† Charles A. Wellington,	E. Lexington.
† Samuel Wells,	155 Boylston St.
† Leander Wetherell,	31 Allen St.
Charles G. White,	39 Commonwealth Ave.
† Charles T. White,	213 Commonwealth Ave.
† James C. White, M.D.,	10 Park Sq.
Laura B. White,	523 Columbus Ave.
† C. O. Whitman,	Newton Highlands.
† Solon F. Whitney,	Watertown.
† Wm. F. Whitney, M.D.,	228 Marlboro' St.
W. L. Whittemore,	Absent.
† Edward Wigglesworth,	81 Beacon St.
† Thomas Wigglesworth,	1 Park St.
† Marshall P. Wilder,	Dorchester.
† Arthur W. Willard,	Groton.
Mary A. Willcox,	Absent.
Edgar N. Williams,	Absent.
† Henry W. Williams, M.D.,	15 Arlington St.
† Arthur E. Wilson,	Cambridgeport.
† Wm. P. Wilson,	1507 Washington St.
Clifton E. Wing, M.D.,	Jamaica Plain.
Arthur Winslow,	Absent.
† Samuel W. Winslow,	52 Pinckney St.
Charles H. Wise,	Roslindale.
† Roger Wolcott,	173 Commonwealth Ave.
† Rev. G. Fred. Wright,	Absent.

E. Bentley Young,	104 Appleton St.
† Edmund L. Zalinski,	Absent.
George W. Thacher,	18 Concord Sq.
