TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA,

FOR PROMOTING USEFUL KNOWLEDGE.

VOL. VIII.—NEW SERIES.

PUBLISHED BY THE SOCIETY.

Philadelphia:
PRINTED BY WILLIAM S. YOUNG,—NO. 88, NORTH SIXTH STREET.
1843.

Trans. Amer. Philos. Society.

New series, vol. VIII.

Published in 3 parts, as follows:

Part I, end of 1841, pp. 1-162.
(date on cover "1841", + "laid on the table" at meeting of Jan. 7, 1842.)

Part II, Dec. 1842, pp. 163-250.
("laid on the table" at meeting of Dec. 16.)

Part III, April, 1843, pp. 251-357.
("laid on the table" at meeting of April 21.)

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FROM THE

LAWS OF THE SOCIETY RELATING TO THE TRANSACTIONS.

1. The Transactions shall be published in numbers, at short intervals, under the direction of the Committee of Publication.

2. Every communication to the Society, which may be considered as intended for a place in the Transactions, shall immediately be referred to a committee to consider and report thereon.

3. If the committee shall report in favour of publishing the communication, they shall make such corrections therein, as they may judge necessary to fit it for the press; or if they shall judge the publication of an abstract or extracts from the paper to be most eligible, they shall accompany their report with such abstract or extracts. But if the author do not approve of the corrections, abstract, or extracts, reported by the committee, he shall be at liberty to withdraw his paper.

4. The order in which papers are read before the Society shall determine their places in the Transactions, priority of date giving priority of location.

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Baron Larrey, of Paris.
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John P. Emmet, of the University of Virginia.
William R. Fisher, M. D., of Philadelphia.

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TRANSACTIONS

OF

THE AMERICAN PHILOSOPHICAL SOCIETY.

ARTICLE I.

Contributions to Electricity and Magnetism. By Joseph Henry, LL. D. Professor of Natural Philosophy in the College of New Jersey, Princeton. Read June 19, 1840.

No. IV.—On Electro-Dynamic Induction. (*Continued.*)

INTRODUCTION.

1. In the course of my last paper, it was stated that the investigations which it detailed were not as complete in some parts as I could wish, and that I hoped to develope them more fully in another communication. After considerable delay, occasioned by alterations in the rooms of the physical department of the college, I was enabled to resume my researches, and since then I have been so fortunate as to discover a series of new facts belonging to different parts of the general subject of my contributions. These I have announced to the Society at different times, as they were discovered, and I now purpose to select from the whole such portions as relate particularly to the principal

subject of my last paper, namely, the induction at the beginning and ending of a galvanic current, and to present them as a continuation, and, in a measure, as the completion, of this part of my researches. The other results of my labours in this line will be arranged for publication as soon as my duties will permit me to give them a more careful examination.

2. In the course of the experiments I am about to describe, I have had occasion to repeat and vary those given in my last paper, and I am happy to be able to state, in reference to the results, that, except in some minor particulars, which will be noticed in the course of this paper, I have found no cause to desire a change in the accounts before published. My views, however, of the connexion of the phenomena have been considerably modified, and I think rendered much more definite by the additional light which the new facts have afforded.

3. The principal articles of apparatus used in these experiments are nearly the same as those described in my last paper, namely, several flat coils and a number of long wire helices. (III. 6, 7, 8.*) I have, however, added to these a constant battery, on Professor Daniell's plan, the performance of which has fully answered my expectations, and confirmed the accounts given of this form of the instrument by its author. It consists of thirty elements, formed of as many copper cylinders, open at the bottom, each five inches and a half in height, three inches and a half in diameter, and placed in earthen cups. A zinc rod is suspended in each of these, of the same length as the cylinders, and about one inch in diameter. The several elements are connected by a thick copper wire, soldered to the copper cylinder of one element, and dipping into a cup of mercury on the zinc of the next. The copper and zinc as usual are separated by a membrane, on both sides of which is placed a solution of one part of sulphuric acid in ten parts of water; and to this is added, on the side next the copper, as much sulphate of copper, as will saturate the solution. The battery was sometimes used as a single series, with all its elements placed consecutively, and at others in two or three series, arranged collaterally, so as to vary the quantity and intensity of the electricity as the occasion might require.

4. The galvanometers mentioned in this paper, and referred to in the last, are of two kinds; one, which is used with a helix, to indicate the action of an

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* When the numerals II. or III. are included in the parenthesis, reference is made to the corresponding Nos. of my contributions.

induced current of intensity, consists of about five hundred turns of fine copper wire, covered with cotton thread, and more effectually insulated by steeping the instrument in melted cement, which was drawn into the spaces between the spires by capillary attraction. The other galvanometer is formed of about forty turns of a shorter and thicker wire, and is always used to indicate an induced current, of considerable quantity, but of feeble intensity. The needle of both these instruments is suspended by a single fibre of raw silk.

5. I should also state, that in all cases where a magnetizing spiral is mentioned in connexion with a helix, the article is formed of a long, fine wire, making about one hundred turns around the axis of a hollow piece of straw, of about two inches and a half long: also the spiral mentioned in connexion with a coil, is formed of a short wire, which makes about twenty turns around a similar piece of straw. The reason of the use of the two instruments in these two cases is the same as that for the galvanometers, under similar circumstances, namely, the helix gives a current of intensity, but of small quantity, while the coil produces one of considerable quantity, but of feeble intensity.

SECTION I.

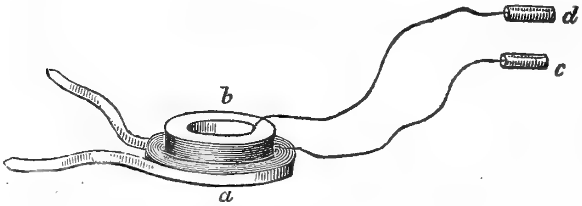
On the Induction produced at the moment of the Beginning of a Galvanic Current, &c.

6. It will be recollected that the arrangement of apparatus employed in my last series of experiments gave a powerful induction at the moment of breaking the galvanic circuit, but the effect at making the same was so feeble as scarcely to be perceptible. I was unable in any case to get indications of currents of the third or fourth orders from the beginning induction, and its action was therefore supposed to be so feeble as not materially to affect the results obtained.

7. Subsequent reflection, however, led me to conclude, that in order to complete this part of my investigations, a more careful study of the induction at the beginning of the current would be desirable, and accordingly, on resuming the experiments, my attention was first directed to the discovery of some means by which the intensity of this induction might be increased. After some preliminary experiments, it appeared probable that the desired result could be obtained by using a compound galvanic battery, instead of the single one before employed. In reference to this conjecture the constant battery before mentioned (3) was constructed, and a series of experiments instituted with it, the results of which agreed with my anticipation.

8. In the first experiment, coil No. 2, which it will be remembered (III. 7) consists of a copper riband of about sixty feet long, and coiled on itself like the main spring of a watch, was connected with the compound battery and helix No. 1, (III. 8,) formed of one thousand six hundred and sixty yards of fine copper wire, and was placed on the coil to receive the induction, as is shown in figure 3, which is again inserted here for the convenience of the reader. This arrangement being made, currents of increasing intensity were passed through the coil by constantly retaining one of its ends in the cup of mercury forming one extremity of the battery, and successively plunging the other end into the cups which served to form the connexions of the several elements of the battery. With the current from one element, the shock at breaking the circuit was quite severe, but at making the same it was very feeble, and could be perceived in the fingers only or through the tongue. With two elements in the circuit, the shock at beginning was slightly increased; with three elements the increase was more decided, while the shock at breaking the circuit remained nearly of the same intensity as at first, or was comparatively but little increased. When the number of elements was increased to *ten*, the shock at making contact was found fully equal to that at breaking, and by employing a still greater number, the former was decidedly greater than the latter, the difference continually increasing until all the thirty elements were introduced into the circuit.

Fig. 3.



a represents coil No. 1, *b* helix No. 1, and *c*, *d*, handles for receiving the shock.

9. In my last paper, a few experiments are mentioned as being made with a compound battery of Cruickshank's construction; but from the smallness of the plates of this, and the rapidity with which its power declined, I was led into the error of supposing that the induction at the ending of the current, in the case of a short coil, was diminished by increasing the intensity of the battery, (see paragraph 19, of No. 3,) but by employing the more perfect instrument of Professor Daniell in the arrangement of the last experiment, I am enabled to correct this error, and to state that the induction at the ending remains nearly the same, when the intensity of the battery is increased. If the induction depends in any degree on the quantity of current electricity in the

conductor, then a slight increase in the induction should take place, since, according to theory, the current is somewhat increased in quantity, in the case of a long coil, by the increase of the intensity of the battery. Although very little, if any, difference could be observed in the intensity of the shock from the secondary current, yet the snap and deflagration of the murcury appeared to be greater from the primary current, when *ten* elements of the battery were included in the circuit, than with a single one. The other results which are mentioned in my last paper in reference to the compound battery are, I believe, correctly given.

10. The intensity of the different shocks in the foregoing experiments was compared by gradually raising the helix from the coil, (see Fig. 3,) until, on account of the distance of the conductors, the shock in one case would be so much reduced as to be scarcely perceptible through the fingers or the tongue, while the shock from another arrangement, but with the same distance of the conductors, would be evident, perhaps, in the hands. The same method was generally employed in the experiments in which shocks are mentioned as being compared, in the other parts of this paper.

11. Experiments were next made to determine the influence of a variation in the length of the coil, the intensity of the battery remaining the same. For this purpose, the battery consisting of a single element, and the arrangement of the apparatus as represented in Fig. 3, the coil was diminished in length from sixty feet to forty-five, then to thirty, and so on. With the first mentioned length the shock, at making contact with the battery, was, of course, very feeble, and could be felt only in the tongue; with the next shorter length it was more perceptible, and increased in intensity with each diminution of the coil, until a length of about fifteen feet appeared to give a maximum result.

12. The diminution of the intensity of the shock in the last experiment, after the length of the coil was diminished below fifteen feet, was due to the diminution of the number of spires of the coil, each of which, by acting on the helix, tends to increase the intensity of the secondary current, unless the combined length of the whole is too great for the intensity of the battery. That this is the fact is shown by the following experiment: the helix was placed on a single spire or turn of the coil, and the length of the other part of the copper riband, which did not act on the helix, was continually shortened, until the whole of it was excluded from the circuit; in this case the intensity of the shock at the

beginning was constantly increased. We may therefore state generally, that, at the beginning of the battery current, the induction of a unit of its length is increased by every diminution of the length of the conductor.

13. In the experiment given in paragraph 11, the intensity of the shock at the *ending* of the battery current diminishes with each diminution of the length of the coil; and this is also due to the decrease of the number of the spires of the coil, as is evident from an experiment similar to the last, in which the helix was placed on a coil consisting of only two turns or spires of copper riband; the shock at the ending, with this arrangement, was comparatively feeble, but could be felt in the hands. Different lengths of coil No. 2 were now introduced into the same circuit, but not so as to act on the helix; but although these were varied from four or five feet to the whole length of the coil, (sixty feet,) not the least difference in the intensity of the shock could be perceived. We have, therefore, the remarkable result, that the intensity of the ending induction of each unit of length of the battery current is not materially altered, at least within certain limits, by changing the length of the whole conductor. From this we would infer that the shock depends more on the intensity of the action than on the quantity of the current, since we know that the latter is diminished in a given unit of the conductor by increasing the length of the whole.

14. We have seen (8) that with a circuit composed of ten elements of the compound battery and the coil No. 2, the shock, at the beginning of the current, was fully equal to that at the ending. It was, however, found that if, in this case, the length of the coil was increased, this shock was diminished; and we may state, as an inference from several experiments, that however great may be the intensity of the electricity from the battery, the shock at the beginning may be rendered scarcely perceptible by a sufficient increase of the length of the primary circuit.

15. It was also found that when the thickness of the coil was increased, the length and intensity of the circuit remaining the same, the shock at the beginning of the battery current was somewhat increased. This result was produced by using a double coil; the electricity was made to pass through one strand, and immediately afterwards through both: the shock from the helix in the latter case was apparently the greater.

16. By the foregoing results we are evidently furnished with two methods

of increasing, at pleasure, the intensity of the induction at the beginning of a battery current, the one consisting in increasing the intensity of the source of the electricity, and the other in diminishing the resistance to conduction of the circuit while its intensity remains the same.

17. The explanation of the effects which we have given, relative to the induction at the beginning, is apparently not difficult. The resistance to conduction in the case of a long conductor and a battery of a single element is so great that the full development of the primary current may be supposed not to take place with sufficient rapidity to produce the instantaneous action on which the shock from the secondary current would seem to depend. But when a battery of a number of elements is employed, the poles of this, previous to the moment of completing the circuit, are in a state of electrical tension; and therefore the discharge through the conductor may be supposed to be more sudden, and hence an induction of more intensity is produced.

18. That the shock at both making and breaking the circuit in some way depends on the rapidity of formation and diminution of the current is shown by the following experiment, in which the tension just mentioned does not take place, and in which, also, the current appears to diminish more slowly. The two ends of the coil were placed in the two cups which formed the poles of the battery, and permanently retained there during the experiment; also, at the distance of about six inches from, say the right hand end of the coil, a loop was made in the riband, which could be plunged into the cup containing the left hand end. With this arrangement, and while only the two extreme ends of the coil were in connexion with the cups of mercury, of course the current passed through the entire length of the riband of the coil, but by plunging the loop into the left hand cup, the whole length of the coil, except the six inches before mentioned, was excluded from the battery circuit. And again, when the loop was lifted out of the cup, the whole length was included. In this way the current in the coil could be suddenly formed and interrupted, while the poles of the battery were continually joined by a conductor, but no shock with either a single or a compound battery could be obtained by this method of operation.

19. The feebleness of the shock at the beginning of the current, with a single battery and a long coil, is not entirely owing to the cause we have stated, (17,) namely, the resistance to conduction offered by the long conductor, but

also depends, in a considerable degree, if not principally, on the adverse influence of the secondary current, induced in the primary conductor itself, as is shown by the result of the following experiment. Helix No. 1 was placed on a coil consisting of only three spires or turns of copper riband; with this, the shock both at making and breaking the circuit with a single battery could be felt in the hands. A compound coil was then formed of the copper ribands of coils No. 3 and 4 rolled together so that the several spires of the two alternated with each other, and when this was introduced into the circuit so as not to act on the helix by its induction, and the battery current passed through, for example, coil No. 3, the shock at making contact with the pole of the battery was so much reduced as to be imperceptible in the hands, while the shock at breaking the contact was about the same as before this addition was made to the length of the circuit. The ends of coil No. 4 were now joined so as to produce a closed circuit, the induced current in which would neutralize the secondary current in the battery conductor itself; and now the shock at making the contact was nearly as powerful as in the case where the short conductor alone formed the circuit with the battery. Hence, the principal cause of the feebleness of the effect at the beginning of the battery current is the adverse action on the helix of the secondary current produced in the conductor of the battery circuit itself. The shock at the breaking of the circuit, in this experiment, did not appear affected by joining or separating the ends of coil No. 4.

20. Having investigated the conditions on which the inductive action at the beginning of a battery current depends, experiments were next instituted to determine the nature of the effects produced by this induction: and first the coils were arranged in the manner described in my last paper, (III. 79,) for producing currents of the different orders. The result with this was similar to that which I have described in reference to the ending induction, namely, currents of the third, fourth, and fifth orders were readily obtained.

21. Also, when an arrangement of apparatus was made similar to that described in paragraph 87 of my last paper, it was found that a current of intensity could be induced from one of quantity and the converse.

22. Likewise, the same screening or rather neutralizing effect was produced, when a plate of metal was interposed between two consecutive conductors of the series of currents, as was described (III. section IV.) in reference to the ending induction. In short, the series of induced currents produced at the be-

ginning of the primary current appeared to possess all the properties belonging to those of the induction at the ending of the same current.

23. I may mention, in this place, that I have found, in the course of these experiments, that the neutralizing power of a plate of metal depends, in some measure, on its superficial extent. Thus a broad plate which extends, in every direction, beyond the helix and coil, produces a more perfect screening than one of the same metal and of the same thickness, but of a diameter only a little greater than that of the coil.

24. The next step in the investigation was to determine the direction of the currents of the different orders produced by the beginning induction, and for this purpose the magnetizing spirals (5) were used, and the results obtained by these verified by the indications of the galvanometer. It should be stated here, as a fact which was afterward found of some importance, that although the needle of the galvanometer was powerfully deflected when the instrument was placed in the circuit of the secondary current, yet a very feeble effect was produced on it by the action of a current of the third, fourth, or fifth order. The directions, however, of these currents, as indicated by the feeble motion of the needle, were the same as those given by the magnetizing spiral.

25. The direction of the different currents produced at the making of the battery current, as determined by these instruments, is as follows, namely: the direction of the secondary current is, as stated by Dr. Faraday, adverse to that of the primary current, and, also, the direction of each succeeding current is opposite to that of the one which produced it. We have, therefore, from these results, and those formerly obtained, (III. 92,) the following series of directions of currents, one produced at the moment of beginning, and the other at that of ending of the battery current.

	At the Beginning.	At the Ending.
Primary current,	+	+
Secondary current,	—	+
Current of the third order,	+	—
Current of the fourth order,	—	+
Current of the fifth order,	+	—

26. These two series, at first sight, may appear very different, but, with a little attention, they will be seen to be of the same nature. If we allow that

the induction at the ending of a galvanic battery should be opposite to that at the beginning of the same, then the sign at the top of the second column may be called minus instead of plus, and we shall have the second series — + — + alternating precisely like the first.

27. In connexion with the results given in the last two paragraphs, it is due to Mr. Sturgeon that I should state that, in a letter addressed to me, and published in the Annals of Electricity, he has predicted, from his theory, that I would find, on examination, the series of alternation of currents for the beginning induction which I have here given. I may, however, add, that it appears to me that this result might have been predicted without reference to any theory. There was no reason to suppose the induction at the beginning would be different in its nature from that at the ending, and therefore the series which would be produced from the former might be immediately inferred from that belonging to the latter, by recollecting that the direction of the induction at the beginning should be opposite to that at the ending. I do not wish it to be supposed, however, from this remark, that I had, myself, drawn any inference from my experiments as to the alternations of currents which might be produced by the beginning induction; the truth is, that this action was so feeble with the arrangement of apparatus I employed, that I supposed it could not produce a series of currents of the different orders.

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28. In the course of the experiments given in this section, I have found that a shock can be produced without using a coil, by arranging about ten elements of the battery in the form of a circle, and placing the helix within this. The shock was felt in the hands at the moment of closing the circuit, but the effect at opening the same was scarcely perceptible through the tongue. An attempt was also made to get indications of induction by placing the helix within a circle of dilute acid, connected with a battery instead of a coil, but the effect, if any, was very feeble.

29. I have shown, in the second number of my contributions, that if the body be introduced into a circuit with a battery of one hundred and twenty elements, without a coil, a thrilling sensation will be felt during the continu-

ance of the current, and a shock will be experienced at the moment of interrupting the current by breaking the circuit at any point. This result is evidently due to the induction of a secondary current in the battery itself, and on this principle the remarkable physiological effects produced by Dr. Ure, on the body of a malefactor, may be explained. The body, in these experiments, was made to form a part of the circuit, with a compound galvanic apparatus in which a series of interruptions was rapidly made by drawing the end of a conductor over the edges of the plates of the battery. By this operation a series of induced currents must have been produced in the battery itself, the intensity of which would be greater than that of the primary current.

30. In this connexion I may mention that the idea has occurred to me that the intense shocks given by the electrical fish may possibly be from a secondary current, and that the great amount of nervous organization found in these animals may serve the purpose of a long conductor.* It appears to me, that in the present state of knowledge, this is the only way in which we can conceive of such intense electricity being produced in organs imperfectly insulated and immersed in a conducting medium. But we have seen that an original current of feeble intensity can induce, in a long wire, a secondary current capable of giving intense shocks, although the several strands of the wire are separated from each other only by a covering of cotton thread. Whatever may be the worth of this suggestion, on which I place but little value, the secondary current affords the means of imitating the phenomena of the shock from the electrical eel, as described by Dr. Faraday. By immersing the apparatus (Fig. 3) in a shallow vessel of water, the handles being placed at the two extremities of the diameter of the helix, and the hands plunged into the water parallel to a line joining the two poles, a shock is felt through the arms; but when the contact with the water is made in a line at right angles to the last, only a slight sensation is felt in each hand, but no shock.

31. Since the publication of my last paper, I have exhibited to my class the experiment (No. III. Sec. 3d) relative to the induction at a distance on a much larger scale. All my coils were united so as to form a single length of conductor of about four hundred feet, and this was rolled into a ring of five and a half feet in diameter, and suspended vertically against the inside of the large folding

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* Since writing the above, I have found that M. Masson has suggested the same idea, in an interesting thesis lately published.

doors which separate the laboratory from the lecture room. On the other side of the doors, in the lecture room, and directly opposite the coil, was placed a helix, formed of upwards of a mile of copper wire, one sixteenth of an inch in thickness, and wound into a hoop of four feet in diameter. With this arrangement, and a battery of one hundred and forty-seven square feet of zinc surface divided into eight elements, shocks were perceptible in the tongue, when the two conductors were separated, to the distance of nearly seven feet; at the distance of between three and four feet, the shocks were quite severe. The exhibition was rendered more interesting by causing the induction to take place through a number of persons standing in a row between the two conductors.

SECTION II.

On apparently two kinds of Electro-dynamic Induction.

32. The investigations arranged under this head had their origin in the following circumstances. After the publication of my last paper, I received, through the kindness of Dr. Faraday, a copy of the fourteenth series of his researches, and in this I was surprised to find a statement which appeared in direct opposition to one of the principal facts of my communication. In paragraph 59, I state, in substance, that when a plate of metal is interposed between the coil transmitting a galvanic current, and the helix placed above it to receive the induction, the shock from the secondary current is almost perfectly neutralized. Dr. Faraday, in the extension of his new and ingenious views of the agency of the intermediate particles in transmitting induction, was led to make an experiment on the same point, and apparently, under the same circumstances, he found that it "makes not the least difference, whether the intervening space between the two conductors is occupied by such insulating bodies as air, sulphur, and shell-lac, or such conducting bodies as copper and other non-magnetic metals."

33. As the investigation of the fact mentioned above forms an important part of my paper, and is intimately connected with almost all the phenomena subsequently described in the communication, I was, of course, anxious to discover the cause of remarkable a discrepancy. There could be no doubt of the truth of my results, since a shock from a secondary current which would paralyze the arms was so much reduced by the interposition of plates of metal as scarcely to be felt through the tongue.

34. After some reflection, however, the thought occurred to me that induction

might be produced in such a way as not to be affected by the interposition of a plate of metal. To understand this, suppose the end of a magnetic bar placed perpendicularly under the middle of a plate of copper, and a helix suddenly brought down on this; an induced current would be produced in the helix by its motion towards the plate, since the copper, in this case, could not screen the magnetic influence. Now, if we substitute for the magnet a coil through which a galvanic current is passing, the effect should be the same. The experiment was tried by attaching the ends of the helix to a galvanometer,* and the result was, as I expected: when the coil was suddenly brought down on the plate the needle swung in one direction and when lifted up, in the other; the amount of deflection being the same, whether the plate was interposed or not.

35. It must be observed in this experiment, that the plate was at rest, and consequently did not partake of the induction produced by the motion of the helix. From my previous investigations, I was led to conclude that a different result would follow, were a current also generated in the plate by simultaneously moving it up and down with the helix. This conclusion, however, was not correct, for on making the experiment, I found that the needle was just as much affected when the plate was put in motion with the helix as when the latter alone was moved.

36. This result was so unexpected and remarkable, that it was considered necessary to repeat and vary the experiment in several ways. First, a coil was interposed instead of the plate, but whether the coil was at rest or in motion with the helix, with its ends separated or joined, the effect on the galvanometer was still the same; not the least screening influence could be observed. In reference to the use of the coil in this experiment, it will be recollected that I have found this article to produce more perfect neutralization than a plate.

37. Next, the apparatus remaining the same, and the helix at rest during the experiment, currents were induced in it by moving the battery attached to the coil up and down in the acid. But in this case, as in the others, the effect on the galvanometer was the same, whether the plate or the coil was interposed or not.

38. The experiment was also tried with magneto-electricity. For this purpose, about forty feet of copper wire, covered with silk, were wound around a

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* The arrangement will be readily understood by supposing in Fig. 3, the handles removed, and the ends of the helix joined to the ends of the wire of a galvanometer; also, by a plate of metal interposed between the helix and the coil.

short cylinder of stiff paper, and into this was inserted a hollow cylinder of sheet copper, and into this again, a short rod of soft iron; when the latter was rendered magnetic, by suddenly bringing in contact with its two ends the different poles of two magnets, a current, of course, was generated in the wire, and this, as before, was found to affect the galvanometer to the same degree, when the copper cylinder was interposed, as when nothing but the paper intervened.

39. The last experiment was also varied by wrapping two copper wires of equal length around the middle of the keeper of a horse-shoe magnet, leaving the ends of the inner one projecting, and those of the outer attached to a galvanometer. A current was generated in each by moving the keeper on the ends of the magnet, but the effect on the galvanometer was not in the least diminished by joining the ends of the inner wire.

40. At first sight, it might appear that all these results are at variance with those detailed in my last paper, relative to the effect of interposed coils and plates of metal. But it will be observed that in all the experiments just given, the induced currents are not the same as those described in my last communication. They are all produced by motion, and have an appreciable duration, which continues as long as the motion exists. They are also of low intensity, and thus far I have not been able to get shocks by any arrangement of apparatus from currents of this kind. On the other hand, the currents produced at the moment of *suddenly* making or breaking a galvanic current, are of considerable intensity, and exist but for an instant. From these, and other facts presently to be mentioned, I was led to suppose that there are two kinds of electro-dynamic induction; one of which can be neutralized by the interposition of a metallic plate between the conductors and the other not.

41. In reference to this surmise, it became important to examine again all the phenomena of induction at suddenly making and breaking a galvanic current. And in connexion with this part of the subject, I will first mention a fact which was observed in the course of the experiments given in the last section, on the direction of the induced currents of different orders. It was found that though the indications of the galvanometer were the same as those of the spiral, in reference to the direction of the induced currents, yet they were very different in regard to the intensity of the action. Thus, when the arrangement of the apparatus was such that the induction at making the battery circuit was so feeble as not to give the least magnetism to the needle, and so powerful

at the ending as to magnetize it to saturation, the indication of the galvanometer was the same in both cases.

42. Also, similar results were obtained in comparing the shock and the deflection of the galvanometer. In one experiment, for example, the shock was so feeble at making contact that it could scarcely be perceived in the fingers, but so powerful at the breaking of the circuit as to be felt in the breast; yet the galvanometer was deflected about thirty-five degrees to the right, at the beginning of the current, and only an equal number of degrees to the left, at the ending of the same.

43. In another experiment, the apparatus being the same as before, the magnetizing spiral and the galvanometer were both at once introduced into the circuit of the helix. A sewing needle being placed in the spiral, and the contact with the battery made, the needle showed no signs of magnetism, although the galvanometer was deflected thirty degrees. The needle being replaced, and the battery circuit broken, it was now found strongly magnetized, while the galvanometer was only moved about as much as before in the opposite direction.

44. Also, effects similar to those described in the last two paragraphs were produced when the apparatus was so arranged as to cause the induction at the beginning of the battery current to predominate. In this case the galvanometer was still nearly equally affected at making and breaking battery contact, or any difference which was observed could be referred to a variation in the power of the battery during the experiment.

45. Another fact of importance belonging to the same class has been mentioned before, (24,) namely, that the actions of the currents of the third, fourth, and fifth orders produced a very small effect on the galvanometer, compared with that of the secondary current; and this is not alone on account of the diminishing power of the successive inductions, as will be evident from the following experiment. By raising the helix from the coil, in the arrangement of apparatus for the secondary current, the shock was so diminished as to be inferior to one produced by the arrangement for a tertiary current, yet, while with the secondary current the needle was deflected twenty-five degrees, with the tertiary it scarcely moved more than one degree; and with the currents of the fourth and fifth orders the deflections were still less, resembling the effect of a slight impulse given to the end of the needle.

46. With the light obtained from the foregoing experiments, I was led to

suppose that some new and interesting results might be obtained by a re-examination of my former experiments, on the phenomena of the interposed plate of metal, in the case where the induction was produced by making and breaking the circuit with a cup of mercury; and in this I was not disappointed. The coil (Fig. 3) being connected with a battery of ten elements, the shocks, both at making and breaking the circuit, were very severe; and these, as usual, were almost entirely neutralized by the interposition of the zinc plate. But when the galvanometer was introduced into the circuit instead of the body, its indications were the same whether the plate was interposed or not; or, in other words, the galvanometer indicated no screening, while, under the same circumstances, the shocks were neutralized.

47. A similar effect was observed when the galvanometer and the magnetizing spiral were together introduced into the circuit. The interposition of the plate entirely neutralized the magnetizing power of the spiral, in reference to tempered steel, while the deflections of the galvanometer were unaffected.

48. In order to increase the number of facts belonging to this class, the last experiments were varied in several ways; and first, instead of the hard steel needle, one of soft iron wire was placed in the spiral, with a small quantity of iron filings almost in contact with one of its ends. The plate being interposed, the small particles of iron were attracted by the end of the needle, indicating a feeble, temporary development of magnetism. Hence the current which moves the needle, and is not neutralized by the interposed plate, also feebly magnetizes soft iron, but not hard steel.

49. Again, the arrangement of apparatus being as in paragraph 46, instead of a plate of zinc, one of cast iron, of about the same superficial dimensions, but nearly half an inch thick, was interposed; with this the magnetizing power of the spiral, in reference to tempered steel, was neutralized; and, also, the action of the galvanometer was much diminished.

50. Another result was obtained by placing in the circuit of the helix, (Fig. 3d,) at the same time, the galvanometer, the spiral, and a drop of distilled water; with these the magnetizing power of the spiral was the same as without the water, but the deflection of the galvanometer was reduced from ten to about four degrees. In addition to these, the body was also introduced into the same circuit; the shocks were found very severe, the spiral magnetized needles strongly, but the galvanometer was still less moved than before. The current of low intensity, which deflects the needle of the galvanometer in

these instances was partially intercepted by the imperfect conduction of the water and the body.

51. To exhibit the results of these experiments with still more precision, an arrangement of apparatus was adopted similar to that used by Dr. Faraday, and described in the fourteenth series of his researches, namely, a double galvanometer was formed of two separate wires of equal length and thickness, and wound together on the same frame; and, also, a double magnetizing spiral was prepared by winding two equal wires around the same piece of hollow straw. Coil No. 1, connected with the battery, was supported perpendicularly on a table, and coils Nos. 3 and 4 were placed parallel to this, one on each side, to receive the induction, the ends of these being so joined with those of the galvanometer and the spiral that the induced current from the one coil would pass through the two instruments, in an opposite direction to that of the current from the other coil. The two outside coils were then so adjusted, by moving them to and from the middle coil, that the induced currents perfectly neutralized each other in the two instruments, and the needle of the galvanometer and that in the spiral were both unaffected when the circuit of the battery was made and broken. With this delicate arrangement the slightest difference in the action of the two currents would be rendered perceptible; but when a zinc plate was introduced so as to screen one of the coils, the needle of the galvanometer still remained perfectly stationary, indicating not the least action of the plate, while the needle in the spiral became powerfully magnetic. When, however, a plate of iron was interposed instead of the one of zinc, the needle of the galvanometer was also affected.

52. From the foregoing results it would seem that the secondary current, produced at the moment of suddenly beginning or ending of a galvanic current, by making and breaking contact with a cup of mercury, consists of two parts, which possess different properties. One of these is of low intensity, can be interrupted by a drop of water, does not magnetize hardened steel needles, and is not screened by the interposition of a plate of any metal, except iron, between the conductors. The other part is of considerable intensity, is not intercepted by a drop of water, develops the magnetism of hardened steel, gives shocks, and is screened or neutralized by a closed coil, or a plate of any kind of metal. Also, the induced current produced by moving a conductor towards

or from a battery current, and that produced by the movement up and down of a battery in the acid, are of the nature of the first mentioned part, while the currents of the third, fourth, and fifth orders partake almost exclusively of the properties of the second part.

53. The principal facts and conclusions of this section were announced to the Society in October, 1839, and again presented in the form in which they are here detailed in June last. Since then, however, I have had leisure to examine the subject more attentively, and after a careful comparison of these results with those before given, I have obtained the more definite views of the phenomena which are given in the next section.

SECTION III.

Theoretical Considerations relating to the Phenomena described in this and the preceding Communications. Read November 20, 1840.

54. The experiments given in the last No. of my contributions were merely arranged under different heads, and only such inferences drawn from them as could be immediately deduced without reference to a general explanation. The addition, however, which I have since made to the number of facts, affords the means of a wider generalization; and after an attentive consideration of all the results given in this and the preceding papers, I have come to the conclusion that they can all be referred to the simple laws of the induction at the beginning and the ending of a galvanic current.

55. In the course of these investigations the limited hypotheses which I have adopted have been continually modified by the development of new facts, and therefore my present views, with the farther extension of the subject, may also require important corrections. But I am induced to believe, from its exact accordance with all the facts, so far as they have been compared, that if the explanation I now venture to give be not absolutely true, it is so, at least, in approximation, and will therefore be of some importance in the way of suggesting

new forms of experiment, or as a first step towards a more perfect generalization.

56. To render the laws of induction at the beginning and the ending of a galvanic current more readily applicable to the explanation of the phenomena, they may be stated as follows:—1. During the time a galvanic current is increasing in quantity in a conductor, it induces, or tends to induce, a current in an adjoining parallel conductor in an opposite direction to itself. 2. During the continuance of the primary current in full quantity, no inductive action is exerted. 3. But when the same current begins to decline in quantity, and during the whole time of its diminishing, an induced current is produced in an opposite direction to the induced current at the beginning of the primary current.

57. In addition to these laws, I must frequently refer to the fact, that *when the same quantity of electricity in a current of short duration is passed through a galvanometer, the deflecting force on the needle is the same, whatever be the intensity of the electricity.* By intensity is here understood the numerical ratio of a given quantity of force to the time in which it is expended; and according to this view, the proposition stated is an evident inference from dynamic principles. But it does not rest alone on considerations of this kind, since it has been proved experimentally by Dr. Faraday, in the third series of his researches.

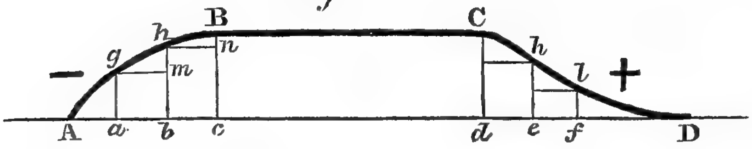
58. In order to form a definite conception of the several conditions of the complex phenomena which we are about to investigate, I have adopted the method often employed in physical inquiries, of representing the varying elements of action by the different parts of a curve. This artifice has been of much assistance to me in studying the subject, and without the use of it at present, I could scarcely hope to present my views in an intelligible manner to the Society.

59. After making these preliminary statements, we will now proceed to consider the several phenomena; and, first, let us take the case in which the induction is most obviously produced in accordance with the laws as above stated, (56,) namely, by immersing a battery into the acid, and also by withdrawing it from the same. During the time of the descent of the battery into the liquid, the conductor connected with it is constantly receiving additional quantities of current electricity, and each of these additions produces an induc-

tive action on the adjoining secondary conductor. The amount, therefore, of induced current produced during any moment of time will be just in proportion to the corresponding increase in the current of the battery during the same moment. Also, the amount of induction during any moment while the current of the battery is diminishing in quantity will be in proportion to the decrease during the same moment.

60. The several conditions of this experiment may be represented by the different parts of the curve, A, B, C, D, Fig. 17, in which the distances, A a, A b, A c, represent the times during which the battery is descending to different depths into the acid; and the corresponding ordinates, a g, b h, c B, represent the amount of current electricity in the battery conductor corresponding to these times. The differences of the ordinates, namely, a g, m h, n B, express the increase in the quantity of the battery current during the corresponding moments of time represented by A a, a b, b c; and since the inductive actions (59) are just in proportion to these increases, the same differences will also represent the amount of induced action exerted on the secondary conductor during the same moment of time.

Fig. 17



61. When the battery is fully immersed in the acid, or when the current in the conductor has reached its state of maximum quantity, and during the time of its remaining constant, no induction is exerted; and this condition is expressed by the constant ordinates of the part of the curve B C, parallel to the axis. Also, the inductive action produced by each diminution of the battery current, while the apparatus is in the progress of being drawn from the acid, will, in a like manner, be represented by the differences of the ordinates at the other end, C D, of the curve.

62. The sum of the several increasements of the battery current, up to its full development, will be expressed by the ordinate c B, and this will, therefore, also represent the whole amount of inductive action exerted in one direction at the beginning of the primary current; and, for the same reason, the

equal ordinate, *Cd,* will represent the whole induction in the other direction at the ending of the same current. Also, the whole time of continuance of the inductive action at the beginning and ending will be represented by A*c* and *d*D.

63. If we suppose the battery to be plunged into the acid to the same depth, but more rapidly than before, then the time represented by A*c* will be diminished, while the whole amount of inductive force expended remains the same; hence, since the same quantity of force is exerted in a less time, a greater intensity of action will be produced, (57,) and consequently a current of more intensity, but of less duration, will be generated in the secondary conductor. The relative intensity of the induced currents will, therefore, evidently be expressed by the ratio of the ordinate *c*B to the abscissa A*c*. Or, in more general and definite terms, the intensity of the inductive action at any moment of time will be represented by the ratio of the rate of increase of the ordinate to that of the abscissa for that moment.*

64. It is evident from the last paragraph, that the greater or less intensity of the inductive action will be immediately presented to the eye, by the greater or less obliquity of the several parts of the curve to the axis. Thus, if the battery be suddenly plunged into the acid for a short distance, and then gradually immersed through the remainder of the depth, the varying action will be exhibited at once by the form of AB, the first part of the curve, Fig. 17. The steepness of the part A*g* will indicate an intense action for a short time A*a*, while the part *g*B denotes a more feeble induction during the time represented by *ac*. In the same way, by drawing up the battery suddenly at first, and afterwards slowly, we may produce an inductive action such as would be represented by the parts between C and D of the ending of the curve.

65. Having thus obtained representations of the different elements of action, we are now prepared to apply these to the phenomena. And, first, however varied may be the intensity of the induction expressed by the different parts of the two ends of the curve, we may immediately infer that a galvanometer,

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* According to the differential notation, the intensity will be expressed by $\frac{dy}{dx}$. In some cases the effect may be proportional to the intensity multiplied by the quantity, and this will be expressed by $\frac{dy^2}{dx}$, x and y representing, as usual, the variable abscissa and ordinate.

placed in the circuit of the secondary conductor, will be equally affected at the beginning and ending of the primary current; for, since the deflection of this instrument is due to the whole amount of a current, whatever may be its intensity, (57,) and since the ordinates cB and Cd are equal, which represent the quantity of induction in the two directions, and, consequently, the amount of the secondary current, therefore the deflection at the beginning and ending of the battery current will, in all cases, be equal. This inference is in strict accordance with the results of experiment; for, however rapidly or slowly we may plunge the battery into the acid, and however irregular may be the rate at which it is drawn out, still, if the whole effect be produced within the time of one swing of the needle, the galvanometer is deflected to an equal degree.

66. Again, the intensity of one part of the inductive action, for example that represented by Ag, may be supposed to be so great as to produce a secondary current capable of penetrating the body, and of thus producing a shock* while the other parts of the action, represented by gB and CD, are so feeble as to affect the galvanometer only. We would then have a result the same as one of those given in the last section, (42,) and which was supposed to be produced by two kinds of induction; for if the shock were referred to as the test of the existence of an induced current, one would be found at the beginning only of the battery current, while, if the galvanometer were consulted, we would perceive the effects of a current as powerful at the ending as at the beginning.

67. The results mentioned in the last paragraph cannot be obtained by plunging a battery into the acid; the formation of the current in this way is not sufficiently rapid to produce a shock. The example was given to illustrate the manner in which the same effect is supposed to be produced, in the case of the more sudden formation of a current, by plunging one end of the conductor into a cup of mercury permanently attached to a battery already in the acid, and in full operation. The current, in this case, rapid as may be its development, cannot be supposed to assume *per saltum* its maximum state of quantity; on the contrary, from the general law of continuity we would infer, that it passes through all the intermediate states of quantity, from that of no current, if the expression may be allowed, to one of full development; there are, however, considerations of an experimental nature which would lead us

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* The shock depends more on the intensity than on the quantity. See paragraph 13.

to the same conclusion, (18,) (90,) and also to the farther inference that the *decline* of the current is not instantaneous. According to this view, therefore, the inductive actions at the beginning and the ending of a primary current, of which the formation and interruption is effected by means of the contact with a cup of mercury, may also be represented by the several parts of the curve, Fig. 17.

68. We have now to consider how the rate of increase or diminution of the current, in the case in question, can be altered by a change in the different parts of the apparatus; and, first, let us take the example of a single battery and a short conductor, making only one or two turns around the helix; with this arrangement a feeble shock, as we have seen, (11,) will be felt at the making, and also at the breaking of the circuit. In this case it would seem that almost the only impediment to the most rapid development of the current would be the resistance to conduction of the metal; and this we might suppose would be more rapidly overcome by increasing the tension of the electricity; and, accordingly, we find that if the number of elements of the battery be increased, the shock at making the circuit will also be increased, while that at breaking the circuit will remain nearly the same. To explain, however, this effect more minutely, we must call to mind the fact before referred to, (17,) that when the poles of a compound battery are not connected, the apparatus acquires an accumulation of electricity, which is discharged at the first moment of contact, and which, in this case, would more rapidly develope the full current, and hence produce the more intense action on the helix at making the circuit.

69. The shock, and also the deflection of the needle, at breaking the circuit with a compound battery and a short coil, (9,) appears nearly the same as with a battery of a single element, because the accumulation just mentioned, in the compound battery, is discharged almost instantly, and, according to the theory (71) of the galvanic current, leaves the constant current in the conductor nearly in the same state of quantity as that which would be produced by a battery of a single element; and hence the conditions of the ending of the current are the same in both cases. Indeed, in reference to the ending induction, it may be assumed as a fact which is in accordance with all the experiments, (9, 13, 73, 74, 75, 76, &c.,) as well as with theoretical considerations,* *that when the cir-*

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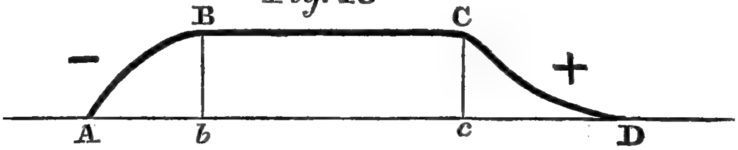
* See the theory of Ohm.

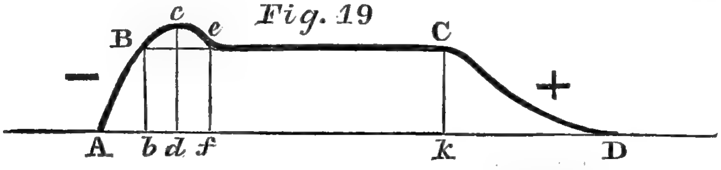
cuit is broken by a cup of mercury, the rate of the diminution of the current, within certain limits, remains the same, however the intensity of the electricity or the length of the conductor may be varied.

Fig. 18



70. The several conditions of the foregoing examples are exhibited by the parts of the curves, Figs. 18 and 19. The gradual development of the current in the short conductor, with a single battery, and the gradual decline of the same, are represented by the gentle rise of AB and fall of CD, Fig. 18; while, in the next Fig., (19,) the sudden rise of AB indicates the intensity which produces the increased shock, after the number of elements of the battery has been increased. The accumulation of the electricity, which almost instantly subsides, is represented by the part B*ce*, Fig. 19, and from this we see, at once, that although the shock is increased by using the compound battery, yet the needle of the galvanometer will be deflected only to the same number of degrees, since the parts B*c* and *ce* give inductive actions in contrary directions, and both within the time of a single swing of the needle, and, consequently, will neutralize each other. The resulting deflecting force will, therefore, be represented by *ef*, which is equal to C*k*, or to *b*B, in Fig. 18.

Fig. 19



The intensity of the shock at the breaking is represented as being the same in the two figures, by the similarity of the rate of descent of the part CD of the curve in each.

71. We have said (69) that the quantity of current electricity in a short conductor and a compound battery, after the first discharge, is nearly the same as with a single battery. The exact quantity, according to the theory of Ohm, in a unit of length of the conductor is given by the formula

$$\frac{n\,A}{r n + R}.$$

In this, n represents the number of elements; A, the electromotive force of one element; r, the resistance to conduction of one element; and R, the length of the conductor, or rather its resistance to conduction in terms of r. Now, when R is very small, in reference to rn, as is the case with a very short metallic conductor, it may be neglected, and then the expression becomes

$$\frac{nA}{rn} \text{ or } \frac{A}{r};$$

and since this expresses the quantity of current electricity in a unit of the length of the circuit, with either a single or a compound battery, therefore, with a short conductor, the quantity of current electricity in the two cases is nearly the same.

72. Let us next return to the experiment with a battery of a single element, (68,) and instead of increasing the intensity of the apparatus, as in the last example, let the length of the conductor be increased; then the intensity of the shock at the beginning of the current, as we have seen, (14,) will be diminished, while that of the one at the ending will be increased. That the shock should be lessened at the beginning, by increasing the length of the conductor, is not surprising, since, as we might suppose, the increased resistance to conduction would diminish the rapidity of the development of the current. But the secondary current, which is produced in the conductor of the primary current itself, as we have seen, (19,) is the principal cause which lessens the intensity of the shock; and the effect of this, as will be shown hereafter, may also be inferred from the principles we have adopted.

73. The explanation of the increased shock at the moment of breaking the circuit with the long conductor, rests on the assumption before mentioned, (69,) that the velocity of the diminution of a current is nearly the same in the case of a long conductor as in that of a short one. But, to understand the application of this principle more minutely, we must refer to the changes which take place in the quantity of the current in the conductor by varying its length; and this will be given by another application of the formula before stated, (71.) This, in the case of a single battery, in which n equals unity, becomes

$$\frac{A}{r + R};$$

and since this, as will be recollected, represents the quantity of current electricity in a unit of length of the conductor, we readily infer from it that, by increasing the length of the conductor, or the value of R, the quantity of current in a unit of the length is lessened. And if the resistance of a unit of the length of the conductor were very great in comparison with that of r, (the resistance of one element of the battery,) then the formula would become

$$\frac{A}{R},$$

or the quantity in a single unit of the conductor would be inversely as its entire length, and hence the amount of current electricity in the whole conductor would be a constant quantity, whatever might be its length. This, however, can never be the case in any of our experiments, since in no instance is the resistance of R very great in reference to r, and therefore, according to the formula, (73,) the whole quantity of current electricity in a long conductor is always somewhat greater than in a short one.

74. Let us, however, in order to simplify the conditions of the induction at the ending of a current, suppose that the quantity in a unit of the conductor is inversely as its whole length, or, in other words, that the quantity of current electricity is the same in a long conductor as in a short one; and let us also suppose, for an example, that the length of the spiral conductor, Fig. 3, was increased from one spire to twenty spires; then, if the velocity of the diminution of the section of the current is the same (69) in the long conductor as in the short one, the shock which would be received by submitting the helix to the action of one spire of the long coil would be nearly of the same intensity as that from one spire of the short conductor; the quantity of induction, however, as shown by the galvanometer, should be nearly twenty times less; and these inferences I have found in accordance with the results of experiments, (75.) If, however, instead of placing the helix on one spire of the long conductor, it be submitted at once to the influence of all the twenty spires, then the intensity of the shock should be twenty times greater, since twenty times the quantity of current electricity collapses, if we may be allowed the expression, in the same time, and exerts at once all its influence on the helix. If, in addition to this, we add the consideration that the whole quantity of current electricity in a long conductor is greater than that in a short one, (73,) we shall

have a further reason for the increase of the terminal shock, when we increase the length of the battery conductor.

75. The inference given in the last paragraph, relative to the change in the quantity of the induction, but not in the intensity of the shock from a single spire, by increasing the whole length of the conductor, is shown to be true by repeating the experiment described in paragraph 13. In this, as we have seen, the intensity of the shock remained the same, although the length of the circuit was increased by the addition of coil No. 2. When, however, the galvanometer was employed in the same arrangement, the whole quantity of induction, as indicated by the deflection of the needle, was diminished almost in proportion to the increased length of the circuit. I was led to make this addition to the experiment (13) by my present views.

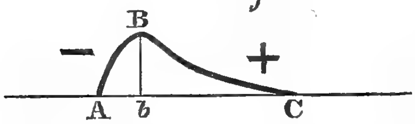
76. The explanation given in paragraph 74 also includes that of the peculiar action of a long conductor, either coiled or extended, in giving shock and sparks from a battery of a single element, discovered by myself in 1831; (see Contrib. No. II.) The induction, in this case, takes place in the conductor of the primary current itself, and the secondary current which is produced is generated by the joint action of each unit of the length of the primary current. Let us suppose, for illustration, that the conductor was at first one foot long, and afterwards increased to twenty feet. In the first case, because the short conductor would transmit a greater quantity of electricity, the secondary current produced by it would be one of considerable quantity, or power to deflect a galvanometer; but it would be of feeble intensity, for although the primary current would collapse with its usual velocity, (69,) yet, acting on only a foot of conducting matter, the effect (74) would be feeble. In the second case, each foot of the twenty feet of the primary current would severally produce an inductive action of the same intensity as that of the short conductor, the velocity of collapsion being the same; and as they are all at once exerted on the same conductor, a secondary current would result of twenty times the intensity of the current in the former case.

77. To render this explanation more explicit, it may be proper to mention that a current produced by an induction on one part of a long conductor of uniform diameter, must exist, of the same intensity, in every other part of the conductor; hence, the action of the several units of length of the primary current must enforce each other, and produce the same effect on its own conductor

that the same current would if it were in a coil, and acting on a helix. I need scarcely add, that in this case, as in that given in paragraph 74, the whole amount of induction is greater with the long conductor than with the short one, because the quantity of current electricity is greater in the former than in the latter.

78. We may next consider the character of the secondary current, in reference to its action in producing a tertiary current in a third conductor. The secondary current consists, as we may suppose, in the disturbance, for an instant, of the natural electricity of the metal, which, subsiding, leaves the conductor again in its natural state; and whether it is produced by the beginning or ending of a primary current, its nature, as we have seen, (22,) is the same. Although the time of continuance of the secondary current is very short, still we must suppose it to have some duration, and that it increases, by degrees, to a state of maximum development, and then diminishes to the normal condition of the metal of the conductor; the velocity of its development, like that of the primary current, will depend on the intensity of the action by which it is generated, and also, perhaps, in some degree, on the resistance of the conductor; while, agreeably to the hypothesis we have assumed, (69,) the velocity of its diminution is nearly a constant quantity, and is not affected by changes in these conditions; hence, if we suppose the induction which produces the secondary current to be sufficiently intense, the velocity of its development will exceed that of its diminution, as in the example of the primary current from the intense source of the compound battery of many elements. Now this is the case with the inductions which produce currents of the different orders, capable of giving shocks or of magnetizing steel needles; the secondary currents from these are always of considerable intensity, and hence their rate of development must be greater than that of their diminution, and, consequently, they may be represented by a curve of the form exhibited in Fig. 20, in which there is no constant part, and in which the steepness of A B is greater than that of B C. There are, however, other considerations, which will be noticed hereafter, (89,) which may affect the form of the part B C of the curve, Fig. 20, rendering it still more gradual in its descent, or, in other words, which tend to diminish the intensity of the ending induction of the secondary current.

Fig. 20



79. It will be seen at once, by an inspection of the curve, that the effect produced, in a third conductor, and which we have called a tertiary current, is not of the same nature as that of a secondary current. Instead of being a single development in one direction, it consists of two instantaneous currents, one produced by the induction of *A B*, and the other, by that of *B C*, in opposite directions, of equal quantities, but of different intensities. The whole quantity of induction in the two directions, will each be represented by the ordinate *B b*, and hence they will nearly neutralize each other, in reference to their action on the galvanometer, in the circuit of the third conductor. I say, they will *nearly* neutralize each other, because, although they are equal in quantity, they do not both act in absolutely the same moment of time. The needle will, therefore, be slightly affected; it will be impelled in one direction, say to the right, by the induction of *A B*, but, before it can get fairly under way, it will be arrested, and turned in the other direction, by the action of *B C*. This inference is in strict accordance with observation; the needle, as we have seen, (24) starts from a state of rest, with a velocity which, apparently, would send it through a large arc, but before it has reached, perhaps, more than half a degree, it suddenly stops, and turns in the other direction. As the needle is first affected by the action of *A B*, it indicates a current in the adverse direction to the secondary current.

80. Although the two inductions in the tertiary conductor nearly neutralize each other, in reference to the indications of the galvanometer, yet this is far from being the case with regard to the shocks, and the magnetization of steel needles. These effects may be considered as the results alone of the action of *A B*; the induction of *B C* being too feeble in intensity to produce a tertiary current of sufficient power to penetrate the body, or overcome the coercive power of the hardened steel. Hence, in reference to the shock, and magnetization of the steel needle, we may entirely neglect the action of *B C*, and consider the tertiary excitement as a single current, produced by the action of *A B*; and, because this is the beginning induction, the tertiary current must be in an opposite direction to the secondary. For a similar reason, a current of the third order should produce in effect a single current of the fourth order, in a direction opposite to that of the current which produced it, and so on: we have here, therefore, a simple explanation of the extraordinary phenomenon

of the alternation of the directions of the currents, of the different orders, as given in this and the preceding paper.

81. The operation of the interposed plate, (32, 47, 48, &c.,) in neutralizing the shock, and not affecting the galvanometer, can also be readily referred to the same principles. It is certain, that an induced current is produced in the plate (III. 64,) and that this must react on the secondary, in the helix; but it should not alter the total amount of this current, since, for example, at the ending induction, the same quantity of current is added to the helix, while the current in the plate is decreasing, as is subtracted while the same current is increasing. To make this more clear, let the inductive actions of the interposed current be represented by the parts of the curve, Fig 20. The induction represented by $A\ B$ will react on the current in the helix, and diminish its quantity, by an amount represented by the ordinate $b\ B$; but the induction represented by $B\ C$, will act in the next moment, on the same current, and increase its quantity by an equal amount, as represented by the same ordinate $B\,b$; and since both actions take place within a small part of the time of a single swing of the needle, the whole deflection will not be altered, and consequently, as far as the galvanometer is concerned, the interposition of the plate will have no perceptible effect.

82. But the action of the plate on the shock, and on the magnetization of tempered steel, should be very different; for, although the quantity of induction in the helix may not be changed, yet its intensity may be so reduced, by the adverse action of the interposed current, as to fall below that degree which enables it to penetrate the body, or overcome the coercive force of the steel. To understand how this may be, let us again refer, for example, to the induction which takes place at the ending of a battery current: this will produce, in both the helix and the plate, a momentary current, in the direction of the primary current, which we have called *plus;* the current in the plate will react on the helix, and tend to produce in it two inductions, which, as before, may be represented by $A\,B$, and $B\ C$, of the curve, Fig. 20; the first of these, $A\,B$, will be an intense action, (78,) in the *minus* direction, and will, therefore, tend to neutralize the intense action of the primary current on the helix; the second, ($B\ C$,) will add to the helix an equal quantity of induced current, but of a much more feeble intensity, and hence the resulting current in the helix

will not be able to penetrate the body; no shock will be perceived, or at least a very slight one, and the phenomena of screening will be exhibited.

83. When the plate of metal is placed between the conductors of the second and third orders, or between those of the third and fourth, the action is somewhat different, although the general principle is the same. Let us suppose the plate interposed between the second and third conductors; then the helix, or third conductor, will be acted on by four inductions, two from the secondary current and two from the current in the plate. The direction and character of these will be as follows, on the supposition that the direction of the secondary current is itself *plus:*

The beginning secondary	intense and	*minus.*
The ending secondary	feeble and	*plus.*
The beginning interposed	intense and	*plus.*
The ending interposed	feeble and	*minus.*

Now if the action, on the third conductor, of the first and third of the above inductions be equal in intensity and quantity, they will neutralize each other; and the same will also take place with the action of the second and fourth, if they be equal, and hence, in this case, neither shock nor motion of the needle of the galvanometer would be produced. If these inductions are not precisely equal, then, only a partial neutralization will take place, and the shock will only be diminished in power; and, also, perhaps, the needle will be very slightly affected.

84. If, in the foregoing exposition, we throw out of consideration the actions of the feeble currents which cannot pass the body, and, consequently, are not concerned in producing the shock, then the same explanation will still apply which was given in the last paper, (III., 94,) namely, in the above example, the helix is acted on by the minus influence of the secondary, and the plus influence of the interposed current.

85. We are now prepared to consider the effect on the helix (Fig. 3) of the induced currents produced in the conductor of the primary current itself. These are true secondary currents, and are almost precisely the same in their action as those in the interposed plate. Let us first examine the induced current at the beginning of the primary, in the case of a long coil and a battery of a single element; its action on the helix may be represented by the parts of the

curve, Fig. 20. The first part, *A B*, will produce an intense induction opposite to that of the primary current; and hence the action of the two will tend to neutralize each other, and no shock, or a very feeble one, will be produced. The ending action of the same induced current, which is represented by ***BD***, restores to the helix the same quantity of current electricity (but in a feeble state) which was neutralized by *A B*, and hence the needle of the galvanometer will be as much affected as if this current did not exist. These inferences perfectly agree with the experiment given in paragraph 19. In this, when the ends of the interposed coil were joined so as to neutralize the induced current in the long conductor, the shock at the beginning of the primary current was nearly as powerful as with a short conductor, while the amount of deflection of the galvanometer was unaffected by joining the ends of the same coil.

86. At first sight it might appear that any change in the apparatus which might tend to increase the induction of the primary current (16) would also tend to increase, in the same degree, the adverse secondary in the same conductor; and that hence the neutralization mentioned in the last paragraph would take place in all cases; but we must recollect that if a more full current be suddenly formed in a conductor of a given thickness, the adverse current will not have, as it were, as much space for its development, and, therefore, will have less power in neutralizing the induction of the primary than before. But there is another, and, perhaps, a better reason, in the consideration that in the case of the increase of the number of elements of the battery, although the rapidity of the development of the primary current is greater, yet the increased resistance which the secondary meets with, in its motion against the action of the several elements, will tend to diminish its effect. Also, by diminishing the length of the primary current, we must diminish (76) the intensity of the secondary, so that it will meet with more resistance in passing the acid of the single battery, and thus its effects be diminished.

87. The action of the secondary current, in the long coil at the *ending* of the primary current, should, also, at first sight, produce the same screening influence as the current in the interposed plate; but, on reflection, it will be perceived that its action in this respect must be much more feeble than that of the similar current at the beginning; the latter is produced at the moment of making contact, and hence it is propagated in a continuous circuit of conducting matter, while the other takes place at the *rupture* of the circuit, and must

therefore be rendered comparatively feeble by being obliged to pass through a small portion of heated air; very little effect is therefore produced on the helix by this induction, (19.) The fact that this current is capable of giving intense shocks, when the ends of a long wire, which is transmitting a primary current, are grasped at the time of breaking the circuit, is readily explained, since, in this case, the body forms, with the conductor, a closed circuit, which permits the comparatively free circulation of the induced current.

88. It will be seen that I have given a peculiar form to the beginning and ending of the curves, Figs. 17, 18, &c. These are intended to represent the variations which may be supposed to take place in the rate of increase and decrease of the quantity of the current, even in the case where the contact is made and broken with mercury. We may suppose, from the existence of analogous phenomena in magnetism, heat, &c., that the development of the current would be more rapid at first than when it approximates what may be called the state of current saturation, or when the current has reached more nearly the limit of capacity of conduction of the metal. Also, the decline of the current may be supposed to be more rapid at the first moment, than after it has lost somewhat of its intensity, or sunk more nearly to its normal state. These variations are indicated by the rapid rise of the curve, Fig. 17, from A to g, and the more gradual increase of the ordinates from h to B; and by the rapid diminution of the ordinates between C and l, and the gradual decrease of those towards the end of the curve.

89. These more minute considerations, relative to the form of the curve, will enable us to conceive, how the time of the ending of the secondary current, as we have suggested, (78,) may be prolonged beyond that of the natural subsidence of the disturbance of the electricity of the conductor on which this current depends. If the development of the primary current is produced by equal increments in equal times, as would be the case in plunging the battery (59) into the acid with a uniform velocity; then the part $A\ B$ of the curve Fig. 17 would be a straight line, and the resulting secondary current, after the first instant, would be one of constant quantity during nearly the whole time represented by Ac; but if the rate of the development of the primary current be supposed to vary in accordance with the views we have given in the last para-

graph, then the quantity of the secondary current will begin to decline before the termination of the induction, or as soon as the increments of the primary begin to diminish; and hence the whole time of the subsidence of the secondary will be prolonged, or the length of *b C*, Fig. 20, will be increased, the descent of *B C* be more gradual, and the intensity of the ending induction of the secondary current be diminished: (see last part of paragraph 78.)

90. Besides the considerations we have mentioned, (88,) there are others of a more obvious character, which would also appear to affect the form of particular parts of the curve. And first we might perhaps make a slight correction in the drawing of Figs. 17, 18, &c., at the point *A*, in consideration of the fact that the very first contact of the end of the conductor with the surface of the mercury is formed by a point of the metal, and hence the increment of development should be a little less rapid at the first moment than after the contact has become larger; or in other words, the curve should perhaps start a little less abruptly from the axis at the point *A*. Also Dr. Page has stated* that he finds the shock increased by spreading a stratum of oil over the surface of the mercury; in this case it is probable that the termination of the current is more sudden, on account of the prevention of the combustion of the metal by means of the oil, and the fact that the end of the conductor is drawn up into a non-conducting medium.

91. The time of the subsidence of the current, when the circuit is broken by means of a surface of mercury, is very small, and probably does not exceed the ten thousandth part of a second, but even this is an appreciable duration, since I find that the spark at the ending presents the appearance of a band of light of considerable length, when viewed in a mirror revolving at the rate of six hundred times in a second; and I think the variations in the time of ending of the current under different conditions may be detected by means of this instrument.

92. Before concluding this communication, I should state that I have made a number of attempts to verify the suggestion given in my last paper, (III. 127,) that an inverse induction is produced by a galvanic current by a change in the distance of the conductor, but without success. These attempts were made

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* Silliman's Journal.

before I had adopted the views given in this section, and since then I have found (80) a more simple explanation of the alternation of the currents.

93. In this number of my contributions, the phenomena exhibited by the galvanic apparatus have alone been discussed. I have, however, made a series of experiments on the induction from ordinary electricity, and the reaction of soft iron on currents, and I think that the results of these can also be referred to the simple principles adopted in this paper; but they require further examination before being submitted to the public.

ARTICLE II.

Description of an entire Head and various other Bones of the Mastodon. By William E. Horner, M. D., and Isaac Hays, M. D. Read October 2, 1840.

The undersigned, a committee appointed by the Society, January 3d, 1840, to report a description of the collection of Mastodon bones recently presented to the Society by some of its members, have the honour to submit the following account:

According to the statement of Mr. D. Wood, from whom these bones were purchased, they were discovered two years since about seven feet below the surface of the ground, in digging a mill-race on the estate of Abraham Halm, three-fourths of a mile east of Bucyrus, Crawford County, Ohio, on the dividing ridge between the Sandusky and Sciota valleys. This ridge, consisting of table land, is one of the highest elevations in Ohio, is well cultivated, and abounds in never-failing springs, which constitute the sources of the Sandusky and Sciota rivers. The waters of the former flow into Lake Erie by a course almost due North, and those of the latter, into the Ohio, by a course nearly due South. The soil in which the bones were buried is entirely alluvial.

The collection contains portions of the skeletons of two animals, one larger than the other. The bones of the larger of these animals are lighter, more worn, more decomposed, and larger in their specific measurements than the other, and are of a different colour. All these bones were sold as common to one skeleton, but that they appertained to different individuals is sufficiently substantiated from what is alleged; and, moreover, by some of the carpal bones of the right side being in duplicate. Whether or not all were really exhumed from the same spot cannot now be ascertained by the committee.

Though both skeletons have been inhumed, they do not seem to be fossilized. The first set has a much lighter specific gravity than corresponding recent bones would have, and the second set has about the same specific gravity as the latter, or perhaps a somewhat greater, but yet with a freshness of surface and of texture which would seem to indicate that either no very long interval could have elapsed since the death of the animal, or that the soil in which they were deposited possessed unusual preservative powers.

Of the skeleton of the larger animal there are the following pieces:

A fragment of the pelvis, containing the right acetabulum.

Inferior end of right scapula.

Inferior end of left scapula, a small fragment.

Upper end of right radius and ulna, with olecranon process, the latter detached.

Lunare—Trapezium—Trapezoides of right carpus.

Head of a rib.

Ten fragments of vertebræ, &c., and a number of undetermined fragments, much comminuted.

The long diameter of the glenoid cavity of the scapula measures nine and a half inches.

The diameter of the acetabulum is seven and a half inches.

The lunare is three and three-eighths of an inch in thickness.

Upon the preceding data, this animal was from a thirteenth to a tenth larger than the Mastodon of the Philadelphia Museum, whose scapula has a glenoid cavity of eight and three-fourths of an inch in its long diameter, and an acetabulum of six and three-fourths of an inch in diameter.

The bones of the second, or smaller animal, are in a state of fine preservation, and consist of

A complete head.

Six anterior cervical vertebræ.

Six vertebræ of thorax and loins, complete, and some fragments of same class of bones.

Sacrum complete, and seven succeeding caudal bones.

The left innominatum complete; the right ischium and pubes, with some fragments of right ilium.

Thirteen ribs of right side.

Eighteen ribs of left side.

Os humeri of right side.
Scaphoides, lunare, cuneiform and unciform of right carpus.
Os femoris, tibia, and os calcis of right side.
Radius and ulna of left side.
Tibia, fibula, and patella of left side.
Os calcis, astragalus, scaphoides and cuboides of left tarsus.

Conformation of Head.

The occipital bone (see Plate I., fig. 1,) forms a plane, looking backwards and upwards, roughened by the insertion of muscles: its superior semicircular ridge is extremely scabrous, and makes a well defined angle with the top of the head. There is no hemispherical protuberance on each side of it, as in the Asiatic Elephant, (see Plate IV., fig. 2, *e;*) on the contrary, the plane of the occipital bone is slightly depressed near the centre of each side. The insertion of the ligamentum nuchæ is somewhat depressed and very scabrous, and makes a triangular area, the base of which, being the line of the occipital ridge, is five inches wide; from this it extends downwards eight and a half inches towards the foramen magnum; it is divided symmetrically by a well-marked vertical ridge.

The occipital condyles rise immediately from the surface of the bone, instead of standing out on a high base, as in the Elephant; they form one-third of a circle, and measure nearly six and three-fourths inches in length, by two and three-fourths in breadth. The plane of the occiput and the cuneiform process form, in their relation to each other, a right angle, upon which is placed the condyles.

The cranium (see Plate II., fig. 1,) presents, in front, a flattened, or slightly raised convexity, from the occipital ridge to the anterior nares, and exhibits there an area of one foot eight inches long, by one foot two and a half inches wide, between the temporal fossæ.

The plane of the occiput and the upper front part of the cranium make, at their line of junction, a well defined angle of ninety-five degrees, (see Plate III.) In an Elephant belonging to the Wistar Museum, the corresponding portion is rounded, but if designated by supposititious planes, the latter would meet at an angle of eighty-five degrees.

The incisive fossa (see Plate IV., fig. 1, *a,*) of upper maxilla is distinguished by great depth, and terminates above in a narrow, profound pit, which penetrates two inches under the anterior nares. Besides the ordinary infra-orbitary foramen, there is a second, much smaller one, a branch from the former, and placed three inches within and above it. This second infra-orbitary foramen has four superficial sulci, two within and two without, radiating from it, and indicating the direction of nerves and blood-vessels.

The malar bone is much broader than in the Elephant. The conformation of the orbit is like that of the latter animal, but it is a section of a more regular circle, and is six and a half inches in diameter. Two and a half inches posterior to the spine of bone, at the internal margin of the orbit, near its middle, there is a small canal, which leads to the infra-orbitar canal, and which, in the Elephant, is merely a groove. The orbit has the same relative position as in the Elephant, in which respect Cuvier* has been led into error by the declaration of Mr. Peale,† that there was no trace of orbit at the anterior part of the arch, (zygomatic;) for we find this arch continued into the orbit of the Mastodon, just as in the Elephant, the greater breadth of the malar bone in the former making the chief difference. The zygomatic suture is nearly the same as in the Elephant.

The meatus auditorius externus (see Plate I., fig. 1,) is a compressed oval orifice, the distance of which, from the anterior margin of the orbit, is seventeen and a half inches.

The temporal fossa is broad, deep, and nearly uniformly concave, with very little of that convexity near its posterior part which exists in the Elephant. The pterygoid processes of the sphenoid bone, said by Cuvier to be larger than in any other quadruped, are eight inches in length, have a well-marked fossa, and present no inconsiderable resemblance to those in the human subject, which is not the case in the Elephant. The tuber of the upper maxillary bone is not so full as in the latter.

The hard palate is destitute of a notch behind, which exists in the Elephant, being flush; it is, in its whole length, nearly a plane, instead of curving down abruptly at its anterior portion, as in the Elephant. It measures, from its posterior margin to its anterior, at a central point between the edges of the alveoli of the tusks, two feet two inches.

The temporal bone presents the articular surface for the lower jaw exclu-

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* Recherches sur les Ossemens Fossiles, Vol. II., p. 301. Paris, 1840.

† Historical Disquisition on the Mammoth, p. 41. London, 1803.

sively on the tubercle at the root of the zygomatic process. This surface resembles, in shape, that on the trapezium of the human hand for the thumb, except that it is proportionately more oblong, as it measures five inches by two and a half; its margin is sharp, elevated, and well defined. There is behind the tubercle a depression corresponding with the glenoid cavity of the Elephant, but it is narrow, deep, and rough; it appears not to have had a coating of cartilage, and, from its constricted condition, could not have entered into the contour of the temporo-maxillary joint.

The upper maxilla has a tooth on each side which measures seven and a fourth by four and a half inches. These teeth converge behind and were placed four inches in advance of the pterygoid process: they are furnished with five denticules, which are much worn.

The left alveolus for tusk in the incisive bone is very complete, the right one is slightly mutilated at the margin. Their depth is nineteen inches—transverse diameter, four and three-fourths of an inch—and vertical diameter five and a half inches.

The following supplementary measurements may be of some value:

From end of alveoli of tusks to occipital condyles three feet two inches.

From inferior margin of foramen magnum to vertex one foot five inches. Transverse diameter of occiput two feet two inches.

From vertex to spine of bone, between anterior nares, one foot nine inches.

From orbit to orbit one foot nine inches.

Incisive fossa four inches deep.

From posterior margin of pterygoid process of sphenoid bone, to anterior edge of alveoli for tusks, two feet four inches.

From anterior edge of foramen magnum to posterior nares five inches.

Depth of temporal fossa, from bottom to the crown of the zygomatic arch, nine inches.

From superior margin of temporal fossa, to inferior margin of pterygoid process, one foot ten inches.

Diameter of orbit six and a half inches.

Across alveoli for tusks, and immediately below infra orbitary foramen, sixteen inches.

Across alveoli for tusks, at their inferior end, eighteen inches and a half.

Breadth of malar bone just at orbit six inches.

From posterior margin of tooth, to posterior margin of os palati, six inches.

Lower Jaw.—The conformation of this is similar to that of the jaw belonging to the Baltimore Museum, and described by one of the members of the Committee.* Its body is semicylindrical; on the external face there is a deep round groove, just above the symphysis, and which presents a rough foliated margin on each side, considerably expanded. The chin presents no alveoli for tusks, as in the Titracaulodon of Godman;† neither are there traces of such alveoli ever having existed.

The jaw contains one tooth on each side, with five denticules, each with two points, all worn, and most so at their outer edge. In front of these teeth are remains of the alveoli of the deciduous teeth preceding them. The teeth are parallel; the left measures eight inches by four and a half—the right eight and a quarter, by four and three-quarters of an inch.

The length of this jaw is two feet six inches. The height of ramus fifteen inches, and its breadth ten inches. The condyle is nearly transverse in its long diameter, with a slight inclination of the latter inwards and backwards; it has no groove dividing its articular surface into an inner and outer portion, as in the specimen in the Baltimore Museum, though there is a faint indication of one. The coronoid process rises an inch and a half higher than the condyle; the latter measures five and a half inches in its long diameter. The angle of the bone is rather well defined and obtuse.

VERTEBRÆ.

The vertebræ, of which there are, as stated, specimens of each class, have a conformation analagous to those of the Elephant.

The first cervical vertebra (see Plate I., Fig. 2) measures fourteen inches between the tips of the transverse processes, and ten inches from the anterior to the posterior margin: immediately behind the superior oblique process there is also a perfect canal for conveying the vertebral artery into the foramen magnum occipitis.

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* Description of Inferior Jaws of Mastodon, &c. By Isaac Hays, M. D. Transactions of the American Philosophical Society, Vol. IV., New Series.

† Transactions of the American Philosophical Society, Vol. III., New Series.

The second cervical vertebra (see Plate I., Fig. 3) exhibits in its processus dentatus a broad regular cone, elevated one and a half inches, and whose summit reaches to the level of the internal margin of the superior oblique processes of the first vertebra. Its spinous process is more robust than in the Elephant, and comes in contact with that of the first by a broad well-marked surface. This vertebra in the specimen before us, is anchylosed with the third in almost the whole length of the long bridge between the oblique processes inclusive. Its transverse diameter in the body is seven and a half inches—and the antero-posterior diameter, from the front of the body to the tip of the spinous process, measures ten inches.

The spinous process of the third, fourth, fifth, and sixth vertebræ is very small and short. These vertebræ are nearly circular, (see Plate II. Fig. 2) and measure nearly six inches in diameter, and nearly two and a half inches in thickness, in their bodies. They shoot up from the anterior root of the transverse process, a conical spine, sixteen or eighteen inches in height, which sets close against the body of the vertebra above, and assists materially in preventing its dislocation. A vertebra of this description, when inverted, resembles a table standing on four legs; the two front legs being these conical spines, and the two hind ones the upper oblique processes. There is an arrangement in the Elephant tending to this, but by no means so finished, as the conical spine is much shorter, and does not touch, by a considerable space, the vertebra above it.

The first six thoracic vertebræ have very long spinous processes; that of the foremost measures twelve inches, of the second thirteen and a half, and of the third about the same; they then diminish in length.

The lumbar vertebræ, sacrum, and the caudal vertebræ, are similar to those of the Elephant.

The sacro iliac junction is anchylosed.

PELVIS.

Its conformation presents the same type as in the Elephant, but the measurements are much more considerable. The innominata join also from the top of the pubes to the anterior part of the tuber of ischia by a synchondrosis articulation; there is, therefore, no pubic arch as in the human subject.

The distance from the anterior superior spinous process to the centre of the sacrum is two feet nine inches. From the same process to the posterior extremity of the symphysis of ischia measures three feet two inches.

From the superior extremity of the tuberosity of the ischium of one side, to the corresponding point of the other, one foot six inches.

Transverse diameter of sacrum, at base, eleven inches; length, one foot five and a half inches.

Antero-posterior diameter of pelvis, at superior strait, one foot six inches.—Transverse diameter of same strait, one foot nine inches.

From anterior point of symphysis pubis to posterior of symphysis ischii, one foot five inches.

From anterior superior spinous process of ilium to symphysis pubis, two feet four inches.

From one anterior superior spinous process to the other, four feet eight inches, and little further back four feet ten inches for the extreme breadth of the pelvis.

From the middle of crista of ilium to inferior point of tuber of ischium, three feet six inches.

Diameters of thyroid foramen eight and five inches.

Diameter of acetabulum six and a half inches.

RIBS.

The ribs resemble those of the Elephant: their length appears to be the same, but their size is greater in about the same proportion with the other bones. The first rib measures in length nineteen and a half inches, and has very distinct processes marking the insertion of the scalenus anticus and medius muscles, and depressions also well marked for the subclavian artery and subclavian vein. The longest rib in the collection measures three feet seven inches along its outer convex edge.

EXTREMITIES.

The conformation of the bones of the anterior and posterior extremities is analagous to those of the Elephant, but they are shorter, thicker, and more strongly marked by the muscles.

The os humeri is two feet five inches long—transverse diameter at condyles eight and a half inches, and at upper end eleven inches. Circumference just above insertion of deltoid two feet, and at middle, one foot four and a half inches.

Ulna, length two feet one and a half inches; circumference in middle, one foot.

Radius, one foot eleven inches long.

Lunare, two and seven-eighths of an inch thick.

Os femoris, two feet eleven inches long; circumference in middle, one foot four inches; diameter of head, six and a half inches; transverse diameter at condyles, eight and a half inches.

Tibia, one foot ten inches in length, and eleven inches in circumference at middle.

Fibula, one foot nine inches long.

SIZE OF THE MASTODON.

The following admeasurements of the bones of the extremities of the Mastodon and Elephant, afford some data for determining the probable size of the former animal.

Mastodon.					Elephant.		
Os Humeri, length	2	feet	5	inches,	2 feet	8	inches.
Ulna	"	2 "	1½	"	2 "	6	"
Radius	"	1 "	11	"	2 "	2	"
Os Femoris	"	2 "	11	"	3 "	3	"
Tibia	"	1 "	10	"	1 "	11	"

The skeleton of the specimen affording the above standard of comparison belongs to a young Elephas Indicus, and measures nine feet from the tips of the spinous processes, of the first two dorsal vertebræ, to the ground. But it has been seen that the ribs of the Mastodon are nearly of the same length as those of the Elephant, and that the extremities are about six inches shorter in the fore-legs and five inches in the hind-legs: the greatest height of the animal described would, consequently, be short of nine feet at the shoulders.*

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* Cuvier limited the stature to twelve feet. Oss. Foss. Vol. II. p. 24.

A portion of the head, and some other bones of a Mastodon, in Mr. Koch's Museum, at St. Louis, Missouri, afford ground to think that the individual was about thirteen feet high. See Bullet. American Philosophical Society, for 1840, paper by W. E. Horner, M. D.

Of the two existing species of Elephants, the Elephas Africanus reaches a stature of from

The cervical vertebræ of this Mastodon are from an eighth to a fifth thicker than they are in the Elephant. The latter measures eleven feet from the anterior nares to the end of the ischia: the Mastodon was probably twelve and a half feet in the same line.

Measurements and estimates thereon give, in the Mastodon, supposing the feet to be of the same vertical height as in the Elephant, the following results:

	Mastodon.	Elephant.
From tips of spinous processes of 1st and 2nd dorsal vertebræ to ground,	8 feet 9 inches.	9 feet.
From tip of spinous process of last lumbar vertebra to ground,	7 feet 10 inches.	8 feet.

The Mastodon above described is inferior in the measurements of its several pieces to the one in the Philadelphia Museum; the latter, however, in being articulated at a height of eleven and a half feet, has probably transcended its natural limits at least eighteen inches: its length also exceeds, probably, the proper bounds. The thorax appears to be unnaturally expanded by the undue length of the costal cartilages: the pelvis, also, by the keeping apart the symphysis of the pubes and ischia, instead of joining it, has an excess in its diameter of from eight to ten inches. The head is likewise thrown too much forward. The probability is, that the Mastodon carried his head with the front part almost vertical, as the Elephant, which would ease much the action of the muscles intended for its support.

In the collection of Mastodon bones previously in the cabinet of the Society, there is a vertebra dentata eight and three-fourths of an inch broad, by eleven and a half in its antero-posterior diameter, and an os calcis ten and a half inches long: the animal, of which these are the remains, was probably from an eighth to a tenth larger than the subject of this paper. Whether the remains of the largest animals of this race have as yet been brought to light, must continue for some

eight to ten feet, and the Elephas Indicus one of from eight to sixteen feet. The Elephas Primogenus, or Fossil Elephant, also called Mammoth or Behemoth, now extinct, and whose remains are so abundant in Siberia and the borders and islands of the Frozen Sea, as to justify the expression that the ground is in places strewed with them, appears to have been about, or a little beyond, the stature of the Indian Elephant. Cuvier's Oss. Foss., Ed. 1812, p. 135, vol. II.

time a question among scientific men; but the Committee are of opinion that ten or ten and a half feet was the greatest natural height of any one whose remains they have examined.

The committee cannot conclude this report without congratulating the Society on the possession of the entire head of this interesting animal. The acquisition is indeed a precious one, not only from its being, so far, unique, but as it furnishes materials for determining nearly all the doubtful points relative to the characters of the genus, and for fixing its relations and position in the animal kingdom, &c.

All that is now wanting, indeed, to complete the history of the osteology of this animal, is the discovery of a head with the tusks *in situ*, so as to determine positively the direction of the latter—whether their convexity was upwards or downwards.

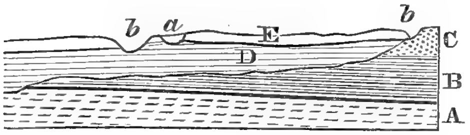
NOTE BY DR. HAYS.

Read May 21, 1841.

Since the preceding paper was read to the Society, I have seen the "Second annual Report on the Geological Survey of the State of Ohio, by W. W. Mather, principal Geologist, and several assistants," in which I find a brief notice of the bones which have just been described, and some facts relative to their geological position, of much interest, and which I will therefore subjoin.

These bones, according to Mr. Briggs, one of the assistants of Mr. Mather, were found in a bed of fresh-water-shell marl, about four feet thick. This marl is composed of argillaceous matter and fresh-water shells, among which were observed lymnæa, planorbis, physa, and some species of cyclas, and is covered by a layer of peat four feet thick. These beds were deposited in a depression in a stratum of yellowish clay, which forms the surface of the country, and contains pebbles of primary and secondary rocks. Beneath this is a stratum of bluish clay, reposing on shale and limestone, containing pebbles of primitive rocks, and of the subjacent shale and water-worn limestone.

Wherever examined, this clay seems to be destitute of organic remains. The shale is part of the formation which extends from the Ohio river to Lake Erie. The limestone is generally destitute of fossils. The following sketch represents the geological structure of a portion of Crawford county, and exhibits the position in which the bones were found.



A, limestone. B, shale. C, sandstone. D, blue clay. E, yellow clay. *a*, bed of fresh-water-shell marl, in which the bones were found. *b, b*, Sandusky river, crossing twice the above profile, extending from east to west.

The fresh-water-shell marl, being deposited in the yellowish clay, is more recent than the latter, and therefore, as Mr. Briggs observes, "the Mastodon has become extinct since the deposite of the materials upon the surface of which are our magnificent forests and beautiful prairies." Thus confirming the opinion expressed by the committee, as to the comparatively very recent period at which this animal became extinct.

It is proper to state, also, that a brief notice of these bones, with a profile sketch of the head, was communicated to Professor Silliman by Mr. J. W. Foster, and have been published in the American Journal of Science and the Arts, Vol. XXXVI., p. 189.

ARTICLE III.

On the Cecidomyia Destructor, or Hessian Fly. By Miss M. H. Morris. Read Oct. 2, 1840.

THE enormous injury to which the wheat crops in the United States have been, for many years, subjected by the Cecidomyia Destructor, or Hessian Fly, induced me to study, minutely, the habits of the insect, with a view to discover some remedy for the evil. Having ascertained that the perfect fly appears in June, and lives but a few days, and that the larva is only to be found in the young wheat, in the succeeding fall, or spring, I was led to infer that the grain itself was the nidus selected, not the culm, as Mr. Say had supposed.

The fact of the egg being laid in the grain does not, however, rest upon inference; I have actually detected the larva in the grain, when peculiar circumstances had prevented it from leaving its birth-place, in order to ascend the stalk, as it is prone to do.

While I admit the correctness of Mr. Say's description of the Cecidomyia, given in the first volume of the Journal of Natural Sciences, I must beg leave to differ from him respecting the history of the insect. He alleges "the egg to be deposited in the stalk of the wheat, between the vagina and the culm, near the root," and that, "in this situation, with the body inverted, the head being invariably down, the infant larva passes the winter;" here he leaves it, and proceeds to describe its appearance in the flax-seed state, evidently supposing that it had not moved from its position from the time of its exclusion from the egg until its change to the pupa. He then states that "the perfect fly appears early in June, lives but a short time, deposites its eggs, and dies."

VIII.—N

If the larva remains in the same place and position, from the time of its exclusion from the egg to the pupa state, how does it get from *near* the *root* to the third joint, and sometimes, although rarely, above it, as the facts prove?

Again, I would ask, if the perfect fly appears in June, lives only a short time, and in that time the female deposites her eggs, where are those eggs placed? surely not in the old and dying stalk of wheat from whence she has derived her subsistence; and I know of no other plant on which she feeds. Mr. Say continues, "the insects from these eggs," deposited in June, "complete the history by preparing for the winter brood;" we are here left in the dark respecting the home and food of this second brood, since there is no wheat growing from June until September, when the grain is again planted.

Had the information of Mr. Say, respecting the history of the insect, been as accurate as his knowledge of its appearance, he would not have left room for these doubts. The eggs described by Mr. Say, I am compelled to believe, were those of some other insect, which he has mistaken for those of the Hessian Fly, as they appear to have been found where his previous impression led him to search for them.

My first observations were made in June, 1836, when the Hessian Fly was making its ravages around us. The insect was then in the pupa, as shown by Mr. Le Sueur's beautifully correct drawings, in the first volume of the Journal of the Academy of Natural Sciences, illustrating Mr. Say's description of the insect. The pupæ were scattered from the root to the third joint of the straw, and the wheat was beginning to ripen, although still soft. In a few days the flies made their appearance in countless numbers, hovering over and settling on the ears of wheat, where they were, no doubt, depositing their eggs in the grain, thus securing a home and future food for their progeny. In about ten days they had all disappeared, and the impoverished grain ripened for the harvest.

In 1837, a field was sown so late that the grain did not vegetate until the following spring. I watched it closely, but could not observe that any injury was sustained until the beginning of May. Then I detected the worm in the root, and, in many instances, in the old grain, where it had originally been deposited, but seldom or ever above the first joint of the straw. I am not prepared to say positively at what time the worm passed into the pupa, but believe it to be about the beginning of June. From this field I preserved a handful of straws, torn up by the roots, and in every instance the pupa was either in the old grain or the root.

Within a week from the time of these observations the wheat was reaped, but the pupa in the stubble was not perfected until August.

In the spring of 1838 I detected the larva in a field that had been sown early in the previous fall; it was always in the centre of the culm, there being from one to six in the same stalk, at various distances, from the root to the third joint. It had a pale, greenish-white, semitransparent appearance; in form bearing some resemblance to the silk-worm. I regret that I made no drawings or notes at the time; this description, therefore, is from memory. The upward path of the worm was distinctly marked. The perfect fly appeared in June.

In the fall of 1837, Mr. Kirk, a farmer of Bucks County, procured Mediterranean wheat, which yielded an abundant crop, free from the Hessian Fly. The seed from this wheat was sown in the fall of 1838. In the spring following he detected the larva thinly scattered in the resulting crop; but the grain of the present year, 1840, from the same stock, has been greatly injured by flies from neighbouring fields, planted with American wheat.

From these facts I have been confirmed in my first impression, that the egg is deposited in the grain, remains dormant until the grain vegetates, is then hatched in or near the grain, lives in the centre of the culm, and mounts with the growing stalk.

Should the egg be hatched in the fall, the slow growth of the wheat allows the insect to penetrate into every shoot, and rise with the growing straw, but if it be retarded until spring, the uninfected shoots grow rapidly, while those containing the larva become sickly and abortive; hence the difference in the position of those found in the wheat vegetating in the fall, and those not appearing until spring.

Various experiments have been tried to destroy the egg in the grain, but the vital principle appears so carefully guarded in insects' eggs, that whatever destroys life injures the grain. The only remedy, then, is to procure seed from an uninfected district.

NOTE.—In Susquehanna and Bradford counties the Hessian Fly has never yet made its appearance.

ARTICLE IV.

Remarks on the Dental System of the Mastodon, with an Account of some Lower Jaws in Mr. Koch's Collection, St. Louis, Missouri, where there is a solitary Tusk on the right Side. By W. E. Horner, M. D., Professor of Anatomy in the University of Pennsylvania. Read Nov. 6, 1840.

THE extinction of an animal having so many claims to our curiosity as the Mastodon, from its localities—its conformation, and its colossal magnitude—an extinction so complete and final that its fiat has reached not only all the individuals of that genus, but also extended its fatal influence to cognate genera of every description without exception, is an event in the revolutions of the earth so confounding, that the mind is lost in seeking for a cause, and dwells on the circumstance with astonishment and awe. An insatiable desire exists for further knowledge on the subject; and we are pleased with almost any attempt to explore the probable history and habits of these animals—their peculiarities of structure—the modifications of development, dependent on their species and genera—and, finally, the particular catastrophe which overwhelmed them at once, or, by a sequence of physical changes in atmosphere and food, brought about their ultimate destruction. It is upon this ground that I propose to offer a few remarks on the Dentition of the Mastodon.

The data from observations already made, on the phenomena of dentition in these animals, leave the inference that, mechanism and texture excepted, a very close analogy existed between the development of their teeth and those of the Elephant. In the mechanism of the tooth of the Elephant we find vertical, transverse strata of bony matter and of enamel, alternating with one another, and depending for their relation upon an original arrangement of the pulp of the tooth and of its capsule well known to anatomists, and which is partially represented by extending the fingers of the two hands, and thrusting them, point to point, between each other. In the Mastodon, besides the division of the triturating surface into denticules, the mechanism resembles that of the human tooth, by the enamel covering completely the crown or body of the tooth, and not being arranged into those transverse vertical layers. The texture of the Mastodon teeth is also closer, or more compact. In both instances the teeth are formed by excretion, and though chemically of similar materials with bone, to wit, calcareous and animal matter, yet they differ organically from it in their mode of production, in their manner of growth, and in their texture. As the result of an excretion, they are destitute of cancellated structure, are in successive laminæ, enclosing one another, and have no blood-vessels penetrating into and diffusing themselves in their texture. They are therefore absolutely inorganic, though porous and filamentous,* and have within themselves neither a power of repair nor of growth. It hence arises that, being of a fixed size, dependent on the size and excretive power of their original germs, such size, which is adequate to the process of mastication in an ungrown animal, is inadequate as the animal increases in magnitude, and a supplementary provision is therefore called for.

The shoulders of a Mastodon, at birth, had a diameter not exceeding, probably, sixteen inches, by about twenty, to enable it to pass through the pelvis of the female, but its full grown state is that of the largest Elephant. Allusion is here made chiefly to the living Elephas Indicus. Remains of fossil Elephants have been found near Verona, in Italy, which indicate a stature of fifteen feet high, so far as a correct conclusion can be formed from an examination of the lower jaw, and a metacarpal bone. A tusk was found there twelve feet long, by nine inches in diameter.† There are, as yet, no exhumations of the Mastodon which exhibit such altitude; the tallest of which we have the remains did not exceed thirteen feet; it is probable, however, that the bulk was not inferior, as the Mastodon appears to have been a stouter animal than the elephant in proportion to its height.

Remains of fossil Elephants have been found in several other parts of Italy, France, Germany, Holland, and Belgium, under circumstances which leave the persuasion that such animals were once indigenous to Europe. The largest

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* See Retzius on Teeth.

† Cuvier Ossen. Fossils, Art. Elephans, page 11. Paris, 1812.

skeleton was probably that which was raised near the Castle of Chaumont, in France, about the year 1613. Its thigh bone measured five feet in length, and its tibia four feet. It passed for the remains of Teutobochus, king of the Cimbrians, who had fought against the Roman general Marius, about one hundred years before Christ. Many publications for and against their authenticity as such, appeared at that time.

We may infer from the preceding remarks how great must be the changes in a dental system in passing from the calf to the adult, so as to secure at all periods a masticating surface of sufficient extent. The process of nature in providing this surface consists in bringing forward, from the back of the jaw bones, a series of teeth, successively larger and larger; and as these teeth emerge from behind, the smaller teeth advance forwards to near the chin, and their alveolar processes are absorbed. The advanced teeth, having no longer the latter support, then drop out.

The teeth, from their inorganic character, suffer less in the influences from time and atmosphere than any other portions of the animal frame; hence they are the last vestiges of individuals. They are also, in many instances, the last traces of races of animals, and our only idea of the latter is furnished upon the analogies of the teeth. The Mastodon, in some of its species, comes under this category: there is no remaining evidence, in certain cases, but the teeth, and in others only the teeth and the lower jaw, the latter seeming to be next to the teeth, in the character of indestructibility. To the naturalist, therefore, it is of consequence to have such a system of dentology as will enable him, on the one hand, to separate different species, and, on the other hand, to avoid the error of multiplying them, contrary to the order of nature.

A distinct species may be ascertained by the number of teeth in the jaw of a mature animal, and by their texture and mechanism. But as different periods of time, between birth and the mature or adult state, exhibit different numbers of teeth, a species, it is clear, cannot be determined upon their number alone, until we know the number existing at each age. Age may also have its peculiar concomitants of mechanism and texture; and, likewise, sex may affect the dental system of the Mastodon, as it does in other animals. In fine, with such narrow limits for correct judgment, the naturalist is much exposed to error, and it would perhaps be safer, in the present state of our knowledge in regard to the facts of dentology in the Mastodon, to refrain from admitting the existence of new species except when the most positive evidences of difference in the texture and number of the teeth existed. In regard to the latter, it may be very safely asserted, that it is yet doubtful what was the entire amount of teeth protruded in the Mastodon, from the beginning to the end of its dentition; what were the teeth which were cotemporaneous, the periods of life of their existence, the peculiarities of sex, and, lastly, the irregularities of dentition in individuals.

The teeth of the Mastodon are all formed upon one type of configuration, the number of denticules excepted; they, therefore, like those of the elephant, do not admit of the division into incisors, cuspidate, and molars, as in some other animals. The teeth are, in fact, all molars. The lower jaw itself resembles somewhat a human lower jaw, cut off in front of the molar teeth, and there joined in the two posterior segments. These teeth invariably succeed each other from behind, as stated; the hindmost ones as they emerge, pushing the others forward, and out of their places, until the latter all drop out, and a large, solitary tooth is finally left on each side of each jaw.

The progress of dentition in the elephant is said to be as follows: the first teeth protrude at eight or ten days after birth, and are fully out at three months. The second are completely protruded in two years from birth, and fall out at six years. The third teeth appear at two years, and the fourth at nine years. The entire succession brings forward eight teeth on each side of each jaw, or thirty-two in the whole set. The periods at which the fifth, sixth, seventh, and eighth teeth protrude, are not so well known; it is ascertained, however, that the intervals of succession go on increasing. Such may have been the case exactly with the Mastodon.

The early ideas of naturalists on the teeth of the Mastodon were very extravagant. Buffon, for example, supposed, from their rectangular form, that they were very numerous; and having only insulated specimens of large teeth to form a judgment on, he concluded that we might infer how enormous would be the size of a head which had twenty-four or even sixteen teeth, each of which weighed ten or eleven pounds, (Epoques de la Nature. Note Justif. 9.) He made the double mistake of supposing that all the teeth were of the same magnitude, and that the entire set was co-existent in the animal. We now know, with some degree of certainty, that the earliest teeth of this animal were not more than an inch and a half square, and that the three immediately successive teeth were a gradual and successive enlargement upon this and each other's volume. In the Museum of Mr. Koch at St. Louis, there is a young head, the long diameter of which is eighteen or twenty inches, and where the fact of four co-existent teeth on each side of each jaw, is exhibited. This specimen, with a dozen lower jaws of different ages and sizes, enables us to trace with some accuracy the stages of dentition until it reaches the large solitary grinder of ten inches in length, and on each side. Judging from these phases of dentition, I should infer that the entire amount of teeth was at least twenty-four.

M. Cuvier had satisfied himself, that the number was at least twelve, and he had almost reached the conclusion, from a comparison of publications, that there were sixteen. To our learned colleague, Dr. Isaac Hays, we owe *a further* conclusion on this subject, to wit, that the number was twenty-four.* I am, indeed, not satisfied, on viewing the difference of size between the smallest and the largest tooth of the Mastodon, that the number did not approximate still more that of the Elephant, and amount to at least twenty-eight, and, possibly, thirty-two.

Among the remarkable observations on the Mastodon, is that of Dr. Godman,† that there were examples of this animal having a short tusk on each side of the chin, and which he named Tetracaulodon. The existence of these tusks in unquestionably adult specimens, as demonstrated by Dr. I. Hays,‡ quashed the objection that they belonged to the sucking state, and were lost as the animal advanced to maturity. The naturalist was left therefore with the conclusion that either a new species of the animal had been discovered, or that it was merely a sexual peculiarity belonging most probably to the male. The perfect similitude of the other teeth with those of the known Mastodon, embarrasses this question deeply, and it may be safely doubted whether we have the materials to solve it.

In examining the specimens of the lower jaw, in Mr. Koch's Museum in St. Louis, I was struck with some, bearing on this question, and of which there are

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* Description of the Inferior Maxillary Bones of Mastodons. Transactions of the American Philosophical Society, Vol. IV. New Series.

† Transactions of the American Philosophical Society, Vol. III. New Series, p. 478.

‡ Loc. cit. p. 22.

three. The first is a large adult with two of the largest class of molars on each side: it is perfect, with the exception of a small fractured surface of the left anterior part of the chin. This specimen has a lower maxillary tusk, twenty lines in diameter and five inches long. It protrudes from the anterior right side of the chin, and is directed horizontally. There is not the smallest indication of there ever having been a similar production from the left side of the chin, the fracture of which has not been deep enough to remove such vestiges, had they existed. The second specimen is also an adult lower jaw of the same size, in which the whole of the chin and the left half of the bone remain. In the right side of the chin, there is a horizontal alveolus, the size of the preceding; the tusk is not in it, but there is a loose one in the cabinet which may have belonged to it. In this jaw there is no corresponding alveolus, or even a vestige on the left side. The third specimen is the chin alone, of a very young and small animal, it is three inches in length by one and a half wide, is fossilized, and cemented thereby to a fragment of limestone about its own size. Here an alveolus for an inferior maxillary tusk exists also for the right side, but not on the left.

The dentition of these three specimens is, by a very curious coincidence, not symmetrical, that is, a tusk exists only on the right side of the chin in each. The questions in regard to the Tetracaulodon of Godman, are rendered still more embarrassing by their existence; for are we to consider them merely as abnormal types of that animal—as known Mastodons—or as still another species, to which, if such, the name of Tricaulodon might be attached? I confess myself unable to suggest a probable solution of this difficulty. Connected with it is, in fact, another: Mr. Koch has the lower part of the head of a Mastodon of middling size in which, from the intermaxillary bone, as usual, protrudes a tusk; but the tusk exists only on the left side, there being not even a vestige of alveolus on the right. We are informed by Tavernier, that some examples of the Elephas Indicus have but one tusk; are we, then, to consider this head as an abnormal instance of the common Mastodon, or is there really an extinct animal, which has an inferior maxillary tusk on the right side, and a superior maxillary on the left? Each jaw sacrificing one tusk.

The minute anatomy of the teeth, as exhibited by the microscope, has latterly been a very favourite object of study. The unquestionable result appears to be, that there are well established differences of texture in different animals, depending upon the osseous filaments entering into their composition, and upon the direction and branching of certain tubes between these filaments.* While we are waiting for the exhumation of more heads of the above animals, possibly a microscopic examination of teeth and of tusks may serve to clear away some of the mysteries which obscure these problems in the extinct race, of which we have been treating.

These details and difficulties, apparently trivial, will perhaps be excused when we recollect that a single print of the cranium of a fossil Elephant, found in Siberia, and published seventy years before by Messerschmidt,† gave to the great Cuvier his first idea on the Theory of the Earth and of its changes, and caused him to execute the work which stood highest in his own estimation, to say nothing of the approbation which it has received from the scientific world, to wit, the Oss. Fossiles.

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* See Muller's Archives for 1837, for an account of the Danish work of Professor Retzius, of Stockholm. The reader may for these, and other investigations on the same subject, consult also with advantage a Compilation called Researches, &c., on the Teeth, by A. Nasmyth. Lond.: 1839.

† Transactions Philosoph. Vol. XI. p. 446.

ARTICLE V.

Observations to determine the Magnetic Intensity at several Places in the United States, with some additional Observations of the Magnetic Dip. By Elias Loomis, Professor of Mathematics and Natural Philosophy in Western Reserve College. Read Nov. 6, 1840.

MAGNETIC INTENSITY.

IN the autumn of 1839, while engaged upon a series of observations for the magnetic dip, the results of which are given in the Society's Transactions, Vol. VII, pp. 101—111, Professor Renwick of New York kindly offered me the use of his apparatus for magnetic intensity. The offer was gladly accepted, and observations made with the needles whenever circumstances would permit. As I had not yet learned to observe alone, and it was seldom I could find a suitable assistant, the observations were few in number; and I should not think them worthy the attention of the Society, were it not that they furnish an approximate value of the magnetic intensity at one station somewhat remote from the Atlantic coast, and in a region where such observations have been seldom attempted.

The apparatus employed in these observations was constructed after the model of that of Professor Hansteen. Three needles were used. The first, made under the direction of Professor Hansteen himself, is 2.35 inches in length, and .16 inch in diameter, mounted in a stirrup of parchment. The second, which was furnished by Major Sabine, is 2.34 inches long, and .14 inch in diameter, mounted in a brass stirrup. The third, by Professor Henry, is 2.40 inches long, .15 inch in diameter, mounted in a silk stirrup. The needles are accordingly distinguished by the names of Hansteen, Sabine, and Henry. They were enclosed in a small cylindrical box of wood, supported by levelling screws, and having a glass tube fitted to the top, from which the needles were suspended by a few filaments of the silkworm's thread. At the bottom of the box was a divided circle for the purpose of noting the arc of vibration, and the temperature was shown by an enclosed thermometer. The bottom of the box being rendered horizontal, and the needle properly placed in the stirrup, it was drawn aside from the magnetic meridian by bringing near it another needle. The registry of the oscillations was commenced when the half arc of vibration was reduced to 30°, and continued to 320 oscillations, the instant of the completion of every tenth vibration being noted. The amplitude of the final arc was generally recorded, being about five degrees. Five intervals of time were thus obtained, each corresponding to 280 vibrations, namely, the interval between the 0th, and 280th vibration, between the 10th, and 190th, etc., and between the 40th and 320th; and the mean of these is taken as the result.

At Dorchester, Princeton, and Philadelphia, the times were noted by a chronometer. At the other stations, a lever watch was used. At Hudson, the watch was compared with the Observatory clock, immediately before and after the observations. At the remaining stations there is a little uncertainty with regard to the time, yet, it is thought, its influence upon the results will not be great.

No correction has been applied for the arc of vibration. In order to determine the correction for temperature, the apparatus was placed upon a large earthen plate, covered by a bell glass, alternately heated from below by a lamp, and surrounded by a freezing mixture. The usual mode of observation was employed, and the results are shown in the following table, the first column of which indicates the time of commencement of each series of observations.

Date.	Needle.	Time of 280 Vibrations.	Temp.	Date.	Needle.	Time of 280 Vibrations.	Temp.
1839, Dec. 11, 1^{h} 32^{m} P. M.	Sabine	$732^{s}.56$	30°.8	1840, Jan. 4, 1^{h} 28^{m} M. P.	Sabine	$732^{s}.06$	17°.9
" " 1 51 "	"	732 .10	28 .1	" " 1 45 "	"	731 .79	17 .1
" " 2 41 "	Hansteen	859 .36	29 .6	" " 2 32 "	Hansteen	858 .47	19 .9
" " 2 59 "	"	858 .42	26 .5	" " 2 53 "	"	859 .14	15 .7
" " 3 41 "	Henry	592 .36	34 .0	" " 3 47 "	Henry	591 .31	21 .7
" " 3 55 "	"	592 .20	30 .4	" " 4 3 "	"	593 .66	17 .9
" " 4 44 "	"	595 .18	89 .4	" " 4 45 "	"	597 .26	85 .0
" " 4 59 "	"	595 .64	90 .9	" " 5 1 "	"	598 .38	85 .0
" " 7 17 "	Hansteen	869 .93	91 .0	" " 7 0 "	Hansteen	870 .10	84 .3
" " 7 38 "	"	868 .29	91 .1	" " 7 20 "	"	870 .31	88 .8
" " 8 9 "	Sabine	745 .87	84 .2	" " 7 53 "	Sabine	748 .11	89 .4
" " 8 26 "	"	747 .31	85 .0	" " 8 11 "	"	746 .83	84 .0

The mean of the preceding observations furnish,

	Time of Vibration.	Temp.	Time of Vibration.	Temp.
Hansteen,	869s.64	88°.8	858s.85	22°.9
Sabine,	747 .03	85 .6	732 .13	23 .5
Henry,	596 .61	87 .6	592 .38	26 .0

Then, by the usual formula $a = \frac{T - T'}{T(t - t')}$ we obtain:—

$$\text{For Hansteen's needle, } a = \frac{10.79}{858.85 \times 65.9} = .000191.$$

$$\text{For Sabine's needle, } a = \frac{14.9}{732.13 \times 62.1} = .000328.$$

$$\text{For Henry's needle, } a = \frac{4.23}{592.38 \times 61.6} = .000116.$$

The standard temperature, to which the following results are reduced, is 60° Fahrenheit. No correction is applied for the diurnal variation of intensity, but the hours of observation are always stated. To test the permanency of the magnetism of the needles, I have been furnished, by Prof. Renwick, with two series of observations, made at New York, besides those made in September, 1839. The results are as follows:

Needle.	Date.	Time of 280 Vibrations.	Temp.	Corrected Time.
Hansteen	1838, June 22, 0^h 6^m P. M.	873s.60	82°.0	869s.94
"	1839, Sept. 9, 11 13 A. M.	869 .40	86 .0	865 .09
"	1840, June 6, 0 4 P. M.	943 .60	80 .2	939 .97
Sabine	1838, June 21, 5 23 "	744 .35	77 .0	740 .21
"	1839, Sept. 9, 10 48 A. M.	744 .34	85 .2	738 .24
"	1840, June 6, 10 23 "	740 .00	78 .8	735 .44
Henry	1838, June 25, 10 21 "	590 .80	77 .0	589 .64
"	1839, Sept. 9, 11 38 "	596 .72	86 .2	594 .91
"	1840, June 6, 11 26 "	598 .20	79 .0	596 .88

In Sabine's needle, the time of vibration continually diminished, and in Henry's increased; indicating, in the former case, a slight increase of magnetic force, and in the latter a diminution. The inequality, however, does not much, if at all, exceed the irregular fluctuations of intensity which may be observed at a single station, within a moderate interval; and as the variation indicated in the two needles are opposite in kind, and will consequently, in part, balance each other in taking the mean, the magnetism of both is regarded as invariable. In Hansteen's needle there is a striking increase in the time of vibration between 1839 and 1840. This is believed to be due to rust contracted in the interval. As, however, the rust was contracted after the subsequent observations, the magnetism of the needle throughout the series is regarded as invariable. The stations of observation were the same as for the dip formerly described, with the exception of that at Dorchester, which was near Mr. Bond's Observatory.

Place.	Date.	Needle.	Time of 280 Vibrations.	Temp.	Corrected Time.
New Haven, Conn.	1839, Sept. 11, 9^h 53^m A. M.	Sabine	$760^s.64$	$81^\circ.8$	$755^s.21$
"	" " 10 24 "	"	763 .34	83 .0	757 .59
"	" " 10 55 "	Hansteen	887 .04	76 .4	884 .27
"	" " 11 24 "	Henry	609 .95	74 .8	608 .90
Dorchester, Ms.	" Sept. 18, 4 48 P. M.	Sabine	778 .24	78 .8	773 .45
"	" " 5 34 "	Hansteen	907 .06	75 .7	904 .35
"	" " 6 0 "	Henry	625 .08	72 .6	624 .17
Providence, R. I.	" Sept. 19, 4 59 "	Sabine	769 .32	70 .4	766 .70
"	" " 5 22 "	Hansteen	898 .92	68 .5	897 .46
Princeton, N. J.	" Sept. 21, 4 51 "	Sabine	739 .24	80 .7	734 .22
"	" " 5 40 "	Hansteen	865 .46	79 .2	862 .29
"	" " 6 3 "	Henry	595 .10	76 .9	593 .93
Philadelphia, Penn.	" Sept. 23, 4 46 "	Sabine	729 .26	70 .3	726 .80
"	" " 5 23 "	Hansteen	851 .68	67 .6	850 .45
"	" " 5 47 "	Henry	585 .28	65 .7	584 .89
Hudson, Ohio.	" Nov. 2, 1 23 "	Sabine	733 .85	58 .1	734 .31
"	" " 1 41 "	"	734 .75	55 .1	735 .93
"	" " 2 7 "	Hansteen	858 .13	54 .1	859 .09
"	" " 2 27 "	"	857 .66	51 .6	859 .03
"	" " 2 52 "	Henry	592 .61	52 .1	593 .15
"	" " 3 5 "	"	591 .41	53 .0	591 .89
"	" Nov. 30, 1 46 "	Sabine	732 .70	47 .6	735 .68
"	" " 2 3 "	"	732 .76	42 .6	736 .94
"	" " 2 24 "	Hansteen	858 .59	41 .0	861 .70
"	" " 2 45 "	"	858 .33	39 .8	861 .63
"	" " 3 10 "	Henry	591 .78	39 .1	593 .21
"	" " 3 23 "	"	591 .54	38 .2	593 .04
"	1840, Jan. 1, 1 40 "	Sabine	731 .48	23 .5	740 .23
"	" " 1 55 "	"	730 .36	21 .5	739 .57
"	" " 2 29 "	Hansteen	856 .63	25 .5	862 .26
"	" " 3 41 "	Henry	590 .75	27 .0	593 .01
"	" " 3 55 "	"	592 .47	16 .9	595 .44

The mean of the preceding observations furnish us with the following table, in which column third is computed from the formula $\frac{h}{h'} = \left(\frac{T'}{T}\right)^2$, and column sixth by multiplying the horizontal intensity by the secant of the dip. The last column represents the total intensity, that of New York being called 1.803, according to the determination of Major Sabine.

		Time.	Horizontal intensity.	Mean.	Dip.	Total intensity.	Total intensity.
New York,	Hansteen	867^{s}.51	.96105	.96707	72° 52′.2	1.00815	1.803
"	Sabine	737 .96	.96998				
"	Henry	593 .81	.97018				
New Haven,	Hansteen	884 .27	.92497	.92364	73 26 .7	.99533	1.7800
"	Sabine	756 .40	.92326				
"	Henry	608 .90	.92269				
Dorchester,	Hansteen	904 .35	.88435	.88182	74 16 .0	.99854	1.7858
"	Sabine	773 .45	.88301				
"	Henry	624 .17	.87810				
Providence,	Hansteen	897 .46	.89798	.89830	73 59 .6	1.00027	1.7889
"	Sabine	766 .70	.89862				
Princeton,	Hansteen	862 .29	.97273	.97414	72 47 .1	1.01066	1.8075
"	Sabine	734 .22	.97989				
"	Henry	593 .93	.96979				
Philadelphia,	Hansteen	850 .45	1.00000	1.00000	72 7 .1	1.00000	1.7884
"	Sabine	726 .80	1.00000				
"	Henry	584 .89	1.00000				
Hudson,	Hansteen	860 .74	.97623	.97344	72 47 .6	1.01040	1.8070
"	Sabine	737 .11	.97222				
"	Henry	593 .29	.97188				

From the preceding observations it may be inferred that New York and Hudson have sensibly the same magnetic intensity, as well as dip.

The only published observations, so far as I am aware, with which the preceding can be compared, are those made by President Bache and Professor Courtenay, and published in the Society's Transactions, Vol. VI., pp. 427—457. The horizontal intensity at New York, (that at Philadelphia being considered unity,) was found, by observations in common air, .97202; by observations in rarefied air, .94702. Mean of the two determinations, allowing each its proper weight, .94705. My own result is .96707. The horizontal intensity at Providence, by President Bache's observations, is .89869; by my own, .89830.

Magnetic Dip.

The following observations of the dip in different azimuths were made with the same instrument formerly described, for the purpose of testing the axles of the needles. They were made at Hudson, from August 27 to September 4, 1840, on the same spot formerly employed. The same mode of observing was adhered to, and each number in the two columns headed "Poles direct," "Poles reversed," is the mean of twenty readings, five being made of each pole in one position of the needle, and the same number after the needle was reversed upon its supports. Thus, 1360 readings were made with each needle. The dip is deduced from the formula $cot.^2\ \delta = cot.^2\ i + cot.^2\ i'$.

NEEDLE No. 1.

Azimuth.	Poles direct.	Poles reversed.	Mean.	Dip deduced.
0	72°26′.4	72°37′.8	72°45′.6	72°45′.6
180	72 51 .9	73 6 .3		
10	72 40 .2	72 54 .9	73 2 .7	72 46 .1
190	73 11 .6	73 24 .0		
100	86 9 .5	87 18 .9	86 44 .2	
280	86 52 .4	86 35 .8		
20	73 24 .6	73 30 .0	73 42 .7	72 46 .1
200	73 52 .3	74 3 .7		
110	84 13 .6	84 32 .8	84 3 .8	
290	83 49 .8	83 38 .8		
30	74 36 .1	74 44 .6	74 56 .2	72 47 .7
210	75 4 .4	75 19 .7		
120	81 20 .1	81 35 .1	81 17 .6	
300	81 1 .8	81 13 .1		
40	76 18 .8	76 31 .1	76 40 .3	72 49 .8
220	76 47 .1	77 4 .3		
130	78 57 .8	79 12 .4	78 46 .8	
310	78 31 .1	78 25 .8		

Azimuth.	Poles direct.	Poles reversed.	Mean.	Dip deduced.
50	78°23′.5	78°30′.8	78°45′.8	72°48′.4
230	78 49 .0	79 19 .7		
140	76 47 .0	77 3 .6	76 39 .2	
320	76 23 .5	76 22 .8		
60	81 9 .7	80 57 .2	81 16 .9	72 49 .5
240	81 18 .5	81 42 .1		
150	75 3 .5	75 24 .0	74 58 .7	
330	74 40 .8	74 46 .6		
70	83 42 .7	83 34 .3	83 56 .2	72 47 .8
250	84 5 .7	84 21 .9		
160	73 58 .0	74 7 .1	73 47 .1	
340	73 29 .0	73 34 .2		
80	86 45 .7	86 31 .1	86 54 .2	72 45 .8
260	87 2 .6	87 17 .4		
170	73 9 .2	73 21 .7	73 0 .8	
350	72 42 .3	72 49 .8		

General mean, 72° 47′.4

NEEDLE No. 2.

Azimuth.	Poles direct.	Poles reversed.	Mean.	Dip deduced.
0	72° 57′.8	72° 32′.7	72° 53′.5	72° 53′.5
180	72 56 .4	73 7 .0		
10	73 14 .5	72 45 .8	73 9 .7	72 55 .0
190	73 17 .9	73 20 .3		
100	87 8 .6	87 18 .3	86 56 .9	
280	86 39 .4	86 41 .3		
20	73 54 .4	73 29 .3	73 50 .9	72 54 .8
200	74 4 .2	73 55 .8		
110	84 10 .5	84 28 .8	84 7 .1	
290	83 58 .5	83 50 .6		
30	74 55 .2	74 31 .4	74 59 .0	72 46 .6
210	75 20 .9	75 8 .2		
120	81 19 .2	81 28 .2	81 9 .1	
300	80 56 .4	80 52 .4		
40	76 51 .2	76 6 .4	76 43 .4	72 55 .1
220	76 57 .9	76 56 .1		
130	79 11 .7	79 8 .6	78 51 .9	
310	78 40 .9	78 26 .3		

Azimuth.	Poles direct.	Poles reversed.	Mean.	Dip deduced.
50	78° 45′.2	78° 24′.2	78° 52′.9	72° 59′.3
230	79 14 .0	79 8 .0		
140	77 0 .0	76 57 .0	76 48 .2	
320	76 58 .8	76 16 .8		
60	80 54 .2	80 51 .3	81 6 .2	72 47 .2
240	81 13 .8	81 25 .4		
150	75 21 .6	75 10 .4	75 1 .8	
330	74 59 .7	74 35 .2		
70	83 56 .7	83 43 .4	84 0 .1	72 52 .6
250	83 57 .1	84 23 .1		
160	74 3 .7	74 1 .7	73 50 .8	
340	73 47 .9	73 29 .9		
80	86 37 .5	86 41 .5	86 53 .2	72 51 .9
260	87 1 .4	87 12 .3		
170	73 14 .5	73 16 .7	73 7 .2	
350	73 13 .3	72 44 .1		

General mean, 72° 52′.9

The results with needle No. 1 are quite satisfactory, the extreme range of the values of the dip from observations in different azimuths being 4′.2. With needle No. 2 the extreme range is 12′.7. This discordance is ascribed to slight rust which has formed upon one of the axles, but which is barely discernible to the naked eye. The mean of the preceding 2720 readings with both needles is 72° 50′.2; the mean of the observations in the meridian is 72° 49′.6. Difference 0′.6. In these observations 0 of azimuth is intended to indicate the magnetic meridian. The dip may then be deduced by the formula $cot.\ \delta = cot.\ i.\ sec.\ \theta.$ The following table gives the result of this comparison:

	Needle No. 1.		Needle No. 2.	
Azimuth.	Inclination.	Dip.	Inclination.	Dip.
0	72° 45′.6	72° 45′.6	72° 53′.5	72° 53′.5
10	73 1 .7	" 46 .9	73 8 .4	" 53 .7
20	73 44 .9	" 45 .9	73 50 .9	" 52 .2
30	74 57 .5	" 45 .6	75 0 .4	" 48 .9
40	76 39 .8	" 48 .2	76 45 .8	" 55 .8
50	78 46 .3	" 50 .2	78 52 .4	" 59 .2
60	81 17 .2	" 57 .6	81 7 .6	" 39 .7
70	84 0 .0	" 55 .0	84 3 .6	" 64 .8
80	86 49 .2	" 15 .4	86 55 .1	" 46 .3
	Mean Dip,	72° 45′.6	Mean Dip,	72° 52′.7

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*That the dips obtained by this method should not perfectly accord with each other will not appear strange when it is considered that an error of one minute in the observed azimuth at eighty degrees causes an error of nearly two minutes in the computed dip; and an error of one minute in the observed inclination causes an error of more than five minutes in the computed dip. The mean result with the two needles by the last method is 72° 49′.1; by the former method of combination, 72° 50′.2; mean of the two methods, 72° 49′.6, which accords perfectly with the result of observations in the meridian.

* The part of this paper which follows, was read November 20, 1840.

The preceding trial appears to me to justify confidence in the needles employed, and to give additional value to my former observations.

The following observations were made in the usual manner:

Magnetic Dip at Hudson, Ohio. Latitude 41° 15′ *N.; Longitude* 81° 26′ *W.*

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, April 15th,	8½—11, A. M.	No. 1,	40	72° 50′.3
“ “ “	“ “	No. 1, poles reversed,	40	44 .1
“ “ “	“ “	Mean of No. 1,	80	47 .2
“ “ “	“ “	No. 2,	40	69 .5
“ “ “	“ “	No. 2, poles reversed,	40	49 .0
“ “ “	“ “	Mean of No. 2,	80	59 .2
“ “ “	“ “	Mean of both needles,	160	72 53 .2

Magnetic Dip at Aurora, Ohio. Latitude 41° 20′ *N.; Longitude* 81° 20′ *W.*

Place of observation thirty rods north-west of the Presbyterian church.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 8th,	9—11, A. M.	No. 1,	40	72° 51′.0
“ “ “	“ “	No. 1, poles reversed,	40	48 .4
“ “ “	“ “	Mean of No. 1,	80	49 .7
“ “ “	“ “	No. 2,	40	57 .3
“ “ “	“ “	No. 2, poles reversed,	40	65 .1
“ “ “	“ “	Mean of No. 2,	80	61 .2
“ “ “	“ “	Mean of both needles,	160	72 55 .5

Magnetic Dip at Windham, Ohio. Latitude 41° 15′ *N.; Longitude* 81° 3′ *W.*

Place of observation fifty rods north of the Presbyterian church.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 8th,	3—5, P. M.	No. 1,	40	72° 57′.2
“ “ “	“ “	No. 1, poles reversed,	40	59 .7
“ “ “	“ “	Mean of No. 1,	80	58 .5
“ “ “	“ “	No. 2,	40	73 14 .9
“ “ “	“ “	No. 2, poles reversed,	40	1 .7
“ “ “	“ “	Mean of No. 2,	80	8 .3
“ “ “	“ “	Mean of both needles,	160	73 3 .4

Magnetic Dip at Bazetta, Ohio. Latitude 41° 20′ *N.; Longitude* 80° 45′ *W.*

Place of observation near the centre of the township.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 9th,	11½—1, P. M.	No. 1,	40	72° 58′.4
“ “ “	“ “	No. 1, poles reversed,	40	57 .3
“ “ “	“ “	Mean of No. 1,	80	57 .9
“ “ “	“ “	No. 2,	40	61 .1
“ “ “	“ “	No. 2, poles reversed,	40	61 .8
“ “ “	“ “	Mean of No. 2,	80	61 .5
“ “ “	“ “	Mean of both needles,	160	72 59 .7

Magnetic Dip at Kinsman, Ohio. Latitude 41° 30′ *N.; Longitude* 80° 34′ *W.*

Place of observation half a mile south-west of the centre of the township.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 10th,	9—11, A. M.	No. 1,	40	73° 2′.0
“ “ “	“ “	No. 1, poles reversed,	40	8 .9
“ “ “	“ “	Mean of No. 1,	80	5 .5
“ “ “	“ “	No. 2,	40	10 .5
“ “ “	“ “	No. 2, poles reversed,	40	11 .1
“ “ “	“ “	Mean of No. 2,	80	10 .8
“ “ “	“ “	Mean of both needles,	160	73 8 .1

Magnetic Dip at Hartford, Ohio. Latitude 41° 19′ *N.; Longitude* 80° 34′ *W.*

Place of observation one mile south of the centre of the township.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 10th,	4—5½, P. M.	No. 1,	40	72° 55′.9
“ “ “	“ “	No. 1, poles reversed,	40	51 .4
“ “ “	“ “	Mean of No. 1,	80	53 .7
“ “ “	“ “	No. 2,	40	64 .0
“ “ “	“ “	No. 2, poles reversed,	40	68 .0
“ “ “	“ “	Mean of No. 2,	80	66 .0
“ “ “	“ “	Mean of both needles,	160	72 59 .8

Magnetic Dip at Warren, Ohio. Latitude 41° 16′ *N.; Longitude* 80° 49′ *W.*

Place of observation a few rods east of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 11th,	12—1½, P. M.	No. 1,	40	72° 55′.2
" " "	" "	No. 1, poles reversed,	40	59 .9
" " "	" "	Mean of No. 1,	80	57 .6
" " "	" "	No. 2,	40	73 4 .2
" " "	" "	No. 2, poles reversed,	40	3 .4
" " "	" "	Mean of No. 2,	80	3 .8
" " "	" "	Mean of both needles,	160	73 0 .7

Magnetic Dip at Cleveland, Ohio. Latitude 41° 30′ *N.; Longitude* 81° 42′ *W.*

Place of observation half a mile south of the American House.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 22d,	2—4, P. M.	No. 1,	40	73° 17′.4
" " "	" "	No. 1, poles reversed,	40	16 .0
" " "	" "	Mean of No. 1,	80	16 .7
" " "	" "	No. 2,	40	7 .0
" " "	" "	No. 2, poles reversed,	40	7 .6
" " "	" "	Mean of No. 2,	80	7 .3
" " "	" "	Mean of both needles,	160	73 12 .0

This result accords better with other observations than my former observation at this place, and is believed to represent more accurately the true dip.

Magnetic Dip at Bedford, Ohio. Latitude 41° 24′ *N.; Longitude* 81° 32′ *W.*

Place of observation a quarter of a mile south of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 23d,	1—3, P. M.	No. 1,	40	72° 50′.6
" " "	" "	No. 1, poles reversed,	40	58 .3
" " "	" "	Mean of No. 1,	80	54 .5
" " "	" "	No. 2,	40	64 .8
" " "	" "	No. 2, poles reversed,	40	58 .5
" " "	" "	Mean of No. 2,	80	61 .6
" " "	" "	Mean of both needles,	160	72 58 .1

Magnetic Dip at Twinsburgh, Ohio. Latitude 41° 20′ *N.*; *Longitude* 81° 26′ *W.*

Place of observation a quarter of a mile north of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 23d,	4—5, P. M.	No. 1,	40	72° 54′.8
" " "	" "	No. 1, poles reversed,	40	48 .7
" " "	" "	Mean of No. 1,	80	51 .8
" " "	" "	No. 2,	40	48 .2
" " "	" "	No. 2, poles reversed,	40	53 .3
" " "	" "	Mean of No. 2,	80	50 .8
" " "	" "	Mean of both needles,	160	72 51 .3

Magnetic Dip at Tallmadge, Ohio. Latitude 41° 6′ *N.; Longitude* 81° 26′ *W.*

Place of observation half a mile south-west of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Sept. 28th,	8—9½, A. M.	No. 1,	40	72° 43′.6
" " "	" "	No. 1, poles reversed,	40	54 .1
" " "	" "	Mean of No. 1,	80	48 .9
" " "	" "	No. 2,	40	53 .8
" " "	" "	No. 2, poles reversed,	40	49 .0
" " "	" "	Mean of No. 2,	80	51 .4
" " "	" "	Mean of both needles,	160	72 50 .1

I have always aimed to remove all iron from my person before commencing a series of observations; but after concluding the preceding, I found, to my surprise, an iron key in my coat pocket. The observations were, therefore, subsequently repeated in the same place.

Magnetic Dip at Shalersville, Ohio. Latitude 41° 15′ *N.; Longitude* 81° 13′ *W.*

Place of observation forty rods west of the Presbyterian church.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Oct. 15th,	2½—4, P. M.	No. 1,	40	72° 59′.1
" " "	" "	No. 1, poles reversed,	40	51 .9
" " "	" "	Mean of No. 1,	80	55 .5
" " "	" "	No. 2,	40	54 .3
" " "	" "	No. 2, poles reversed,	40	61 .0
" " "	" "	Mean of No. 2,	80	57 .6
" " "	" "	Mean of both needles,	160	72 56 .6

Magnetic Dip at Streetsboro, Ohio. Latitude 41° 15′ *N.; Longitude* 81° 20′ *W.*

Place of observation a quarter of a mile west of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Oct. 16th,	9—11, A. M.	No. 1,	40	72° 46′.2
" " "	" "	No. 1, poles reversed,	40	55 .8
" " "	" "	Mean of No. 1,	80	51 .0
" " "	" "	No. 2,	40	52 .6
" " "	" "	No. 2, poles reversed,	40	57 .4
" " "	" "	Mean of No. 2,	80	55 .0
" " "	" "	Mean of both needles,	160	72 53 .0

Magnetic Dip at Tallmadge, Ohio. Latitude 41° 6′ *N.; Longitude* 81° 26′ *W.*

Place of observation the same as formerly.

Date.	Hour.	Needle.	No. Readings.	Dip.
1840, Oct. 31st,	2—3½, P. M.	No. 1,	40	72° 53′.5
" " "	" "	No. 1, poles reversed,	40	44 .1
" " "	" "	Mean of No. 1,	80	48 .8
" " "	" "	No. 2,	40	47 .6
" " "	" "	No. 2, poles reversed,	40	47 .5
" " "	" "	Mean of No. 2,	80	47 .5
" " "	" "	Mean of both needles,	160	72 48 .2

This result is almost identical with the former observation, indicating that the effect of the iron key was scarcely appreciable.

The preceding observations, as well as those which I have formerly made in Ohio and Michigan, are tolerably well represented by parallel, straight, and equidistant isoclinal lines, running from N. 80° W. to S. 80° E.; and the line of 73° passes five or six miles south of Cleveland.

ARTICLE VI.

On the Perchlorate of the Oxide of Ethule or Perchloric Ether. By Clark Hare and Martin H. Boyè. Read December 4, 1840.

THE energetic properties of perchloric acid, and its stability, compared with the other compounds of chlorine with oxygen, led us to the belief that this acid might be combined with the substance which performs the part of a base in that class of organic salts which are generally designated by the name of *ethers,* and for which Berzelius, in consequence of his theoretical views, has adopted the name of oxide of ethule. For this purpose a concentrated solution of perchlorate and sulphovinate of barytes, in equivalent proportions, was subjected to distillation. The sulphovinate of barytes may be considered as a double sulphate of barytes and the oxide of ethule; and we anticipated that, when heat was applied, a double decomposition would take place between the latter and the perchlorate of barytes. So long as the salts remained in solution no reaction occurred, but as soon as they became solid in consequence of the distillation of the water, a reciprocal decomposition ensued, and a sweet ethereal liquid distilled into the receiver. This *liquid* is the *perchlorate of the oxide of ethule.*

As this substance is extremely explosive, in order to prepare it with safety it is necessary to operate on small quantities. We have employed from seventy to ninety grains of crystallized sulphovinate of barytes, with an equivalent proportion of perchlorate of barytes*; but we would recommend, especially on the first

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* The amount of barytes in the perchlorate should be ascertained by an experiment, as it retains water with great tenacity. It may be worth while to mention, that the perchlorate of potassa can-

performance of the experiment, the employment of considerably smaller quantities. The salts should be intimately mixed in a mortar, and placed in a small retort attached to a refrigerator containing ice, and a receiver similarly cooled. The retort is to be heated in an oilbath, in which a thermometer is suspended, so as to indicate the temperature. A wooden screen, furnished with openings covered with thick plate-glass at such intervals as to afford a full view of the different parts of the apparatus, should be erected in front of it, and strings passed around the screen and attached to a bar traversing on a pivot, and supporting an argand spirit lamp, by which heat is communicated to the oilbath, so as to enable the flame of the lamp to be removed from or applied to the apparatus, according to the indications of the thermometer, without exposing the person of the operator. After the heat has reached 212° F., below which the salts employed do not react on each other, it should be raised very gradually, and the distillation finished below 340° F. Under these circumstances but little danger is to be apprehended from the retort, but the ether in the receiver must be treated with the greatest caution, since it has exploded in our hands in attempting to remove it with a pipette from the stratum of water which covers it. This water, therefore, should be removed by the cautious use of strips of blotting paper, moistened at the end, and introduced into the tube employed as a receiver.

To avoid the danger attendant on the management of the ether in its pure state, it may be received in strong alcohol, since it is not explosive when dissolved in alcohol. If the experiment be performed with seventy grains of sulphate of barytes, from one to two drachms of absolute alcohol will be found sufficient for this purpose. By the addition of an equal volume of water, the ether may subsequently be separated from this solution, in small quantities, for the purpose of examination. But, in this case a loss of ether is sustained, by the decomposing influence of the water employed.

The perchlorate of ethule obtained in this way is a transparent, colourless liquid, possessing a peculiar, though agreeable smell, and a very sweet taste, which, on subsiding, leaves a biting impression on the tongue, resembling that of the oil of cinnamon. It is heavier than water, through which it rapidly

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not be substituted for the perchlorate of barytes, since the sulphovinate is decomposed without acting on it. We were equally unsuccessful in an attempt to procure the ether by the distillation of perchlorate of barytes and concentrated sulphovinic acid.

sinks.* It explodes by ignition, friction, or percussion, and sometimes without any assignable cause. Its explosive properties may be shown, with but little danger, by pouring a small portion of the alcoholic solution into a small porcelain capsule, and adding an equal volume of water. The ether will collect in a drop at the bottom, and may be subsequently separated by pouring off the greater part of the water, and throwing the rest on a moistened filter, supported by a wire. After the water has drained off, the drop of ether remaining at the bottom of the filter may be exploded either by approaching it to an ignited body, or by the blow of a hammer. We are induced to believe that, in explosive violence, it is not surpassed by any substance known in chemistry. By the explosion of the smallest drop, an open porcelain plate will be broken into fragments, and by that of a larger quantity, be reduced to powder. In consequence of the force with which it projects the minute fragments of any containing vessel in which it explodes, it is necessary that the operator should wear gloves, and a close mask, furnished with thick glass-plates at the apertures for the eyes, and perform his manipulations with the intervention of a moveable wooden screen.*

In common with other ethers, the perchlorate of ethule is insoluble in water, but soluble in alcohol; and its solution in the latter, when sufficiently dilute, burns entirely away without explosion. It may be kept for a length of time unchanged, even when in contact with water; but the addition of this fluid, when employed to precipitate it from its alcoholic solution, causes it partially to be decomposed. Potassa, dissolved in alcohol, and added to the alcoholic solution, produces, immediately, an abundant precipitate of the perchlorate of that base, and, when added in sufficient quantity, decomposes the ether entirely. It would appear, therefore, impracticable to form either perchlorovinates or perchlorovinic acid.

We have subjected the perchlorate of ethule to the heat of boiling water without explosion or ebullition.

It may be observed that this is the first ether formed by the combination of an inorganic acid containing more than three atoms of oxygen with the oxide of ethule, and that the chlorine and oxygen in the whole compound are just sufficient to form chlorohydric acid, water and carbonic oxide with the hydrogen and carbon.

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* Having suffered severely on several occasions from the unexpected explosion of this substance, we would earnestly recommend the operator not to neglect the precautions mentioned above.

The existence of a compound of the oxide of ethule with an acid containing *seven* atoms of oxygen led us to attempt to combine, by the same method, this base with nitric acid. For this purpose we subjected a mixture of sulphovinate and nitrate of barytes to the same treatment as described above, but the reaction, even when conducted with the greatest possible care, is destructive, hyponitrous ether and gaseous matters being the principal products obtained. Nor were we more successful in our attempts to procure a sulphurous or hyposulphuric ether by the same process.

ARTICLE VII.

Observations on the Storm of December 15, 1839. *By William C. Redfield, A. M.*
Read January 15, 1841.

In the table and map which are annexed to these remarks will be found the observations which have been obtained of the direction of wind in this storm, in the states of Connecticut, Rhode Island, Massachusetts, New Jersey, and parts of the states of Maine, New Hampshire, Vermont, and New York.

The arrows on the map denote, approximately, the direction of wind, at or near the hour of noon, at the several places of observation. The concentric lines, drawn at intervals of thirty miles, were added, not as precisely indicating the true course of the wind, but to afford better means of comparison for the several observations.

It will be seen, that of forty-eight distinct sets of observations, which are comprised in the annexed schedule, about thirty are derived from the meteorological journals of scientific and intelligent observers, or from the log-books of vessels exposed to the storm. And I take this occasion to offer my thanks to the gentlemen who have so kindly furnished me with their observations.

The position assumed for the axis of the gale, at noon, should, perhaps, be nearly in line with the position of the ship Morrison and Cape Cod Bay; at which places the wind was then blowing from opposite points of the compass, but not in actually opposing directions. The Morrison was from China, bound to New York; and I have reason to believe that her position at noon may be safely relied on. The violence of the gale was here so great that the ship, as I am informed, was lying to without canvass. This ship had encountered the western side of the gale, suddenly, at 7, A. M., and the sun shone chiefly unobscured during the greater part of the day.

The gale was severe over the entire surface comprised in the map, except, perhaps, on its extreme northern and north-western portions, and excepting, also, the lighter winds which were observed near the apparent axis of the gale, in the region of Buzzards' and Cape Cod Bays, &c., in the afternoon and evening. A very heavy fall of snow accompanied the gale in the states of Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine; also, in some parts of New York and southern Vermont. Some snow also fell in the western and northern parts of New York and Vermont, but attended with more moderate and variable winds, chiefly from the north and west.

The south-westerly and southerly winds, which connect the south-easterly with the westerly winds in the circuit of rotation, are found at Nantucket in the afternoon, by the farther advance of the storm, and also in the log-books of a number of vessels whose positions were eastward and southward of the ship Morrison, but beyond the limits of the map.

The barometric minimum, as in other storms, appears to have nearly coincided, in its progress, with the apparent axis of the gale.

My main object in collecting the observations contained in the subjoined schedule has been to establish the course of the wind in the body or heart of the storm at a given time, and apart from all other considerations. I am in possession, however, of more extended observations of this gale. Many of these appear to agree with some of the following characters or modes of action which pertain, more or less, to many of the storms or gales that visit the United States and other regions. These characters have claimed attention from almost the earliest period of my inquiries.

1. The body of the gale usually comprises an area of rain or foul weather, together with another, and perhaps equal, or greater area of fair or bright weather.

2. The fall of rain or snow often extends, in some direction, greatly beyond the observed limits of the gale.

3. The gale itself not unfrequently exhibits an apparently unequal extent of action, or degree of violence, on different sides of its apparent axis of rotation.

This peculiarity, as well as the second, is most common in winter storms, and in those which sweep over an extensive continental surface; and, like other irregularities, is less noticeable in the storms which are traced solely on the ocean.

4. The barometric indications of a gale commonly extend much beyond the observed limits of its action.

5. The body of the gale constitutes a determinate sheet or stratum of moving air; and of this sheet or stratum a large portion sometimes overlies another and more quiescent stratum of air, the latter having, perhaps, a different motion; as in common winds of the temperate and higher latitudes: in which case the gale is either not felt at the surface of the earth, or the observed changes of wind are found, in part, unconformable to the whirlwind theory.

6. Owing to the convergent and somewhat variable courses of storms in the extra tropical latitudes, as well as to their unequal rates of progress, two storms will sometimes cover, in part, the same field, one of which will overlie the other, and, perhaps, thin out at its margin, in the same manner as common winds. This, also, may occasion a different order of change in the observed winds and weather from that which is more commonly noticed in a regular whirlwind storm.

Owing to such causes, the oscillations of the barometer are often irregular; and this is particularly noticeable in the higher latitudes.

7. In most gales of wind there is, probably, a subordinate motion, inclining gradually downward and inward in the circumjacent air, and in the lower portions of the gale; and a like degree of motion, spirally upward and outward, in the central and higher portions of the storm. This slight vorticular movement is believed to contribute largely to the clouds and rain which usually accompany a storm or gale; and is probably due, in part, to the excess of external atmospheric pressure on the outward portions of the revolving storm.

8. In storms which are greatly expanded there is sometimes found an extensive area of winds of little force and variable direction, lying within the circuit of the true gale, and attended throughout, with a depressed state of the barometer. This more quiescent portion of air in the centre of a gale has been found to extend, in some cases, to a diameter of several hundred miles.

In the case now before us, the direction of the arrows representing the course of the wind at noon, as carefully drawn on a larger map, shows an average convergence, or inward inclination, of about six degrees. But it is not deemed safe to rely upon this result in a single case, which is liable to be affected by the errors of observation and the deflecting influences of the great valleys and lines of elevation, as well as by the errors of approximation which often arise from referring all winds to eight, or, at most, to sixteen points of the compass.

It is not intended, on this occasion, to support the foregoing characteristics by such extended details of evidence as their discussion would necessarily demand; and they are mentioned here only because the true character of the rotation in these gales, as well as the necessary or incidental connexion of this rotation with other phenomena which attend them, has seemed to be often misapprehended.

As relates to the whirling or rotary action in the case before us, it may be remarked, that had we obtained no observations from the north-western side of the axis of this gale, it would have been easy, in the absence of more strictly consecutive observations than are usually attainable, to have viewed the initial south-easterly wind of the gale,* and the strong north-westerly wind which soon followed, as two distinct sheets, or currents of wind, blowing in strictly opposing directions: and if we could so far lose sight of the conservation of spaces and areas, the laws of momentum and gravitation, together with a continually depressed barometer within the storm, we might then have supposed one of these great winds, if not both, to have been turned upward by an unseen deflection, and doubled back upon itself in the higher atmosphere. But the case neither calls for nor admits these speculations. If, however, the axis of this gale had chanced to pass westward and northward of our limits of correct observation, in pursuing its north-easterly course, as did, perhaps, that of the storm of December 21st, 1836, which has been ably examined and discussed by Professor Loomis,† it is, in such case, more than probable that its whirlwind character would not have been established.

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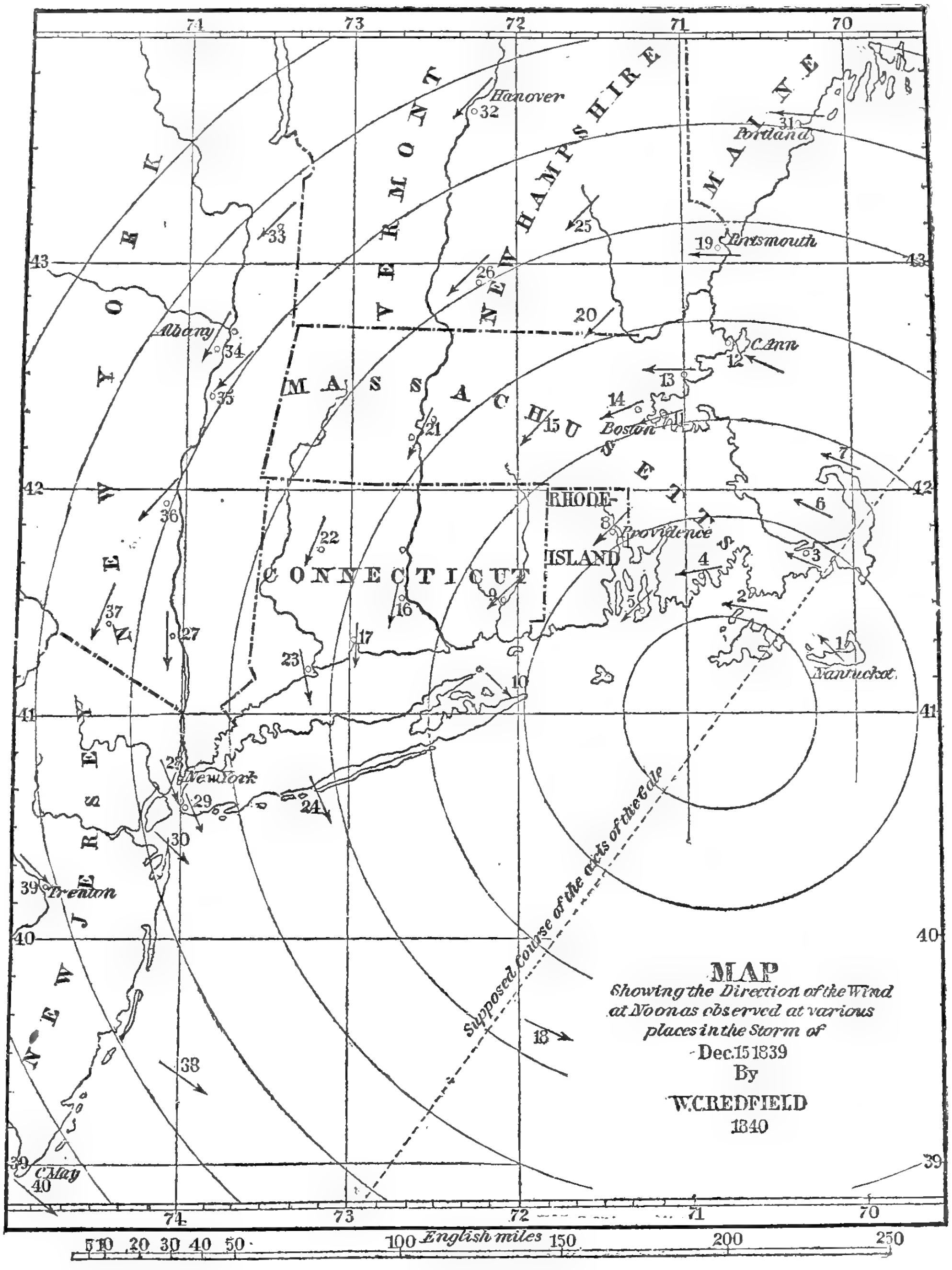
* Observed between the coast of Massachusetts and latitude 25° N.

† Trans. Am. Phil. Soc., Vol. VII., p. 125—163.



MAP
Showing the Direction of the Wind at Noon as observed at various places in the Storm of Dec. 15 1839
By
W. C. REDFIELD
1840

Schedule of Observations on the Direction of Wind in the Storm of December 15*th*, 1839: *With a Map indicating the Direction of the Wind at or near the hour of Noon. By* WILLIAM C. REDFIELD.

No.	*Places of Observation.*	*A. M.*	*Noon.*	*P. M.*	*Observers and Authorities.*
1	Nantucket, Ms.	E.	S.E. at 1 *p. m.*	S. W.	Report of James Mitchell, as published by Mr. Espy.
2	Woodville, Ms.		"A little S. of E."	Clouds broke at W. before 2 P. M.	Observations on board Steamboat Telegraph, by William Mitchell of [Nantucket.
3	Barnstable, Ms.	N. E. at 7 *a. m.*	[E. S. E.]	E. at 2 *p. m.*: S. E. at Sunset.	Report to Editor of Boston Courier. *I take the mean of E. and S. E. for true direction at Noon.* W.C.R.
	Do.	Gale from S. E.		S.W. *p. m.*: Clear at Sunset.	Letter of Wm. H. Brown to W. C. R.
4	New Bedford, Ms	Sunrise, N.E. mod.	[E. by N.]	2 *p. m.* E. N. E.: 3½ p. m. S.	Joseph Congdon's Meteorological Journal. *I take E. by N. as the mean for Noon.*
	Do.	do. E. fresh,		do. E: Sunset S S E	Sam'l Rodman's. do. as publ'd by Mr. Espy.
5	Newport, R. I.	N. E.	N. E.	N. E.	Meteorological Journal published at Newport.
6	Cape Cod Bay,	E. S. E.	E. S. E.	E. S. E. at 2 *p. m.*	Report of Capt. Slemmer, Brig Columbus.
7	Provincetown, Ms.	E. S. E.	E. S. E.	E. S. E.	Marine Reports in Boston Newspapers.
8	Providence, R.I.	N. E.	N. E.	N. E.	Professor Caswell's Meteorological Journal.
9	Norwich, Ct.	N. E.	N. E.	N. E.	Norwich Courier.
10	Culloden Point, N.Y.	*"changed to*	*N. W. at Noon."*		Capt. Green's Account, as published by Mr. Espy.
11	Boston, Ms.	Sunrise, N. E.	E. N. E. [E. 17° N.]	Sunset, E. S. E.	Wm. Cranch Bond's Meteorl. Journal. *I take the mean of the observations at Noon.*
	Do.	E. by N.	E. by N.	E. by N.	Robert Treat Paine's Observations.
12	Gloucester, Ms.	E. S. E.	E. S. E.	E. S. E.	Letter from Gloucester, in the Boston Newspapers.
13	Salem, Ms.	Eastward.	Eastward.	Eastward.	Salem Gazette.
14	Waltham, Ms.	N. E.	[E. N. E.]	E.	Monthly Met. Jour., by C. F., in the Boston Daily Centinel.
15	Worcester, Ms.	N. E.	N. E.	N. E.	Met. Journal at State Lunatic Hospital—in National Ægis.
16	Middletown, Ct.	N. N. E.	[N. by E.]	N.	Reported by Professor Smith. *I take N. by E. for the mean at Noon.*
	Do.	N.		N. N. E.	Dr. Barratt's Met. Journal.
17	New Haven, Ct.	N. by W.	[N. 3° E.]	N. N. W.	Report of Capt. Woolsey, Steamboat Providence. *I take the mean of N. 3° E.*
	Do.	N. N. E.		N. N. E. till 1½ *p.m.*	Judge Darling's Meteorological Journal.
18	Ship Morrison, at sea: Lat. 39° 35 N. Lon. 71° 50 W.	S. E.: W. N. W.	W. N. W.	W. N. W.	Ship's Log Book—also, Statements of Capt. Benson and his Officers.
19	Portsmouth, N. H.	E.	E.	E.	Weekly Meteorological Journal, published at Portsmouth.
20	Nashua, N. H.	N. E.	N. E.	N. E.	Nashua Telegraph.
21	Northampton, Ms.	N. E.	[N. N. E.]	N. E.	Observations of W. Atwill and others. *I assume the approximate mean of N. N. E. for Noon.*
	Amherst, Ms.	N. by W.		N. by W.	Professor Snell's Met. Journal.
22	Litchfield, Ct.	Night of 14, 15, N.E	[N. N. E.]	N. at Night of 15th.	Litchfield Enquirer. *Assumed mean for noon of* 15*th, N. N. E.*
23	Stratford, Ct.	N. by W.	N. by W.	N. by W.	Rev. J. R. Linsley's Meteorological Journal.
24	Fire Island Beach, N.Y.	Midnight, N. E.: veered by N.	N. N. W.	N. N. W.	Captains Cartwright and Skiddy, employed at the Beach.
25	Concord, N. H.	Northeasterly.	N. E.	N.E. and more N'ly	Letter from Concord to S. G. Arnold; from Mr. Arnold.
26	Keene, N. H.	N. E.	N. E.	N. E.	Rev. Z. S. Barstow's Meteorological Journal.
27	West Point, N.Y.	N.	N.	N.	Meteorological Journal of the Medical Department.
28	New-York City,	N. by W.: N. N.W.	N. N. W.	N.W. by N.	Meteorological Journal of W. C. Redfield.
	Fort Wood, N.Y. Harbor	N.	[N. N. W.]	N. W.	Met. Journal of Medical Officer. *Mean of N. N. W. taken for Noon.*
29	Flatbush, N.Y.	N.	[N. N. W.]	N. W.	Rev. T. M. Strong's Met. Jour. *Mean of N. N. W. assumed for Noon.*
30	Sandy Hook Bay, N.Y.	N.	N. W.	N. W.	Log Book of Bark Osceola.
31	Portland, Me.	N. E.: at 11 E.	[E. 6° S. mean.]	E. by S.	Met. Report of Keeper of Marine Observatory: Published at Portland.
32	Hanover, N.H.	N. E.	[N. E.]	N.	Professor Young's Meteorological Journal.
33	Salem, N.Y.	N. E.	N. E.	N. E.	William Brand and W. Larkin; Meteorological Journal.
34	Albany, N. Y.	N. E.	[N. 28° E.]	N. E.	T. Romeyn Beck, M. D. Met. Journal. *Mean assumed for Noon, N. 28° E.*
	Lansingburgh, N.Y.	N. N. E.		N.	E. T. Foote, Meteorological Journal.
35	Kinderhook, N.Y.	N. E.	N. E.	N. E.	Silas Metcalf, Meteorological Journal.
36	Kingston, N.Y.	N. E.	N. E.	N. E.	Isaac Blauvelt; Meteorological Journal.
37	Goshen, N.Y.	N. E.	[N. N. E.]	N.	Nathaniel Webb and John S. Crane; Met Jour. *Mean assumed for [noon, N. N. E.*
38	Bark Ann Louisa, off Absecom, N. J.	W. N. W.	N. W.	N.W.	Ship's Log Book, and Statement of Capt. Wilson.
39	Trenton, N. J.	N. W.	N. W.	N.W.	Dr. F. A. Ewing's Meteorological Journal.
40	Cape May, N. J.	N. W.	N. W.	N.W.	Marine Reports, and Letter from Cape May, in Philad. Newspapers.

Abbreviations.—N. H. State of New Hampshire; Me. Maine; Ms. Massachusetts; R. I. Rhode Island; Ct. Connecticut; N. Y. New-York; N. J. New Jersey.——*Note.* My own observations on the 15th P. M. have on a former occasion been erroneously printed N. W. by *W.*; for which read N. W. by *N.*

ARTICLE VIII.

On the Purturbations of Meteors approaching near the Earth. By Benjamin Pierce, A. A., Hollis Professor of Mathematics and Natural Philosophy in Harvard University; in a Letter to S. C. Walker, Esq. Read January 15, 1841.

My Dear Sir,

Many sources of almost unceasing occupation have prevented my giving Mr. Erman's* paper on Meteors that early attention which I intended. I shall now turn my attention to the point which you suggested of the earth's attraction. Almost the whole labour has fortunately been saved for me by Laplace, in the Méc. Cél., Vol. IV., Book IX., Chap. II., "On the Perturbations of a Comet, when it approaches very near to a Planet." He has there proved (8038, Bowd. Ed.,) that "we may, in the calculation of such a comet, suppose the planet to have a sphere of activity, in which the *relative* motion of the comet is affected only by the planet's attraction; and that beyond this point the *absolute* motion of the comet about the sun is performed in exactly the same manner as if the sun alone acted upon it." The radius of this sphere is by (8035)

$$r. \sqrt[5]{(\tfrac{1}{2}\, m^2)};$$

in which

$r =$ the radius vector of the planet,

$m =$ its mass divided by the sun's mass;

so that, in the present case, this radius, which we denote by r_0, is

$$r_0 = 0{\cdot}0053,$$

in which the unit is the same as Erman's.

Now the relative orbit of the meteoric ring is directed nearly to the centre

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* Schumacher's Astr. Nachr., No. 385.

of the earth, and I shall regard it as exactly directed towards this centre; in which case, the only effect of the earth's attraction is to increase the relative velocity without changing the relative direction. The only change which is, therefore, required in Erman's paper is to increase the relative velocity v' by this increase of velocity. The increased velocity is determined by the formula

$$v_0'^2 = v'^2 + \frac{2g}{R} - \frac{2g}{r_0}$$

in which

$R =$ the earth's radius,
$g =$ the attractive force of the earth at the unit of distance,
$v_0' =$ the increased velocity.

Hence

$$\frac{2g}{R} - \frac{2g}{r_0} = 0{\cdot}13932, \qquad v_0'^2 = v'^2 + 0{\cdot}13932$$

and the five values of v_0', corresponding to the five values of v', calculated by Erman, are

0·91118, 1·41818, 1·69177, 1·93830, 2·17363.

Nothing farther seems needed upon this point, and I therefore leave it to notice an omission by Professor Erman.

He has neglected the negative sign of the radical in the equation

$$v' = -e\ cos.\ u \pm \sqrt{(v^2 - e^2\ sin.\ ^2u)},$$

and this sign may be used as long as the resulting value of v' is not negative. Thus, for the value of v

$$= 0{\cdot}77382$$

we should find

$$v' = 0{\cdot}29426$$
$$\text{velocity in perihelion} = 2{\cdot}235$$
$$\text{perihelion distance} = 0{\cdot}4186$$
$$T = 0{\cdot}60973$$
$$\omega = 12^\circ\ 3'$$

which shows that Erman's conclusions, regarding the relative velocity and the inclination of the orbit, are unsound.

In reviewing some of his numerical results, I differ a little from him, but the difference is of no practical importance.

Another most important point for consideration is the difference of direction of the different meteors. Now this difference of direction amounts to more than 10° on the average (according to Erman) from the mean direction, and cannot, for the maximum, be less than 25°. This difference of direction may arise

1. From the difference in their elliptic orbits about the sun.
2. From their mutual action.
3. From the earth's attraction.

1. Supposing, with Erman, the breadth of the ring to be 2°, the difference arising from the first cause cannot be more than 1° from the mean direction.

2. The deviations arising from their mutual attractions must be trifling; they cannot, for instance, be supposed greater than they would be if all the meteors but the disturbed one, which we may be considering, were combined into one planet, about which this disturbed one moved as a satellite. Now if we consider that the variation in the moon's *absolute* direction from the earth's is only about 2°, we shall have no hesitation in neglecting this second cause of disturbance.

The difference in direction arising from the first two causes is absolute, and may be somewhat magnified when converted into relative direction, but not much, unless the relative velocity v' is very small. There is also a difference of absolute velocity, which will produce a difference of relative direction of about the same order of magnitude with that arising from the difference of absolute direction.

3. The observed difference of direction must then be chiefly referred to the principal disturbing cause, the earth; and the following method of calculation is sufficiently accurate for the present case. Let

v' = the relative velocity of the meteors at the moment of entering the sphere of the earth's influence, which sphere we may, for this calculation, suppose to be infinite,

ϕ = the angular deflection of the meteor's relative motion,

then no other meteor will be so much deflected as the one which just grazes the surface of the earth; and for this meteor we have

$$cosec.\ \phi = 1 + \frac{v'^2 R}{m}$$

$$v'^2 = \frac{m}{R} (cosec.\ \phi - 1)$$

whence, for a deviation of 15°, v' must be less than one-third of the earth's velocity; that is, far less than either of Erman's supposed values of v'; and for the least value of v', which Erman has given, namely,

$$v' = 0{\cdot}83122,$$

we have

$$\phi = 2^\circ\ 38',$$

which appears to be entirely contrary to a large majority of the observations.

Now, for

$$v' = 0{\cdot}33333 = \tfrac{1}{3}$$

we find

$$w = 14^\circ\ 10', \quad \upsilon = {\cdot}75 = \tfrac{3}{4}$$

so that the plane of the meteors cannot differ much from that of the ecliptic, and their relative velocity cannot exceed one-third of the earth's velocity. The other elements of the orbit are of less interest, and I shall not stop to calculate them. A ring so nearly in the plane of the earth's orbit must be subject to very great perturbations, and if there is one, I think that no observations which we can make will enable us to calculate its motions with any degree of accuracy.

Believe me, my dear sir,
most sincerely yours,
B. PIERCE.

CAMBRIDGE, *December* 24, 1840.

ARTICLE IX.

Researches concerning the Periodical Meteors of August and November. By Sears C. Walker, A. P. S. Read January 15, 1841.

§ I. OF THE RELATIVE VELOCITIES OF SHOOTING STARS.

THE discovery of the existence of a radiant, or its antipode, the convergent point for the relative paths of the shooting stars composing the splendid spectacle of November 12th, 1833, and its confirmation on several subsequent, but less brilliant displays of these bodies, has opened the field for fresh researches concerning their geometrical relations. The earliest attempt to deduce the necessary inferences from such a discovery was made by Prof. Olmsted,[1] shortly after the great shower of 1833. In this inquiry he was followed, in 1834, by Prof. Twining[2] and Mr. Espy[3]; in 1835, by Arago[4], Biot[5] and others; and, in 1836 and 1837, more concisely, by Quetelet[6] and Olbers[7], and, subsequently, by Mr. Herrick[8] and Prof. Lovering.[9] Finally, in 1839, a full and systematic inquiry on the subject was instituted by Prof. Erman,[10] Jr., of Berlin. An abstract of the

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[1] Silliman's Journal, vol. xxvi., p. 144. See also subsequent volumes.

[2] Idem. vol. xxvi., art. viii.

[3] Journal Franklin Institute, vol. xv., p. 9.

[4] Annuaire du Bureau des Longitudes, 1836.

[5] Sill. vol. xxxii., p. 181.

[6] Quetelet's Catalogue des Principales apparitions d'étoiles filantes. Nouveaux Mémoires de l'Académie, &c., de Bruxelles, 1839. Also Annuaire de l'Observatoire de Bruxelles, 1837.

[7] Die Sternschnuppen, Schumacher's Jahrbuch for 1838, p. 319, note. Also Schumacher's Astronomische Nachrichten, Nos. 372, 384.

[8] Sill. vol. xxxiii., art. xx., and vol. xxxv., art. xix.

[9] Idem. vol. xxxv., art, x.

[10] Astr. Nachr., Nos. 385, 390, 402, and 404.

limits assigned by this author for the elliptic elements of some of these bodies, considered as asteriods, has been published in the proceedings of this Society for August 21st, 1840. An examination of Professor Erman's analysis having led to the conclusion that his limits for these elements are too restricted, and that more simple formulæ might be obtained by adopting instead of the earth's actual velocity, the well known Gaussian constant as the unit of linear velocities, induced me to undertake the discussion afresh. In doing so, however, it is proper to remark, as must be obvious to every one, that the nature of the subject is such as to deprive the discussion of that demonstrative character which distinguishes the results of astronomy proper. Such a circumstance, however, should not deter us from aiming at the greatest precision in our knowledge of the geometrical relations of these small bodies, which the nature of the case permits.

The principal data which the theory of shooting stars derives from observation are their relative velocities and directions as seen by an eye in motion, and the dates of remarkable showers, or brilliant meteoric displays. These data, if furnished with precision, are sufficient for the completion of their theory, considered as cosmical bodies. In the case of a newly discovered planet or comet, a single observation furnishes only a geocentric position, the distance, relative velocity, and direction of motion, being as yet unknown. Hence three successive positions, at known intervals, are required in order to determine, by Kepler's and Newton's laws, the (geocentric or heliocentric) distance, velocity and direction of motion, at one of the three dates,—from which all the elements of the elliptic orbit of the planet or comet may be derived. When we consider the precision of observation, and the length of elapsed time, which are requisite for determining the path of a planet or comet, it will appear surprising at first, that enough should ever be known concerning the geometrical relations of a body, which appears for a moment and then vanishes for ever, to enable us even to form a conjecture concerning its true motion in the heavens for an indefinite period past and to come. There are, however, several important advantages in the case of shooting stars which do not present themselves in a single observation of a newly discovered planet or comet. The shooting star or asteroid is necessarily within a few seconds of its node, and its heliocentric radius vector differs from that of the spectator by a quantity so small as to be safely neglected in computations for the approximate elements of its orbit. A similar remark applies to the heliocentric longitude of the observer and asteroid, which may be regarded as common. By the ordinary computations for the transfer of co-ordinates from the centre of the earth to the position of the spectator, or quite as well by neglecting quantities so small, it is always possible to determine three data for the orbit of every meteor that is seen, namely, the node, radius vector, and time of passing the node. To complete the six elements it is only necessary to know, at the same time, three other quantities, the asteroid's true or relative velocity in space, and its direction with reference to two given planes, the equator or ecliptic, for instance, and a secondary to the same. The determination of the first of these three requisites, the relative velocity of shooting stars, was first undertaken in 1798, by two students of Gottingen, Brandes and Benzenberg,[11] and was pursued with a zeal which terminated only in the death of the former. A notice of their labours has been given by Olbers, and by Quetelet. An abstract by Professor Loomis of the results obtained by Brandes, in 1823, may be found in Silliman's Journal,[12] giving the results of corresponding observations in Breslaw and its vicinity. In 1824, Quetelet[13] and others in Brussels and its neighbourhood engaged in similar researches. On the memorable occasion of the display of November 12th, 1833, among the myriads of meteors seen, one only was known to have been beheld at several places. It was distinguished by its extraordinary size and brilliancy, and by the duration (ten minutes at least) of its train, which, after assuming various serpentine shapes, "terminated in a luminous nebula of several times the diameter of the moon, floating onwards with a velocity greater than that of the clouds." Mr. Twining,[14] after a full discussion of all the facts connected with this meteor, concludes that its apparent path was about forty-eight geographical miles, and its duration about three seconds, making a mean relative velocity of about sixteen miles per second. Corresponding observations were made at Breslaw and its vicinity by Boguslawski and others, Nov. 13th, 1836, and August 9th, 1837. I have not been able to obtain the single results, and therefore quote the remark of Olbers,[15] that results obtained for the November meteors of 1836 "show that the periodical meteors also have the same height and relative velocity as the ordinary shooting stars hitherto

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[11] Versuche, die entfernung, &c., der Sternschnuppen zu bestimmen. Hamburg, 1800.

Bestimmung der geographischen Länge durch Sternschnuppen, Von I. F. Benzenberg. Hamburg, 1802.

[12] Vol. xxviii., p. 95. [13] Catalogue, &c., p. 5. [14] Silliman, vol. xxvi., p. 46.

[15] Schumacher's Jahrbuch, for 1838, p. 322. Note.

observed." Also, Quetelet[16] remarks that Mr. Boguslawski obtained "results analogous" to those of his table for the relative velocities of the meteors of August 9th, 1837. On the 29th of August, 1838, the younger Littrow[17] obtained corresponding observations of several meteors in Vienna and its vicinity. An effort by Mr. E. C. Herrick and others, in April, 1839, in New Haven, Middlebury, Williamstown, Cambridge, and other places, was unsuccessful for want of coincidences, like a similar attempt of Brandes and others in 1817. The method adopted in all instances is to prove the identity[18] of the meteors seen at two different places. Then the space traversed, and the duration give the relative velocity. The Vienna observations of 1838, for relative velocities, have not been fully reduced, the memorandums for duration not being complete. Such results, as far as obtained, are given in Table I., chiefly from Quetelet's Memoir on Shooting Stars. The results obtained by Twining, and the remarks quoted from Olbers and Quetelet are important in the present inquiry, as they show that the mean relative velocity, 18.3 geographical miles per second from all the results yet obtained, may be taken for a first approximation in estimating the elements of the elliptic orbits of those meteors or asteroids whose relative direction is known. It is much to be desired that Table I. should be farther extended, and, as an encouragement to enterprise in this department of meteorology, we have the high authority of Bessel,[19] who "doubts not that every desirable degree of perfection is attainable by observation, in so far as regards our knowledge of the geometrical relations of shooting stars."

On examining Table I. it will appear that the single results arrange themselves on both sides of the mean result 18.3 miles per second, with an average discrepancy of about 5.2 miles per second. As far as we can judge from so small a number of results, necessarily somewhat imperfect, it would seem that the mean relative velocity of shooting stars tends towards that of the earth in its orbit, namely, 16.4589 geographical miles (of 60 to a degree) per second, with

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[16] Catalogue, &c., p. 6. Note.

[17] Annalen der K. K. Sternwarte in Wien, 1838. p. xviii.

[18] See Loomis' Notice of Brandes' Memoir, above quoted, p. 98.

[19] Uber Sternschnuppen Astr. Nachr. 381, p. 50. "Ich zweifle nicht, dass die Kentniss der Sternschnuppen, in so fern von den *geometrischen* Verhältnissen, die man daran wahrnehmen kann, die Rede ist, so vollständig gemacht werden kann, als man zu wünschen berechtigt ist."

average discrepancies of less than one-third of that value. The first result is such as we should naturally expect, since, in the case of bodies moving with all varieties of directions and velocities, there must be a compensation of these velocities resolved each at the time of visibility in the direction of the observer's tangential motion. The second result—the smallness of the average discrepancy—if it leads to any conclusion at all, shows that the average true velocity of the meteors is small, or the mean discrepancy of the relative velocities would be greater. Lastly, this mean relative velocity of shooting stars is so great as to preclude the possibility of a terrestrial or lunar origin. Since it follows from the laws of gravity, according to the remark of Olbers,[20] Laplace,[21] Hassler,[22] and others, that the mean relative velocity of a satellite of the earth, at its nearest possible approach to the observer, is only about 4.29 geographical miles, and its maximum in a re-entering orbit only 6.06 geographical miles. Hence all bodies of our system which, when visible to us, have a relative velocity beyond this limit, must be moving relatively to the earth in a hyperbolic orbit, and must, in a few hours, leave the earth's sphere of activity, and again become, as they must have been before, *cosmical* bodies. The grounds for the latter remark, that bodies having a relative velocity of 18.3 miles cannot have acquired the same by any force belonging to the atmosphere, nor by any volcanic or other explosive force in the earth or moon, are manifest. Indeed, the explosive force of gunpowder communicates a velocity of only a fourth of a geographical mile per second,[23] and a velocity of seventy times that amount cannot be ascribed to any force known to exist in the earth or moon; and certainly no such force must, on account of this observed relative velocity alone, be presumed to exist, when other phenomena point to the sun's central force as amply sufficient to furnish such a relative velocity as the resultant of a cosmical body's true and the observer's known tangential motion.

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[20] Jahrbuch, for 1837, p. 56. Note.

[21] Systeme du Monde, L. iv. chap. v.

[22] Mem. Am. Phil. Soc. Vol. vi., P. II., Art. xv.

[23] Monat. Corr. June 1812, p. 564. The velocity of a twenty-four pound cannon-ball is stated by Lagrange at 1398 Paris feet per second.

Table I.

Relative Second's Velocities of Meteors in Geographical Miles.

Date.	Designation. of Meteor.	Second's velocity. $\varkappa\gamma$.	Observer and Computer.
1798.	a	24.	Brandes.
"	b	18.	"
1823.	a	20.	"
"	b	24.	"
"	c	32.	"
1824.	a	15.	Quetelet.
"	b	22.8	"
"	c	13.5	"
"	d	9.	"
"	e	15.	"
"	f	10.2	"
1833, November 12.	a	16.	Twining.
1836, November 13.	a b c d	average	Boguslawski.
1837, August 9.	unknown	average	"
Mean second's velocity,	$18^{m}.3 \pm 1^{m}.4 = 1.112 = \gamma$		
Earth's mean do.,	$16^{m}.4589 = \varkappa$		

The mean value of Table I. is further confirmed, by considerations derived from the mean duration and mean length of the visible paths of meteors. Mr. Custodes[24] found, from ninety-eight shooting stars, seen 9th August, 1837, at Dusseldorf, that the mean duration of visibility was 1″ 12.‴ 7; that of twenty-eight of the largest size 1″ 45.‴ 9—none over 3.″ Benzenberg, from observations at various seasons of the year, concludes that the mean duration was more than 1.″ These observations were made by means of a clock marking *thirds*, (tertian-clock.) The length of the paths of the four meteors seen at Breslaw and at a station in its vicinity, are given by Olbers.[25] Also those of ten coincidences at Vienna and Calvarienburg, August 29th, 1838, are given by the younger Littrow,[26] both, as follows, in geographical miles of sixty to a degree.

1836, November 12,	meteor	a,	visible path	5.96 miles.
"	"	b,		24.88
"	"	c,		32.88
"	"	d,		43.52
1838, August 29,	"	a,		12.28
"	"	b,		29.28
"	"	c,		17.20

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[24] Schumacher's Jahrbuch, 1838, p. 324. [25] Idem. p. 322, note. [26] Annalen, &c. for 1838, p. xxi.

1838, August 29,	meteor	d,	visible path	13.36 miles.
"	"	e,		12.28
"	"	f,		31.26
"	"	g,		20.84
"	"	h,		26.44
"	"	i,		0.36
"	"	k,		13.16
		14 mean		22.64
For mean duration $1''.21$, mean velocity				18.71

Prof. Locke, of the Ohio Medical College, and Mr. Dwelle, made corresponding observations in Cincinnati, and its vicinity, in August, 1834. The results were published shortly afterwards, in the Cincinnati Gazette of that year. They found the average height about forty-five miles, the average velocity about twenty miles per second, and the average duration about 1^s. They also noticed an unusual number of meteors about the 10th of August.

§ II.—OF THE RELATIVE DIRECTIONS OF SHOOTING STARS IN SPACE.

DIVISION I.—OF THE SHOOTING STARS SEEN ON ORDINARY NIGHTS.

The remaining requisite for the complete determination of the orbits of these asteroids is their relative tangential direction as seen by an observer in motion, both orbital and rotary; in other words, the apparent path and direction of the meteor as affected by annual and diurnal aberration. The observation of a single meteor's path gives no clue to the solution of the question. If, however, we mark on a globe the points of appearance and vanishing of a meteor, and connect them by a great circle, then the inclination of the plane of this circle to a line drawn from the centre of the globe to any given point may be measured; or, the problem may be solved analytically, and the inclination computed. Thus, on any occasion in which a great number of paths have been delineated, we may assume any point in the sphere as the trial point, and compute the R. A. and Dec. of the points of nearest approach of this trial point to the several planes in which the observed paths are contained. Then, if there is any general tendency of the relative directions to one point in the sphere more than to another, this circumstance will be indicated by the position of the points of nearest approach, and the mean of these several positions will afford an approximate convergent point, from which the actual convergent point for the evening may be ascertained. As a trial point it appears most natural to commence with the antipode of the observer's tangential direction, this being the point towards which a tendency of the relative paths should naturally be impressed. Indeed, if we suppose the meteors moving with all varieties of true direction and velocity, a compensation of the latter should be expected to take place, as has been found to be the case with the former; and the outstanding, uncompensated position of the convergent point should be, as just stated, the point opposite the observer's true direction. The only observers, as far as I know, who have detected such a relative convergent point, on ordinary nights, are Mr. Fitch, of New Haven,[27] who found this point to advance in the ecliptic from August to December, remaining always about 90° in advance of the sun, or 90° in arrear of the earth, and Mr. E. C. Herrick[28] and others, who noticed the same phenomenon in April, 1839. Professor Forshey,[29] of Mississippi, who has given much attention to this subject, and C. L. Von Littrow,[30] adjunct at the Imperial Observatory of Vienna, who nightly traced the paths of meteors for nearly a year, from 1837 to 1838, speak of the existence of a convergent point as being peculiar to the dates of August 9th—12th, and Nov. 11th—13th. Also, Olbers[31] makes the prevalence of parallelism of paths and a radiant point in Leo the distinguishing feature of the November phenomenon of 1838, these being present on the 13th, but not on the 12th of that year. Nor do I read of any other authors but Messrs. Fitch and Herrick, and their associates, who have discovered this motion. The *a priori* probability of the tendency towards such a convergent point, by the meteors seen on ordinary nights, is so great that it is next to a miracle that it should not occur. In case of its occurrence, the average discrepancy of the single results from

[27] Sill. vol. xxxiii., p. 386.

[28] Letter received from Mr. Herrick.

[29] Mentioned in conversation, August, 1840.

[30] Annalen, &c., 1838, p. xvii.

[31] Astr. Nachr., 372.

the theoretic convergent point, if well observed, would, like those of the single relative velocities from the observer's true velocity, afford us some clue towards the discovery of the mean true velocities of shooting stars seen on ordinary nights. The fact that Messrs. Fitch and Herrick detected the existence of this actual relative convergent point, conformable to the theoretic, leads to a conclusion similar to that derived from the table of relative velocities; namely, that the true velocity of the meteors is small compared with that of the observer, whence the greater prevalence of the theoretic convergent point. It is probable, then, that this tendency of a part of the meteors, on ordinary nights, towards the vicinity of the point opposite to the observer's direction of motion, continues throughout the year, and that on each night another portion of the meteors appears to be *non-conformable*, or *sporadic*, as they are termed by Olbers and Quetelet. Hence we infer that *convergent* meteors, so called on ordinary nights, must be those which move with *small*, and *sporadic* meteors those which move with *greater* true velocity. This circumstance has been noticed with respect to their relative angular velocities by Mr. Dutton.[32] A consideration of the circumstances connected with the elements of elliptic motion of these asteroids leads to a classification of the orbits of the *convergent* and *sporadic* meteors seen on common nights. The former could not have the prevalent character of convergency towards the point opposite to the observer's direction of motion, without having their true velocity small. Then they must have their perihelia near the sun, perhaps inferior to Mercury, and must be near their aphelia, and have, therefore, pretty eccentric orbits, in order to reach the earth in their aphelia. The *sporadic* meteors may be justly considered as a class of asteroids superior to the convergent meteors, whether having their perihelia near the sun, and being very eccentric, with aphelia far superior to that of the earth, or having their perihelia not much inferior to that of the earth. In each of the respective cases they must have great true velocities, and, moving in all varieties of true direction, the average deflection of their relative directions from the point opposite the observer's direction is so great that they are called *non-conformable* or *sporadic*. It will be shown, in the sequel, that the conclusion drawn from the table of observed relative velocities, as well as from the existence of a convergent point, on common nights, opposite to the observer's true direction, namely, that a large portion of meteors seen on ordi-

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[32] Sill. xxxv. p. 172.

nary occasions are asteroids, having their perihelia more aggregated together as distance from the sun diminishes, is *a priori* rendered probable from the known analogies of the solar system. This general classification of these shooting stars, founded only on probable grounds, seems to be all the inference that we are able to draw from the existence of an actual convergent point on common nights, conformable to the theoretic, and from the facts known respecting their relative velocities. Of the particular elements of motion of the individuals seen, there are no grounds for forming even a conjecture. The simple circumstance of this compensation of their true directions, and true normal velocities, while it warrants the general conclusion that they are inferior asteroids, also leads to a belief that the planes of their orbits are promiscuous in position.

The impossibility of determining the relative direction of single meteors, on ordinary nights, by observations at a single station, and the sources of error pointed out chiefly by Bessel,[33] in regard to duration, absolute time, position of point of appearance and vanishing, and the uncertainty whether the visible path to observers in different stations is common, must, even when several stations are employed, hinder, if not entirely frustrate, all our attempts to deduce the cosmical elements of motion of any one of the meteors seen on ordinary nights. Hence it would seem that if the elliptic elements of any one of these asteroids are ever to be known, it must be chiefly by means of corresponding observations on those extraordinary occasions when the occurrence of a new feature, not present on common nights, enables us to determine with precision their relative directions by observations at a single station.

§ II.—Division 2.—Of the convergent Point of the relative Paths of Meteors on the Occasions of extraordinary Displays.

The ordinary number of meteors visible by a single observer is, according to Olbers,[34] Quetelet,[35] Herrick,[36] and others, about eight per hour. Those occasions in which a greater number is seen are more or less extraordinary. In most instances of these extraordinary displays, another circumstance is noticed on careful observation. The relative directions or deflections from the anti-

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[33] Uber Sternschnuppen,—already quoted.

[34] Jahrbuch, for 1838, p. 325.

[35] Catalogue, &c., p. 12, 13.

[36] Silliman, vol. xxxv., p. 172.

pode of the observer's direction are not compensated as on ordinary nights, but there remains an outstanding uncompensated tendency towards a point more or less deflected from this antipode, indicating the prevalence of a true mean velocity, of greater or less magnitude, in a perpendicular to the observer's direction. The meteors which do not appear to tend towards this extraordinary convergent point are termed *sporadic*, and in such cases the term includes both classes of *sporadic* and *convergent* meteors of ordinary nights. It seems to me, in conformity with the opinion of Olbers, that the appearance of an extraordinary convergent point is a better and surer criterion of an extraordinary display of meteors than a moderate excess of numbers above the mean. Let us suppose that an observer on the earth's surface, in his annual and rotary motion, falls in with a portion of planetary space interspersed with these small bodies, separated by intervals of not many hundred miles, yet so far separated as to exhibit no tendency towards *fixedness* of relative position, like the particles of the single bodies themselves, or like the solids, liquids, or even gases, connected with the earth,—their mutual perturbations, owing to the smallness of their masses, not being much greater than those of the principal planets of the system. Let us suppose, however, that besides proximity in position in the system, the separate bodies have also common elements of motion, the discrepancies in the latter being of the same order as those of position relatively to the whole system, whether from common circumstances connected with their origin, or primitive projectile force. Then we should have all the phenomena of an extraordinary display of meteors, namely, unusual numbers, and unusual position of the convergent point of their relative paths. This position could readily be determined by the method already stated; and the mean relative direction in space of this flock of bodies could be ascertained by a single observer, at one station, with a precision which, but for their common relations, no corresponding observations at any variety of stations could afford. Then the only remaining element for the complete determination of the mean elliptic elements of this small system, or cluster of asteroids, would be the relative velocity of one of them, or their mean relative velocity, (the single velocities being nearly common by hypothesis.) In the absence of a complete determination of this velocity, if it were presumable that this mean value was analogous to that of Table I., then, since the mean error of the position of the convergent point is very small, and may be neglected, a system of elements derived from the adoption of the mean value in Table I. would have that degree of plausibility which naturally belongs to the statements quoted from Olbers and Quetelet, respecting the relative velocities of meteors in extraordinary showers, and the coincidence therewith of the single instance of relative velocity for one of the November meteors computed by Professor Twining. I shall here subjoin the principal data which we possess concerning the convergent point for the extraordinary displays of August 9th—11th and November 11th—13th. The angle of deflection of the former from the theoretic convergent point for isolated meteors is 39°.4; that of the latter only 8°.2, a quantity not much exceeding the probable error. So that one important criterion of extraordinary character is wanting in the November period, namely, a well marked and manifest deflection of their convergent point from that of isolated and promiscuous meteors. The convergent point of the "meteoric abundance," so called, of December 7th, 1838, was found by Mr. Herrick[37] to be nearly the same as that of the August period. This would give a deflection of 104° from the point opposite the observer's direction. As this phenomenon is not known to have presented itself before nor since, it may, perhaps, be considered as an example of an isolated cluster of these bodies having common elements of motion in a plane highly inclined to the ecliptic, in a period which we have no means of estimating, since the want of corresponding observations concerning the relative velocity of any one of these bodies leaves us in doubt how far these velocities were conformable with those of Table I. One consequence follows, however, from this high angle of deflection, that the mean normal velocity of the cluster could not have been less than that of the observer, and that the single bodies must have been superior planets. An attempt will be made to deduce the most plausible estimate of the elements of the asteroids of August and November, after discussing the circumstances connected with the question of their anniversary returns.

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[37] Sill. xxxv., p. 363. Perhaps a part of the same cluster or ring was seen by Benzenberg, in 1798, on the 6th of December. The uncertainty concerning the convergent point prevents us from deciding. If this point were common, a period of forty years would give a relative velocity of about 11 geographical miles per second.

TABLE II.

Convergent Point of the August Meteors.

August Meteors. Place of Observation and Date.	Apparent R. A. of point of convergence. α	Apparent Dec. of the point of convergence. δ	No. of Observations.	Probable Error of single result.	Probable Error of final result.
1837. Berlin, August 10,	217°.18	—57°.26	46	± 20°.1	± 2°.96
" Breslaw, " "	221 .76	—51 .41	200	± 19 .5	± 1 .38
1839. Berlin, " 9,	224 .86	—50 .18	50	± 11 .9	± 1 .68
" " " 10,	223 .88	—52 .39	48	± 13 .3	± 1 .92
" " " 11,	218 .45	—51 .05	43	± 13 .5	± 2 .06
" Königsberg, 10,	214 .85	—55 .59	75	± 21 .0	± 2 .42
" " 11,	215 .11	—55 .29	74	± 17 .4	± 2 .02
1840. Philadelphia, $9^d\ 10^h\ 57^m$	216 .14	—55 .76	12	± 2 .3	± 0 .67
" " 9 13 4	214 .71	—55 .43	15	± 4 .1	± 1 .05
" " 9 15 6	219 .25	—55 .12	29	± 1 .2	± 0 .22

TABLE III.

Convergent Point of the November Meteors.

Date. Mean Time, Philadelphia.	R. A. of Convergent Point. α	South Dec. of Convergent Point. δ	Observer and Station.
1833, November, $12^d.750$	333°.0	— 17°.0	Strong, Buffalo.
" .701	328 .0	15 .0	Merrick, Middletown, Ct.[38]
" .743	328 .3	23 .5	" "
" .748	330 .0	20 .0	Olmsted, New Haven.
" .745	329 .0	21 .7	Riddell, Worthington, Ohio.
" .774	331 .0	21 .5	" " "
" .745	328 .2	23 .8	Aiken, Emmettsburg, Md.
" .748	326 .5	23 .0	Thompson, Mississippi.
" .652	329 .5	uncertain	Parker, Gulf of Mexico.[38]
1834, " .700	324 .5	30 .2	Loomis, New Haven.[39]
" .700	330 .0	20 .0	West Point.
1835, " 13.700	330 .0	20 .0	Merrick, Amenia Academy, N. Y.
" .700	332 .7	20 .7	McCaffney, Mt. St. Mary's Col. Md.
1836, " 12.631	326 .7	30 .1	Dunster, Springvail, Maine.[39]
" .631	325 .0	25 .0	Olmsted, New Haven.[39]
" .582	330 .0	20 .0	Shæffer, New York city.
1837, " .625	326 .0	24 .5	Olmsted, New Haven.
" .684	330 .0	20 .0	Shæffer, New York city.
" .666	329 .8	20 .9	Barnard, New York city.
" .667	330 .0	20 .0	Obermeyer, Emmettsburg, Pa.
" .667	334 .4	25 .0	Fitch, New Haven.
1838, " .700	327 .0	26 .5	Twining, Middleburg, Vt.
" .721	335 .0	19 .9	Fitch, Gulf of Mexico.[39]
" 13.408	322 .0	— 18 .1	Littrow, Vienna.

Mean position of convergent point, 1833—1838 $\alpha =$ 329°.0
$\delta = -$ 22 .0
1833, only, $\alpha =$ 329 .3
$\delta = -$ 20 .7

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[38] Sill. xxvi. p. 330.

[39] Idem. xxxiii. p. 382, and xxxv. p. 370.

§ III.—Of Periodical or Anniversary Displays of Meteors.

The question of the periodicity, or the anniversary character of remarkable displays of shooting stars, was first started in 1833 and 1834, after the splendid spectacle of November 12th of that year, by Professors Olmsted and Twining,[40] who had had "coincident ideas" on the subject. Three remarkable showers of these meteors have certainly occurred, in 1799, 1832, and 1833, at nearly the same point of the ecliptic, or earth's actual orbit; and either this coincidence must be accidental, or there is an unusual aggregation of these small bodies in the plane in which the earth is then found, which should lead us to expect other great displays to be witnessed in traversing the same part of our orbit. Whether any such have occurred since 1833 is a point that has been ably discussed by Bache,[41] Olmsted,[42] Twining,[43] Lovering,[44] Herrick,[45] Forshey,[46] and others in this country, and recently by many continental writers,

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[40] Silliman, already quoted, vol. xxvi., p. 349, July, 1834. The following passage is explicit: "Hitherto we have reasoned from the known laws alone of the solar system; but the conclusion now forces itself upon every reader, that if these bodies had an *orbit*, they had also a *period*, and ought again to encounter the earth at some future time, or even to have encountered it in times past, in the same part of its orbit—that is, at the same time of the year. When, therefore, the startling confirmation of our theory springs up before us, that both the meteors of 1799, seen by Humboldt at Cumana, and by Ellicott in the vicinity of the United States, and those of 1832, seen at Mocha in Switzerland, and on the Atlantic, appeared at the same annual period with those of 1833, that is, on the 12th and 13th of November, (civil reckoning,) we begin to feel as if further doubt were irrational."

[41] Sill., xxvii., p. 335, xxviii., p. 305, and xxix., p. 383. Prof. Bache considers the meteors on the anniversaries of November 12th—13th, 1834 and 1835, as presenting nothing extraordinary, either in numbers or direction of convergent point.

[42] Silliman's Journal passim, since 1833. Prof. Olmsted thinks the anniversary returns have continued from 1831 to 1838, and have since fallen off. See xxxv. p. 370.

[43] Sill. xxvii., p. 339. Prof. Twining considers the recurrence in November 12th, 1834, on a diminished scale as established, as also Nov. 13th, 1838. Sill. xxxv. p. 369.

[44] Idem. xxxv., p. 324. Prof. Lovering disbelieves in the anniversary returns of the November period since 1833, and ascribes the convergent point to the observer's motion.

[45] Idem., xxxviii. p. 377, and xl. p. 203.

[46] Mem. Am. Phil. Soc. 1840.

Arago,[47] Biot,[48] Quetelet,[49] Olbers,[50] Boguslawski,[51] Bessel,[52] Littrow,[53] and others. The earliest notice on this subject in Europe was by Arago, in 1835, after the November term of 1834. The intimation on this subject by Olmsted, and its distinct announcement by Twining early in the summer of 1834, are matters of record, and have one year's priority to that of Arago, for the November meteors, and two years' priority to a similar announcement (since so happily verified) for the August period first made by Quetelet, in December, 1836. The last seven anniversaries of the 12th and 13th of November have been carefully watched in Philadelphia by Professor Bache and others, without rewarding them with the display of any unusual phenomenon, except, perhaps, that of the characteristic small deflection of the convergent point already described. At New Haven, and several other stations, however, an unusual number, and peculiar convergent point have been noticed; and in Europe, in 1836, 1837, and 1838, the extraordinary phenomenon is said to have presented its anniversary return. Boguslawski reports its return in 1839, in moderate numbers. In 1840, I believe, no unusual number was seen. The decision of the question, whether the theory of the annual periodicity of the November phenomenon must be considered as established by past experience, depends upon the sense in which the word periodicity is employed. If by this term we mean the recurrence of such remarkable and brilliant displays as those of 1799 and 1833, and, perhaps, of 1832, it is clear that no return since 1833 has been witnessed. If, on the contrary, we restrict the term to the appearance of twenty or more of these bodies per hour, or twice the average number, I suppose that the years 1834—1839, inclusive, have presented such

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[47] Annuaire, &c., 1836.

[48] Sill., already quoted.

[49] Catalogue, &c.

[50] Astr. Nachr. No. 372, p. 180. Olbers considers the display witnessed by Klüver, at Bremen, November 13th, 1838, as the "peculiar November phenomenon," such as occurred on the 11th, in 1799, on the 12th, in 1832 and 1833, and since 1834 on the 13th, always returning somewhat later. Those of the 12th November, 1838, though quite numerous, he rejects, as not moving in parallel paths, nor coming from the constellation Leo, as was the case with those of the 13th.

[51] Astr. Nachr. 391 and 412.

[52] Bessel states the number of meteors seen November 13th, 1838, at the Königsberg Observatory, at one hundred per hour. Astr. Nachr., 371.

[53] Littrow reports the number, at same date, seen per hour at the Vienna Observatory, to be one hundred and sixty-seven, see Annalen, &c., 1838, p. xvi., and ascribes the convergent point to the observer's motion in space.

a phenomenon on the 12th or 13th of November, to some spectators, either in America or Europe. If we require, in addition to numbers, a parallelism of relative paths, and a common tendency towards a point within 8° of the antipode of the observer's true direction, there is still no conclusive evidence of a failure of the phenomenon from 1832 to 1839. Whether, however, their numbers or directions, except in 1832 and 1833, have in themselves any thing remarkable or extraordinary, or which extensive anniversary observations would not exhibit at other seasons of the year besides November and August, are questions on which a difference of opinion may naturally exist. The portions of earth's heliocentric longitude at which this peculiar November phenomenon, whether considered more or less extraordinary, has occurred, are given by Bessel in the paper above quoted, with a remark, that there are no grounds for a definitive conclusion either of the constancy of position of this point in the earth's orbit, or of a variation of it proportional to the time.

TABLE IV.

Mean time, Paris.	⊙ From true Equinox.	⊙ From Mean do. 1800.
1799, Nov. 11^{d} 20^{h} 36^{m}	50° 0′	50° 0′
1832, " 12 13 0	50 42	50 15
1833, " 12 21 0	50 48	50 20
1834, " 13 21 30	51 34	51 5
1836, " 13 15 30	51 51	51 21
1838, " 13 15 0	51 20	50 48

After all that has been written concerning the November meteors, there is a *possibility* that the anniversary character of the meteor showers of 1799, 1832, and 1833 may have been *accidental;* that is to say, that the coincidence of the heliocentric longitude and radius vector of the three remarkable clusters that appeared at these respective dates, with those of the earth, may have been the natural consequence of the motions of three independent groups, having nothing else in common in their geometrical relations. In such a view of the case, the occasional appearance of an extraordinary number of these bodies, at certain positions on the earth's surface, on the 12th or 13th of November, since 1833, may have been the result rather of extraordinary assiduity in searching for them, than of any thing extraordinary in the distribution of these bodies in the system. The small deflection of the supposed convergent point of 8° would then be regarded as a possible error of observation, and a complete compensation of normal velocities would be considered as having taken place, and nothing would remain, either in their numbers or directions, but a *promiscuous* character; except, perhaps, a probable slowness of their true motions, making their relative tendency to the same point in the heavens more conspicuous.

There is another anniversary period about the tenth of August which may be termed Quetelet's period, from the circumstance of its first announcement by that celebrated philosopher, which is far better established than that of November, and presents phenomena more extraordinary, and more peculiar than have been witnessed at that of the latter, with the single exception of the great numbers in 1799, 1832, and 1833. This August phenomenon has been witnessed on more than half the anniversaries of this century. The group of bodies composing each display is more extensive, and the well determined mean normal velocity quite too great, to be explained on the supposition of their true directions and velocities being promiscuous in space. I shall here append Quetelet's table of the dates of remarkable showers of meteors, with a few additions, either more recent in occurrence, or since brought to notice, by Humboldt, Boguslawski, Erman, Jun., or others. A more extensive list has been prepared by Mr. Herrick, of New Haven, chiefly from his own researches, which it is hoped will soon be made public. The August and November meteors are most numerous from midnight to sunrise. This circumstance has been noticed by Prof. Olmsted,[54] Mr. Herrick,[55] and others, and is ascribed, by the latter, to the position of the observer, whose geocentric direction then corresponds most nearly with that of his actual motion. Custodes,[56] however, found the meteors of August 11th, 1834, most numerous before midnight. Mr. Herrick[57] has noticed, with respect to the meteoric abundance of Dec. 6th, 1798, and Dec. 7th, 1838, that the display was as great before as after midnight. This would lead us to suppose their relative velocity, of the latter, so great, as to have a character independent of the observer's motion. It has already been stated that the true velocity of the December *flock* must have been at least equal to that of the earth. Hence that we are led to conclude, from observation, that those meteors which for other reasons are supposed to have

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[54] Sill. xxxv. p. 370.

[55] Idem. xxxiii. p. 359, xxxvii. p. 333, and xxxix. p. 330.

[56] Schu. Jahrb. 1838, p. 324, Note.

[57] Idem. xxxv. p. 363.

a slow true motion, give confirmation of the same, by appearing most abundant when the observer moves in front of the earth's centre—a circumstance that does occur with meteors moving more slowly in space.

Table V.

Catalogue of Remarkable Appearances of Shooting Stars.

Year.	August.	November.	Other Months.
533			
763			March
*855			16 October
902			October
1029	August		
1060			
1090			
1095			25 April
1096			
*1106			12 February
1202			19 October
**1366			24 October
1741		25th Nov.	
1777			17 June
1779	9 August		
1781	8 “		
1784	middle		12 and 26 July
1785			25 “
1798	9 “		15 Oct. and 6th Dec.
1799	9 “	11th Nov.	
1803			20 or 22 April
1805			23 October
1806	10 “		
1811	10 “		
1812		in November	
1813	11 August	8 “	
1815	10 “		
1818	14 “	19 “	
1819	6 and 13 “		
1820	9 “	12 “	2 September
1822		12 “	10 “
1823	10 and 13 “		
1824	12 “		
1826	3 and 10 “	6 “	
1827	14 “		
1828	10 “		
1829	14 “		
1830			7 and 12 Dec.
1831	10 “	13 “	
1832		11 12 “	
1833	10 “	12 “	
1834	10 “	12 “	
1835	10 “	13 “	2 January
1836	8 and 9 “	11 12 “	
1837	10 “	12 13 “	
1838	10 “	13 14¶ “	2 Jan., 8 Oct., 7 Dec.
*1839	9 10 11 “	13 ¶ “	
***1840	9 10 “		

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§ IV.—General Conclusions from the Facts stated in the preceding Sections.

The facts presented in the preceding sections suggest certain conclusions, as more or less plausible.

1. The existence of a convergent point, opposite to the observer's direction of motion is readily explained, by the known motion of the observer, and the fact, that such a point is observable, shows that there is a compensation of normal velocities, and hence a promiscuous character of the true directions and

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[58] * Astr. Nachr. Nos. 391, and 412. [59] ** Ibid. No. 390. [60] *** Prof. Forshey's paper Mem. A. P. S. 1840. [61] ¶ Sill. XXXV. p. 362.

velocities of the meteors. The degree of deflection of single shooting stars from the theoretic convergent point, affords a classification of these meteors into *sporadic* and *convergent*, the *former* having a greater normal velocity than the *latter*, and hence, the effect of the other component of their relative velocity and direction being less manifest. This difference of velocities, naturally suggests a further classification of the orbits of these bodies, according to the cosmical theory, into very inferior asteroids, visible near their aphelion, and having small true velocities, and therefore conforming closely with the principal component of their relative directions, namely, the observer's tangential motion extended in an opposite direction. The *sporadic* meteors in contra-distinction from the others, may then be regarded as asteroids, superior to the convergent class, and, in many instances, superior to the earth. Then their true velocities being great, this component causes so great a deflection of their relative paths, that their relation to the other component is overlooked.

2. It is possible that the above classification may apply to the meteors of the 12th and 13th November, seen since 1833; since the supposed deflection of the convergent point of only 8° or less, may be ascribed to the errors of observation.

3. The convergent point of the great shower of 1833, which exhibited a similar deflection of about 8°, was much better ascertained, since telescopes were directed towards it,[62] and its height was measured with a quadrant.[63] This doubtless presents an exception to the last remark, in which case we must regard it as an extraordinary group, or cluster, or flock of these bodies, having a common, small normal velocity, and according to Twining's computations, a great relative velocity, nearly the same as that of the observer taken with an opposite sign. Such a cluster must then have had the other component or true velocity of the group very small, and hence its perihelion must have been near the sun. In fact, Prof. Olmsted's convergent point, and Twining's relative velocity, taken as data, would give an orbit coming nearly or quite in contact with the sun, and presenting the singular circumstance of the *ballistic* curve, so called with respect to the sun, in the same manner, as projectiles from gunpowder, or other forces on the surface of the earth.

4. The groups composing the displays on the same anniversary, in 1799,

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[62] Sill. xxv., p. 374.

[63] Idem. xxvi., p. 331.

1832, and 1833, may or may not have been parts of the same extensive nebula, or elliptic ring, or lens, having the sun in the focus of the orbit of each individual. On this point we are unable to decide, for want of knowledge of the deflection of the peculiar convergent points of the groups of 1799, and 1832[64]. If the deflection of this convergent point had been known to be very different on these occasions, we should naturally pronounce them to have been different and independent groups. On the contrary, if this deflection had been known to be common, the probability of their being different portions of the same group, ring, or lens would be much increased, and would be a necessary conclusion, unless we admit, which I think is extremely improbable, a promiscuous character in their true directions and velocities, making a perfect compensation of normal velocities, and resolving the supposed deflection of 8° into the errors of observation. In fact, to suppose a perfectly *promiscuous* character in the elements of motion, of such multitudes of bodies, and that after revolving around the sun for so long a term, they should by mere accident exhibit at the same period of the year, and same portion of space, three such brilliant displays as those of 1799, 1832, and 1833, is to assign an effect without a cause.

5. Isolated groups, like that of December 7th, 1838, having no established anniversary or periodical character, but a great normal velocity, may be regarded as clusters of these small superior asteroids, having common elliptic elements, for whose approximate determination no other datum is wanting but the relative velocity of the group.

6. The display of the 10th of August, if witnessed only once, would lead to a conclusion similar to the preceding for December 7th, 1838. But when we consider that the same phenomenon is recorded for more than half the anniversaries of this century, and in every instance, when carefully observed, has exhibited the same true mean normal velocity and direction of motion, and the same node, and radius vector; it becomes far more worthy of the consideration of astronomers, and some law of distribution of the individuals composing these groups, and of the groups themselves, is required to explain these remarkable coincidences. Here all the peculiarities of periodical meteors are shown in their greatest perfection. The uniformity in their relative directions indicates

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[64] Olbers considers the character of parallelism of paths, of the bodies composing the displays of 1799, 1832, and 1833, to have been common to the three displays.

a similar uniformity of the other component, namely, their true velocity and direction, which, with that of the observer taken with a contrary sign, gives their relative velocity and direction as a resultant; for either there must be this uniformity, in their true velocities, or a compensation between the true velocities and directions—such as will produce a uniform true component in length and position. Now, the latter circumstance is extremely improbable. Its occasional occurrence might be considered *accidental;* but its repetition in nine hundred out of one thousand instances in one night, (the exceptions amounting to the tenth or twentieth part being readily accounted for,) indicates the prevalence of a general law, and we are thence compelled to suppose the true velocities and directions the same at the successive anniversaries. If this be admitted, then these successive groups, seen at yearly intervals, are moving, in each instance, in the *same part* of the *same orbit.* This *identity* of *orbits* is thus established. It will be seen in the sequel that there are only three independent variable elliptic elements of a meteor seen in proximity with the observer. These are the inclination i, the mean daily motion n, and the angle of eccentricity ϕ; the three remaining elements (the ascending node ☊, perihelion ϖ, and epoch H,) being known functions of the first three, and of the meteors' given position in the system. Now we have already arrived, by induction, at the conclusion that the true velocity g is common in quantity and direction. An induction precisely similar, but having less force on account of the greater number of variables, and consequently of possible combinations, compells us to admit that these three elements, i, n, and ϕ, are common to the successive convergent meteors. For though the same value of g in quantity and direction might sometimes recur on the principle of a compensation of the discrepancies of i, n, and ϕ, yet the uniformity of such recurrence (with only such exceptions as are referable to another law known to prevail) points to a uniformity of cause to be found only in the identity (or perfect similarity) of the successive combinations of i, n, and ϕ, that is of the orbits of the successive individuals of the meteor group. Again, suppose, as in Table II., this principle of similarity of orbits established in this way for the individuals composing the respective flocks seen at Berlin and Breslaw in 1837, and also for those seen at Berlin and Konigsberg in 1839. Then, since the three dependent elements, ☊, ϖ, and H, have no new feature in 1839, the other three elements, i, n, and ϕ, must be supposed to be common to the two phenomena of 1837 and 1839, or we must suppose a compensation of their discrepancies throughout the two displays, an event the more improbable as the aggregate of the concurrent events of 1837 and 1839 is increased. These events amount in all to five hundred and thirty-six on these two occasions. When we add to these fifty-six concurrent results in 1840, and recollect that the number of events, confirmatory in their general character, and amounting to some thousands, as recorded in the observations at various stations in Europe and America in the years 1836—1840, about the 10th of August, the only legitimate conclusion is that these anniversary flocks of shooting stars are moving in the *same part* of the *same orbit*, round some *central body*. I have already shown that this *central body* can be no other than the sun. As there is no good reason for the contrary, I am led to extend the same general conclusion to the respective August anniversaries enumerated in Table V., and to suppose the tenth or twentieth part of the single meteors seen on those occasions which were unconformable, to have composed the ordinary promiscuous or sporadic meteors seen throughout the year. In such a case, these periodical phenomena, as Prof. Erman[65] remarks, can only be explained by one of two hypotheses—either that the successive displays are parts of the same group or cluster, with a half yearly or yearly period, or that there exists in the particular part of the system which has for its radius vector 1.013, and its heliocentric longitude 137°—139°, without any latitude, a continuous succession of these bodies at all seasons of the year, moving always in the same orbit, though only encountered annually by the earth. It is obvious that the latter supposition of continuity of succession of these moving bodies at the same point of space, and in the same direction, requires the farther hypothesis of their forming a part of a conic-sectional ring, or lens, having the sun in its focus. In this case the anniversary display must continue to be witnessed while the radius vector, and anomaly of the node, remain the same, or while their periodical fluctuations are less than the breadth of the ring. When they exceed this breadth, the phenomenon ceases to recur, till, in the course of time, the node returns to the same anomaly and corresponding radius vector.

7. The remaining remarkable showers of meteors in the catalogue, may be accounted for by supposing the earth, at the successive dates, to have encoun-

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[65] Astr. Nachr., Nos. 385 and 390.

tered isolated nebulæ, or swarms or clusters of these asteroids. Perhaps the group, ring, or lens, which now furnishes the August or November displays, may have undergone, in the position of its plane, and line of apsides, such variations as to embrace a part of these remarkable epochs. On the hypothesis of a single cluster, with a yearly or half yearly period, this event would not be improbable. On the hypothesis of a ring, a change of plane, to a great extent, could hardly be considered probable. It seems more natural, however, since the relative direction of these asteroids in ancient displays, is unknown, in the absence of proof of identity with the groups of recent appearance, to regard the ancient displays of Quetelet's catalogue as isolated clusters, whose meeting with the earth was purely *accidental;* that is to say, was regulated by a law of the distribution of these single bodies, and their groups, in space—which must always remain unknown for want of data for its determination.

§ V.—OF THE RESPECTIVE PLAUSIBILITIES OF THE HYPOTHESIS OF A SINGLE CLUSTER, WITH A HALF YEARLY OR YEARLY PERIOD, AND THAT OF A CONTINUOUS RING, FOR THE PERIODICAL METEORS OF AUGUST AND NOVEMBER.

In order to judge of the plausibility of the theory of a single cluster and that of a continuous ring for the August and November asteroids, I here subjoin the results of a computation based upon these respective hypotheses; using, in connexion with them, the most plausible values of γ, α, and δ, derived from the preceding tables. These values are not sufficiently exact to furnish the particular elements of the orbits of these meteors. They serve, however, to show, by specific examples, that the general conclusions already announced concerning the character of some of their elements, the perihelion distance and semiaxis major, for instance, have not been drawn at random. The results would also be modified by the application of the effect of the earth's disturbance, and of the resistance of its atmosphere.

TABLE VI.

Explanation of the Nomenclature.	Symbol.	1833. November. 12d.734.	1840. August. 9d.456.
Right ascension of the convergent point,	α	329° .3	216°.1
Declination,	δ	— 20 .7	— 55 .8
Longitude,	λ	324 .2	234 .4
Latitude,	β	— 7 .7	— 38 .8
Longitude of the sun,	$\odot$	230 .9	137 .5
“ “ earth,	$\oplus$	50 .9	317 .5
“ “ observer's true direction in space,	L	142 .2	47 .9
Latitude,	B	+ 0 .2	— 0 .1
Elongation of the convergent point from the point [L B],	ψ	172 .2	140 .6
Deflection of the convergent point, from antipode of [L B] $= \psi - 180$	φ	7 .8	39 .4
Second's velocity in geographical miles, of observer's mean motion,	$\varkappa$	$16^{m}.459$	—
“ “ “ true motion at date,	G	16 .7	16 .4
“ “ of meteor's mean rel. mot., Table I.,	K	18 .3	—
“ “ of relative motion in half yearly period,	$K_{\prime}$	27 .1	12 .7
“ “ “ yearly “	$K_{\prime\prime}$	33 .0	25 .2
Factor to convert K into parts of the Gaussian constant, $(k = 0.0172021.)$	$\frac{1}{\varkappa}$	0 .06076	—
True mean normal velocity,	N	$2^{m}.3$	$10^{m}.4$
Mean relative second's velocity of meteors (in parts of k) $= \frac{K}{\varkappa}$	γ	1 .112	—
Maximum do. in periodical orbit,	$K_{\prime\prime\prime}$	39 .7	33 .3
Elliptic Elements derived from mean values of γ, λ, and β, in the foregoing portion of the table.		Elements.	Elements.
Semi-axis major in parts of the earth's mean distance,	a	0 .502	0 .686
Epoch for January 1st, preceding,	H	74° .2	28°.5
Ascending node,	☊	230 .9	137 .5
Longitude of perihelion,	π	231 .0	144 .2
Inclination from 0° to 180°,	i	121 .1	78 .9
Mean daily motion,	n	2 .77	1 .73
Angle of eccentricity,	φ	76 .2	29 .2
Period in parts of siderial year,	$a^{\frac{3}{2}}$	0 .356	0 .568

From this table it appears that a half yearly period, as originally proposed by Mr. Olmsted, or a yearly period as since maintained by Olmsted and Boguslawski, for the November meteors, or in other words, the anniversary return of a single cluster of these asteroids, cannot be reconciled with Twining's computed value of their relative velocity, nor with the mean result in Quetelet's table of these velocities, nor with Olbers' remark concerning Boguslawski's computations of the relative velocity of the meteors of November 13th, 1836. Hence, notwithstanding the able arguments adduced by Boguslawski, in favour of the hypothesis of a single cluster, with annual returns for these meteors, the above objection seems insurmountable, and we are compelled to resort to one of the two hypotheses already stated, namely, that of the earth's accidental coincidence in position, with remarkable clusters in 1799, 1832, and 1833, and of a promiscuous character of the motions and orbits of the individuals composing the occasional abundances seen since 1833, on the 12th—13th November; or else to adopt, with Erman, that of a more or less continuous ring or lens with slight variations of the length and position of the radius vector of the node, so as to have exhibited the magnificent spectacles occasionally recorded, and at other years only a moderate abundance, or even an ordinary number.

For the August asteroids, the supposition of a single cluster with half yearly period, gives a relative velocity rather too small, and a yearly period too great to conform precisely with the average value in Table I.; and a period of 0.57 year affords a better agreement; still the half yearly value is within the limits of the probable errors of the observed mean value, and accordingly, the supposition of a single cluster with half yearly period being possible, there is no need of resorting, with Prof. Erman, to that of a continuous ring, unless the *a priori* probability of the latter hypothesis, or other circumstances which have been overlooked in this inquiry, tend to give greater plausibility to the theory of the existence of the ring, than to that of the cluster of half yearly period.

§ VI.—Of certain Analogies in the Solar System and Siderial Heavens, tending to Confirm the preceding Conclusions.

I have already alluded to certain analogies, which would lead us to expect a gradual aggregation of these or other cosmical bodies in the vicinity of the sun, a conclusion, also, authorized from the observed geometrical relations of these asteroids, when seen by an observer on the earth. A similar law of aggregation is known to prevail with respect to the primary planets of our system. The same remark applies to the distribution of the perihelia of secondaries, or satellites round their primaries. This law of distribution of the perihelia of the primary and secondary planets round their central bodies, admits of very simple numerical formulæ for its expression. Comets, from the great eccentricity of their orbits, afford, perhaps, a closer analogy with meteors. Though the law of distribution of the perihelia of comets is unknown, still an inspection of the catalogue of their elements shows that four fifths have their perihelia beneath that of the earth, and six tenths beneath that of Venus.

These circumstances, and the known fact that, in the different systems, inferiority of size and mass is generally connected with inferiority of perihelion distance, afford a double analogy for concluding *a priori* that the perihelia of these minute asteroids are gradually condensed as the distance from the sun diminishes, although the law of their aggregation in space will doubtless remain always unknown for want of data for its determination. Since countless millions of these bodies are annually encountered in the small portion of planetary space with which the earth comes in contact, we are led to the inference that the number of the perihelia of these bodies inferior to that of Venus, or even Mercury, is inconceivably great. Indeed, this would be the case, if these bodies were there scattered as sparsely as in the regions traversed by the earth. But the analogies I have mentioned strengthen the probability that no such rarity prevails within the limits of Mercury's, or Venus' mean distance; and this conclusion once arrived at, a new analogy comes in for its support. I allude to the extremely interesting discussion between Bessel and Encke, in Schumacher's Astr. Nachr., Nos. 289, 305, and 310, in which the former objects to the hypothesis of a resisting medium, from the fact that its existence is indicated by no other phenomenon in nature. The reply of the latter is, that no other phenomenon in nature is capable of its indication. Encke's comet is only found to be resisted while within the distance of Venus. Now as Halley's comet never goes far within the limit at which this resistance is sensible, and Biela's comet never approaches this limit, the perihelion distance of the former being superior to Mercury, and that of the latter little inferior to that of the earth, neither of these bodies can afford a contradiction or confirmation. The planets Mercury and Venus, the one within this limit, and the other on its border, are too dense and massive, compared with Encke's comet, to enable us to detect such a resistance. It is with deference to the opinion of these distinguished authors that I venture to suggest the possibility of such an aggregation of these small asteroids within the mean distance of Mercury, as may produce a sensible effect in resisting the progress of a body so light as Encke's comet, which Sir John F. W. Herschel[66] supposes to be incomparably

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[66] Herschel's Astronomy, Chap. x. 303. The author remarks, "that the most unsubstantial clouds which float in the highest regions of our atmosphere, and seem at sunset to be drenched in light, and to glow throughout their whole depth as if by actual ignition, must be looked upon as dense and massive bodies, compared with the filmy and almost spiritual texture of a comet."

more rare than the thinnest clouds that float in the upper regions of the atmosphere. Should future observations establish on a firmer basis the general facts contained in the preceding tables, and thus warrant the opinion, that these small masses are much more closely aggregated together in the vicinity of the sun, then the theory which I have proposed, and that of the resisting medium will mutually strengthen each other. It may be further remarked, that should this theory of shooting stars be found to explain all their known phenomena, and to explain some portion of the resistance encountered by Encke's comet, an answer would be furnished to some interesting inquiries, by Sir J. F. W. Herschel in his Astronomy, page 310th, note. "What is the law of density of the resisting medium which surrounds the sun? Is it at rest or in motion? If the latter, in what direction does it move? Circularly round the sun, or traversing space? If circularly in what plane?" To these it would be answered, that the resistance is owing in part, at least, to the comet's meeting in its course an immense number of these small masses, each of which is pursuing its own orbit in a conic section round the sun, disturbed by the other planets, and by the meteors in its vicinity. That the law of their aggregation is unknown for reasons already mentioned; but that we have reason to suppose that the individual bodies retain their relative position or configuration by the general law of gravity, and not by any such law as that which regulates the relative position of the particles of an elastic fluid, or liquid, usually understood by the word medium.

I have thus discussed one feature of the present theory, namely, the gradual aggregation of these bodies in approaching the sun. I shall now suggest another, derived from the distribution of matter in the siderial heavens, of which the planetary space forms a part. This portion of space is continually changing, if the solar system, as was supposed by Herschel, and proved since by Argelander,[67] has a proper motion in space. According to the opinion of Laplace, new portions of matter formerly revolving round that central body, or group, whose sphere of activity was greatest, must, in consequence of the motion of our system in space, be continually falling within the sun's sphere of attraction, and forming comets, asteriods, or planets. It is only necessary to extend the theory a little farther to include the small shooting stars, aerolithes, or asteroids. Now we notice in the heavens that matter is not uniformly distributed,

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[67] Astr. Nachr., No. 363.

but we see a constant tendency to condensation into nebulæ of particular shapes and degrees of density—into the milky way—into clusters more or less resolvable—into rings, round, or perspectively, or really flattened—into planetary discs, which, when turned edgewise towards us, might present, as is often found to be the case, a section of a lens. Now that which is seen in the immensity of space, with bodies concerning whose dimensions no conjecture can be formed, may also occur in miniature, with respect to groups of these small asteroids, either from common circumstances connected with their original projectile motion, or origin, or time and place of first falling within the sun's sphere of activity, owing to the sun's proper motion in space. Or, in case of a uniform distribution at any time in a particular portion of the system, their mutual attractions, and those of the other bodies of the system, together with physical changes from variations of temperature, may naturally tend to produce the gradual formation of clusters, or, possibly, of circular or flattened rings or lenses, either continuous or interrupted, the individuals of which continue to circulate round the sun for many years almost in the same planes. A single flock or cluster of these bodies might extend for many thousand, or, possibly, hundred thousand miles, and have a general resemblance, though not a perfect uniformity of their elliptic elements. I have mentioned a general resemblance in their elements. This is all that could be expected, for a perfect uniformity of elements would require the several bodies of the group to be bound together by some law of fixedness of relative position, like the single particles of a solid, which does not here prevail.

The principal points in this theory for which I have endeavoured to find known analogies are,

1. That the perihelia of the orbits of these meteors are gradually aggregated together as the distance from the sun diminishes.

2. That by far the greater part of these bodies never reach the earth's mean distance.

3. That while this general law of distribution prevails in the planetary space, portions of this space have, besides the average number conformable to this law, special clusters, groups, or flocks of great extent, possibly composing entire rings or lenses embracing the sun.

4. That the individuals composing these clusters have similar elements of elliptic motion, and continue to move round the sun in a plane which, for a considerable period, undergoes but little change in space.

5. That in such a plane there may be an indefinite number of these irregular groups at various mean distances from the sun; or there may be a tendency to the formation of a continuous, or imperfect and interrupted ring, the ring itself being a conic section, probably an ellipse. The ring of Saturn furnishes such an analogy in a secondary system, and, according to Cassini[68] and Laplace, most probably the zodiacal light in the solar system.

Of the degree of plausibility of these hypotheses, *a priori*, every one must judge from such analogies as have been pointed out, and others which naturally suggest themselves. It will readily appear that if we admit them as the basis of the theory of shooting stars, we may readily infer from them the necessity of all the phenomena which I have pointed out as deductions from the established facts and statistics of meteorology.

By the general prevalence of the first and second law we should expect that a great portion of the shooting stars seen on ordinary nights, being small planets or asteroids, having their perihelia inferior to Mercury, must, at the time of visibility, be generally near their aphelia, and have a small space velocity, and, moving in all directions, the mean relative direction must be nearly opposite the observer's true direction, and the actual velocity of any single meteor resolved in the plain normal to the observer's direction must be small, and must exhibit itself as a small discrepancy from the mean convergent point for the evening. This character must prevail throughout the year, independent of any clusters or flocks which the earth may fall in with in its orbital motion.

On the same principle of distribution of perihelia, supposing all varieties of eccentricity to occur, some of these bodies, having perihelia inferior to that of Mercury, must have their aphelia far superior to the earth, and, by their mean distance and period, must belong to the class of superior planets. This class of superior asteroids of great eccentricity, and other asteroids having perihelia superior to the former, must, even with moderate eccentricities, still be considered as superior planets; and have, at the earth's mean distance, a true velocity greater than that of the earth; and moving in all varieties of directions, though the observer's true motion in space serves to impress on them a relative tendency opposite to his own, still the velocity of the asteroid in the normal plane being very great, the deflection of its relative direction from the mean

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[68] Schumacher's Jahrb. 1837, p. 281.

convergent point, namely, the antipode of the observer's true direction, is so great that its connexion therewith does not appear, and the meteor is pronounced to be *unconformable*, *non-convergent*, or *sporadic*.

Again, if the third and fourth laws are supposed to prevail, the earth must, besides encountering the usual number of inferior and superior asteroids, also, on certain occasions, traverse the planes abounding in flocks or clusters already described, at the time when these clusters are in the nodes of their orbit. Still these flocks or groups of asteroids are not necessarily seen, since they only become visible to us when, besides being near their nodes, and we in the plane of their orbit, their radius vector is also within a few hundred miles, or, relatively to the earth's mean distance, sensibly the same as that of the observer. The coincidence in point of time of these three separate events, with reference to any one group or cluster of asteroids of moderate extent, supposing these groups to be distributed either indiscriminately in the system, or, according to a similar law to that which prevails relative to isolated asteroids, is a compound event of extreme improbability. Indeed, the visibility of a portion of such a group is only so far more probable than that of any isolated asteroid, as the cubical contents of the group are greater than those of the earth.[69] Still, if the number of groups is indefinitely great, the event must sometimes occur. And if we attribute to our meeting with such isolated clusters the remarkable showers in Quetelet's catalogue, the only elements wanting would be the dimensions of these clusters, and an estimate of the annual number of isolated meteors encountered by the earth, in order to estimate the frequency of the distribution of these clusters in the system, compared with that of the single asteroids. When this complex event actually occurs, (our falling in with such a cluster, the individuals of which have similar, though not perfectly identical elements of motion round the sun,) the mean velocity of the group, in a plane normal to the direction of the observer's motion, deflects the convergent point from the antipode of the observer's direction. On such an evening, therefore, there should be two convergent points, the one for the asteroids of the cluster proper, the other the same as on ordinary nights. The convergent point for the cluster having hitherto been regarded as the principal convergent point, the other, if there be any, has always been overlooked, and all the isolated asteroids have been termed *unconformable* or *sporadic*.

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[69] This is not quite exact, but near enough in general terms.

§ VII.—NOTICE OF SEVERAL THEORIES OF AEROLITES AND SHOOTING STARS.

Previous to the researches of Brandès and Benzenberg, the prevailing opinion, with some exceptions, was that the shooting stars and fire-balls were of atmospheric or volcanic origin. Halley, whose labours, after Newton, established the rank of comets as periodical primary bodies of our system, was also of the opinion that the solar system contains myriads of small bodies, moving round the sun in conic sections. Many distinguished astronomers had maintained the same opinion, and Chladni had entered into an extensive discussion on this subject. He supposed that these isolated bodies pursue their paths in orbits unknown to us, till, by their entrance into the earth's atmosphere, they become luminous by ignition, and either just penetrating the surface of the atmosphere, leave it to pursue their orbit round the sun, or, entering more deeply, take fire and explode, or fall to the earth in the character of aerolites.

In 1775 Dr. Olbers,[70] in a lecture at the museum of Bremen, suggested the idea of the lunar origin of aerolites, inclining, at the same time, to a belief that they were the product of the earth's volcanoes. The hypothesis of their volcanic origin was thought to receive confirmation from the fall of a shower of aerolites at Sienna, eighteen hours after an eruption of Vesuvius. Mr. Hamilton[71] had remarked that "stones of the same nature, as far as the eye could judge," had been found on Mount Vesuvius. Dr. Olbers, having computed the direction and projectile force required to send these fire-balls from Mount Vesuvius to Sienna in eighteen hours, and having found it not greater than that which is requisite for the up-heaving of mountains, a phenomenon known to have occurred in the historical period, was strongly persuaded of the correctness of the volcanic hypothesis.

The appearance of Howard's[72] celebrated work on the chemical constituents of these aerolites, in 1802, and of Brandès' and Benzenberg's Researches on the distance, velocity, and orbits of shooting stars, in the same year, threw new light on the subject. The former showed that the chemical constituents of the

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[70] Zach's Monatliche Correspondenz, vol. vii., p. 148.

[71] Philosophical Transactions for 1795.

[72] Idem., 1802.

meteoric stones were the same wherever found, and different from any known terrestrial product. The latter work showed that shooting stars, whatever might be the character of their chemical constituents, bore a close resemblance to the fire-balls in their geometrical relations, and had a velocity and altitude as great, if not greater, than those of the fire-balls whose paths had been determined. Howard's researches set aside, at once, the theory of the atmospheric or volcanic origin of the fire-balls, since, on such grounds, it was impossible to account for their chemical constituents. Accordingly, Laplace,[73] in a letter to Zach, announces his theory of the *selenitic* origin of the fire-balls, and especially of the shower of aerolites at Sienna. He had found, by computation, that a projectile force of six times that of gunpowder, in a lunar volcano, would suffice to throw these masses beyond the sphere of the moon's activity, and make them satellites of the earth. The aerolites might then be the products of the lunar volcanoes sent forth in such a direction, and with such a velocity as to have their perigee within the earth's atmosphere. This view of the subject was maintained to the last by Laplace, and is repeated at length in his Systeme du Monde, published in 1824. This theory would account for the similarity of their chemical constituents, and would throw new light on the subjects of the constituents of the lunar volcanoes.

Olbers, in 1803, in the February number of the M. C., again brings forward his theory of their lunar origin, suggested, but not made prominent, in 1795, and gives a statement of the projectile velocity required at the moon's surface, namely, about 7780 Paris feet per second, in order that these bodies should reach the earth. Our cannon balls have a velocity of 1800 to 2000 Paris feet per second, as stated in the Memoires de l'Academie, &c., of Paris, for 1769, p. 247, et seq. The moon is known to be highly volcanic, and to have little or no atmosphere, hence the plausibility of this supposition of the requisite volcanic force being about four or five times that of gunpowder. There was a conclusion, however, from the observations of Brandès and Benzenburg, in 1798, namely, that one of the meteors observed in common actually moved *upwards* from the direction of the earth's surface, which could not be explained either by the theory of their *selenitic* or *cosmical* origin. This circumstance, and the slowness of the motion of some *spent* fire-balls, induced Chladni to

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[73] Monatliche Correspondenz, September, 1802.

waive his theory of the *cosmical* origin of meteors, and to resort again to that of a terrestrial origin. It does not appear that much new light was thrown upon this subject previous to the resumption of corresponding observations by Brandès and others in 1823, and Quetelet and others in 1824. The three theories, *cosmical, selenitic,* and *terrestrial,* had each their advocates. The first failed to account for the upward motion of meteors, if not for the uniformity of chemical constituents. The second accounted for the chemical facts, but failed to explain the upward motion of a meteor, as well as their great relative velocity, computed by Brandès in 1798. The last accounted for the upward motion, but not for the relative velocity nor chemical constituents. The chemical objection could be partly removed by a resort to the earth's atmosphere for the origin of motion; which would also account, though rather unsatisfactorily, for their upward motion, but would still be inadequate to explain their observed relative velocity.[74]

As late as 1834, Berzelius,[75] and also Benzenberg, express themselves decidedly in favour of the *Olbersian* or *selenitic* theory. In 1836, however, Olbers, the original proposer of the theory in 1795, being firmly convinced of the correctness of Brandès' estimate of the relative velocity of meteors, renounces his *selenitic* theory, and adopts the *cosmical* theory as the only one which is adequate to explain the established facts then before the public. Arago and Quetelet had previously done the same. Littrow, in 1838, and Bessel, in 1839, fall in with the others. Professor Erman, Jun., in Berlin, and Boguslawski,[76] in Breslaw, in 1839 and 1840, have extended their inquiries on the bearing of the facts known up to these dates upon the cosmical theory. It is to Bessel's paper, already quoted, that we are indebted for the removal of the principal ground of objection to the *cosmical* theory, namely, that of the ascent of meteors. He has there shown that every instance in which Brandès' computations gave an upward motion of a meteor may be made to indicate the reverse, by applying a correction of the observed points of beginning and end of the apparent path of a meteor not much exceeding the probable error of such

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[74] Dr. Olbers accounts for the serpentine motion of meteors that approach near the earth's surface, by partial explosions, after the manner of rockets.

[75] Olbers' paper, Schumacher's Jahrbuch for 1837, p. 54.

[76] Astr. Nachr., 391 and 412.

observations. The chemical objection is not very weighty, for we may as well suppose a uniformity of constituents in *cosmical* as in lunar substances.

The opinion of Arago is contained in the following extract from Quetelet:[77] "Brandès avait soigneusement appelé l'attention sur l'apparition remarquable des météores qui se montrèrent pendant la nuit du 10 Août, 1823, mais il avait perdu de vue que le même phénomène s'était déjà présenté, à lui, à la même époque, en l'année 1799. La supposition d'un retour périodique pour ces sortes de phénomènes, ne pouvait guère naître du reste qu'en présence de faits plus énergiquement prononcés. Il fallait le magnifique spectacle que déploya le nuit du 11 au 12 Novembre, 1832, pour réveiller la curiosité des savants et pour rappeler le souvenir effacé du phénomène tout aussi extraordinaire du 11 au 12 Novembre, 1799. Le hasard, on pourrait dire, plutôt que des combinaisons scientifiques, amena à constater un fait qui assure désormais aux étoiles filantes un rang si important dans notre système planétaire. *Ainsi se confirme de plus en plus,* comme le remarquait M. Arago, *l'existence d'un zone composée de millions de petits corps, dont les orbites rencontrent le plan de l'écliptique vers le point que la terre va occuper tous les ans du* 11 *au* 13 *Novembre. C'est un nouveau monde planétaire qui commence à se révéler à nous.*"

That of Olbers is translated from his paper in Schumacher's Jahrbuch for 1837, pp. 279 and 280. "Perhaps the phenomenon of 1799 and 1833 has not been renewed. It appears, nevertheless, that a great multitude of the small molecules that compose the shooting stars move round the sun in orbits that intersect the plane of the earth's orbit, especially between the 19th and 21st degree of Taurus. These orbits, very close to each other, and completely parallel, compose, as it were, a common path for myriads, nay millions of these very small asteroids, which, in intervals nearly common, perhaps of five or six years, finish their circuit round the sun. They also seem to be quite unequally portioned out in this common path, sometimes in thick swarms, sometimes more widely separated. In 1799 and 1833, and, perhaps, in 1832, the earth passed through one of these thickest swarms. In 1831, 1834, and 1836, only isolated, though numerous meteoric asteroids were met. Perhaps there are many of these thick swarms moving in this common path; perhaps, also, the inhabitants of the earth must wait till 1867, before they see this wonderful

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[77] Catalogue, &c., p. 4.

phenomenon again in all its splendour, as in 1799 and 1833. In the interval, however, it is of the highest importance that philosophers of every country should give the most careful attention, on the well known days of November, to the current appearances of these periodical shooting stars, as they are properly called in contradistinction from those sporadic meteors which occur throughout the year."

The objections of Dr. Olbers to the theory of the zodiacal light as the origin of the November meteors, ascribed to Biot, but, in fact, first proposed by Professor Olmsted, and still I believe maintained, are stated in the 281st and 282d pages of the same work. Dr. Olbers pronounces it impossible to explain the motions of the November meteors, whose relative velocity he states at from sixteen to twenty geographical miles per second, by the supposition of a direct orbit round the sun, such as theory ascribes to the zodiacal light. Moreover, the nodes of the sun's equator are not in the 20th degree of Taurus, but in the 20° of Gemini.

I may here remark, in confirmation of Olbers' statement, that the data of Tables I. and III., as presented in Table VI., give to the November meteors an orbit inclined 121°.1 to the ecliptic, in other words retrograde.

The opinion of the younger Littrow,[78] based upon a year's observations of these bodies, is as follows:—"Shooting stars are most probably of cosmical origin, as is shown by their return at stated periods of the year, and at particular portions of the heavens, both of which seem to depend upon the motion of the earth."

"The dates of the 10th of August and 12th of November are properly considered as periods when a richer fall of shooting stars may be expected."

"The phenomena of these two dates are different from those of ordinary nights. While the former exhibit a certain regularity in the place of their appearance and their directions, the latter seem to wander without rule in all parts of the heavens."

"The shooting stars of August and November are also of a different nature, in as much as they appear in quite opposite parts of the heavens, and the former are seen going towards that part of the celestial sphere from which the

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[78] Annalen, &c., for 1838, p. xviii.

earth is coming, while the latter seem to come from a part of the heavens towards which the earth is going."

"Accordingly, the universe may be considered as replete with bodies of a similar kind, revolving round the sun. In certain portions, also, there is a tendency to the formation of connected systems of these bodies. Two of these systems seem to describe paths round the sun that lie near the portions of the earth's orbit which it passes through in August and November. The peculiarities of the August and November meteors above mentioned may, perhaps, be best explained by supposing the orbit of the former nearly perpendicular, and of the latter nearly parallel to the orbit of the earth."

The latter supposition of Mr. Littrow cannot be reconciled with the conclusions in Table VI., drawn from the data of Tables I. and III., which give a high inclination for the November meteors, as was also remarked by Olbers.

Bessel's[79] opinion has already been referred to. It is stated as follows:—"Far more weighty grounds than those for ordinary shooting stars are at hand, which render it probable that those of November have a cosmical origin."

Professor Erman's theory of a ring for the August and November asteroids, and Professor Boguslawski's theory of a yearly period for the cluster of the latter, have been already alluded to.

The telescopic appearance of the meteors of the 9th and 10th of August, 1839, has been carefully described by the late Mr. E. P. Mason. And the opinion of that nice observer and zealous astronomer is contained in a manuscript not yet printed, and which is here offered to the public, in compliance with a request of the author made to me a few weeks before his decease.

"The nights of the 9th and 10th of August, 1839, are the evenings of the alleged recurrence of the August shower of meteors. They fell in extraordinary numbers, and of very uncommon brilliancy, during both nights. I have never seen nor heard of any telescopic observations of these bodies, and therefore take this occasion to offer my own on these evenings, as the statement would be too brief for a separate article, and I shall probably have no better

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[79] Astr. Nachr. 381, p. 349. "Es sind zwar Gründe vorhanden, welche den cosmischen Ursprung der November-Sternschnuppen, selbst *vorzugsweise* vor den gewöhnlichen, wahrscheinlich machen."

opportunity of making it. Although it has no relation to the subject of nebulæ, which I was then observing, (unless we suppose these bodies to be the remnants of an original nebulous structure of our own system,) yet the subject of meteors is now attracting so much attention in Europe as to render the early publication of this notice not unimportant.

"During four or five evenings in the vicinity of August 9th, between twenty and thirty meteors passed the field of view. About twenty of these occurred on the 9th and 10th, during which nights I had the field almost constantly under my eye, until three or four o'clock in the morning. Their apparent brightness and velocity, as magnified by the whole power of the telescope, were, on the average, about the same, or rather less than that of those seen by the naked eye, (which latter class, to avoid repetition of the phrase, I will call the *ordinary* meteors.) They were of a very sensible size, more so than that of ordinary meteors of the same absolute brightness. On the average they were about half or one-third the diameter of Jupiter, and none were as large as that body. Their outline, however, was somewhat indefinite, like a star out of focus. In short, if such objects as the planetary nebulæ H. IV. 16 and 18, (which, and others of that class, had been observed a few evenings before,) could pass a field of view of between 30° and 40° of *apparent* diameter in about $0^{s}.2$ or $0^{s}.3$, I conceive they would exhibit, in every respect, all that could be gathered from so few of these objects during their brief intervals of transit. One only of the number appeared star-like, and of the twelfth magnitude. Their directions were so various that any judgment of their general tendency was relinquished.

"It is believed that these facts are not merely idly curious. We are enabled to gather from them the same information concerning the comparative remoteness of these *telescopic* meteors, that we already have of the relative distance of telescopic stars to those usually visible; for the chances were very great against the passage of a *single ordinary* meteor, during either night, across the minute space of sky actually occupied by the field of view. The appearance of so many of the telescopic within this space proved them to be vastly more numerous: and they were proportionally fainter; because invisible to the naked eye, and because the whole light of so large a telescope was unable to magnify them into an equality even with those seen by unassisted vision. Now, in these two particulars, great *increase of number*, and proportionate *fee-*

bleness of individual *light*, consists all our knowledge of what remoteness to assign the telescopic fixed stars, and still farther on, the crowded hosts of the milky way, upon the scale of distance of which the nearest fixed star is the unit. The testimony is even far stronger in the case of the telescopic meteors; for the proportionate minuteness of their actual unmagnified *velocity* confirms, in the highest degree, what seems otherwise sufficiently evident, that we must allow them to have been many times farther off than those of ordinary occurrence. Why may we not *gage* the strata of meteors or meteoric matter, at the time of an expected shower, with that kind and degree of certainty which attends Sir William Herschel's gages of our sidereal system and milky way?

"Unless there is reason for a great difference between the absolute velocities of the more distant and the nearer of these bodies, the telescopic meteors which were seen on the above evenings could not have been much less than eighty times as far above the earth as those seen by the naked eye, which (according to the observations of Brandès and Benzenberg) probably darted most thickly at a height of fifty or sixty miles. This latter quantity, multiplied by eighty, or the magnifying power of the telescope, indicates a probable elevation of at least four thousand miles. At this vast height, if the atmosphere exist at all, it must be in a state inconceivably rare, rivalling the supposed resisting medium in its tenuity. It will at once be seen that telescopic observations, of the nature of those made with the fourteen feet reflector, have a peculiar bearing on the cause of the ignition of meteors, and, perhaps, on inquiries connected with the extent of the earth's atmosphere, and with the resisting medium. If carried out with energy, many of the misty theories concerning the nature and constitution of meteors will probably melt away, and we may have at least the comfort of compelling speculation to the effort of reinvention. A nebulous or gaseous constitution seems to be indicated by the observations, as far as they have a bearing on this point.

"I have seen (I believe in the London Times) a communication from Sir James South, the celebrated English astronomer, in which, after expressing great gratification at the recurrence of the annual shower on this same occasion, he remarks that he endeavoured to bring a hand telescope to bear upon the brightest of these objects, as they successively flashed, but without success, although 'a tolerably quick shot' in this kind of observation. This is the only attempt at telescopic examination of which I am aware."

In the Journal of the Franklin Institute[80] a letter addressed to Mr. Espy by me is published, describing a singular telescopic appearance noticed while watching for the emersion[81] of μ Ceti from the dark limb of the moon, at forty minutes past twelve, on the night of the 7th of August, 1833, with a five feet Dollond, day eye-piece, power 30. The same event was seen by Mr. William H. C. Riggs, with a three and a half feet Dollond, and also by his assistant, Mr. Black, with the naked eye. Having observed the moon frequently for many years with a telescope, in the city of Philadelphia, and never witnessed any thing of the kind before nor since, I am inclined to ascribe the phenomenon to a cluster of small meteors. At the time, I supposed the bodies seen to be cinders from some neighbouring chimney. And it was not till after the great display of November 12th of the same year that my attention was called to this appearance, and its date identified by the occultation. The small bodies seen in the telescope traversing the moon's disc were semi-opake when on the disc, and had a phosphorescent appearance; their discs were not more than $20''$ in diameter. They appeared to move downwards, all in perfectly parallel directions. Sometimes several of them were seen traversing the moon's disc at once. The time of passing through the field was, perhaps, $0^s.15$, as nearly as could be estimated. The downward motion observed at the time is consistent with the tendency towards the convergent point for the August meteors. The number seen could not have been less than fifty per minute in the field of view of the telescope, which was about a degree. The phenomenon lasted half an hour at least before the emersion; how long it continued afterwards I do not know, as no farther observations were made.

It must not, however, be forgotten that Professors Olmsted and Twining, who, early in 1834, had "coincident ideas on the subject," were the first to suggest the theory of annual periodicity of the November meteors, and to revive the cosmical theory in connexion therewith. In their early efforts at forming a theory, some opinions were advanced that have since been found untenable. Of this class may be mentioned the supposed parallax of the radiant point by the former giving for it a distance of about two thousand two hundred miles, and that of a parallax in declination by the latter. This last conclusion, based chiefly on the observations of Captain Parker in the Gulf of Mexico, in 1833, is, perhaps, set aside by the more recent and careful observations of Mr. Fitch,

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[80] Vol. xv., p. 234.

[81] Erroneously printed *immersion* of *m* Ceti in that Journal.

in the same gulf, in 1838. Another opinion of Professor Olmsted, that the radiant body was relatively at rest with respect to the observer, is at variance with other known phenomena, since, according to the data of Section I., the relative velocity of the separate asteroids in space was not much inferior to that of the observer. Also, the radiant body itself, I suppose, must be given up, as no such stationary position of a gravitating body is possible, a relative motion being requisite to give sufficient centrifugal force to the body to prevent it from falling at once to the earth. Moreover, it was remarked by Professor Twining, and is now generally admitted, that the radiant and convergent points are the perspective vanishing points of lines nearly parallel. Professor Olmsted first adopted the half yearly period[82] of a single cluster, to explain the anniversary phenomena of 1799, 1832, and 1833. This he afterwards relinquishes for a yearly[83] period. I have shown that neither the half yearly nor yearly period, with single cluster, will correspond well with the table of relative velocities, nor with that of the serpentine meteor as determined by Professor Twining. In reviewing Professor Olmsted's hypothesis respecting the observer's and radiant body's equal velocities and parallel directions, Mr. Espy[84] intimates that such a coincidence is not possible in a perihelion or aphelion, but is possible in some part of the orbit of such a body. The following view of this question, differing from both, is derived from the analytical expressions for the tangential directions and velocities of any two bodies moving in orbits round the sun:—

$$(1)\qquad \begin{aligned} g &= \sqrt{\left(\frac{2}{r} - \frac{1}{a}\right)} = \frac{p}{r \sin u} \\ G &= \sqrt{\left(\frac{2}{R} - \frac{1}{A}\right)} = \frac{P}{R \sin U} \end{aligned}$$

In which

$a =$ asteroids semiaxis major,
$g =$ " linear tangential velocity,
$r =$ " radius vector,
$u =$ " angle between radius vector and tangent to orbit,
$p =$ " semiparameter.

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[82] Sill., vol. xxix., p. 378. [83] Idem., vol. xxxi., p. 393.

[84] Journal of the Franklin Institute, vol. xv., p. 10, note.

The capital letters denoting the same quantities for the earth. Now, as Professor Olmsted supposes the velocities common, and the radii vectores are known to be common to terms of the order of the earth's radius divided by its radius vector, the semiaxes majores, a and A, must be common, as well as the periods to the terms of the same order. Again, since u and U are supposed to be common in quantity and position, the parameters and consequent eccentricities, and also the planes of orbit must be common, that is to say, the two bodies must belong to the same system, and must have the ordinary secondary relation of primary and satellite, or they would immediately fall together. It appears, then, that such a coincidence as that which these authors refer to, is not possible in *any part* of the orbits of two bodies having respectively a half yearly and yearly period.

The mean angular second's motion n of a satellite round the earth, in seconds of space, at the distance of its own radius, $\varsigma = \sin \varpi$, abstracting perturbations and resistance of medium, is

$$n = \frac{1}{86400} \cdot \frac{k}{\sin 1''} \cdot \frac{\sqrt{(m + m')}}{\sin^{\frac{3}{2}} \varpi} = 257''.08, \tag{2}$$

$$\nu = \frac{n}{60} = 4.285 \text{ geog. miles,}$$

$$\sqrt{2} \times \nu = 6.06 \text{ geog. miles.}$$

Where

$k =$ Gauss' constant given above,
$m =$ the earth's mass in parts of the sun's,
$m' =$ the satellites ——————
$m = 0.0000028192,$
$m' = 0$
$\varpi = 8''.5776 =$ sun's horizontal parallax,
$\nu =$ mean second's velocity in geographical miles.

Whence we have, as already stated, about six geographical miles as the greatest seconds motion which a periodical satellite can have round the earth. Hence the necessity of the cosmical theory; for we cannot refer them, with Professor Olmsted, to a radiant body with a yearly period, keeping itself constantly near the earth; nor can we suppose them satellites of the earth—nor projectiles from the moon—nor from the earth's volcanoes—nor atmospheric scintillations; and there remains no other plausible source of motion but the sun's attraction.

§ VIII.—INVESTIGATION OF THE FORMULÆ FOR COMPUTING THE ELLIPTIC ELEMENTS OF AN ASTEROID FROM ITS OBSERVED RELATIVE VELOCITY AND DIRECTION.

Having stated the general principles by which this modification of the cosmical theory is deduced from known facts, I shall proceed to point out the method of computation by which the data in Table VI. are obtained.

For this purpose let the true motion of the meteors and observer in space, as well as their difference, or the relative motion of the meteors, be referred to the rectangular co-ordinates X, Y, & Z, having their positive values respectively directed towards the vernal equinox, the summer solstice, and north pole of the ecliptic, and let these motions be referred respectively to the sun's mass, earth's mean solar second, mean distance, and mean linear velocity,[85] as the units of mass, time, space, and velocity. Let $G_\circ$, $L_\circ$, and $B_\circ$ denote respectively the earth's centre's true velocity, and the longitude and (latitude = 0) of the point $L_\circ$ of the ecliptic towards which the earth's centre is moving in a *tangential* direction. Then, by the usual formulæ for the transfer from rectangular to polar co-ordinates, we have

$$\begin{aligned} X_\circ &= G_\circ \cos L_\circ \cos B_\circ \\ Y_\circ &= G_\circ \sin L_\circ \cos B_\circ \\ Z_\circ &= G_\circ \sin B_\circ = 0. \end{aligned} \tag{4}$$

In the same manner we have for the true *tangential* motion of the meteors in their orbit towards the point $[l\, b]$ with the velocity g,

$$\begin{aligned} z &= g \cos l \cos b \\ y &= g \sin l \cos b \\ z &= g \sin b \end{aligned} \tag{5}$$

and for their relative motion towards the point $[\lambda\, \beta]$ with the velocity γ

$$\begin{aligned} \xi &= \gamma \cos \lambda \cos \beta \\ \eta &= \gamma \sin \lambda \cos \beta \\ \zeta &= \gamma \sin \beta. \end{aligned} \tag{6}$$

Also (ϕ) denoting the geographical latitude, (the eccentricity of the earth's meridian being neglected,) and making $(G) = 365.2564 \times \sin (8''.5776)$, $G_{,} = (G) \cos (\phi)$, μ the siderial time, ω the obliquity of the ecliptic, we have for the velocity of the observer's actual rotary motion referred to the same axes,

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[85] This unit is $\frac{k}{86400}$, where k is the Gaussian constant given above.

$$\begin{aligned} X_{,} &= G_{,} \cos (\mu + 90^\circ) \\ Y_{,} &= G_{,} \sin (\mu + 90^\circ) \cos \omega \\ Z_{,} &= - G_{,} \sin (\mu + 90^\circ) \sin \omega \end{aligned} \tag{7}$$

and

$$\begin{aligned} X &= G \cos L \cos B = X_0 + X_{,} \\ Y &= G \sin L \cos B = Y_0 + Y_{,} \\ Z &= G \sin B \qquad = \quad + Z_{,} \end{aligned}$$

$$\begin{aligned} x &= g \cos l \cos b = G \cos L \cos B + \gamma \cos \lambda \cos \beta = X + \xi \\ y &= g \sin l \cos b = G \sin L \cos B + \gamma \sin \lambda \cos \beta = Y + \eta \\ z &= g \sin b \qquad = G \sin B \qquad + \gamma \sin \beta \qquad = Z + \zeta \end{aligned} \tag{8}$$

If we add together the squares of the three equations (8) ψ being the angle of elongation of the convergent point from the observer's true direction, we obtain

$$\begin{aligned} g^2 &= G^2 + \gamma^2 + 2\, G\, \gamma \left[\cos B \cos \beta \cos (L - \lambda) + \sin B \sin \beta\right] \\ g^2 &= G^2 + \gamma^2 + 2\, G\, \gamma \cos \psi \\ \cos \psi &= \cos B \cos \beta \cos (L - \lambda) + \sin B \sin \beta \\ \gamma &= - G \cos \psi \pm \sqrt{(g^2 - G^2 \sin^2 \psi)} \end{aligned} \tag{9}$$

In Table VI. ψ comes out in the second quadrant both for the August and November meteors. Hence both signs before the radical are possible, and the only geometrical limit which these equations furnish, in order that g, G, and γ shall be positive and rational, is that of the true normal velocity ($G \sin \psi$.) This being necessarily the minimum of the true velocities, and the minimum required by the condition that γ must be rational, we have for its limit

$$g = G \sin \psi \tag{10}$$

Marking with a negative sign at top the quantities that result from the use of the lower or negative sign before the radical in the last of (9) we have the following *geometrical* limits of the values of g and γ:

$$\begin{aligned} \text{Maximum of } g &= + \infty \\ \text{“} \qquad \bar{g} &= G \\ \text{“} \qquad \gamma &= + \infty \\ \text{Minimum of } g &= G \sin \psi \\ \text{“} \qquad \bar{g} &= G \sin \psi \\ \text{“} \qquad \gamma &= - G \cos \psi \\ \text{“} \qquad \bar{\gamma} &= 0 \end{aligned} \tag{11}$$

These limits are derived from the principles of the geometry of position, and have no reference to the limits of g and γ, deduced from the laws of elliptic motion. The most general interpretation of the cosmical theory of these asteroids is to suppose them to be moving in conic sections, in which those of (11) are the only necessary limits. In fact, the sporadic meteors, and the clusters which have no known periodical character, may have for their orbits either of the three conic sections. The case is quite different for the meteors which appear at anniversary periods, and annually exhibit the same normal velocity, too great to be ascribed to the errors of observation, and too uniform at each appearance not to be the result of identity of elements. The first principle of inductive reasoning which leads us not to assign two causes for an event where one is sufficient, would also lead us not to require for a series of connected events the repeated exertion of a cause, where a primitive exertion of it, and the subsequent action of known laws, are sufficient to account for the succession.

Now if we suppose that groups of bodies which, at yearly intervals, present the same combination of elliptic elements, are moving in non-periodical curves, (the parabolas or hyperbolas,) we must suppose that the primitive cause, whatever it may be, which gave to the bodies of our system their original projectile motion is continually exerted afresh so as annually to present the appearance just described. This is quite unreasonable; and accordingly, while we admit that the three classes of conic sections are possible for the *sporadic* meteors, and *isolated* clusters of unknown period, we must restrict those of anniversary occurrence to the class of ellipses, or periodical orbits, unless the observed relative velocity in Table I., combined with the convergent points in Tables II. and III., should require the contrary. Now, in equation (1) the maximum value of g^2 in a periodical orbit is (a being less than $+\infty$) equal to $\frac{2}{r}$ or $\frac{2}{R}$, neglecting the small discrepancies, or computing R for the position of the observer, or meteor, if its distance from the observer is known. Then we have for the maximum value of γ in a periodical orbit

$$\gamma = -G\cos\psi + \sqrt{\left(\frac{2}{R} - G^2\sin^2\psi\right)} \tag{12}$$

The values of γ in Table VI., computed from this formulæ, are, when multiplied by $\varkappa$, to convert them into geographical miles per second, respectively 39.8 for the November meteors, 33.3 for those of August, and 12.0 miles for those of December. As these values for August and November exceed the greatest velocities in Table VI., both observation and theory, in their present state, require us to restrict the anniversary meteors to elliptic orbits. Analogy, also, leads us, in the case of *sporadic* meteors and isolated clusters, to make the same restriction. The value of 12.0, however, for the December meteors, is too small to include all the values of Table I. in a periodical orbit, unless observation should show that, on the occasion of a high angle of deflection of the convergent point, the value of $\varkappa\gamma$ falls below the average in Table I. The limits of (11) and (12) give for elliptic or periodical orbits

$$\begin{array}{ll}
\text{Maximum of} & g = \sqrt{\left(\frac{2}{R} - \frac{1}{a < +\infty}\right)} \\
\text{``} & \bar{g} = G \\
\text{``} & \gamma = -G\cos\psi + \sqrt{\left(\frac{2}{R} - G^2\sin^2\psi\right)} \\
\text{``} & a = +\infty \\
\text{``} & \bar{a} = \dfrac{1}{\frac{2}{R} - G^2} \\
\text{Minimum of} & g = G\sin\psi \\
\text{``} & \bar{g} = G\sin\psi \\
\text{``} & \gamma = -G\cos\psi \\
\text{``} & \bar{\gamma} = 0 \\
\text{``} & \bar{a} = \dfrac{1}{\frac{2}{R} - G^2\sin^2\psi}
\end{array} \tag{13}$$

The limiting value of g^2, or $\frac{2}{R}$, is adopted by Olbers[86] and Professor Erman, Jun.,[87] for the orbits of these asteroids. Their reasons for the restriction are not, however, stated. Professor Erman, Jun., has overlooked the limits which have the negative sign over them, and has, therefore, too much restricted the limits of the elliptic elements of these anniversary asteroids, possible according to the principles of the geometry of position. This oversight pervades the results and conclusions throughout that interesting paper. Its effect is particularly manifest in the formulæ there given for computing the maximum motion of the convergent point in a finite period, which he makes about 0°.1 per hour in a retrograde direction. Now, by applying the proper limit to the reciprocal of γ, which Professor Erman makes a coefficient of this motion, (since the limit of $\bar{\gamma}$ is 0, and that of $\frac{1}{\bar{\gamma}}$ is $+\infty$,) we may have, without any

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[86] See passage already quoted.

[87] Astr. Nachr. 385.

contradiction from the geometry of position, a motion of the convergent point in a finite period of time indefinitely great, instead of 0°.1. There are other variable elements omitted in Mr. Erman's formulæ for computing this motion, which will be referred to in the next section. It remains to point out the use of the formulæ of (8) in computing the elliptic elements from observed values of γ, λ, and β, and the known values of X, Y, and Z. These equations may assume the following well known forms:

$$
\begin{aligned}
\tan l &= \frac{Y+\gamma \sin\lambda \cos\beta}{X+\gamma\cos\lambda\cos\beta} & &= \frac{Y+\eta}{X+\xi} \\
\tan b &= \frac{Z+\gamma\sin\beta}{X+\gamma\cos\lambda\cos\beta}.\ \cos l & &= \frac{Z+\zeta}{X+\xi}.\ \cos l \\
&= \frac{Z+\gamma\sin\beta}{Y+\gamma\sin\lambda\cos\beta}.\ \sin l & &= \frac{Z+\zeta}{Y+\eta}.\ \sin l \\
g &= \frac{X+\gamma\cos\lambda\cos\beta}{\cos l\cos b} & &= \frac{X+\xi}{\cos l\cos b} \\
&= \frac{Y+\gamma\sin l\cos\beta}{\sin l\cos b} & &= \frac{Y+\eta}{\sin l\cos b} \\
&= \frac{Z+\gamma\sin\beta}{\sin b} & &= \frac{Z+\zeta}{\sin b}
\end{aligned}
\tag{14}
$$

In making the computations, either of the formulæ (9) may be used as a check to test the accuracy of the computation. The subsidiary quantities, $G_\circ$, $L_\circ$, and $B_\circ = 0$, are readily obtained thus:

$$
\begin{aligned}
\oplus &= \text{the earth's longitude} \\
\varepsilon &= \text{`` eccentricity} \\
\ominus &= \text{sun's longitude} = \oplus + 180^\circ \\
R_\circ &= \text{earth's radius vector} \\
G_\circ \surd R_\circ &= \surd(2 - R_\circ) \\
\surd(1 - \varepsilon^2) &= G_\circ R_\circ \sin(L_\circ - \oplus) \\
(\phi) &= 39^\circ.95 \\
G_{,} &= 0.011644 = 365.2564 \times \sin\varpi \cos(\phi)
\end{aligned}
\tag{15}
$$

Now the quantities L and B differ from $L_\circ$ and ($B_\circ = 0$) by less than a degree, and the deflection of the convergent point from the plane of the $L_\circ$ and $B_\circ$, or, in other words, from the ecliptic, being in a southerly direction, and also southerly with respect to the plane of L and B, the true motion of the meteor must be southerly, and it must be tending towards its descending node. Also, the meteor's radius vector and heliocentric longitude being sensibly the same as the observer's, and within quantities of the order of the earth's mean distance divided by its semi-diameter, the same as those of the earth's centre, those of the latter may be employed in the computation with sufficient precision, and we shall have, denoting by Ω the heliocentric longitude of the point $[l\ b]$ and making $u =$ the angle of inclination of the meteor's tangential direction to its radius vector, reckoned in the plane of its orbit in the order of the actual motion,

$$\Omega = \oplus + u$$

$\text{☊} = \oplus$, for northern $= \ominus$ for southern convergent point

$\Omega - \text{☊} = \Omega - \oplus$ " $= \Omega - \ominus$ " " "

$$\cot i = \cot b \sin (l - \text{☊})$$

$$\cos u = \cos b \cos (l - \oplus)$$

$$g\ r \sin u = \sqrt{p} = \sqrt{a} \cos \phi$$

$p =$ semiparameter

$$a = \frac{1}{\frac{2}{r} - g^2}$$

$\sin \phi = e =$ sine of angle of eccentricity.

$v =$ true anomaly

(16) $E =$ eccentric do.

$M =$ mean do.

$$e\ r \cos v = p - r = a \cos^2 \phi - r$$

$$r \sin v = a \cos \phi \sin E$$

$$M = E - e \sin E$$

$$\pi = \oplus - v = \Omega - u - v$$

$k =$ Gaussian constant $= 0.0172021$

$\omega = 206264.67 =$ radius in seconds

$n = k \sqrt{(1 + \mu)}\ a^{-\frac{3}{2}} = a^{-\frac{3}{2}}$, for $k = 1$, and $\mu = 0$.

$T = a^{\frac{3}{2}} =$ periodic time in siderial years.

$t_{,} =$ interval since preceding new year

$H = \pi + M - n\ t_{,} =$ epoch for preceding new year.

The values of Table VI. were computed by formulæ (14), (15), and (16). The numerical values of the fundamental equations are here subjoined, as they may save the labour of fresh computation by others who may engage in similar inquiries. The numbers, $_1$, $_2$, $_3$, below the letters, refer respectively to the group of meteors of 1833, November 12.734, 1840, August 9.456, and 1838, December 7.333.

$$
\begin{aligned}
x_1 &= -0.80025 + 0.80423 \times \gamma_1 \\
y_1 &= +0.62056 - 0.57905 \times \gamma_1 \\
z_1 &= +0.00336 - 0.13385 \times \gamma_1 \\[6pt]
x_2 &= +0.66830 - 0.45439 \times \gamma_2 \\
y_2 &= +0.74084 - 0.63354 \times \gamma_2 \\
z_2 &= -0.00252 - 0.62622 \times \gamma_2 \\[6pt]
x_3 &= -0.98371 - 0.45439 \times \gamma_3 \\
y_3 &= +0.27412 - 0.63354 \times \gamma_3 \\
z_3 &= -0.00445 - 0.62622 \times \gamma_3 \\[6pt]
\gamma_1 &= +1.00337 \pm \surd[g_1^2 - 0.01874] \\
\gamma_2 &= +0.77144 \pm \surd[g_2^2 - 0.40035] \\
\gamma_3 &= -0.27612 \pm \surd[g_3^2 - 0.96660]
\end{aligned}
\tag{17}
$$

§ IX.—OF THE VARIATIONS OF THE RELATIVE VELOCITY AND CONVERGENT POINT.

The convergent point on ordinary nights, according to the observations of Mr. Herrick and Mr. Forshey, varies with the point which is opposite the observer's true direction. And if there is a similar tendency to compensation of the relative velocities, then the mean relative velocity of shooting stars varies with that of the observer. I have already referred to Professor Erman's formulæ for this variation, and have shown that the restrictions are too great, from an unnecessary limit of the value of the reciprocal of γ. Let us suppose that the observer, in his annual and rotary motion, falls in with a group of these bodies having nearly the same elements, and that he encounters the individuals at successive dates, t, t', t'', &c. It is manifest that if all the other elements were common, the position of the plane of the orbit of the successive meteors must vary with the observer's change of position, so that the elements cannot be identical. The differences may be embraced in two classes, those which increase with the time, and those which arise from discrepancies of the elements. Denoting the former by Δ, and the latter by d, and their joint effect by δ, we have in the interval $(t' - t)$,

$$\begin{aligned}\delta\xi &= \xi' - \xi = \xi + \mathrm{d}x + \Delta(x - X)\\ \delta\eta &= \eta' - \eta = \eta + \mathrm{d}y + \Delta(y - Y) \qquad (18)\\ \delta\zeta &= \zeta' - \zeta = \zeta + \mathrm{d}z + \Delta(z - Z)\end{aligned}$$

for the variations of ξ, η, and ζ. Hence, in estimating the variations $\delta\gamma$, $\delta\lambda$, and $\delta\beta$, some allowance must be made for the quantities $\mathrm{d}\gamma$, $\mathrm{d}\lambda$, and $\mathrm{d}\beta$, arising from discrepancies of the true elements of the meteors seen at the dates t, t', &c. Professor Erman's formulæ, on the contrary, proceed upon the presumption of $\mathrm{d}\xi = -\Delta X$, &c. Now, as $\mathrm{d}x, + \Delta x$, &c., cannot, even in the thickest flocks of meteors, vanish entirely their aggregate effect in a finite interval of a few hours, may be such as to preponderate over that of $\Delta(-X)$, and in this manner the variation $\delta\lambda$, in a few hours, may come out positive, as reported by Professor Forshey, August 9th, 1840. Also, on ordinary nights, if a convergent point is found to prevail, we should have

$$\delta\xi = \xi' - \xi = \xi + (\mathrm{d}x + \Delta x) - \Delta X = \delta x - \Delta X \qquad (19)$$

and so on for $\delta\eta$ and $\delta\zeta$; now if during an interval $t' - t$ of several nights we find by observation, with Mr. Fitch and Mr. Herrick, $\delta\lambda = \Delta(L + 180,)$ $\delta\beta = -\Delta B = 0$, we are led to the inference that $\delta\gamma = \Delta(-G)$, and $\mathrm{d}\xi = -\Delta X$, &c. And that a compensation has taken place among the true velocities and directions of the meteors seen near each date, so that the convergent point has corresponded, in position and variations, with those of the antipode of the observer's actual direction.

On the occasion of great displays like that of November, 1833, when telescopes were directed to the radiant point, and its altitude was measured with a sextant, it is probable that $\mathrm{d}\,x$, $\mathrm{d}\,y$, and $\mathrm{d}\,z$ were very small; in such a case a precise measure of the position of this point in the heavens might possibly, by giving the value of $\delta\lambda$ and $\delta\beta$ in a finite interval, enable us to determine γ from the terms $\mathrm{d}x$, $\mathrm{d}y$, and $\mathrm{d}z$, of which it would be a function. I do not, however, think such a precision can ever be obtained.

There is another point of view in which the knowledge of the values of $\mathrm{d}\,x$, d y, and d z, for variations of γ, λ, and β, may be useful, and that is in enabling us to estimate the probable errors of any system of elements for a group or cluster of these meteors derived from assumed values of γ, λ, and β. The formulæ for computing variations of elements for a change of *radial positions* and *distances* in an orbit, or of *geocentric positions* and *distances* in the heavens, are stated at length by writers on the laws of elliptic motion, Gauss, Littrow, Santini, and others. As I do not recollect to have met with similar expressions for the variations of *tangential directions* and *velocities*, or *relative directions* and *velocities*, I shall here point out the method employed in preparing the requisite formulæ.

In the formulæ (8), making $\gamma' = \gamma \cos \beta$, $g' = g' \cos b$, and differentiating, we obtain, after making the requisite reductions,

$$\mathrm{d}g' = +\cos(\lambda - l)\cos\beta \,.\, \mathrm{d}\gamma - \frac{\gamma'}{\omega}\sin(\lambda - l) \,.\, \mathrm{d}\lambda - \frac{\gamma'}{\omega}\cos(\lambda - l)\tan\beta \,.\, \mathrm{d}\beta$$

$$\mathrm{d}l = \frac{\omega}{g'}\sin(\lambda - l)\cos\beta \,.\, \mathrm{d}\gamma + \frac{\gamma'}{g'}\cos(\lambda - l) \,.\, \mathrm{d}\lambda - \frac{\gamma'}{g'}\sin(\lambda - l)\tan\beta \,.\, \mathrm{d}\beta$$

$$(20)\quad \begin{aligned} \mathrm{d}b = {} & \frac{\omega}{g'}\cos^2 b\left[\tan\beta - \tan b\cos(\lambda - l)\right]\cos\beta \,.\, \mathrm{d}\gamma \\ & + \frac{\gamma'}{g'}\cos b\sin b\sin(\lambda - l) \,.\, \mathrm{d}\lambda \\ & + \frac{\gamma'}{g'}\cos^2 b\left[1 + \tan b \tan\beta\cos(\lambda - l)\right] . \,\mathrm{d}\beta \end{aligned}$$

Expressions equivalent to those given by the authors above quoted for the variations of *positions* and *distances*, as might be expected from the symmetrical form of the fundamental equations, from which they are derived. Also, as before, $\Omega = \pi + v + u$, denoting the longitude on the orbit of the point [l b] towards which the true motion of the asteroid is directed, and $\Omega - \text{☊} = \pi + v + u - \text{☊}$, being the argument of latitude, the equations

$$(21)\quad \begin{aligned} \tan(l - \text{☊}) &= \cos i \tan(\pi + v + u - \text{☊}) \\ \sin b &= \sin i \sin(\pi + v + u - \text{☊}) \\ \tan b &= \sin i \tan(\pi + v + u - \text{☊})\cos(l - \text{☊}) \\ &= \tan i \sin(l - \text{☊}) \\ \cos(\pi + v + u - \text{☊}) &= \cos b \cos(l - \text{☊}) \\ g' &= g \cos b \end{aligned}$$

give by differentiation, substitution, and reduction,

$$\begin{aligned}
\mathrm{d}g' &= \cos b\,.\,\mathrm{d}g - \frac{g}{\omega}\sin b\sin(l-\Omega)\,.\,\mathrm{d}i - \frac{g}{\omega}\sin b\sin i\cos(l-\Omega)\,[\mathrm{d}\pi+\mathrm{d}v+\mathrm{d}u-\mathrm{d}\Omega]\\
\mathrm{d}l &= -\,\mathrm{d}\Omega - \tan b\cos(l-\Omega)\,.\,\mathrm{d}i + \frac{\cos i}{\cos^2 b}\,[\mathrm{d}\pi+\mathrm{d}v+\mathrm{d}u-\mathrm{d}\Omega]\\
\mathrm{d}b &= \sin(l-\Omega)\,.\,\mathrm{d}i + \sin i\cos(l-\Omega)\,[\mathrm{d}\pi+\mathrm{d}v+\mathrm{d}u-\mathrm{d}\Omega]
\end{aligned}\tag{22}$$

Expressions which I do not recollect to have met with before. They differ from the formulæ given by Gauss, *Theoria Motus*, p. 49, and by Santini, *Elementi di Astronomia*, Vol. I., Cap. XVII., Prob. IX. and X., and by other writers on the theory of elliptic motion, in containing *tangential directions* and *velocities* instead of *orbital positions* and *distances*, and having in the bracket an additional variable, u, which does not enter into the expressions for the variations of the latter class, and which here introduces new relations between the remaining elements ϕ and n, of which it is a function.

In order to obtain $\mathrm{d}g'$, $\mathrm{d}l$, and $\mathrm{d}b$, in terms of the variations only of the elements proper, we must substitute the values of $\mathrm{d}g$, $\mathrm{d}v$, and $\mathrm{d}u$, in terms of those of the elements. From the *Theoria Motus*, p. 15, with small modifications, we have

$$\begin{aligned}
\mathrm{d}v &= \frac{a\,a}{r\,r}\cos\phi\,[\mathrm{d}H + t_{,}\,\mathrm{d}n - \mathrm{d}\pi] + \frac{(2+e\cos v)\sin v}{\cos\phi}\,.\,\mathrm{d}\phi\\
\mathrm{d}r &= \frac{r}{a}\,.\,\mathrm{d}a + \frac{a}{\omega}\tan\phi\sin v\,[\mathrm{d}H + t_{,}\,\mathrm{d}n - \mathrm{d}\pi] - \frac{a}{\omega}\cos\phi\cos v\,.\,\mathrm{d}\phi
\end{aligned}\tag{23}$$

and from the equations

$$\begin{aligned}
n &= a^{-\frac{3}{2}}\\
p &= a\cos^2\phi\,. = g^2 r^2 \sin^2 u = \left(\frac{2}{r}-\frac{1}{a}\right) r^2 \sin^2 u
\end{aligned}\tag{24}$$

by means of differentiation, making, for conciseness, $N' = \frac{r-a}{2a-r}$, and putting for $\tan u$, its value $= \tan\big(\Omega - (\pi + v)\big)$

$$\begin{aligned}
\mathrm{d}n &= -\frac{3}{2}\,.\,\frac{n}{a}\,.\,\mathrm{d}a\\
\mathrm{d}g &= \frac{1}{2\,a\,a\,g}\,.\,\mathrm{d}a - \frac{1}{r\,r\,g}\,.\,\mathrm{d}r\\
\mathrm{d}u &= \tan\big(\Omega - (\pi+v)\big)\left[\frac{2}{3}N'\,.\,\frac{\mathrm{d}n}{n} + N'\,\omega\,.\,\frac{\mathrm{d}r}{r} - \tan\phi\,.\,\mathrm{d}\phi\right]
\end{aligned}\tag{25}$$

expressions which, substituted in (22), would, after reduction, furnish the general solution of the problem for all relations of an orbit to the ecliptic.

In the present case, the asteroid being near the observer, or (neglecting the small quantities already mentioned) near the earth's centre, and consequently near its node, recollecting that

$$\tan u = \tan\Big({\scriptstyle\Omega} - (\pi + v)\Big) = \tan\,({\scriptstyle\Omega} - \oplus) = \tan\,({\scriptstyle\Omega} - \text{☊})$$

$$(26)\qquad \begin{aligned} \sin\,(l - \text{☊}) &= \pm \sin\,(l - \oplus) \\ \cos\,(l - \text{☊}) &= \pm \cos\,(l - \oplus) \\ \tan b &= \tan i \sin\,(l - \text{☊}) \\ \mathrm{d}\,\text{☊} &= 0 \\ \mathrm{d}\pi + \mathrm{d}v &= \mathrm{d}\oplus = 0 \end{aligned}$$

and using the *upper* sign for a convergent point *north* of the ecliptic, and observing that d H may be neglected, since it could only be introduced into these formulæ by making part of the value of d v, which, in this instance, disappears, and calling $N = \frac{2}{3} \cdot \frac{r - a}{2a - r} \cdot \frac{1}{n}$, and substituting and reducing, there result for the case of a meteoric asteroid, the following expressions of the meteor's *true curtate velocity* and *direction*, in terms of those of the three independent elements,

$$(27)\qquad \begin{aligned} \mathrm{d}g' &= \pm \frac{g'}{\omega} \tan b \sin\,(l - \oplus)\,\mathrm{d}i + \frac{g'}{\omega} N \left[\frac{r}{2\,(a - r)} - \tan^2 b\right] . \,\mathrm{d}n + \frac{g'}{\omega} \tan^2 b \tan\phi \,.\, \mathrm{d}\phi \\ \mathrm{d}l &= \mp \tan b \cos\,(l - \oplus) \,.\, \mathrm{d}i + N . \frac{\tan\,(l - \oplus)}{\cos^2 b} . \,\mathrm{d}n - \frac{\tan\,(l - \oplus) \tan\phi}{\cos^2 b} . \,\mathrm{d}\phi \\ \mathrm{d}b &= \pm \sin\,(l - \oplus) \,.\, \mathrm{d}i + N \tan b \,.\, \mathrm{d}n - \tan b \tan\phi \,.\, \mathrm{d}\phi \end{aligned}$$

More simple expressions for the variations of some of the elements may be derived from the equations (9) and from the expression

$$(28)\qquad \sqrt{}\,a \cos\phi \sin i = g\,r \sin b = r\,Z + r\,\gamma \sin\beta$$

thus respectively

$$(29)\qquad \begin{aligned} \mathrm{d}n &= -3n^{\frac{1}{3}}\omega\,(\gamma + G\cos\psi) . \,\mathrm{d}\gamma - 3n^{\frac{1}{3}}G\gamma' \sin\,(L - \lambda) . \,\mathrm{d}\lambda + 3n^{\frac{1}{3}}\,G\gamma' \Big[\cos\,(L - \lambda) \tan\beta - \sin B\Big] . \,\mathrm{d}\beta \\ \mathrm{d}\phi &= \cot\phi \cot i \,.\, \mathrm{d}i - \frac{\cot\phi}{3\,n} . \,\mathrm{d}n - \frac{r\,n^{\frac{1}{3}}\,\omega \sin\beta}{\sin i \sin\phi} . \,\mathrm{d}\gamma - \frac{r\,n^{\frac{1}{3}}\,\gamma'}{\sin i \sin\phi} . \,\mathrm{d}\beta \end{aligned}$$

These expressions establish the principle stated in Section IV., No. 6, that the independent elements may be reduced to three. They would, if the data of Tables I., II., and III. possessed the requisite precision to warrant the presumption that the elements of Table VI. are approximations towards the real values, enable us to estimate the effect of the uncertainty of the assumed values of γ, λ, and β. At present this cannot be considered the case. It is worthy of remark, however, that by proceeding from the values of Table VI. for the November meteors, and making γ, λ, and β vary within limits assigned to their probable errors by Professor Twining, while the general character of i and a remains the same, that is to say, retrograde or highly inclined, and inferior, the value of ϕ may approach nearly to 90°, and the perihelion distance, $\frac{p}{1+e}$, may approach the value of the sun's semi-diameter, or sin $(16' \; 1''.)$ This will readily be inferred from the largeness of the negative coefficient of $d\gamma$ in the last equation of (29). This circumstance gives to the remarkable serpentine meteor of the great November display, as has been already stated, the character of an emanation from the sun's atmosphere. How far such a conclusion, founded on this single result, may be considered as plausible, must be left to others to decide. I will merely remark, that if the position of the convergent point had been such as to give this value of ϕ, with i small, and a consequent motion direct, this circumstance would be somewhat confirmatory of the nebular hypothesis of Laplace; since, if one class of small asteroids may with reason be supposed to have had their origin in the sun's atmosphere, analogy may authorize us to suppose a similar origin for the projectile motion of the larger asteroids and planets, in the gradual condensation of the nebulous portions of matter composing the system, the motion of rotation being converted into an orbital motion. The analogy fails, however, on account of the high inclination of the orbit of the meteor derived from the same data.

NOTE.

In Section I. of this paper I made mention of the observations of Professor Locke, published in 1834, in the "Cincinnati Daily Gazette." Those of the 8th and 10th of August, 1834, published on the 11th and 12th of August in the same year, are worthy of being reprinted from the files of that paper, as they show that, although the periodicity of the August meteors was first discovered by Quetelet in 1836, the position of their radiant and convergent points was first discovered, and pointed out with precision by an American, in 1834, as had been done the previous autumn by Professor Olmsted and others for the November meteors.

CINCINNATI DAILY GAZETTE, *August* 11*th*, 1834.

"METEORS.

"MR. EDITOR,

"On the evening of August 8th I observed, in the course of two hours, thirty meteors or 'shooting stars.' As I could not have in view more than one-fourth of the visible heavens at once, there were probably one hundred and twenty meteors to be seen in that time. I do not mention this as any thing uncommon, but merely to draw the attention of astronomers to the subject. If they will mark the course of remarkable meteors upon the fixed stars, and note the time, we can obtain the parallax of some identical one, and thus ascertain its place in the regions of space. If observers at Dayton, Oxford, Lexington, Louisville, &c., will join me, I will devote the hours from 6 to 10, and, in some cases, from 8 to 11, to observations of this kind.

"The following observations were made on the evening of the 8th:—

"1. 9*h.* 25*m.* 30*s.* A meteor passed from half way between Alpha and Beta of Capricornus to Delta of Sagittarius.

"2. 9*h.* 30*m.* From Beta of Sagittarius to Alpha of Delphinus. The course of this was nearly upward.

"3. 10*h.* 18*m.* 34*s.* From one degree below Beta Aquarius to Epsilon of Sagittarius, nearly parallel to the first.

"4. 10*h.* 40*m.* From Eta of Draco to Epsilon of Corona. This was a brilliant meteor, leaving a phosphorescent train after it for a few seconds. These observations were noted by Carey's nine-inch globe of 1816. I was surprised to discover that most of these meteors had such apparent motions as would be produced by bodies moving parallel to each other in straight lines. That is, they describe parts of great circles, which, if produced, would all meet and cut each other in two opposite points, like the meridians of a globe cutting each other at the poles. They appeared to move from a point in the north-east above the horizon to an opposite one in the south-west, below the horizon. By tracing the track of the above observations on the globe, the radiating point or pole was found near the star Algol, in the constellation Perseus, and the opposite, or convergent point, in the constellation Lupus. This was the course of most of the meteors. Others again, as the 2d, had a course nearly at right angles to these. But I saw none which was not referrible to one of these two courses. The poles did not appear to move with the earth, but they retained their places amongst the fixed stars. Are these phenomena, as suggested by Professor Olmsted, indeed celestial in their origin, and independent of the earth's rotation?

"Yours, &c.
"JOHN LOCKE."

"METEORS, No. II. (*Ibid., Aug.* 12*th.*)

"MR. EDITOR,

"Since the 8th I have continued my observations on the 9th and 10th. The results are as follow:—

* * * * * * * * * *

"On the 9th many other meteors were seen, but not noted. No common point of radiation or convergence was ascertained.

"*Aug.* 10. 1st Obs. 9*h.* 12*m.* A meteor passed above, and very near to Beta of Libra, and thence obliquely downward, below and near to Gamma of the same.

"2d Obs. 9*h.* 14*m.* 20*s.* From *m* of Antinous to Mu of Sagittarius, downward in the eastern edge of the milky way.

"3d Obs. 9*h.* 18*m.* 29*s.* From Beta of Aquarius to Psi of Capricornus.

"4th Obs. 9*h.* 26*m.* From Zeta of Serpentarius to Sigma of the same. Course downwards along the western edge of the milky way. The course of all these, as well as that of all others observed this evening, was towards one common point in the constellation of Ara. This point was south about eighteen degrees west, and fifteen degrees below the horizon. "JOHN LOCKE."

* * * * * * * * * *

ERRATA.

Page 202, Table IV., heading of the second and third columns, for "⊙" read "⊕."
Page 93, line 12th, for "August" read "September."

ARTICLE X.

Astronomical Observations made at Hudson Observatory, Latitude 41° 14′ 40″ *North, and Longitude* 5*h.* 25*m.* 45*s. West. By Elias Loomis, Professor of Mathematics and Natural Philosophy in Western Reserve College. Read April* 2*d and* 16*th*, 1841.

The instruments of the observatory and the mode of using them have remained unchanged since my former paper was communicated to the Society, and the objects observed have been generally the same. The clock has been once stopped. In my former communication I remarked that the pendulum appeared to be over-compensated. This opinion was confirmed by subsequent observations, and on the 31st of January, 1840, 6.2 ounces of mercury were taken from the cistern, leaving the column 6.12 inches in height. Since that time the clock has been constantly running, and its rate has been tolerably satisfactory.

I. LATITUDE OF HUDSON OBSERVATORY.

During the past season I have observed nine culminations of Polaris. The observations were made alternately direct, and, by reflexion from mercury, generally a dozen at each culmination. The three microscopes were invariably read at each observation; the observations were reduced to the meridian by the usual method, and corrected for refraction by Bessel's tables. The errors of the microscopes were found to be as follow:

North Polar Distance.	A.	B.	C.	Mean.
358° 25′—30′	− 2″.6	+ 0″.1	+ 0″.2	− 0″.77
279 0 — 5	− 2 .2	− 0 .9	− 6 .6	− 3 .23

The following are the results of the observations:

Lower culmination of Polaris, June 4, 1840,	41° 14′ 40″.4
8,	40 .2
9,	42 .2
13,	42 .3
15,	42 .6
16,	41 .3
18,	45 .0
19,	43 .1
23,	43 .4
Mean of nine culminations,	41 14 42 .3

The result of last year's observations of Polaris was 41° 14′ 38″.1. The places of Polaris were taken from the Nautical Almanac, and the above results are both affected by the error of the tables, but with opposite signs, as the latter result was derived from upper, and the former from lower culminations. The mean of the two is 41° 14′ 40″.1, the value which I at present employ.

II. Observed Transits of the Moon and Moon culminating Stars at Hudson Observatory.

The following list is supplemental to that given on pages 49, 50. The observations are all reduced to the central wire. When the object is observed at all the wires, the reduction is equal to $0^{s}.112 \times$ secant of the declination, which correction is readily taken from a table, and is sensibly constant for all the following stars. When an object is not observed at all the wires, each observation is separately reduced to the central wire. For a star, this reduction is equal to the equatorial interval multiplied by the secant of the declination. For the moon this factor is computed by the formula

$$\frac{1 - \sin\pi \cos\phi \sec\delta}{3600 - A} \,.\, 3600 \sec\delta$$

Where π = the moon's horizontal parallax.
ϕ = latitude of the place.
δ = moon's true declination.
A = moon's hourly motion in right ascension, expressed in seconds of time.

Two imperfect transits of the moon contained in my former paper, namely, Nos. 29 and 35, were incorrectly reduced. The seconds should read, instead of

$41^{s}.39$	$41^{s}.23$
49.70	49.96

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
	1839.				
	Oct. 14	δ Sagittarii	5	18^{h} 10^{m} $13^{s}.66$	— $0^{s}.23$
51		Moon 1 L.	5	18 50 17 .20	
		τ Sagittarii	5	18 56 25 .74	
	15	τ Sagittarii	5	18 56 25 .50	— 0 .24
		h^2 Sagittarii	5	19 26 27 .00	
52		Moon 1 L.	5	19 47 2 .12	
		c Sagittarii	5	19 52 17 .80	
		σ Sagittarii	5	20 9 38 .64	
	16	c Sagittarii	3	19 52 17 .41	— 0 .45
		σ Capricorni	5	20 9 38 .12	
53		Moon 1 L.	5	20 42 33 .62	
		η Capricorni	5	20 54 46 .46	
		ζ Capricorni	5	21 6 22 .18	
	17	η Capricorni	5	20 54 45 .80	— 0 .74
		ζ Capricorni	5	21 6 21 .36	
54		Moon 1 L.	5	21 36 35 .64	
		δ Capricorni	3	21 37 40 .63	
55	18	Moon 1 L.	5	22 29 30 .08	— 1 .37
		λ Aquarii	5	22 43 43 .20	
	20	λ Piscium	5	23 33 19 .18	— 0 .71
		q Piscium	5	23 53 3 .62	
56		Moon 1 L.	5	0 15 40 .82	
		δ Piscium	5	0 39 49 .44	
	21	δ Piscium	5	0 39 47 .68	— 1 .76
57		Moon 1 L.	5	1 11 29 .20	
		η Piscium	5	1 22 20 .72	
		β Arietis	5	1 45 13 .42	
	22	η Piscium	5	1 22 19 .26	— 1 .42
		β Arietis	5	1 45 12 .08	
58		Moon 1 L.*	5	2 10 50 .46	
		Moon 2 L.	5	2 13 16 .54	
59	23	Moon 2 L.	5	3 16 57 .10	— 0 .61
		η Tauri	5	3 37 21 .58	
		A′ Tauri	5	3 54 37 .38	
	24	η Tauri	5	3 37 21 .48	— 0 .29
		A′ Tauri	5	3 54 36 .90	
60		Moon 2 L.	5	4 24 22 .32	
		τ Tauri	5	4 32 1 .32	
		ι Tauri	5	4 52 54 .60	
	Nov. 15	σ Aquarii	5	22 21 18 .10	— 0 .56
61		Moon 1 L.	5	22 56 51 .92	
		φ Aquarii	5	23 5 9 .90	
		k′ Piscium	5	23 17 51 .46	
	1839.				
	Nov. 16	φ Aquarii	5	23^{h} 5^{m} $9^{s}.04$	— $0^{s}.87$
		k′ Piscium	5	23 17 50 .58	
62		Moon 1 L.	5	23 48 4 .20	
		ω Piscium	4	23 50 12 .61	
		d Piscium	5	0 11 29 .06	
	17	ω Piscium	5	23 50 12 .60	— 0 .20
		d Piscium	5	0 11 28 .76	
63		Moon 1 L.	5	0 41 7 .70	
		ε Piscium	5	0 53 45 .68	
	18	ε Piscium	5	0 53 44 .40	— 1 .28
64		Moon 1 L.	3	1 37 31 .88	
		β Arietis	5	1 44 54 .18	
		θ′ Arietis	3	2 8 19 .67	
65	19	Moon 1 L.	5	2 38 34 .24	— 0 .75
		δ Arietis	5	3 1 34 .24	
	22	β Tauri	5	5 15 13 .34	— 0 .94
		ϰ Aurigae	5	6 4 12 .36	
66		Moon 2 L.	5	6 8 9 .24	
	1840.				
	Feb. 15	6 Cancri	5	7 53 43 .82	— 0 .26
		θ Cancri	5	8 22 30 .86	
67		Moon 1 L.	5	8 47 43 .80	
		ξ Cancri	5	9 0 12 .12	
		q Cancri	5	9 10 5 .72	
	Mar. 11	β Tauri	5	5 16 2 .92	— 0 .41
		C. Tauri	5	5 43 8 .86	
68		Moon 1 L.	5	6 22 44 .74	
		ε Geminorum	5	6 33 58 .10	
		τ Geminorum	5	7 0 50 .28	
	13	β Geminorum	5	7 35 23 .04	— 0 .40
		φ Geminorum	5	7 43 34 .32	
69		Moon 1 L.	5	8 26 48 .18	
		δ Cancri	5	8 35 27 .58	
		α^2 Cancri	5	8 49 35 .98	
	17	π Leonis	5	11 28 36 .30	— 0 .32
70		Moon 1 L.	5	11 49 8 .06	
		Moon 2 L.	5	11 51 14 .58	
		η Virginis	5	12 11 34 .52	
	April 8	ε Geminorum	5	6 33 41 .96	— 0 .66
71		Moon 1 L.	5	7 7 28 .52	
		ι Geminorum	5	7 15 24 .10	
		β Geminorum	5	7 35 8 .04	
	9	ι Geminorum	5	7 15 23 .44	— 0 .66

* Limb somewhat deficient.

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
	1840.				
	April 9	β Geminorum	5	7^h 35^m $7^s.38$	
72		Moon 1 L.	5	8 8 56 .38	
		θ Cancri	5	8 22 4 .50	
		δ Cancri	5	8 35 12 .0	
	11	λ Leonis	5	9 22 10 .80	— $0^s.69$
		ο Leonis	5	9 32 12 .14	
73		Moon 1 L.	5	9 57 30 .94	
		ρ Leonis	5	10 23 59 .48	
	13	χ Leonis	5	10 56 19 .92	— 0 .53
		q Leonis	5	11 8 37 .50	
74		Moon 1 L.	5	11 32 40 .64	
		β Virginis	5	11 41 56 .16	
		b Virginis	5	11 50 19 .74	
	15	γ′ Virginis	5	12 33 6 .68	— 0 .60
75		Moon 1 L.	5	13 3 56 .32	
		α Virginis	5	13 16 19 .42	
	19	b Scorpii	5	15 40 53 .56	— 0 .60
		δ Scorpii	5	15 50 24 .22	
		α Scorpii	5	16 19 7 .88	
76		Moon 2 L.	5	16 25 49 .72	
	May 10	χ Leonis	5	10 56 1 .50	— 0 .95
77		Moon 1 L.	5	11 18 4 .58	
		υ Leonis	5	11 28 1 .44	
78	June 8	Moon 1 L.	5	12 34 48 .80	— 1 .10
		ψ Virginis	5	12 45 58 .08	
		g Virginis	5	12 59 27 .18	
	9	ψ Virginis	5	12 45 56 .96	— 1 .19
		g Virginis	5	12 59 25 .92	
79		Moon 1 L.	5	13 20 35 .66	
		x Virginis	5	13 41 6 .48	
	11	λ Virginis	5	14 10 20 .94	— 0 .64
		20 Libræ	5	14 54 37 .06	
80		Moon 1 L.	3	14 56 50 .39	
81	13	Moon 1 L.	5	16 42 16 .70	— 0 .64
		A Ophiuchi	5	17 5 23 .84	
		θ Ophiuchi	5	17 12 4 .78	
	July 3	α Leonis	5	9 59 21 .84	— 1 .15
82		Moon 1 L.	5	10 41 55 .24	
	6	γ′ Virginis	5	12 33 1 .40	— 1 .15
83		Moon 1 L.	5	13 3 35 .24	
		α Virginis	5	13 16 14 .44	
84	8	Moon 1 L.	5	14 39 18 .96	— 0 .80
		$α^2$ Libræ	5	14 41 29 .06	
		20 Libræ	2	14 54 10 .35	
	9	$α^2$ Libræ	4	14 41 28 .46	— 0 .66
		20 Libræ	5	14 54 9 .62	
85		Moon 1 L.	5	15 30 11 .86	
		b Scorpii	5	15 40 48 .86	
		δ Scorpii	5	15 60 19 .94	
	10	b Scorpii	5	15 40 47 .60	— 1 .04
		δ Scorpii	5	15 50 19 .12	
		α Scorpii	5	16 19 2 .40	
86		Moon 1 L.	5	16 23 22 .96	
	1840.				
	July 10	τ Scorpii	5	16^h 25^m $22^s.38$	
	11	α Scorpii	5	16 19 1 .64	— $0^s.83$
		τ Scorpii	5	16 25 21 .48	
87		Moon 1 L.	5	17 18 22 .48	
		l^2 Ophiuchi	5	17 21 5 .08	
		Sagittarii	5	17 48 14 .76	
	13	φ Sagittarii	1	18 35 3 .84	— 0 .88
88		Moon 1 L.	5	19 9 25 .46	
		χ′ Sagittarii	5	19 14 56 .24	
		h^2 Sagittarii	5	19 26 22 .42	
	15	v Capricorni	5	20 30 18 .46	— 0 .87
89		Moon 2 L.	5	20 56 57 .74	
		s Capricorni	5	21 6 15 .52	
		ε Capricorni	5	21 27 28 .86	
90	16	Moon 2 L.	5	21 46 27 .36	— 0 .87
		ι Aquarii	5	21 57 8 .56	
		θ Aquarii	5	22 7 43 .70	
91	Aug. 4	Moon 1 L.	5	14 19 48 .04	— 1 .09
		$α^2$ Libræ	5	14 41 2 .48	
	5	$α^2$ Libræ	5	14 41 1 .46	— 1 .02
92		Moon 1 L.	5	15 10 17 .72	
93	6	Moon 1 L.	5	16 3 53 .98	— 1 .03
		σ Scorpii	2	16 11 27 .08	
		α Scorpii	5	16 19 35 .32	
	7	σ Scorpii	5	16 11 26 .18	— 1 .00
		α Scorpii	5	16 19 34 .22	
94		Moon 1 L.	5	16 58 23 .66	
		A Ophiuchi	5	17 5 29 .60	
		θ Ophiuchi	5	17 12 10 .20	
95	8	Moon 1 L.	5	17 54 1 .00	— 1 .32
		$γ^2$ Sagittarii	4	17 55 29 .47	
		λ Sagittarii	5	11 18 3 .02	
	9	$γ^2$ Sagittarii	5	17 55 28 .12	— 1 .46
		λ Sagittarii	5	18 18 1 .44	
96		Moon 1 L.	5	18 49 38 .90	
		τ Sagittarii	5	18 56 52 .98	
		χ′ Sagittarii	5	19 15 28 .10	
	11	$β^2$ Capricorni	5	20 11 54 .14	— 1 .32
97		Moon 1 L.	5	20 36 55 .94	
		μ Aquarii	5	20 43 54 .14	
	13	δ Capricorni	5	21 38 2 .72	— 1 .32
		ι Aquarii	5	21 57 38 .12	
98		Moon 2 L.	5	22 18 54 .78	
		η Aquarii	5	22 26 58 .06	
		λ Aquarii	5	22 44 5 .80	
	14	η Aquarii	5	22 26 56 .78	— 1 .20
		λ Aquarii	5	22 44 4 .68	
99		Moon 2 L.	5	23 7 4 .06	
		λ Piscium	5	23 33 41 .86	
	17	ε Piscium	4	0 54 22 .41	— 1 .48
100		Moon 2 L.	5	1 37 0 .18	
		β Arietis	3	1 45 32 .28	
	21	β Tauri	5	5 15 47 .96	— 1 .01

No.	Date.	Star.	No. Wires Obs.	Meridian Transit.	Clock's Rate.
	1840.				
101	Aug. 21	Moon 2 L.	5	5^h 45^m 11^s.34	
	31	α Virginis	4	13 16 13 .46	— 1^s.26
102		Moon 1 L.	5	13 59 11 .44	
	Sept. 6	ϕ Sagittarii	5	18 35 2 .88	— 0 .89
		σ Sagittarii	5	18 44 44 .10	
103		Moon 1 L.	5	19 21 29 .18	
		h^2 Sagittarii	5	19 26 21 .54	
		57 Sagittarii	5	19 42 17 .26	
	7	57 Sagittarii	5	19 42 16 .26	— 1 .00
104		Moon 1 L.	5	20 14 50 .88	
		π Capricorni	5	20 17 31 .82	
		υ Capricorni	5	20 30 18 .60	
	12	n Piscium	5	23 39 0 .44	— 0 .95
		ω Piscium	5	23 50 22 .94	
105		Moon 2 L.	5	0 26 35 .12	
		δ Piscium	5	0 39 40 .48	
		ε Piscium	5	0 53 55 .86	
	13	δ Piscium	5	0 39 39 .34	— 0 .91
		ε Piscium	5	0 53 55 .18	
106		Moon 2 L.	5	1 18 49 .86	
		η Piscium	5	1 22 12 .44	
		β Arietis	5	1 45 5 .18	
	14	β Arietis	5	1 45 4 .30	— 0 .88
107		Moon 2 L.	5	2 14 25 .34	
		ν Arietis	5	2 28 59 .92	
		ε Arietis	5	2 49 19 .92	
	17	τ Tauri	5	4 31 51 .16	— 0 .98
		ι Tauri	5	4 52 44 .34	
108		Moon 2 L.	5	5 24 6 .30	
	Oct. 3	δ Sagittarii	5	18 9 38 .84	— 1 .32
		λ Sagittarii	5	18 17 59 .38	
109		Moon 1 L.	5	18 59 0 .20	
		π Sagittarii	2	19 0 8 .15	
		h^2 Sagittarii	5	19 26 51 .96	
	5	c Sagittarii	5	19 52 39 .90	— 1 .23
		$β^2$ Capricorni	5	20 11 52 .22	
110		Moon 1 L.	5	20 44 6 .64	
		η Capricorni	5	20 55 8 .92	
		s Capricorni	5	21 6 44 .04	
	6	η Capricorni	5	20 55 7 .02	— 1 .71
		s Capricorni	5	21 6 42 .52	
111		Moon 1 L.	5	21 34 12 .84	
		δ Capricorni	5	21 38 1 .78	
		ι Aquarii	5	21 57 36 .98	
112	7	Moon 1 L.	5	22 23 17 .48	— 1 .22
		η Aquarii	5	22 26 55 .94	
		λ Aquarii	5	22 44 4 .12	
	12	ψ Arietis	5	2 21 45 .34	— 1 .07
113		Moon 2 L.	5	2 51 33 .20	
		δ Arietis	5	3 2 12 .30	
		g Arietis	5	3 14 35 .22	
	13	g Arietis	5	3 14 34 .50	— 0 .92
	1840.				
114	Oct. 13	Moon 2 L.	5	3^h 55^m 41^s.28	
		υ′ Tauri	5	4 16 26 .96	
		τ Tauri	5	4 32 21 .60	
	Nov. 2	υ Capricorni	2	20 30 16 .08	— 1^s.11
115		Moon 1 L.	5	21 11 39 .18	
		γ Capricorni	5	21 30 33 .40	
		δ Capricorni	5	21 37 32 .28	
116	3	Moon 1 L.	5	22 0 1 .92	— 1 .35
		θ Aquarii	5	22 7 41 .68	
		σ Aquarii	5	22 21 29 .50	
	5	$κ^2$ Piscium	5	22 51 41 .58	— 0 .77
		γ Piscium	5	23 8 8 .70	
117		Moon 1 L.	5	23 36 22 .88	
		n Piscium	5	23 38 59 .38	
		ω Piscium	5	23 50 22 .30	
	6	n Piscium	5	23 38 58 .36	— 1 .10
		ω Piscium	5	23 50 21 .12	
118		Moon 1 L.	5	0 26 44 .44	
		δ Piscium	5	0 39 38 .78	
		ε Piscium	5	0 53 54 .40	
	9	ν Arietis	5	2 28 57 .78	— 1 .18
		ε Arietis	5	2 49 17 .78	
119		Moon 1 L.*	3	3 22 2 .34	
		Moon 2 L.	5	3 24 34 .44	
		η Tauri	5	3 37 12 .62	
		A′ Tauri	5	3 54 28 .44	
	10	η Tauri	5	3 37 11 .08	— 1 .36
		A′ Tauri	5	3 54 27 .26	
120		Moon 2 L.	5	4 32 44 .74	
		ι Tauri	5	4 52 45 .02	
		β Tauri	5	5 15 23 .24	
	15	q Cancri	5	9 9 9 .22	— 0 .80
		ξ Leonis	5	9 22 26 .00	
121		Moon 2 L.	5	9 51 25 .58	
		α Leonis	5	9 58 57 .68	
	16	ν Leonis	5	9 48 42 .46	— 1 .02
		α Leonis	5	9 58 56 .66	
122		Moon 2 L.	5	10 42 3 .18	
	30	ι Capricorni	5	21 13 12 .36	— 1 .36
123		Moon 1 L.	5	21 41 14 .08	
		μ Capricorni	5	21 44 26 .16	
		30 Aquarii	5	21 54 43 .36	
	Dec. 1	μ Capricorni	5	21 44 25 .44	— 0 .83
		30 Aquarii	5	21 54 42 .28	
124		Moon 1 L.	5	22 27 59 .24	
		κ Aquarii	3	22 29 19 .30	
		λ Aquarii	5	22 44 7 .42	
	2	κ Aquarii	5	22 29 18 .06	— 1 .26
		λ Aquarii	5	22 44 6 .14	
125		Moon 1 L.	5	23 14 39 .38	
		k′ Piscium	5	23 18 34 .26	
		λ Piscium	5	23 33 43 .20	

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* Limb somewhat deficient.

III. OBSERVED OCCULTATIONS OF FIXED STARS AT HUDSON OBSERVATORY.

No.	Date.	Star.	Immersion. Siderial Time.	Emersion. Siderial Time.	Remarks.
	1839.				
1	Oct. 17	δ Capricorni	$21^h\ 56^m\ 48^s.79$	$22^h\ 10^m\ 7^s.79$	Imm. pretty good; Em. tolerable.
	1840.				
2	April 11	α Leonis		10 48 13 .54	Tolerable observation.
3	" 19	τ Scorpii	16 36 44 .15	17 33 50 .65	Imm. uncertain to 2^s or 3^s; Em. good.
4	May 6	μ' Cancri	11 32 43 .00		Good.
5	" "	* 7 Mag.	11 37 42 .20		Good.
6	Oct. 13	η Phiadum		20 29 12 .94	Perhaps 3^s or 4^s late.
7	Nov. 2	ι Capricorni	20 44 50 .52	22 1 19 .57	Imm. tolerable; Em. perhaps 2^s late.

IV. SECOND COMET OF 1840.

On the 14th of March, 1840, I received a letter from Mr. S. C. Walker, containing the elements of two comets recently discovered at the Berlin Observatory by Mr. Galle, accompanied by an intimation that one of them might be still visible. I immediately computed an ephemeris, and on the first succeeding pleasant evening, the 18th, readily found it nearly in the place expected. I observed it afterwards, on the 19th, 21st, and 25th of March, as, also, on the 1st and 2d of April. After this there was no clear evening until the 7th, when I searched for it in vain. The atmosphere was quite transparent, and there was nothing to interfere with observations but the moon, now five days old. I did not search for it afterwards. When first discovered, the comet was faint, but brightest in the central parts, resembling a small nebula, nearly circular, and about one minute in diameter; but its margin was exceedingly ill-defined. On the 19th the nucleus was remarked to be somewhat eccentric, and on the lower side of the comet, as seen in an inverting telescope. No remarkable change in the comet's appearance was subsequently observed, except that its brightness diminished somewhat more rapidly than had been anticipated. As it would not bear an illumined field, I could make no use of the spider-line micrometer, and was compelled to confine myself to a more inconvenient and less satisfactory mode of observing. For right ascension, I brought the comet into the middle of the field of the equatorial, and counted the seconds elapsed between its egress from the field and that of some neighbouring star. This process was repeated six or eight times. For declination, I again brought the comet into the middle of the field, and, by rapidly turning the screw of the declination circle, brought it to the margin of the field. The graduation, which is to 10″, was then read off. I performed the same operation with the star of comparison, and repeated the process several times. These observations occupied nearly the whole of the evening that the comet could be conveniently observed. I thus obtained *differences* of right ascension and declination between the comet and known stars. The following table exhibits a summary of the observations. The place of α Arietis is from the Nautical Almanac; of θ′ Arietis from Pond's Catalogue of 1112 Stars; and of η and ψ Arietis from the Astronomical Society's Catalogue.

1840.	Siderial Time at Hudson.	Star.	Mag.	Apparent Places of the Stars.		Comet minus Star.			
				A. R.	Dec.	A. R.	Obs.	Dec.	Obs.
March 18	$7^h\ 45^m\ 28^s.67$	α Arietis	3	$1^h\ 58^m\ 9^s.76$		+ $32^s.80$	5		
	7 56 12 .98				+ 22° 42′ 16″.3			+ 7′ 30″.9	2
19	7 39 15 .25			1 58 9 .76		+ 140 .94	8		
	7 40 38 .96				+ 22 42 16 .2			— 25 14 .2	3
21	8 11 13 .89	η Arietis	6	2 3 50 .54		+ 12 .80	10		
	7 39 26 .77				+ 20 27 20·.6			+ 47 11 .8	3
25	8 7 43 .76	θ′ Arietis	6	2 9 14 .21		+ 85 .80	5		
	8 29 19 .58				+ 19 9 34 .9			+ 5 48 .2	4
April 1	8 45 10 .65	ψ Arietis	6		+ 16 59 44 .1			— 51 42 .9	1
2	8 49 41 .00			2 22 2 .12		+ 38 .00	3		
	8 24 21 .01				+ 16 59 44 .2			— 77 29 .3	2

From these data we obtain the apparent places of the comet affected by parallax, and the *difference* of refraction of the comet and stars of comparison. In the following table these corrections are applied, and the times reduced to Berlin Observatory, by adding $6^h\ 19^m\ 22^s.3$ for difference of longitude.

1840.	Berlin Mean Time.	Comet's A. R.	Comet's Dec.
March 18	$14^h\ 18^m\ 12^s.34$	29° 40′ 43″.8	
	14 28 54 .89		+ 22° 49′ 51″.8
19	14 8 4 .04	30 7 45 .1	
	14 9 27 .52		22 17 5 .9
21	14 32 5 .63	31 1 2 .5	
	14 0 23 .72		21 14 49 .0
25	14 12 52 .44	32 40 7 .8	
	14 34 24 .72		19 15 35 .1
April 1	14 22 41 .82		16 7 29 .7
2	14 23 15 .53	35 39 25 .0	
	13 57 59 .69		15 42 2 .0

Continuation of Mr. Loomis' Paper. Read April 16, 1841.

Being desirous of determining the comet's orbit with the greatest possible accuracy, I sought for a collection of European observations. For such as I have obtained I am indebted to the kindness of Mr. S. C. Walker. They embrace thirty-four observations at Hamburg, from January 29th to March 24th, which are published in an abridged form in the Society's proceedings, Vol. I., p. 275; twenty-six observations at Bonn, from February 3d to March 19th, given in connexion with Kysæus' Ephemeris, in the Astronomiche Nachrichten, No. 399; and twelve observations at Berlin, from January 25th to February 21st. These, together with my own, make seventy-eight observations, and are all which I have been able to obtain. In comparing the observations I availed myself of Kysæus' Ephemeris, which was found to represent the comet's course tolerably well. The Hamburg observations are given more fully in the Astronomische Nachrichten, Nos. 402 and 405. The comet's place for February 4th, 17^h 47^m, does not accord with the other observations, and I have therefore rejected it, presuming it must contain some error, and have employed the mean of the remaining observations for the same evening. The declination for March 1st is also obviously erroneous, and I have rejected it entirely. The Hamburg places are called *apparent*, by which I understand that they are corrected for refraction merely. I have computed the correction for parallax, and applied it to each observation. The Berlin observations were supposed to have been already corrected for parallax. The following table exhibits the corrections of Kysæus' Ephemeris by each of the observations:

			Corrections.		
			A. R.	Dec.	
Jan.	25	Berlin	— 2″.7	+ 1″.7	1.
	26	"	— 24 .6	+ 10 .4	
	27	"	+ 8 .2	+ 3 .7	
	29	"	+ 39 .1	— 6 .6	
	29	Hamburg	+ 9 .4	— 33 .9	
	30	Berlin	+ 21 .0	— 3 .7	
	30	Hamburg	+ 18 .2	— 13 .3	
Feb.	2	Berlin	+ 25 .1	— 10 .9	
	2	Hamburg	0 .0	— 23 .3	
	3	Berlin	+ 16 .1	— 8 .4	
	3	Hamburg	+ 20 .3	— 27 .5	
	3	Bonn	+ 29 .5	+ 4 .9	
	4	Hamburg	+ 7 .3	— 7 .5	
	4	Bonn	+ 39 .0	+ 1 .0	
	8	Hamburg	— 8 .6	+ 16 .3	2.
	8	Bonn	+ 1 .5	— 1 .3	
	9	Berlin	+ 4 .6	— 11 .1	
	9	Hamburg	— 17 .8	+ 8 .9	
	11	Berlin	— 21 .3	— 4 .6	
	11	Hamburg	— 8 .2	+ 1 .9	
	11	Bonn	— 8 .4	— 3 .2	
	12	Hamburg	— 8 .0	+ 10 .2	
	12	Bonn	— 27 .5	— 26 .5	
	13	Hamburg	— 16 .7	+ 4 .3	
	13	Bonn	— 25 .9	— 20 .1	
	17	Hamburg	— 15 .9	+ 7 .7	
	17	Bonn	— 12 .3	+ 3 .5	
	19	Berlin	— 21 .8	+ 2 .8	3.
	20	Berlin	— 18 .0	+ 3 .3	
	20	Hamburg	— 14 .6	+ 4 .0	
	21	Berlin	— 8 .1	+ 5 .5	
	21	Hamburg	— 30 .5	+ 1 .3	
	21	Bonn	— 2 .4	— 4 .4	
	22	Hamburg	— 28 .0	+ 9 .7	
	22	Bonn	— 22 .9	— 0 .6	
	23	Hamburg	— 10 .2	+ 10 .4	
	23	Bonn	— 7 .7	+ 15 .2	
	24	Hamburg	— 18 .5	+ 2 .5	
	24	Bonn	— 7 .1	+ 15 .3	
	25	Hamburg	— 24 .0	+ 7 .1	
	25	Bonn	— 8 .6	+ 18 .2	
	26	Bonn	— 28 .6	+ 23 .4	
	27	Bonn	— 25 .2	+ 11 .9	
Feb.	28	Hamburg	— 35″.6	+ 18″.4	4.
	28	Bonn	— 27 .6	+ 18 .4	
	29	Hamburg	— 39 .4	+ 24 .3	
	29	Bonn	— 24 .4	+ 16 .9	
March	1	Hamburg	— 27 .2		
	1	Bonn	— 20 .0	+ 14 .0	
	2	Bonn	— 25 .6	+ 22 .7	
	3	Hamburg	— 31 .8	+ 12 .0	
	3	Bonn	— 21 .3	+ 19 .0	
	4	Hamburg	— 25 .9	+ 17 .8	
	4	Bonn	— 24 .5	+ 17 .0	
	5	Hamburg	— 39 .5	+ 6 .3	
	5	Bonn	— 23 .5	+ 17 .6	
	6	Hamburg	— 32 .4	+ 19 .9	
	6	Bonn	— 20 .9	+ 21 .5	
	7	Hamburg	— 41 .7	+ 23 .5	5.
	7	Bonn	— 27 .5	+ 15 .4	
	8	Bonn	— 30 .4	+ 22 .2	
	9	Hamburg	— 32 .4	+ 24 .1	
	11	Hamburg	— 39 .5	+ 25 .2	
	11	Bonn	— 32 .1	+ 22 .1	
	16	Hamburg	— 30 .0	+ 25 .0	
	17	Hamburg	— 22 .3	+ 22 .4	
	18	Hamburg	— 28 .5	+ 17 .9	
	18	Hudson	— 41 .6	+ 26 .3	
	19	Bonn	— 33 .2	+ 22 .7	6.
	19	Hudson	— 45 .4	— 23 .3	
	20	Hamburg	— 53 .1	+ 23 .9	
	21	Hamburg	— 26 .9	+ 35 .0	
	21	Hudson	— 42 .3	+ 0 .6	
	22	Hamburg	— 40 .4	+ 20 .7	
	24	Hamburg	— 34 .6	+ 23 .5	
	25	Hudson	— 42 .5	+ 18 .3	
April	1	Hudson		+ 61 .7	
	2	Hudson	— 56 .0	+ 27 .2	

The preceding observations I have divided into six groups, and taken the average of all the corrections. This may be regarded as the mean error of the ephemeris for the middle date of each group, and applying this correction to the ephemeris with an opposite sign, we obtain the comet's true places. The

Hudson observations in right ascension accord with each other quite as well as the European observations; the declinations seem entitled to very little weight. The results are shown in the following table.

Berlin Mean Time.	Corrections of Ephemeris.		Comet's Places by Ephemeris.		Corrected Places freed from Aberration.	
	A. R.	Dec.	A. R.	Dec.	A. R.	Dec.
Jan. 31, 8^{h}	+ 14″.7	— 8″.1	326° 24′ 50″.6	+ 61° 25′ 23″.5	326° 25′ 5″.3	+ 61° 25′ 15″.4
Feb. 12,	—12 .7	— 1 .1	358 8 37 .6	51 2 51 .8	358 8 24 .9	51 2 50 .7
23,	—17 .3	+ 7 .8	13 19 53 .3	40 11 24 .7	13 19 36 .0	40 11 32 .5
Mar. 3,	—28 .0	+ 17 .6	21 1 45 .4	32 39 1 .4	21 1 17 .4	32 39 19 .0
12,	—32 .6	+ 22 .4	26 35 13 .5	26 27 52 .4	26 34 40 .9	26 28 14 .8
24,	—40 .2	+ 25 .0	32 10 37 .8	19 51 50 .7	32 9 57 .6	19 52 15 .7

It is important to know the probable error of the preceding results. If we regard the corrections in each group as observed values of the *same* quantity, we obtain the probable error of the mean by the formula $E = \sqrt{\frac{.4549\, \Sigma\, (\chi - a)^2}{n\, (n - 1)}}$.

These errors are exhibited below, those in right ascension being each multiplied by the cosine of the corresponding declination. The last column represents the probable error of the entire observation, being equal to $\sqrt{\text{A. R. error}^2 + \text{Dec. error}^2}$.

	A. R.	Dec.	Total Error.
January 31,	1″.5	2″.3	2″.7
February 12,	1 .1	2 .3	2 .5
23,	1 .1	1 .3	1 .7
March 3,	.9	.8	1 .2
12,	1 .3	.7	1 .5
24,	1 .7	.8	1 .9

The supposition that the correction of the Ephemeris remains constant throughout the entire period embraced by one group is incorrect, and we should obtain a more satisfactory result if we knew the proper correction of the Ephemeris for the date of each observation. As, however, the above corrections follow no obvious law, it is impossible to obtain, very satisfactorily, the correction for each date by interpolation. I have therefore contented myself with the above numbers, and conclude that if an orbit can be found, whose errors are confined within these limits, nothing more can reasonably be demanded. The preceding right ascensions and declinations were converted into longitudes and latitudes by employing the apparent obliquity of the ecliptic, and the longitudes were referred to the mean equinox of January 1, 1840, by applying the precession and nutation.

The perturbations remained to be computed. In this operation I followed the method of Bessel for the comet of 1807. I employed intervals of eighteen days, the middle days of the several intervals being February 9th, February 27th, and March 16th. The values of A, B, and C for their dates, being the united effects of the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, and Uranus, expressed in ten thousand millionth parts of a unit, are as follow:

	A.	B.	C.
February 9,	— 115342	— 39226	+ 64303
27,	— 81595	— 61489	+ 36573
March 16,	— 104112	— 76746	+ 25572

From these are deduced

	A'.	B'.	C'.
February 9,	+ 22805	+ 132129	— 31608
27,	— 44625	+ 98296	— 11076
March 16,	— 98327	+ 83979	— 25737

Hence were computed the variations of the elements of the comet's orbit for each interval of eighteen days, and from them the total amount of variation from January 31st to March 25th. The perturbations in longitude and latitude were thence deduced for January 31st, February 18th, March 7th, and March 25th, from which were obtained, by interpolation, the perturbations for intermediate dates. The following is the result:

	Longitude.	Latitude.
January 31,	0″.0	0″.0
February 12,	0 .0	— 1 .1
23,	— 0 .2	— 1 .9
March 3,	— 0 .4	— 2 .3
12,	— 0 .7	— 2 .5
24,	— 1 .1	— 2 .7

Applying these corrections with opposite sign to the comet's observed places, we obtain the places such as they would have been observed had it not been for the disturbing action of the planets. The following table exhibits the comet's corrected places, together with those of the earth for the same times, from the Nautical Almanac.

	Comet.		Earth.		
Berlin Mean Time.	Longitude.	Latitude.	Longitude.	Latitude.	Log Radius Vector.
Jan. 31, 8^h	15° 0′ 50″.0	+ 65° 37′ 49″.6	131° 3′ 29″.6	+ 0″.3	9.9936814
Feb. 12,	24 50 22 .3	46 10 41 .5	143 12 42 .4	— .7	9.9945791
23,	29 22 27 .8	31 27 35 .5	154 17 46 .9	+ .5	9.9956259
March 3,	32 2 14 .6	22 0 28 .2	163 19 40 .4	— .1	9.9966147
12,	34 14 5 .2	14 26 39 .0	172 19 2 .2	— .4	9.9976458
24,	36 45 4 .7	6 27 27 .7	184 13 40 .3	+ .7	9.9991232

The longitudes are referred to the mean equinox of January 1, 1840. Assuming Kysæus' approximate elements, the preceding places furnished me twelve equations of condition, from which were deduced the following parabolic elements, by the method of minimum squares:

Perihelion passage, Berlin mean time, March 12. 981921.
Longitude of perihelion, ... 80° 20′ 24″.4
" ascending node, . . 236 48 39 .3
Inclination of orbit, ... 59 14 2 .4
Log. of perihelion distance, . . . 0.0870185.

The errors of this orbit are as follow, the errors in longitude being multiplied by the cosine of the corresponding latitude:

	Longitude.	Latitude.
January 31,	+ 4″.4	+ 2″.6
February 12,	— 1 .4	— 1 .9
23,	— 6 .1	+ 1 .5
March 3,	— 2 .7	— 1 .7
12,	+ .1	— .7
24,	+ 5 .9	+ 1 .1

These errors certainly are not very great, yet they exceed what has already been assigned as the limit of the probable error of the observations. It is, then, probable that the orbit was not a parabola, especially as the errors follow an obvious law, the extremes being positive, and the middle ones generally negative. It remains to vary the other element, namely, the eccentricity. This was done by means of the following equations of condition, computed by the formulæ of Gauss and Bessel, in which the variations of the elements were

$$d = 0.0002$$
$$t = 0.01$$
$$p = n = i = 1'$$
$$e = 0.001$$

The first six of the following equations are dependent upon the longitudes, and are severally multiplied by the cosine of the corresponding latitude.

$$
\begin{array}{lrrrrrr}
E = & -32.625\,\delta & +\ 6.603\,\tau & +30.109\,\pi & -32.467\,\nu & +40.720\,\iota & -\ 4.672\,\varepsilon \\
E = & -23.385 & -\ 0.510 & +10.100 & -28.875 & +36.707 & -\ 5.400 \\
E = & -17.756 & -\ 4.192 & -\ 1.295 & -25.476 & +27.782 & -\ 3.631 \\
E = & -14.750 & -\ 6.078 & -\ 7.428 & -22.914 & +20.407 & -\ 1.879 \\
E = & -12.881 & -\ 7.296 & -11.611 & -20.726 & +13.814 & -\ 0.186 \\
E = & -11.604 & -\ 8.241 & -15.225 & -18.389 & +\ 6.335 & +\ 2.002 \\
E = & +24.462 & -34.932 & -64.694 & +22.945 & +19.768 & -34.780 \\
E = & +16.770 & -35.444 & -61.086 & +30.666 & -\ 1.309 & -26.121 \\
E = & +\ 7.297 & -\ [illegible].135 & -51.018 & +32.773 & -\ 8.379 & -14.846 \\
E = & +\ 1.240 & -\ [illegible]7.124 & -43.649 & +32.861 & -\ 8.888 & -\ 6.763 \\
E = & -\ 3.118 & -23.649 & -38.145 & +32.375 & -\ 7.202 & -\ 0.600 \\
E = & -\ 7.146 & -20.085 & -33.374 & +31.510 & -\ 3.734 & +\ 5.529
\end{array}
$$

From these equations I obtained the following elliptic elements:

Perihelion passage, Berlin mean time, March 13. 158768.

Longitude of perihelion, ...	80° 12′ 3″.52
" ascending node, . .	236 50 34 .67
Inclination of orbit, ...	59 12 36 .14
Log. of perihelion distance, . . .	0.0865202
Eccentricity, ...	0.99323412
Semi-axis major, . .	180.383
Periodic time, . . .	2422.6 years.

The errors of this orbit are as follow:

	Longitude.	Latitude.	Total Error.
January 31,	+ 0″.6	+ 1″.8	1″.9
February 12,	+ 0 .4	— 3 .9	3 .9
23,	— 2 .6	+ 2 .0	3 .3
March 3,	+ 0 .1	+ 0 .6	0 .6
12,	+ 0 .5	+ 1 .1	1 .3
24,	+ 0 .9	— 1 .5	1 .7

The total error of four of the observations is less than the limit of probable error before determined, and that of the other two is greater. The excess and defect are nearly equal. On the whole, then, the accordance is highly satisfactory. The sum of the squares of the errors in the elliptic orbit is 34.62; in the parabolic, 117,85. There seems, then, no room for hesitation in the choice between the two orbits. It is much to be regretted that observations could not have been made for a longer time after the perihelion passage. They would have served to determine, with greater accuracy, the eccentricity of the orbit, an element which must now be admitted to be liable to considerable uncertainty.

ERRATA

IN PROFESSOR LOOMIS' ASTRONOMICAL OBSERVATIONS, 1ST SERIES, VOL. VII.

Page 44, line 22, for “pin” read “pier.”
45, 10, for “division” read “divisions.”
45, 21, for “120°” read “110°.”
45, 31, for “pin” read “pier.”
50, 44, first column, for “o Capricorni” read “θ Capricorni.”
51, 8, for “Piradum” read “Pleiadum.”

ERRATA IN PROFESSOR LOOMIS' SECOND MAGNETIC ARTICLE, VOL. VII.

Page 102, line 24, for “Aug. 18” read “Aug. 19.”
103, 105, 107, 109, 111, running title, for “dips” read “dip.”
106, line 11, for “8h” read “4h.”
106, line 12, for “Hampton” read “Hamden.”

ERRATA IN PROFESSOR LOOMIS' STORM ARTICLE, VOL. VII.

Page 125, line 10, for “seems” read “seemed.”
125, 19, for “Register” read “Regents.”
127, 46, for “Casinovia” read “Cazenovia.”
127, 47, for “Genornem” read “Gouverneur.”
130, 11, for “nich” read “inch.”
141, 4, for “ships” read “ship.”
145, 31, for “Rendues” read “Reudus.”
146, 25, for “appearances” read appearance.”

ARTICLE XI.

Expansion of F $(x + h)$. *By Pike Powers, of the University of Virginia.*

Read April 2, 1841.

A FUNCTION may be regarded as the general expression of a series of numbers which vary according to some given law; the place or number of the term being denoted by x, and its value by Fx. The series may always be represented wholly or in part by a curve whose ordinates correspond to the different values of Fx, and its abscissas to those of x.

In any function certain values may always be assigned to x, between which the difference of any two consecutive values of Fx will not be *infinitely* greater than the difference of the corresponding values of x.

The only functions which the writer can conceive of as not subject to the preceding remark are, 1. Such as undergo, incessantly, abrupt changes from increase to decrease, or the reverse: 2. Those which, while they vary in the same sense through a finite interval, yet undergo always an infinite change for a finite change in x. It seems obvious, however, that if such functions can be analytically expressed, they cannot admit of Taylor's theorem. (See note.)

Supposing x to be confined within the limits referred to above, we have

$$\frac{F(x+h) - Fx}{h} = \phi(x \,.\, h); \tag{1}$$

$\phi(x \,.\, h)$ reducing to a finite quantity $\phi(x \,.\, 0)$ when $h = 0$.

In like manner we may write

$$\frac{\phi(x \,.\, h) - \phi(x \,.\, 0)}{h} = \phi'(x \,.\, h),$$

or

$$\phi(x \,.\, h) = \phi(x \,.\, 0) + h.\, \phi'(x \,.\, h),$$

where $h\,\phi'(x \,.\, h) = 0$ when $h = 0$.

Now if $\phi'(x \,.\, h)$ should be finite when $h = 0$, we should have

$$\phi'(x \,.\, h) = \phi'(x \,.\, 0) + h \,.\, \phi''(x \,.\, h);$$

and, by continuing this process, and substituting for $\varphi''\ (x\,.\,h)$, $\varphi'\ (x\,.\,h)$, $\varphi\ (x\,.\,h)$ &c., their values, we should get easily the common development of $F\ (x + h)$.

But let us suppose that $\varphi'\ (x\,.\,0)$ is infinite, that is, that as h approaches 0, $\varphi'\ (x\,.\,h)$ increases without limit according to a law depending upon the form of the function.

Whatever this law may be, as functions vanishing with h admit of an infinite diversity of form, it seems obvious that there must be some one fh, such that $\dfrac{\varphi''\ (x\,.\,h)}{fh}$ shall increase with the same rate as $\varphi'\ (x\,.\,h)$, $\varphi''\ (x\,.\,0)$ being finite. We may write, then,

$$h.\ \varphi'\ (x\,.\,h) = \frac{h}{fh}.\ \varphi''\ (x\,.\,h).$$

As fh is inferior to h in degree, since $h.\ \varphi'\ (x\,.\,h)$ vanishes with h, and as the powers of h admit of every shade of magnitude, and diminish towards 0 with every possible degree of rapidity, it appears evident that for very small values of h, fh may be replaced by h^v where $v < 1$. Hence

$$\frac{h}{fh}\ \varphi''\ (x\,.\,h) = h^{1-v}\ Q' = h^{\alpha}.\ Q',$$

where $\alpha = 1 - v$, and Q' is so chosen as to agree with $Q''^{v}\ (x\,.\,h)$ for very small values of h. By similar reasoning we have

$$Q' = \varphi''\ (x\,.\,0) + h^{\beta}.\ Q''.$$

Putting Q for $\varphi\ (x\,.\,h)$ we may write (1) under the form

$$F\ (x + h) = Fx + h.\ Q.$$

And if we replace $\varphi\ (x\,.\,0)$, $\varphi'\ (x\,.\,0)$, &c., by P, P', &c., we shall have

$$\begin{aligned} F\ (x + h) &= Fx + h\,.\ Q, \\ Q &= P + h^{\alpha}.\ Q', \\ Q' &= P' + h^{\beta}.\ Q'', \\ &\ \ \vdots \qquad \vdots \\ Q''^{n} &= P''^{n} + h^{\sigma}.\ {}^{`}Q; \end{aligned}$$

${}^{`}Q$ being finite when $h = 0$. Multiplying the 2d equation by h, the 3d by $h^{1+\alpha}$, &c., adding, and putting a for $1 + \alpha$, b for $1 + \alpha + \beta$, &c., we have

$$F\ (x + h) = Fx + Ph + P'h^{a} + \mathrm{P}''h^{b} + \ldots\ldots\ h^{s}.\ Q; \qquad (2)$$

which differs only in the 2d term from the development assumed by Poisson.

The equation

$$F\ (x + h) = Fx + Ph + h.\ R,$$

which is derived from (1) by a simple transformation, R taking the place of $h.\,\phi'\,(x\,.\,h)$, and consequently vanishing with h, is sufficient to establish all the rules of differentiation.

Observing that in the preceding investigation x was confined within certain limits, while h remained arbitrary, we may replace x by a number r within the limits supposed, and h by $x - r$ which denotes the variable difference between the general and special values of x. Equation (2) will then become

$$u = Fx = Fr + p\,(x-r) + p'\,(x-r)^a + p''\,(x-r)^b + \ldots\ldots\, M;$$

where $p\,p'\,p''$, &c., denote the values of $P\,P'\,P''$, &c., when $x = r$, and M the value of $h^s.\,`Q$ when $x = r$, and $h = x - r$.

Differentiating successively, and denoting the differential coefficients of M by $M'\,M''$, &c., we have

$$\begin{aligned}
\frac{du}{dx} &= p + a\,p'\,(x-r)^{a-1} + b\,p''\,(x-r)^{b-1} + \ldots\ldots\ldots\ldots\, M', \\
\frac{d^2u}{dx^2} &= a\,(a-1)\,(x-r)^{a-2} + b\,(b-1)\,p''\,(x-r)^{b-2} + \ldots\ldots\, M'', \qquad (3) \\
\frac{d^3u}{dx^3} &= a\,(a-1)\,(a-2)\,(x-r)^{a-3} + b\,(b-1)\,(b-2)\,(x-r)^{b-3} + M'''.
\end{aligned}$$

We may suppose that each term in these equations is the only one which contains the power of $x - r$ peculiar to it, for if there were several terms containing the same power of $x - r$, they might be united into one.

Observing, now, that the exponents a, b, c, &c., are each greater than unity, and are arranged in ascending order, if we make $x = r$, and suppose $\frac{du}{dx}, \frac{d^2u}{dx^2}$, &c., to remain finite, the first of equations (3) becomes

$$\left(\frac{du}{dx}\right) = p;$$

a result already established, and implied in the process of differentiating.

With regard to the 2d equation we must have

$$a > 2, \text{ or } a < 2, \text{ or } a = 2.$$

If $a > 2$, every term in the 2d member antecedent to M'' will vanish, and if M'' does not vanish, it must either be finite or infinite. But, since $\left(\frac{d^2u}{dx^2}\right)$ is finite, M'' cannot be infinite. If it reduces to a finite quantity A, then M'*

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* See Mr. Bonnycastle's paper, pages 245, 246, Vol. VII. of these Transactions.

must contain a term $A\ (x - r)$, and M a term $A\ (x - r)^2$, and it is only necessary to give this term its proper place in the series in order to get the same result which $a = 2$ will furnish. If $a < 2$, the 1st term will be infinite, and cannot be cancelled by any of the terms antecedent to M″, since they all contain powers of $x - r$ different from the first; nor by any term in M'', since that term would then contain the same power of $x - r$ with the first, which is contrary to the arrangement of the series. We must have, then, $a = 2$. Therefore $a\ (a - 1) = 1\ .\ 2$,—all the terms after the first vanish, since M'' cannot remain finite for the same reason as in the preceding case,—and we have

$$\left(\frac{d^2 u}{d x^2}\right) = 1.\ 2.\ p' \quad \therefore \quad p' = \frac{1}{1\ .\ 2} \left(\frac{d^2 u}{d x^2}\right).$$

In the same way we can show that

$$p'' = \frac{1}{1\ .\ 2\ .\ 3} \left(\frac{d^3 u}{d x^3}\right), \text{ \&c.}$$

As r is any value of x between the supposed limits, the results obtained are evidently general, and will give all the terms of the series until we reach a coefficient which becomes infinite for $x = r$, and then the remainder of the expansion must be supplied in some other way. Using the notation of Lagrange, we have generally, therefore,

$$F x = F r + F' r\ (x - r) + F'' r\ .\ \frac{(x - r)^2}{1\ .\ 2} + \ldots\ldots\ (x - r)^s.\ q;$$

which, when $r = 0$, becomes

$$F x = F\ (0) + x.\ F'\ (0) + \frac{x^2}{1\ .\ 2}\ F''\ (0) + \ldots\ldots\ldots\ldots\ x^s.\ q'.$$

Equation (2) also becomes

$$F\ (x + h) = F x + h.\ F' x + \frac{h^2}{1\ .\ 2}\ F'' x + \ldots\ldots\ldots\ldots\ h^s.\ `Q.$$

The limits within which the value of the last term is found may be determined by the method of Lagrange, and the development will be complete. The reader will find a summary view of this method in the subjoined note, furnishing itself an exact though indirect solution of the problem.

NOTE.

The validity of the reasoning used in the foregoing demonstration, to show the existence of $F'x$ in a finite form in all cases where x is confined within certain limits, will perhaps appear more evident from the following remarks.

Postulate 1. There are no functions which, throughout their whole range of values, change incessantly from increase to decrease as x varies, and that by quantities infinitely greater than the change in x. It is scarcely possible to give the graphic representation of such functions, much less their analytical expression. A line continually returning upon itself thus, , or a spiral whose coils are compressed into almost absolute contact, would be an approximative expression of them. We conclude, then, that in any function Fx, values a and $a + n\,h$ may be assigned to x, differing by a finite quantity $n\,h$, and such that from Fa to $F\,(a + n\,h)$, Fx shall constantly increase or constantly decrease.

Postulate 2. There are no functions which, while they undergo a constant increase or decrease through finite intervals of value, yet always receive an infinite change for a finite change in x. And here we again appeal to observation, and the apparent impossibility of exhibiting such functions in either a geometric or algebraic form.

Theorem 1. Now suppose that $\frac{F\,(x + h) - Fx}{h}$ approaches infinity as h approaches 0, for all values of x. Then the following ratios,

$$\frac{F\,(x+h) - Fx}{h},\ \frac{F\,(x+2h) - F\,(x+h)}{h},\ \frac{F\,(x+3h) - F\,(x+2h)}{h},\ \ldots\ \frac{F\,(x+nh) - F\,[x+(n-1)\,h]}{h},$$

will all be infinitely great when h is infinitely small.

Let n be taken so great that $n\,h$ shall be finite, and let x be such that Fx constantly increases or constantly decreases from Fx to $F\,(x + n\,h)$. The numerators of the preceding ratios will be all of the same sign; their sum is obviously $F\,(x + n\,h) - Fx$; and if P denote the least of these numerators, $n\,P < F\,(x + n\,h) - Fx$. But

$$\frac{P}{h} = \frac{n\,P}{n\,h} = \infty\text{; hence } \frac{F\,(x + n\,h) - Fx}{n\,h} = \infty.$$

But this result is impossible by postulate 2. Hence in any function Fx there must be some values of x, such that

$$\frac{F\,(x + h) - Fx}{h} = \text{a finite quantity } F'x, \text{ when } h = 0.$$

From which we readily derive

$$F\,(x + h) = Fx + h\,.\,F'x + h\,.\,R,$$

R vanishing with h.

As to the method used by Lagrange to determine the limits of the expansion of $F\,(x + h)$, it may not be amiss to observe that when the existence of the differential coefficients in a finite form is admitted, this method furnishes in all cases an exact and simple mode of exhibiting the true value of $F\,(x + h)$. This fact has been most singularly overlooked.

Cauchy apparently, and De Morgan confessedly, have made Lagrange's method the basis of their demonstrations of Taylor's theorem. We will now exhibit the method of Lagrange, after premising that the equation

$$F\,(x + h) = Fx + h \,.\, F'x + h \,.\, R$$

will readily establish the following well known theorem.

Theorem 2. When $F'x$ is positive, Fx and x vary in the same sense, and when negative, in an opposite sense; consequently, if $F\,(0) = 0$, and $F'\,(0)$ be not infinite, Fx will be positive or negative at the same time with x, when $F'x$ is positive.

Let us suppose that for $x = a$, and $x = b$, and for all intermediate values, $F'x$, $F''x \,\ldots\, F^{(n)}x$ are all finite and continuous, and let us replace x by $a + h$, h admitting all values from 0 to $b - a$.

Now let A and B be the greatest and least values of $F'\,(a + h)$: then

$$A - F'\,(a + h) > 0, \text{ and } F'\,(a + h) - B > 0.$$

Hence the primitives of these expressions taken with regard to h, and so as to vanish with h, will likewise be positive. Theorem (2).

$$A\,h - F\,(a + h) + Fa > 0, \text{ and } F\,(a + h) - B\,h - Fa > 0.$$

Next let A' and B' be the greatest and least values of $F''\,(a + h)$: then

$$A' - F''\,(a + h) > 0, \text{ and } F''\,(a + h) - B' > 0.$$

By taking the primitives as before, we have

$$A'h - F'\,(a + h) + F'a > 0, \text{ and } F'\,(a + h) - B'h - F'a > 0;$$

and by taking them again, we have

$$A'\frac{h^2}{2} - F(a + h) + h \,.\, F'a + Fa > 0, \text{ and } F(a + h) - B'\frac{h^2}{1\,.\,2} - h \,.\, F'a - Fa > 0,$$

or

$$F\,(a + h) < Fa + h \,.\, F'a + \frac{h^2}{1\,.\,2}A', \text{ and } F\,(a + h) > Fa + h \,.\, F'a + \frac{h^2}{1\,.\,2}B'.$$

By continuing this process, we shall finally get

$$F(a + h) < Fa + h \,.\, F'a + \frac{h^2}{2} \,.\, F''a + \frac{h^3}{1\,.\,2\,.\,3} \,.\, F'''a + \,\ldots\ldots\, \frac{h^n}{1\,.\,2\,.\,3\,..\,n} \,.\, A^{(n)}$$

$$F(a + h) > Fa + h \,.\, F'a + \frac{h^2}{1\,.\,2} \,.\, F''a + \frac{h^3}{1\,.\,2\,.\,3} \,.\, F'''a + \,\ldots\ldots\, \frac{h^n}{1\,.\,2\,.\,3\,..\,n} \,.\, B^{(n)}$$

$A^{(n)}$ and $B^{(n)}$ representing the greatest and least values of $F^{(n)}\,(a + h)$.

Hence if $F^n\,(a + h)$ be continuous, and $h = b - a$, there will be some value $F^n\,(a + \theta\,h)$ intermediate between $A^{(n)}$ and $B^{(n)}$ such that

$$F\,(a + h) = Fa + h \,.\, F'a + \frac{h^2}{1\,.\,2} \,.\, F''a + \,\ldots\ldots\ldots\, \frac{h^n}{1\,.\,2\,.\,3\,..\,n} \,.\, F^n\,(a + \theta\,h),$$

where $\theta < 1$. This is precisely the expression obtained by Cauchy. It is general, since a is any value of x subject to the conditions stated, and it gives always the exact value of $F\,(x + h)$ when x and h are such that $F^n\,(x + \theta\,h)$ shall be finite, since $\frac{h^n}{1\,.\,2\,.\,3\,..\,n}$ will always finally converge.

With regard to the negative values of h, we shall have, by theorem (2),

$$A - F'(a-h) > 0,\ F'(a-h) - B > 0,$$

$$Ah - F(a-h) + Fa < 0,\ F(a-h) + Bh - Fa < 0,$$

or

$$F(a-h) > Fa - Ah,\ F(a-h) < Fa - Bh;$$

and the reasoning continued as before will lead to a similar result.

It may be observed, in conclusion, that the integrations effected above are perfectly allowable, since the equation

$$F(x+h) = Fx + h\,.\,F'x + h\,.\,R$$

is sufficient for all purposes of differentiation and integration. And it is immaterial whether any other primitives than those obtained exist, since we are not seeking *the only expansion* of $F(x+h)$, but *one true expansion* of it. (See Calc. des Fonctions, Leçon 9me.)

ARTICLE XII.

Description of New Fresh Water and Land Shells. By Isaac Lea. Read Jan. 15, 1841.

LAMARCK, in describing the genus *Melania*, says that they are nearly all exotic. In fact, he does not mention a single species as inhabiting the rivers of Europe. In the United States, we find a great number distributed over a wide geographical range, from the Columbia River to the St. Lawrence. Separating Mr. Say's genus *Anculosa* from *Melania*, we have remaining, described by him and other Zoologists, about sixty species, which, with the fifty-seven now proposed, will make the large number of about one hundred and seventeen species known to inhabit the waters of the United States. The waters of Tennessee seem particularly productive of the different forms of this genus, and I have no doubt that many new ones will be added to the catalogue, as we have numerous ardent and industrious naturalists labouring in the field of investigation.

The greater part of the species which I now propose, it will be observed, were collected by Dr. Troost, who, in his Geological Survey of the state of Tennessee during several years, gave attention enough to its Natural History, to enable us to add largely to the Mollusca already known. Mr. S. M. Edgar and Dr. Currey, assistant geologists in that survey, have also obliged me by the use of their specimens.

As the indigenous and exotic species of the genus *Melania* now known are so numerous, I propose to divide them into sections, comprising—

1. The Smooth.
2. The Plicate.
3. The Carinate.
4. The Sulcate.
5. The Striate.
6. The Tuberculate.
7. The Granulate.
8. The Cancellate.
9. The Spinose.

SECTION I.—SMOOTH MELANIÆ.

MELANIA HILDRETHIANA. Plate 5., Fig. 1.

Testâ lævi, fusiformi, subcrassâ, corneâ; spirâ brevi, mucronatâ; suturis valdè impressis; anfractibus quinis, convexis; aperturâ magnâ, ovatâ, infernè angulatâ, vel albâ vel purpureâ.

Shell smooth, fusiform, rather thick, horn-colour; spire short, pointed at the apex; sutures deeply impressed; whorls five, convex; aperture large, angular at base, ovate, white or purple.

Hab. Ohio River, near Marietta. Dr. Hildreth.
My Cabinet, and Cabinets of Dr. Hildreth and P. H. Nicklin.
Diam. .25, Length .37 of an inch.

Remarks.—The aperture of this little species is nearly two-thirds the length of the shell. In outline it is allied to *M. fusiformis* herein described. It may be distinguished by the sutures being more impressed, and the base being more angular. One of the specimens is purple on the columella, and at the base. I dedicate it to Dr. Hildreth, to whose kindness I owe several specimens.

MELANIA CASTANEA. Plate 5., Fig. 2.

Testâ lævi, clavæformi, subtenui, tenebroso-castaneâ; spirâ elevatâ, prope apicem carinatâ; suturis parvis; anfractibus octonis, convexiusculis; aperturâ parvâ, ellipticâ, purpureâ.

Shell smooth, club-shaped, rather thin, dark brown; spire elevated, carinate towards the apex; sutures small; whorls eight, somewhat convex; aperture small, elliptical, purple.

Hab. Maury County, Tenn. Thos. R. Dutton.
My Cabinet, and Cabinet of T. R. Dutton.
Diam. .25, Length .67 of an inch.

Remarks.—This species is remarkable for its club-shaped form. It differs from the *clavæformis* herein described, in having a less pointed apex, in being a smaller species, and in being of a darker colour. The first three or four whorls are carinate, and disposed also to be striate and plicate. The aperture is about one-third the length of the shell. The three individuals before me are entirely purple inside, and this gives a very dark appearance to the shell.

MELANIA LÆVIGATA. Plate 5., Fig. 3.

Testâ lævi, obtuso-conicâ, subtenui, nitidâ, luteolâ; spirâ breviusculâ, prope apicem carinatâ; suturis linearibus; anfractibus septenis, subconvexis; aperturâ sub-grandi, ellipticâ; infernè angulatâ, albidâ.

Shell smooth, obtusely conical, rather thin, shining, yellowish; spire rather short, carinate towards the apex; sutures linear; whorls seven, rather convex; aperture rather large, elliptical, angular at base, whitish.

Hab. Alabama River at Claiborne. Judge Tait.
My Cabinet.
Diam. .25, Length .55 of an inch.

Remarks.—With the *M. Taitiana* herein described, came two specimens of this species, which differs from the *Taitiana* in the elevation of the spire, and the form and size of the aperture. In the most perfect specimen, the columella and base are purplish: The aperture is more than one-third the length of the shell. The upper whorls are slightly carinate on their lower portion.

MELANIA KIRTLANDIANA. Plate 5., Fig. 4.

Testâ lævi, acuto-conicâ, sub-crassâ, nitidâ, corneâ; spirâ elevatâ, prope apicem carinatâ; suturis impressis; anfractibus novenis, convexiusculis; aperturâ parvâ, ellipticâ, albidâ.

Shell smooth, acutely conical, rather thick, shining, horn-coloured; spire elevated, towards the apex carinate; sutures impressed; whorls nine, rather convex; aperture small, elliptical, whitish.

Hab. Richmond, Indiana; Duck Creek, near Cincinnati; and Miami, Ohio. T. G. Lea. Little Miami, Dr. Warder.
My Cabinet, and Cabinets of T. G. Lea, P. H. Nicklin, and Dr. Warder.
Diam. .30, Length .87 of an inch.

Remarks.—This is a finely-formed, graceful species, with an indistinct carina on the lower part of the whorls, near the apex. The aperture is nearly one-third the length of the shell. I name it after Professor Kirtland, of Poland, Ohio.

MELANIA TAITIANA. Plate 5., Fig. 5.

Testâ lævi, conoideâ, subtenui, nitidâ, corneâ; spirâ decisâ, ad apicem carinatâ; suturis impressis, anfractibus subconvexis; aperturâ parvâ, ellipticâ, infernè subangulatâ, albidâ.

Shell smooth, conical, rather thin, shining, horn-colour; spire truncate; carinate towards the apex; sutures impressed; whorls rather convex; aperture small, elliptical, subangular at base, whitish.

Hab. Alabama River, at Claiborne. Judge Tait.
My Cabinet, and Cabinet of P. H. Nicklin.
Diam. .25, Length .80 of an inch.

Remarks.—Several years previously to the death of my friend, Judge Tait, he sent me a number of this species, which in form resembles *M. blanda*, described herein. Most of them are without bands; some, however, are finely banded, and all are mutilated at the apex. I dedicate this species to my lamented friend, to whose kindness I owe so many beautiful and interesting objects in the natural history and geology of Alabama.

MELANIA DUBIOSA. Plate 5., Fig. 6.

Testâ lævi, conoideâ, subtenui, corneâ; spirâ subelevatâ; suturis linearibus; anfractibus septenis, subconvexis; aperturâ ellipticâ, parvâ, infernè subangulatâ, albidâ.

Shell smooth, conical, rather thin, horn-colour; spire rather elevated; sutures linear; whorls seven, somewhat convex; aperture elliptical, small, subangular at the base, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinets of Dr. Troost and P. H. Nicklin.
Diam. .30, Length .75 of an inch.

Remarks.—This is a rather small species, somewhat like *M. simplex*, Say; but seems to me to differ, in having a more elevated spire, and a smaller aperture. The aperture is rather more than one-third the length of the shell.

MELANIA EBENUM. Plate 5., Fig. 7.

Testâ lævi, obtuso-conoideâ, crassâ, nigrâ; spirâ obtusâ; suturis parvis; anfractibus subconvexis; aperturâ subgrandi, ovatâ, infernè subangulatâ, intus purpuratâ.

Shell smooth, obtusely conical, thick, black; spire obtuse; sutures small; whorls somewhat convex; aperture rather large, ovate, subangular at base, within purplish.

Hab. Robinson County, Tenn. Dr. Currey.
My Cabinet, and Cabinet of Dr. Currey.
Diam. .30, Length .47 of an inch.

Remarks.—A very dark-coloured and rather robust species. It resembles *M. tenebrosa* herein described, but differs in having the whorls rather more convex, and in the outer lip being more curved. All the specimens received had the apex eroded. The number of whorls is therefore not ascertained. The aperture is more than one-third the length of the shell. It is usually purplish on the whole of the inside of the aperture. Some specimens are, however, bluish.

MELANIA RUFA. Plate 5., Fig. 8.

Testâ lævi, turritâ, subtenui, nitidâ, tenebroso-rufâ; spirâ elevatâ; suturis impressis; anfractibus convexis, superioribus carinatis; aperturâ parvâ, ellipticâ, infernè subangulatâ, intus purpuratâ.

Shell smooth, turreted, rather thin, shining, dark-red; spire elevated; sutures impressed; whorls convex, towards the apex carinate; aperture small, elliptical, subangular below, within purplish.

Hab. Mamma's Creek, Tenn. S. M. Edgar.
My Cabinet, and Cabinet of Mr. Edgar.
Diam. .30, Length .85 of an inch.

Remarks.—In form this species resembles *M. teres* herein described. It differs in the colour being red, and in being carinate on the superior whorls. The most perfect specimen in my possession has the few first whorls broken. I should suppose a perfect one would have eight whorls, and the aperture be one-fourth the length of the shell.

MELANIA FUSIFORMIS. Plate 5., Fig. 9.

Testâ lævi, fusiformi, subtenui, luteâ, mucronatâ; spirâ brevi; suturis linearibus; anfractibus senis, ultimo magno et inflato; aperturâ ovato-productâ, albidâ.

Shell smooth, fusiform, rather thin, yellow, pointed at the apex; spire short; sutures linear; whorls six, the last being large and inflated; aperture ovately elongated, whitish.

Hab. Tennesee. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .27, Length .50 of an inch.

Remarks.—This is a very remarkable species in regard to its form, resembling as it does the young of some species of *Columbella.* The aperture is about two-thirds the length of the shell, and is somewhat angular at base, above it turns inward. One of six individuals before me has two rather broad bands. On the superior whorls may be observed an indistinct stria.

MELANIA CLAVÆFORMIS. Plate 5., Fig. 10.

Testâ lævi, clavæformi, subtenui, castaneo-fuscâ, nitidâ; spirâ acutâ; suturis subimpressis; anfractibus octonis, convexis; aperturâ productâ, pallido-purpureâ.

Shell smooth, club-shaped, rather thin, chestnut brown, shining; spire acute; sutures somewhat impressed; whorls eight, convex; aperture elongated, light purple.

Hab. Ocoee District, Tenn. Dr. Troost.
" Clinch River, Tenn. Dr. Warder.
My Cabinet, and Cabinets of Dr. Troost, Dr. Warder, and P. H. Nicklin.
Diam. .27, Length .67 of an inch.

Remarks.—The aperture is about one-third the length of the shell. In colour it differs from most species.

MELANIA GRACILIS. Plate 5., Fig. 11.

Testâ lævi, clavæformi, subtenui, corneâ; spirâ acutâ; suturis impressis; anfractibus octonis, convexis: aperturâ parvâ, ovatâ, albidâ.

Shell smooth, club-shaped, rather thin, horn-coloured; spire acute; sutures impressed; whorls eight, convex; aperture small, ovate, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .32, Length .75 of an inch.

Remarks.—This resembles the *clavata* in form, but is rather more robust. It differs also in colour. The aperture is rather more than one-third the length of the shell.

MELANIA SUBSOLIDA. Plate 5., Fig. 12.

Testâ lævi, subfusiformi, subsolidâ, corneâ; spirâ acutâ; suturis impressis; anfractibus subconvexis; aperturâ subproductâ, intus purpureâ.

Shell smooth, subfusiform, somewhat solid, horn-coloured; spire acute; sutures impressed; whorls somewhat convex; aperture somewhat elongated, within purple.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .32, Length .82 of an inch.

Remarks.—This species has a strong resemblance to *M. simplex*, Say. It is however more elevated in the spire. It is purplish within, but white towards the margin of the lip.

MELANIA OCOËENSIS. Plate 5., Fig. 13.

Testâ lævi, conoideâ, subcrassâ, tenebroso-corneâ; spirâ obtusâ, apud apicem-lineis notatâ; suturis impressis; anfractibus subconvexis; aperturâ parvâ, ovatâ, cæruleâ.

Shell smooth, conical, somewhat thick, dark horn-coloured; spire obtuse, toward the apex lined; sutures impressed; whorls somewhat convex: aperture small, ovate, bluish.

Hab. Ocoee District, Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .32, Length .92 of an inch.

Remarks.—Five specimens are before me, all of which are more or less decollate. None of them have bands. Oblique, irregular striæ may be observed more or less on all those which I have examined.

MELANIA SUBCYLINDRACEA. Plate 5., Fig. 14.

Testâ lævi, subcylindraceâ, subcrassâ, corneâ; spirâ obtuso-elevatâ; suturis impressis; anfractibus convexis; aperturâ parvâ, ovatâ, albidâ.

Shell smooth, sub-cylindrical, somewhat thick, horn-colour; spire obtusely elevated; sutures impressed; whorls convex; aperture small, ovate, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .32, Length .85 of an inch.

Remarks.—This is a club-shaped species with an aperture about the third of the length of shell. All the specimens sent by Dr. Troost are more or less decollate.

MELANIA SORDIDA. Plate 5., Fig. 15.

Testâ lævi, conoideâ, subcrassâ, tenebroso-corneâ; suturis impressis; anfractibus subconvexis; aperturâ subgrandi, subrotundâ, intus cæruleâ.

Shell smooth, conical, somewhat thick, dark horn-coloured; sutures impressed; whorls somewhat convex; aperture rather large, somewhat rounded, within bluish.

Hab. Tennessee. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .40, Length 1.02 of an inch.

Remarks.—The whole of five individuals before me have the apex decollate. This species closely resembles the *Ocoëensis* herein described. It is, however, larger in the aperture, which is more rotund, and the species seems to be larger.

MELANIA REGULARIS. Plate 5., Fig. 16.

Testâ lævi, conoideâ, subcrassâ, tenebroso-corneâ; spirâ elevatâ; suturis subimpressis; anfractibus planulatis; aperturâ parvâ, albidâ.

Shell smooth, conical, rather thick, dark horn-coloured; spire elevated: sutures somewhat impressed; whorls flat; aperture small, whitish.

Hab. Oconee District, Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .40, Length 1.22 of an inch.

Remarks.—This species has a regularly increasing and elevated spire. Neither of the three before me have perfect tips. The number of whorls must be about ten. The aperture is about one-fourth the length of the shell.

MELANIA FULIGINOSA. Plate 5., Fig. 17.

Testâ lævi, fusiformi, subinflatâ, subcrassâ, tenebroso-fuscâ; spirâ obtusâ; suturis impressis; anfractibus senis, subconvexis; aperturâ magnâ, ad basim angulatâ et canaliculatâ.

Shell smooth, fusiform, somewhat inflated, rather thick, dark brown; spire obtuse; sutures impressed; whorls six, somewhat convex; aperture large, at the base angular and channeled.

Hab. Big Bigby Creek, Maury Co. Tenn. T. R. Dutton.
My Cabinet, and Cabinet of Mr. Dutton.
Diam. .50, Length .85 of an inch.

Remarks.—In general form this species resembles the *M. Duttoniana*, (nobis) but differs in being less elevated in the spire, in being without tubercles, and of a very dark colour; the substance of the shell is disposed to be purple. The epidermis is thick and very dark. Mr. Dutton found it rare.

MELANIA NICKLINIANA. Plate 5, Fig. 18.

Testâ lævi, obtuso-conoideâ, solidâ, valdè tenebrosâ; suturis impressis; anfractibus senis, subconvexis; aperturâ magnâ, subrotundâ, intus purpuratâ.

Shell smooth, obtusely conical, solid, very dark; sutures impressed; whorls six, slightly convex; aperture large, somewhat rounded, within purple.

Hab. Bath County, Va. P. H. Nicklin.
My Cabinet, and Cabinet of Mr. Nicklin.
Diam. .27, Length .45 of an inch.

Remarks.—This is a robust, small species which seems not to have been before noticed. It was found by Mr. Nicklin in a small stream of cold water at the Hot Springs in Virginia. It is amongst the smallest species I have seen. The purple colour of the interior of most of the specimens, gives the shell a very dark appearance. I owe to the kindness of Mr. Nicklin, to whom I dedicate it, the possession of several specimens of this species. I am under obligations to him also for a fine suite of *M. inflata* (nobis). They were found in New River, Va. being that part of the great Kanawha which is above its junction with the Gauley River. Some of the specimens have longer spires; some are lineolate, some banded, and others are without bands. Thus presenting characters differing so much, as almost to deceive one as to their being identical.*

* Since the above was written I have received from Dr. Warder of Cincinnati a specimen from New River, which, with a re-examination of Mr. Nicklin's specimens, satisfies me that the shell described by Mr. Conrad in the appendix to his "Fresh Water Shells of the United States," under the names of *M. Rogersii* and *dilatata* are identical with my *inflata*, my description bearing date the previous year to his.

Within a few days I have observed in the Boston Journal of Nat. Hist. vol. 3, No. 3, descriptions of two

MELANIA VIRIDIS. Plate 5, Fig. 19.

Testâ lævi, subfusiformi, subcrassâ, viridi; spirâ brevi, obtuso conoideâ; suturis linearibus; anfractibus quinis, subconvexis; aperturâ ovatâ, subgrandi, albâ.

Shell smooth, subfusiform, rather thick, green; spire short, obtusely conical; sutures linear; whorls five, somewhat convex; aperture ovate, rather large, white.

Hab. Vicinity of Cincinnati, Ohio. T. G. Lea.
My Cabinet, and Cabinets of T. G. Lea, and P. H. Nicklin.
Diam. .27, Length .32 of an inch.

Remarks.—Inhabits with the *M. occidentalis* herein described, and resembles it. It is a smaller species, has one more whorl, has a higher spire, and among nine individuals before me, I see no indications of transverse striæ. The aperture is rather more than half the length of the shell.

MELANIA OCCIDENTALIS. Plate 5, Fig. 20.

Testâ lævi, subglobosâ, subcrassâ, viridi; spirâ brevi, mucronatâ; suturis linearibus; anfractibus quaternis, subconvexis; aperturâ ovatâ, magnâ, intus vel purpureâ vel albâ.

Shell smooth, subglobose, rather thick, green; spire short, pointed; sutures linear; whorls four, somewhat convex; aperture ovate, large, within purple or white.

Hab. Vicinity of Cincinnati, Ohio. T. G. Lea.
My Cabinet, and Cabinets of T. G. Lea, and P. H. Nicklin.
Diam. .30, Length .37 of an inch.

Remarks.—This is a fine species about the size of *Melania subglobosa*, Say, (*Anculosa*) and it has been confounded with it. I have specimens of *subglobosa* which were brought by Prof. Vanuxem from the Holston, at the time he gave

new species of *Anculosa* by Mr. Anthony. *Anculotus carinatus* and *Anculotus Kirtlandianus*, both from the falls of the Kanawha. Judging from the description and figures, I am led to the conclusion, that both these were identical with *M. inflata*, and from the great variety of this proteus species, I am not surprised at its being mistaken. The peculiar character, however, of the angle and channel of the base in this species, is evident throughout. I am not aware of the animal having been yet observed: when examined, it may prove to be a true *Anculosa*. If so, the synonymy will stand thus:

Anculosa inflata, Lea.
    Melania dilatata, Conrad.
    Melania Rogersii, Conrad.
    Anculotus carinatus, Anthony.
    Anculotus Kirtlandianus, Anthony.

them to Mr. Say for description. They certainly do not appear to me to be the same, although in many characters they agree. The animal of *occidentalis* I have not seen; the operculum is spiral; at present I prefer to place it among the *Melania*. Some of the varieties before me are very beautifully furnished with raised revolving striæ. When there is a single one, it gives the shell the appearance of being carinate, as it appears near the centre of the whorl. In some specimens these striæ are more numerous; in a single one I have counted fifteen. There appear to be no bands on the outside, but sometimes purple lines on the inside mark the places of the exterior striæ. There is generally more or less colour in the interior and about the columella, the base of which is disposed to be angular. The aperture is nearly three-fourths the length of the shell.*

MELANIA NIAGARENSIS. Plate 5, Fig. 21.

Testâ lævi, obtuso-conicâ, crassâ, corneâ; spirâ brevi; suturis linearibus; anfractibus subplanulatis; aperturâ subgrandi, ellipticâ, intus purpureâ.

Shell smooth, obtusely conical, thick, horn-coloured; spire short; sutures linear; whorls rather flat; aperture rather large, elliptical, within purple.

Hab. Falls of Niagara.
My Cabinet, and Cabinet of P. H. Nicklin.
Diam. .25, Length .55 of an inch.

Remarks.—I obtained this shell many years since at the foot of the falls of Niagara, where it exists in abundance. It may generally have been confounded with *M. depygis*, Say. When I procured it, I placed it in my cabinet under that name with a mark of doubt. It is a smaller shell than the *depygis*, has a shorter spire and a narrower aperture. This species has a purple columella and interior, which in some cases are very dark. The specimens procured were all more or less eroded, and the apex removed. The number of whorls is either six or seven. The aperture is nearly half the length of the shell.

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* Since the above was written, I have seen in the "Boston Journal of Science," the description and figure by Mr. Anthony, of *Anculotus costatus* which in some respects answers to this shell. Mr. A. says that his shell has "about five costæ revolving around it."

MELANIA GLOBULA. Plate 5, Fig. 22.

Testâ lævi, subglobosâ, tenebroso-fuscâ, fasciatâ; spirâ brevi; suturis impressis; anfractibus quaternis, subconvexis; aperturâ magnâ, subrotundâ, intus cæruleâ.

Shell smooth, subglobose, dark brown, banded; spire short; sutures impressed; whorls four, rather convex; aperture large, nearly round, within bluish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .22, Length .25 of an inch.

Remarks.—This is a small globose species, with two very broad bands, one immediately over, and the other below the middle of the body whorl. The columella is white, inclined to a rusty hue. The interior of the base is reddish. Some of the specimens are small, and present a variety in which the columella is redder, and the epidermis more yellow, with the same distinctive bands. The aperture is nearly two-thirds the length of the shell.

MELANIA ALTILIS. Plate 5, Fig. 23.

Testâ lævi, subglobosâ, crassâ, pallido-corneâ; spirâ brevi; suturis parvis; anfractibus quaternis, supernè subangulatis; aperturâ magnâ, subrotundâ, albâ.

Shell smooth, subglobose, thick, pale horn-colour; spire short; sutures small; whorls four, obtusely angular above; aperture large, nearly round, white.

Hab. Santee Canal, South Car. Professor Ravenel.
" Susquehanna River, at Havre de Grace, Md.
Paludina altilis. Professor Ravenel's letter.
My Cabinet, and Cabinet of P. H. Nicklin.
Diam. .27, Length .32 of an inch.

Remarks.—Last summer I found a number of this globose little species on the banks of the Susquehanna, and then considered it new, but on examination I found I had the same species, Prof. Ravenel having sent it to me many years since under the name of *Paludina altilis.* I am not aware that Prof. R. has ever described it, never having seen any account of it. His specific name for it is retained, but I have placed it among the *Melania*, it having a distinct spiral operculum. It belongs to a natural group in the genus *Melania*, which have very low spires and a very large body whorl. There is a very slight impression on the superior part of the whorls below the suture. The aperture is about two-thirds the length of the shell. The epidermis in young specimens is a very pale yellow, almost white.

MELANIA STRIGOSA. Plate 5, Fig. 24.

Testâ lævi, turrito-acutâ, tenui, pallido-luteâ, supernè striatâ; spirâ exsertâ; suturis impressis; anfractibus novenis, planulatis; aperturâ parvâ, ellipticâ, ad basim angulatâ, intus cæruleâ.

Shell smooth, acutely turrited, thin, pale yellow, striate above; spire drawn out; sutures impressed; whorls nine, flattened; aperture small, elliptical, angular at the base, within bluish.

Hab. Tenn. Dr. Troost.
" Holston River. Dr. Warder.
My Cabinet, and Cabinets of Dr. Troost, and Dr. Warder.

Diam. .27, Length .85 of an inch.

Remarks.—This species is somewhat like the *teres* herein described. It may be distinguished, however, at once by its flattened whorls and darker colour.

MELANIA VIRGATA. Plate 5, Fig. 25.

Testâ lævi, subrotundâ, subtenui, luteâ, bifasciatâ, nitidâ; spirâ brevi; suturis linearibus; anfractibus convexis; aperturâ magnâ, ellipticâ, albidâ.

Shell smooth, rounded, rather thin, yellow, double-banded, shining; spire short; sutures linear; whorls convex; aperture large, elliptical, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.

Diam. .20, Length .30 of an inch.

Remarks.—A single specimen only of this small species was sent to me by Dr. Troost. It seems to be mature, and is remarkable for the two broad bands which nearly cover the whorls. The aperture is about half the length of the shell.

MELANIA TENEBROSA. Plate 5, Fig. 26.

Testâ lævi, conoideâ, subcrassâ, subnigrâ; spirâ subelevatâ; suturis impressis; anfractibus planulatis; aperturâ subgrandi, ellipticâ, ad basim angulatâ, intus cæruleâ.

Shell smooth, conical, rather thick, nearly black; spire rather elevated; sutures impressed; whorls flattened; aperture rather large, elliptical, at the base angular, within bluish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .30, Length .72 of an inch.

Remarks.—Two specimens of this species were sent to me by Dr. Troost, both of which are decollated. On one there is a slight disposition to striæ on the upper remaining whorl. In general outline it resembles a small *Virginica*, Say.

SECTION II.—PLICATE MELANIÆ.

MELANIA TERES. Plate 5, Fig. 27.

Testâ plicatâ, acuto-turritâ, tenui, corneâ; spirâ exsertâ; suturis impressis; anfractibus novenis, convexis; aperturâ parvâ, ellipticâ, intus albidâ.

Shell folded, acutely turrited, thin, horn-coloured; spire drawn out; sutures impressed; whorls nine, convex; aperture small, elliptical, within whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinets of Dr. Troost, and P. H. Nicklin.
Diam. .25, Length .87 of an inch.

Remarks.—This is a remarkably elevated species, with the whorls much inflated, and the last whorl very small. Some of the specimens before me are but obscurely folded.

MELANIA OBTUSA. Plate 5, Fig. 28.

Testâ plicatâ, fusiformi, subcrassâ, corneâ; spirâ obtusâ; suturis impressis; anfractibus quaternis, ultimo semi-plicato; aperturâ magnâ, albidâ.

Shell folded, fusiform, rather thick, horn colour; spire obtuse; sutures impressed; whorls four, the last semi-plicate; aperture large, whitish.

Hab. Tenn. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. .27, Length .55 of an inch.

Remarks.—A fusiform species with costæ or folds half-way down the last whorl.

MELANIA LECONTIANA. Plate 5, Fig. 29.

Testâ plicatâ, conoideâ, crassâ, corneâ; spirâ obtuso-elevatâ; suturis parvis; anfractibus senis, planulatis; aperturâ magnâ, ellipticâ, cœruleâ.

Shell folded, conical, thick, horn colour; spire obtusely elevated; sutures small; whorls six, flattened; aperture large, elliptical, bluish.

Hab. Georgia. Major Le Conte.

My Cabinet, and Cabinet of Major Le Conte.

Diam. .35, Length .80 of an inch.

Remarks.—The folds of this species extend over the whole shell, except the inferior half of the body whorl. The aperture is large, and somewhat dilated, being nearly one-half the length of the shell.

I owe the possession of several specimens to the kindness of Major Le Conte, to whom I dedicate it.

MELANIA CORRUGATA. Plate 5, Fig. 30.

Testâ plicatâ, conoideâ, subtenui, diaphana, transversè striatâ, corneâ; spirâ subelevatâ; suturis valdè impressis; anfractibus septenis, convexis, supernè cancellatis; aperturâ subgrandi, ellipticâ, infra angulatâ, albidâ.

Shell folded, conical, rather thin, translucent, transversely striated, horn colour; spire rather elevated; sutures very much impressed; whorls seven, convex, cancellated above; aperture rather large, elliptical, angular below, whitish.

Hab. Tenn. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. .22, Length .50 of an inch.

Remarks.—This is a small, folded species of which a single specimen was received from Dr. Troost. The superior whorls are carinated. The folds extend to the body whorl. The aperture is rather more than one-third the length of the shell.

MELANIA MONOZONALIS. Plate 6, Fig. 31.

Testâ plicatâ, fusiformi, subcrassâ, fasciatâ, pallidâ; spirâ obtusâ; suturis linearibus; anfractibus quinis, subconvexis; aperturâ magnâ, ellipticâ, infra angulatâ, albâ.

Shell folded, fusiform, rather thick, banded, light-coloured; spire obtuse; sutures linear; whorls five, rather convex; aperture large, elliptical, angular at base, white.

Hab. Tenn. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. 21, Length .42 of an inch.

Remarks.—But a single specimen of this was sent to me by Dr. Troost. It is a very distinct species, and remarkable for a single broad band on the upper part of the whorl. In other specimens this band may not always be found to present the same character; and the number of bands in others again may even be increased. The aperture is about one-half the length of the shell.

MELANIA TEREBRALIS. Plate 6, Fig. 32.

Testâ plicatâ, acuto-turritâ, subtenui, nitidâ, rufo-fuscâ; spirâ valdè elevatâ; suturis valdè impressis; anfractibus novenis, convexis, supernè carinatis; aperturâ parvâ, ellipticâ, albidâ.

Shell folded, acutely turrited, rather thin, shining, reddish brown; spire much elevated; sutures much impressed; whorls nine, convex, carinate above; aperture small, elliptical, whitish.

Hab. Tenn. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. .24, Length .67 of an inch.

Remarks.—This species differs in the form of the folds from any which have come under my notice. These folds are distant from each other, but slightly raised, and give the shell a varicose appearance. The mouth is about the fifth part of the length of the shell.

MELANIA COLUMELLA. Plate 6, Fig. 33.

Testâ obscuro-plicatâ, conoideâ, subtenui, corneâ; spirâ subelevatâ, propè apicem striatâ; suturis impressis; anfractibus senis, subconvexis; aperturâ parvâ, ellipticâ, infernè angulatâ, albidâ.

Shell obscurely plicate, conical, rather thin, horn colour; spire rather elevated, striate towards the apex; sutures impressed; whorls six, somewhat convex; aperture small, elliptical, angular at base, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .26, Length .63 of an inch.

Remarks.—This species is remarkable for the impressed curve on the columella. In its general character it resembles the *M. blanda* herein described. The aperture is about one-third the length of the shell.

MELANIA BLANDA. Plate 6, Fig. 34.

Testâ plicatâ, conoideâ, subtenui, nitidâ, corneâ; spirâ subelevatâ, propè apicem striatâ; suturis impressis; anfractibus septenis, subplanulatis; aperturâ parvâ, ellipticâ, infernè angulatâ, albidâ.

Shell folded, conical, rather thin, shining, horn colour; spire rather elevated; towards the apex striate; sutures impressed; whorls seven, rather flattened; aperture small, elliptical, angular at the base, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .26, Length .69 of an inch.

Remarks.—A single specimen of this species was received from Dr. Troost. The folds are obscure and the striæ small. The aperture is not quite one-third the length of the shell.

MELANIA CREBRI-COSTATA. Plate 6, Fig. 35.

Testâ crebri-plicatâ, conoideâ, subcrassâ, corneâ; spirâ elevatâ; suturis linearibus; anfractibus septenis, planulatis; aperturâ parvâ, ellipticâ, infernè angulatâ, cœruleâ.

Shell closely folded, conical, rather thick, horn colour; spire elevated; sutures linear; whorls seven, flattened; aperture small, elliptical, below angular, bluish.

Hab. Robinson County, Tenn. Dr. Currey.
My Cabinet, and Cabinet of Dr. Currey.
Diam. .28, Length .90 of an inch.

Remarks.—This is rather a slender shell, and is peculiar for its numerous folds, which are slightly curved and parallel. They extend over the whole shell, except the inferior half of the body whorl. The aperture is about one-third the length of the shell.

MELANIA CURREYANA. Plate 6, Fig. 36.

Testâ plicatâ, conoideâ, subcrassâ, corneâ; spirâ subelevatâ; suturis irregulariter impressis; anfractibus septenis, subconvexis; apcrturâ parvâ, infernè angulatâ, intus purpuratâ.

Shell folded, conical, rather thick, horn colour; spire somewhat elevated; sutures irregularly impressed; whorls seven, rather convex; aperture small, angular below, purplish within.

Hab. Barren River, Ky. Dr. Currey.
My Cabinet, and Cabinet of Dr. Currey.
Diam. .27, Length .73 of an inch.

Remarks.—Two specimens of this species are before me, which I owe to the kindness of Dr. Currey of Nashville, after whom I name it. It is remarkable for its large and strong folds. It is without striæ, and the body whorl is smooth, except near to the suture. The aperture is about one-third the length of the shell. One of the specimens has quite a dark purple aperture, and the lip is thickened and reflexed. In these two specimens the ribs seem disposed to alternate in size.

MELANIA EDGARIANA. Plate 6, Fig. 37.

Testâ plicatâ, conoideâ, subtenui, striatâ, luteo-fuscâ; spirâ elevatâ; suturis irregulariter impressis; anfractibus octonis, subplanulatis; aperturâ parvâ, ellipticâ, infernè angulatâ, cæruleâ.

Shell folded, conical, rather thin, striate, yellowish brown; spire elevated; sutures irregularly impressed; whorls eight, rather flattened; aperture small, elliptical, angular below, bluish.

Hab. Cany Fork, Tenn. Mr. S. M. Edgar.
My Cabinet, and Cabinet of Mr. Edgar.
Diam. .29, Length .77 of an inch.

Remarks.—I owe to Mr. Edgar's kindness several specimens of this pretty species, which I name after him. It is remarkable for being folded and transversely striate on all the whorls, except the lower part of the body whorl, which is striate only. The crossing of the folds and striæ give it a cancellated appearance. The aperture is rather more than one-fourth the length of the shell. The number of striæ on the body whorl is about ten.

MELANIA DECORA. Plate 6, Fig. 38.

Testâ plicatâ, turrito-acutâ, subtenui, corneâ, supernè striatâ; spirâ acutâ, elevatâ; suturis impressis; anfractibus novenis, subplanulatis; aperturâ parvâ, ellipticâ, albidâ.

Shell folded, acutely turrited, rather thin, horn colour, above striate; spire acute, elevated; sutures impressed; whorls nine, rather flattened; aperture small, elliptical, whitish.

Hab. Tenn. Dr. Troost.
" Green River, Ky. Dr. Currey.
My Cabinet, and Cabinets of Dr. Troost and P. H. Nicklin.
Diam. .26, Length .82 of an inch.

Remarks.—This species resembles *M. costulata,* herein described. It is, however, more elevated in the spire, and the folds are closer. On the two lower whorls the folds become obsolete.

MELANIA COSTULATA. Plate 6, Fig. 39.

Testâ plicatâ, conoideâ, subtenui, luteâ, supernè carinatâ; spirâ subproductâ; suturis impressis; anfractibus novenis, subconvexis; aperturâ parvâ, subovatâ, intus cœruleâ.

Shell folded, conical, rather thin, yellow, above carinate; spire rather elongated; sutures impressed; whorls nine, rather convex; aperture small, sub-ovate, within bluish.

Hab. Barren River, Ky. Dr. Currey.
" Tenn. Dr. Troost.
My Cabinet, and Cabinets of Dr. Currey, Dr. Troost, and P. H. Nicklin.
Diam. .30, Length .82 of an inch.

Remarks.—In its general characters this species resembles *M. laqueata,* Say. It may be distinguished in its being of less diameter and being more slender.

The specimens received from both Dr. Troost and Dr. Currey, were covered with a deposite of the oxide of iron, giving them a black hue. Under this the epidermis is yellow. The aperture is about one-third the length of the shell.

MELANIA NITENS. Plate 6, Fig. 40.

Testâ plicatâ, subcrassâ, tenebroso-fuscâ; spirâ obtusâ; suturis impressis; anfractibus septenis, subconvexis; aperturâ parvâ, ellipticâ, ad basim angulatâ, intus subrufâ.

Shell folded, somewhat thick, dark brown; spire obtuse; sutures impressed; whorls seven, somewhat convex; aperture small, elliptical, angular at the base, reddish within.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .30, Length .76 of an inch.

Remarks.—This is a shining, dark brown species, with rather regular ribs on the superior whorls. The aperture is about one-third the length of the shell. A single specimen only was received.

MELANIA PLICATULA. Plate 6, Fig. 41.

Testâ plicatâ, conoideâ, tenui, tenebroso-corneâ; spirâ subelevatâ; suturis impressis; anfractibus octonis, subconvexis, supernè striatis; aperturâ parvâ, ellipticâ, ad basim subangulatâ, intus albidâ.

Shell folded, conical, thin, dark horn colour; spire rather elevated; sutures impressed; whorls eight, rather convex, striate above; aperture rather small, elliptical, at the base somewhat angular, within whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinets of Dr. Troost and Mr. Edgar.
Diam. .35, Length .85 of an inch.

Remarks.—Dr. Troost and Mr. Edgar both procured this species from Tennessee, but their labels do not state the district. The ribs are numerous and close, and most individuals have two striæ above, which, crossing the ribs, produces a granulation. The mouth is about one-third the length of the shell.

MELANIA CONCINNA. Plate 6, Fig. 42.

Testâ plicatâ, turrito-acutâ, subtenui, fuscâ; spirâ exsertâ; suturis impressis; anfractibus novenis, carinatis, planulatis; aperturâ parvâ, ellipticâ, ad basim angulatâ, intus albidâ.

Shell folded, acutely turrited, thin, brown; spire drawn out; sutures impressed; whorls nine, carinate, flattened; aperture small, elliptical, angular at the base, whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .25, Length .75 of an inch.

Remarks.—A single individual only was received from Dr. Troost. Its mouth is about one-fourth the length of the shell. It is remarkably flattened on the whorls, and the superior part is transversely striate.

SECTION III.—CARINATE MELANIÆ.

MELANIA BABYLONICA. Plate 6, Fig. 43.

Testâ carinatâ, turritâ, subcrassa; spirâ subelevatâ, propè apicem striatâ; suturis impressis; anfractibus septenis, supernè angulatis; aperturâ subgrandi, ellipticâ, albâ.

Shell carinate, turrited, rather thick; spire rather elevated, striate at the apex; sutures impressed; whorls seven, angular above; aperture rather large, elliptical, white.

Hab. Yellow Springs, Green Co., Ohio. T. G. Lea.
My Cabinet.
Diam. .36, Length .78 of an inch.

Remarks.—A single specimen only of this shell has come under my notice. If the prominent character of this specimen, the large carina on the superior part of the whorls, be persistent, it marks a very distinct species. On the first four whorls, the striæ are well defined. On the remaining three the carina alone exists. The aperture is more than one-third the length of the shell.

MELANIA EXARATA. Plate 6, Fig. 44.

Testâ carinatâ, conica, subcrassâ, nigrâ; suturis exaratis; anfractibus planulatis, carinatis; aperturâ parvâ, ad basim angulatâ et canaliculatâ, intus tenebrosâ.

Shell carinate, conical, rather thick, black; sutures rather deeply grooved; whorls flattened, carinate; aperture small, at the base angular and channelled, dark within.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .28, Length .57 of an inch.

Remarks.—I received only two specimens of this species, both of which are decollated. It is perfectly distinct, and remarkable for its jetty hue, its carina, and its deeply impressed sutures, which are caused by the carina.

MELANIA POTOSIENSIS. Plate 6, Fig. 45.

Testâ carinatâ, conoideâ, subtenui, fuscâ; spirâ obtuso-elevatâ; suturis valdè impressis; anfractibus octonis, convexis; aperturâ magnâ, ovatâ, purpuratâ.

Shell carinate, conical, rather thin, brown; spire obtusely elevated; sutures much impressed; whorls eight, convex; aperture large, ovate, purplish.

Hab. Potosi, Missouri. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .28, Length .62 of an inch.

Remarks.—The rotundity of the outer lip in this is different from the species generally, with the same elevation of spire. The aperture is more than one-third the length of the shell, and is entirely purple, in the only two specimens before me. In one specimen the carina is distinct on all the whorls but the last, in the other it is not visible on the last two whorls.

MELANIA ACUTO-CARINATA. Plate 6, Fig. 46.

Testâ carinatâ, conoideâ, subcrassâ, nitidâ, tenebroso-fuscâ; spirâ obtuso-elevatâ; suturis impressis; anfractibus senis; aperturâ subgrandi, ellipticâ, infernè angulatâ, intus purpuratâ.

Shell carinate, conical, rather thick, shining, dark brown; spire obtusely elevated; sutures impressed; whorls six; aperture rather large, elliptical, angular at base, purplish within.

Hab. Tenn. Dr. Currey.
My Cabinet, and Cabinet of Dr. Currey.
Diam. .30, Length .66 of an inch.

Remarks.—I received a single specimen only of this species. It seems to be distinct in its large carina which extends over all the whorls, but it is scarcely distinct on the last. The columella is remarkably indented. The aperture is nearly one-half the length of the shell.

MELANIA WARDERIANA. Plate 6, Fig. 47.

Testâ carinatâ, clavæformi, subcrassâ, tenebrosâ; spirâ conicâ; suturis linearibus; anfractibus octonis, convexis; aperturâ ovata, subgrandi, intus carneâ.

Shell carinate, club-shaped, rather thick, very dark; spire conical; sutures linear; whorls eight, convex; aperture ovate, rather large, within flesh-colour.

Hab. Cedar Creek, a branch of Clinch River, Russell County. Virginia. J. A. Warder, M. D.

My Cabinet, and Cabinets of Dr. Warder, and T. G. Lea.

Diam. .37, Length .76 of an inch.

Remarks.—I have two specimens before me. The two lowest whorls are smooth. The superior ones are carinate, with a small intermediate stria. The upper whorls diminish very rapidly. The exterior of the shell is nearly black and shining, and its colour appears to arise from a deposite of ferruginous matter, as the substance of the shell is reddish. The aperture is rather more than one-third the length of the shell. I name it after Dr. Warder of Cincinnati, to whom I owe the possession of this and other interesting specimens.

SECTION IV.—SULCATE MELANIÆ.

MELANIA SULCOSA. Plate 6, Fig. 48.

Testâ transversè sulcatâ, conoideâ, crassâ, luteolâ; suturis impressis; anfractibus planulatis; aperturâ parvâ, ovatâ, albidâ.

Shell transversely sulcate, conical, thick, yellowish; sutures impressed; whorls flattened; aperture small, ovate, whitish.

Hab. Tenn. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. .32, Length . of an inch.

Remarks.—A single specimen only, and that imperfect, is before me. The body whorl has seven or eight distinctly marked striæ. On the penultimate there are three, and these give a sulcate appearance to the shell.

SECTION V.—STRIATE MELANIÆ.

MELANIA STRIATA. Plate 6, Fig. 49.

Testâ striatâ, conoideâ, subtenui, tenebroso-fuscâ, supernè carinatâ; spirâ subelevatâ; suturis impressis; anfractibus octonis, convexis; aperturâ parvâ, ellipticâ, intus subrufâ.

Shell striate, conical, rather thin, dark brown, carinate above; spire somewhat elevated; sutures impressed; whorls eight, convex; aperture small, elliptical, within reddish.

Hab. Tennessee. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. .21, Length .49 of an inch.

Remarks.—Rather a small species of a dark reddish brown. In some individuals the folds are numerous.—In others the striæ predominate and cover nearly all the whorls. The aperture is rather more than one-third the length of the shell.

MELANIA PILULA. Plate 6, Fig. 50.

Testâ striatâ, subglobosâ, crassâ, tenebroso-fuscâ; suturis subimpressis; anfractibus convexis; aperturâ ovatâ, magnâ, infrâ subangulatâ, intus purpuratâ.

Shell striate, subglobose, thick, dark brown; sutures somewhat impressed; whorls convex; aperture ovate, large, angular at the base, within purplish.

Hab. Tennessee. Dr. Troost.

My Cabinet, and Cabinet of Dr. Troost.

Diam. .34, Length .43 of an inch.

Remarks.—This is a very distinct species, and is quite as globose as *M. subglobosa,* Say. Two specimens were received, the spires of which are not perfect. I should presume, that when perfect, they would be found to have four whorls. The raised striæ are very distinct, and consist of eighteen in these two individuals. The aperture is about half the length of the shell. One specimen is dark purple within the aperture.—The other is bluish, with a tinge of purple on the columella.

MELANIA CIRCINCTA. Plate 6, Fig. 51.

Testâ supernè striatâ, turritâ, subtenui, pallido-luteâ, fasciata; spirâ exsertâ; suturis parvis; anfractibus novenis, subconvexis, in medio carinatis; aperturâ subparvâ, ellipticâ, ad basim angulatâ, intus albâ.

Shell striate above, turrited, rather thin, pale yellow, banded; spire drawn out; sutures small; whorls nine, slightly convex, carinate in the middle; aperture rather small, elliptical, angular at the base, and white within.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .35, Length .90 of an inch.

Remarks.—This beautiful species is peculiar for its pale yellow ground and broad band, which is placed immediately upon the carina. A very indistinct band may be observed below the carina, where in some individuals may also be observed a few striæ. In some, the striæ on the superior part of the shell are accompanied by indistinct ribs.

SECTION VI.—TUBERCULATE MELANIÆ.

MELANIA VENUSTA. Plate 6, Fig. 52.

Testâ supernè subtuberculatâ, fusiformi, subtenui, luteolâ; spirâ subobtusâ; suturis rugoso-impressis; anfractibus senis, convexis; aperturâ productâ, ad basim angulatâ et canaliculatâ, intus albidâ.

Shell disposed to be tuberculate, fusiform, somewhat thin, yellowish above; spire rather obtuse; sutures roughly impressed; whorls six, convex; aperture elongated, at the base angulated and channelled, within whitish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.
Diam. .43, Length .80 of an inch.

Remarks.—Dr. Troost sent me a single specimen of this species which is very distinct. The columella is very much thickened, particularly above, in which it resembles the genus *Melanopsis.* The aperture is rather more than half the length of the shell. In this specimen a single obscure band may be observed within, close to the base of the columella.

MELANIA FLORENTIANA. Plate 6, Fig. 53.

Testâ tuberculatâ, ellipticâ, ponderosâ, pallidâ; spirâ obtusâ; suturis impressis; anfractibus senis, subconvexis; aperturâ productâ, albidâ.

Shell tuberculate, elliptical, ponderous, pale; spire obtuse; sutures impressed; whorls six, slightly convex; aperture elongated, whitish.

Hab. Tennessee River, Florence, Alabama. T. R. Dutton.
My Cabinet, and Cabinet of Mr. Dutton.
Diam. .47, Length .87 of an inch.

Remarks.—An elliptical species resembling the *M. olivula,* Conrad. Its aperture is so much elongated as to be more than half the length of the shell. Three of the specimens are without bands, a fourth has several very indistinct ones. The whorls are somewhat flattened on the superior part and are disposed to be tuberculated below the sutures. In the young the tubercles are more distinct. In some of the adult specimens they are entirely wanting.

MELANIA DUTTONIANA. Plate 6, Fig. 54.

Testâ tuberculatâ, fusiformi, subcrassâ, luteolâ, fasciatâ; spirâ elevatâ, ad apicem acutâ; suturis enormiter lineatis; anfractibus septenis, supernè depressis; aperturâ productâ, ad basim angulatâ et canaliculatâ, intus albidâ.

Shell tuberculate, fusiform, rather thick, yellowish, banded; spire elevated, pointed at the apex; sutures irregularly lined; whorls seven, depressed above; aperture elongated, angular and channelled at the base, within whitish.

Hab. Waters of Tennessee. Dr. Troost. Duck River, Maury Co., Tenn. T. R. Dutton.
My Cabinet, and Cabinets of Prof. Troost and Mr. Dutton.
Diam. .57, Length 1.09 of an inch.

Remarks.—This is a beautiful species. The most perfect specimens are remarkable for their fusiform shape and their long aperture, which presents a curved columella and extended sinus somewhat like the genus *Io*. The bands in some individuals are numerous and distinct, the largest being nearest the base. The tubercles form a row round the middle of the whorls of most specimens, but in some, though rarely, this part is carinate or rounded. Some are slightly tuberculated below the suture. Among the young specimens some are costate near the apex, others entirely smooth and without bands. I owe the fine specimen figured to Mr. Dutton, after whom I name it.

SECTION VII.—GRANULATE MELANIÆ.

MELANIA HOLSTONIA. Plate 6, Fig. 55.

Testâ granosâ, conoideâ, subcrassâ, nigrâ; spirâ subelevatâ; suturis impressis; anfractibus supernè planulatis; aperturâ ovatâ, purpureâ.

Shell grained, conical, somewhat thick, black; spire somewhat elevated; sutures impressed; whorls flattened above; aperture ovate, purple.

Hab. Tenn. Dr. Troost. Holston River, Tenn. Mr. S. M. Edgar.
My Cabinet, and Cabinets of Dr. Troost and Mr. Edgar.
Diam. .38, Length .79 of an inch.

Remarks.—A very distinct species with four series of small, rather sharp elevations round the whorls, the two inferior ones rather indistinct. Only two specimens have come under my notice, and both have the apex decollated.

SECTION VIII.—CANCELLATE MELANIÆ.

MELANIA CALIGINOSA. Plate 6, Fig. 56.

Testâ cancellatâ, conoideâ, subcrassâ, transversè striatâ, tenebroso-fuscâ; spirâ elevatâ; suturis enormiter impressis; anfractibus octonis, subconvexis; aperturâ parvâ, ellipticâ, intus purpuratâ.

Shell cancellate, conical, somewhat thick, transversely striated, very dark brown; spire elevated; sutures irregularly impressed; whorls eight, rather convex; aperture small, elliptical, purplish within.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinets of Dr. Troost and P. H. Nicklin.
Diam. .34, Length .91 of an inch.

Remarks.—A fine cancellate species with ten or eleven revolving striæ on the body whorl, crossing the folds. The aperture is about one-third the length of the shell. It nearly answers to Mr. Conrad's description of *M. nassula*, but has five striæ on the penultimate whorl while the *nassula* has seven. It differs from *M. catenaria*, Say, in having a more elevated spire, and in having two or three more revolving striæ. In some individuals the aperture is bluish white.

MELANIA NODULOSA. Plate 6, Fig. 57.

Testâ cancellatâ, conoideâ, crassâ, tenebroso-fuscâ; suturis enormiter impressis; anfractibus subconvexis; aperturâ subgrandi, ellipticâ, infrâ subangulatâ, intus cæruleâ.

Shell cancellate, conical, thick, dark brown; sutures irregularly impressed; whorls somewhat convex; aperture rather large, elliptical, subangular below, within bluish.

Hab. Tenn. Dr. Troost.
My Cabinet, and Cabinet of Dr. Troost.

Diam. .34, Length .82 of an inch.

Remarks.—Two imperfect specimens only were received from Dr. Troost, and both are much eroded at the apex, consequently the number of whorls could not be ascertained. The body whorl has about twenty well defined raised striæ, which on the superior part are crossed by folds causing numerous elevated points, giving the whole of the upper part of the shell a granulate appearance. It is somewhat like *M. catenaria*, Say, but may be distinguished at once by the number of striæ.

Read December 21st, 1838.

MELANIA CINCINNATIENSIS. Plate 6, Fig. 58.

Testâ carinatâ, valdè depressâ, infernè compressâ, fuscâ, trifasciatâ, bicarinatâ, apice acuminatâ; anfractibus quaternis; aperturâ subrotundâ.

Shell carinate, much depressed, below compressed, brown, three-banded, with two carinæ, pointed at the apex; whorls four; aperture rounded.

Hab. Near Cincinnati, Ohio. T. G. Lea.
My Cabinet, and Cabinet of T. G. Lea.

Diam. .14, Length .16 of an inch.

Remarks.—This is a very minute species recently taken in the vicinity of Cincinnati,* by my brother T. G. Lea. It is very remarkable for its roof-shaped spire, and two carinæ, which are coloured.

Read October 2d, 1840.

WHEN I presented my last paper on the family *Naïades* to the society, I considered that but few species remained to be described, and I intended to have turned my attention almost exclusively to the anatomical structure of the various species attainable. Circumstances have disappointed this intention, and the number of new species has, owing to the kind attention of many friends, increased upon my hands far beyond my expectations. Descriptions of these are now made out, and many of them will be found of great interest to the student of this branch of Zoology.

UNIO EXIGUUS. Plate 7, Fig. 1.

Testâ ellipticâ, subcompressâ; valvulis tenuibus; natibus subprominentibus; epidermide tenebrosâ, virido-radiatâ, politâ; dentibus cardinalibus lamellatis; lateralibus longis subcurvisque; margaritâ cœruleâ et iridescente.

Shell oval, rather compressed; valves thin; beaks somewhat prominent; epidermis dark, with green rays, polished; cardinal teeth lamellar; lateral teeth long and somewhat curved; nacre blue and iridescent.

Hab. Chatahochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .6, Length .1, Breadth 1.7 of an inch.

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* More recently found by Dr. Troost in the Holston, Tennessee.

Shell oval, rather compressed; substance of the shell very thin and transparent; beaks somewhat prominent; ligament long and thin; epidermis polished, dark, the whole disk being nearly covered with deep green rays; cardinal teeth lamellar, erect, pointed; lateral teeth long, lamellar and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed across the cavity of the beaks; cavity of the shell shallow; cavity of the beaks shallow and somewhat angular; nacre blue and very iridescent behind.

Remarks.—This species is nearly allied to *U. iris* (nobis.) Like it, it has numerous green rays passing over the whole disk, more dense on the posterior portion. It differs in being less transverse and being apparently without undulations at the beaks, those of the *iris* being remarkable. The cardinal tooth in the left valve is but slightly cleft, and the anterior portion is more elevated and pointed.

UNIO CUCUMOIDES. Plate 7, Fig. 2.

Testâ plicatâ, emarginatâ, latissimâ, subcylindraceâ; valvulis subcrassis; natibus vix prominentibus; epidermide nigrâ; dentibus cardinalibus parvis, tuberculatis; lateralibus longissimis rectisque; margaritâ albâ.

Shell folded, emarginate, very broad, somewhat cylindrical; valves rather thick; beaks scarcely prominent; epidermis black; cardinal teeth small, tuberculate; lateral teeth very long and straight; nacre white.

Hab. Hunter's River, New South Wales. Dr. Jay.
Cabinet of Dr. Jay.

Diam. 1.4, Length 2.2, Breadth 5.5 inch.

Shell folded over the posterior half, emarginate at base, very broad, somewhat cylindrical, subbiangular behind; folds small and numerous; substance of the shell rather thick, thinner behind; beaks scarcely prominent and placed near to the anterior margin; ligament very long and thick; epidermis black; cardinal teeth small, tuberculate; lateral teeth very long and straight; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices placed in a row across the centre of the cavity of the beaks; cavity of the shell deep and rounded; cavity of the beaks very small; nacre white.

Remarks.—This is among the most remarkable species of Unio which have come under my notice. It resembles *U. monodontus*, (Say) in outline as well as in the imperfection of the cardinal and lateral teeth, both of which, however, are more perfect in the *U. cucumoides*. In the specimen before me there is a deep muscular impression above and distinct from the great anterior cicatrix. This is nearly round and penetrates the base of the cardinal tooth. It may be that it is formed by a branch of the anterior adductor muscle. An examination of the animal only can decide this point. In the above description it will be observed that the anterior cicatrices are described as being confluent. This alludes to the cicatrices of the adductor muscle and the muscle of locomotion as usual. The third cicatrix of the anterior part is now, I believe, for the first time observed. The dorsal and basal margin are nearly parallel. The nacre is stained with epidermal matter as it usually is in shells of this form.

This specimen was kindly lent to me for description by Dr. Jay, who received but a single one from Sidney, New South Wales. In its general form and tuberculate exterior it resembles a cucumber.

UNIO CUNEOLUS. Plate 7, Fig. 3.

Testâ triangulari, compressâ, valdè inæquilaterali; valvulis subcrassis; natibus elevatis; epidermide luteâ, striatâ, radiis maculatis; dentibus cardinalibus parvis; lateralibus longis rectisque; margaritá albâ et iridescente.

Shell triangular, compressed, very inequilateral; valves rather thick; beaks elevated; epidermis yellow, striate, with spotted rays; cardinal teeth small; lateral teeth long and straight; nacre white and iridescent.

Hab. Holston River, Tenn. Mr. S. M. Edgar.
My Cabinet, and Cabinets of Mr. Edgar and Dr. Currey.
Diam. .6, Length 1, Breadth 1.4 inches.

Shell triangular, compressed, flattened on the sides, very inequilateral; substance of the shell thick before, thinner behind; beaks elevated; ligament short and thin; epidermis yellow, striate, with numerous green interrupted rays over the whole disk; cardinal teeth small, single in the right valve and double in the left; lateral teeth long and straight; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed on the under side of the cardinal tooth, cavity of the shell small: cavity of the beak angular and rather deep; nacre white and very iridescent.

Remarks.—I have before me two specimens of this species brought by Mr. Edgar from Tennessee. In form and size it approaches the *U. Barnesianus* (nobis,) but is more triangular, more flattened on the sides and has the marks of growth closer.

UNIO CINCINNATIENSIS. Plate 8, Fig. 4.

Testâ nodosâ, quadratâ, inflatâ, emarginatâ, inæquilaterali; valvulis crassis; natibus elevatis; epiderdime luteâ, valdè radiatâ; dentibus cardinalibus subgrandibus; lateralibus sublongis rectisque; margaritâ albâ.

Shell nodulous, quadrate, inflated, emarginate, inequilateral; valves thick; beaks elevated; epidermis yellow, much rayed; cardinal teeth rather large; lateral teeth rather long and straight; nacre white.

Hab. Ohio River at Cincinnati. T. G. Lea.
My Cabinet, and Cabinet of T. G. Lea.

Diam. 1.2, Length 1.5, Breadth 1.9 inches.

Shell with a row of nodules from the beak to the basal margin, quadrate, inflated, emarginate at basal and posterior margins, inequilateral; substance of the shell very thick, thinner before; beaks large and elevated; ligament short and thin; epidermis yellow, with numerous green capillary rays over the whole disk; cardinal teeth rather large, double in both valves; lateral teeth rather long, thick and straight; anterior cicatrices distinct; posterior cicatrices confluent: dorsal cicatrices placed on the under side of the cardinal tooth; cavity of the shell rather deep; cavity of the beak small and angular; nacre milky white.

Remarks.—This is a very rare species. A very imperfect specimen was sent to me by my brother more than ten years since. I then thought that it might be a variety of the species which I afterwards called *U. perplexus.* Since then I have seen seven specimens, and their constant difference from the *perplexus* clearly marks their specific distinction. It is very closely allied to another species described by Mr. Conrad under the name of *U. Phillipsii.* It differs from it, however, in having the tubercles in a more regular manner arranged over the medial part of the disk.

The rays are so numerous in some specimens as to give a dark green hue to the whole disk, except at the anterior margin, where it is always more or less yellow. The umbonial slope is elevated, and in some individuals disposed to be tuberculate.

UNIO STONENSIS. Plate 8, Fig. 5.

Testâ ellipticâ, valdè compressâ, planulatâ, valdè inæquilaterali; valvulis crassis; natibus prominulis, ad apices undulatis; epidermide luteo-fuscâ; dentibus cardinalibus parvis; lateralibus longis, crassis curvisque; margaritâ salmonis colore tinctâ et iridescente.

Shell oval, very much compressed, flat-sided, very inequilateral; valves thick; beaks slightly prominent, undulated at the tip; epidermis yellowish-brown; cardinal teeth small; lateral teeth long, thick and curved; nacre salmon-coloured and iridescent.

Hab. Stone's River, Tenn. S. M. Edgar.
My Cabinet.

Diam. .1, Length 1.9, Breadth 3.3 inches.

Shell oval, very much compressed, flat-sided, very inequilateral; biangular behind; substance of the shell thick; beaks slightly prominent and minutely undulate at tip; ligament long and thick; epidermis yellowish-brown, roughly striate; cardinal teeth small, striate, lobed; lateral teeth long, curved and thick; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in a row behind the cardinal tooth; cavity of the shell very shallow; cavity of the beaks scarcely perceptible; nacre salmon-coloured and iridescent.

Remarks.—This fine shell seems to be pretty closely allied to *U. gibbosus*, Barnes. It is, however, a less transverse species, more compressed and more equilateral. The nacre is very fine and in this specimen salmon-coloured,—this tint may not prove to be permanent. Having but a single specimen before me, I am unable to say whether it occurs rayed. This individual is entirely without rays. The transverse striæ are rough.

UNIO LESUEURIANUS. Plate 8, Fig. 6.

Testâ subrotundâ, subinflatâ; valvulis crassis; natibus prominentibus; epidermide fuscâ, striatâ, radios maculatos habente; dentibus cardinalibus subgrandibus; lateralibus parvis rectisque; margaritâ albâ et iridescente.

Shell nearly round, somewhat inflated; valves thick; beaks prominent; epidermis brown, striate with spotted rays; cardinal teeth rather large; lateral teeth small and straight; nacre white and iridescent.

Hab. Cany Fork and Holston Rivers, Tenn. S. M. Edgar.
My Cabinet, and Cabinet of Mr. Edgar.

Diam. .7, Length 1.3, Breadth 1.5 inches.

Shell nearly round, somewhat inflated; substance of the shell thick, thinner behind; beaks prominent; ligament rather long and thin; epidermis brown, striate, with several interrupted rays over the umbones; lines of growth approximate; cardinal teeth rather large, single in the right and double in the left valve; lateral teeth small and straight; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed under the cardinal tooth; cavity of the shell rather deep and rounded; cavity of the beaks deep and angular; nacre white and iridescent.

Remarks.—Two specimens only of this species were brought by Mr. Edgar. It seems to be most nearly allied to *U. subrotundus* (nobis;) but differs in the rays, in being less polished, in being less inflated and particularly in having the marks of growth more approximate, and more numerous.

I name this shell after the distinguished naturalist and companion of Peron, my old friend C. A. Lesueur.

UNIO DACTYLUS. Plate 9, Fig. 7.

Testâ transversâ, subinflatâ; valvulis tenuibus; natibus prominulis; epidermide luteâ; dentibus cardinalibus minimis, erectisque; lateralibus longis subcurvisque; margaritâ albâ et iridescente.

Shell transverse, rather inflated; valves thin; beaks somewhat prominent; epidermis yellow; cardinal teeth very small and erect; lateral teeth long and rather curved; nacre white and iridescent.

Hab. Cany Fork River, Tenn. S. M. Edgar.
My Cabinet, and Cabinet of Mr. Edgar.

Diam. .6, Length .1, Breadth 1.9 inches.

Shell triangular, inflated, narrow-elliptical; substance of the shell thin, thicker before; beaks somewhat prominent; ligament rather long and thin; epidermis yellow; umbonial slope rounded; cardinal teeth very small, erect, pointed in the left valve, the anterior lobe being much the highest; lateral teeth long and rather curved; anterior cicatrix distinct; posterior cicatrix confluent; dorsal cicatrix placed in the centre of the cavity of the beaks; cavity of the shell rather deep and rounded; cavity of the beaks very shallow; nacre white and very iridescent at the posterior margin.

Remarks.—A single specimen only of this shell came in the collection from Mr. Edgar. It has no remarkable characteristics, yet it cannot be referred to any species known to me. It has some resemblance to *U. pictorum*, Lam., and is somewhat like *U. lanceolatus* (nobis,) but may be easily distinguished from both these species. I presume it is always without rays,—the individual before me having no trace of them.

UNIO BIANGULATUS. Plate 9, Fig. 8.

Testâ obovatâ, inflatâ, posticè biangulari; valvulis tenuibus; natibus subprominentibus; epidermide tenebroso-fuscâ; radiatâ; dentibus cardinalibus subgrandibus, elevatis; lateralibus subgrandibus curvisque; margaritâ albâ et iridescente.

Shell obovate, inflated, biangular behind; valves thin; beaks rather prominent; epidermis dark brown, rayed; cardinal teeth rather large, elevated; lateral teeth rather large and curved; nacre white and iridescent.

Hab. Cany Fork River, Tenn. Prof. Troost and Mr. S. M. Edgar.
My Cabinet, and Cabinets of R. O. Currey, M. D., Mr. Edgar and Prof. Troost.
Diam. 1.2, Length 1,8, Breadth 2.8 inches.

Shell obovate, inflated, biangular behind; substance of the shell thin, thicker before; beaks rather prominent, approximating the anterior margin; ligament rather long and thick; epidermis dark brown, sometimes yellowish, with indistinct interrupted rays on the posterior portion; umbonial slope subangular; posterior slope with an imperfect fold which makes a second angle; cardinal teeth rather large, erect, pointed, double in the left valve and single in the right; lateral teeth rather large and curved, lamellar near the termination; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices large and placed on the upper side of the cavity of the beaks; cavity of the shell large; cavity of the beaks rather deep and angular; nacre white and iridescent.

Remarks.—When the specimen is entirely perfect, the double angle of the posterior margin marks this shell very distinctly. It has some resemblance to a young *U. perdix* (nobis.) The nacre is very pearly and very thin, leaving a broader margin than usual. Three specimens out of four before me have interrupted rays indistinctly painted on the posterior part of the shell.

UNIO STRIGOSUS. Plate 9, Fig. 9.

Testâ transversâ, compressâ, valdè inæquilaterali, posticè biangulatâ; valvulis subtenuibus; natibus subprominentibus, compressis; epidermide tenebroso-fuscâ; dentibus cardinalibus parvulis; lateralibus longis subrectisque; margaritâ purpureâ et iridescente.

Shell wide, compressed, very inequilateral, biangular behind; valves rather thin; beaks somewhat prominent, compressed; epidermis dark brown; cardinal teeth very small; lateral teeth long and nearly straight; nacre purple and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .5, Length .1, Breadth 2.2 inches.

Shell wide, compressed, very inequilateral, biangular behind; substance of the shell rather thin; beaks somewhat prominent, compressed; ligament long and thin; epidermis dark brown; cardinal teeth very small and lobed; lateral teeth long and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed on the plate over the cavity of the beaks; cavity of the shell very shallow; cavity of the beaks scarcely perceptible; nacre purple and iridescent.

Remarks.—This species belongs properly to the group of which the *U. complanatus*, Soland, is the type. In outline it resembles *U. angustatus* (nobis,) but is a more compressed species. Two individuals only were received, one of which is nearly white in the nacre. The cardinal teeth are remarkably small, and, in the oldest specimen, stand nearly in the direction of the lateral teeth.

UNIO TENER. Plate 10, Fig. 10.

Testâ ellipticâ, valdè compressâ, valdè inæquilaterali; valvulis tenuibus; natibus subprominentibus; epidermide luteo-fuscâ; dentibus cardinalibus parvis; lateralibus longis subcurvisque; margaritâ albâ et iridescente.

Shell elliptical, much compressed, very inequilateral; valves thin; beaks rather prominent; epidermis yellowish brown; cardinal teeth small; lateral teeth long and rather curved; nacre white and iridescent.

Hab. Big Pigeon River, Tenn. S. M. Edgar.
My Cabinet.

Diam. .7, Length 1.3, Breadth 2.1 inches.

Shell elliptical, much compressed, very inequilateral, subbiangulate behind; substance of the shell thin, thicker before; beaks rather prominent; ligament long and thin; epidermis yellowish brown and obscurely rayed; cardinal teeth small, single in the right and double in the left valve; lateral teeth long and rather curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed under the plate between the lateral and cardinal teeth; cavity of the shell very shallow; cavity of the beaks very shallow and angular; nacre white and very iridescent on the posterior part.

Remarks.—A single specimen only of this species was taken by Mr. Edgar. In outline it nearly resembles *U. radiatus*, but is a thinner and flatter shell and with very indistinct rays.

UNIO TENNESSEENSIS. Plate 10, Fig. 11.

Testâ ellipticâ, transversâ, inflatâ; valvulis crassis; natibus subprominentibus; epidermide luteâ; dentibus cardinalibus magnis erectisque; lateralibus magnis subcurvisque; margaritâ albâ et iridescente.

Shell elliptical, wide, inflated; valves thick; beaks rather prominent; epidermis yellow; cardinal teeth large and erect; lateral teeth large and somewhat curved; nacre white and iridescent.

Hab. Stone's River, Tenn. S. M. Edgar.
My Cabinet.

Diam. 1.3, Length 1.9, Breadth 3 inches.

Shell elliptical, wide, inflated, more full over the umbonial slope; substance of the shell thick, thinner on the posterior portion; beaks rather prominent; ligament rather long; epidermis yellow, without rays, and coarsely wrinkled; umbonial slope very round; cardinal teeth large, erect, pointed, double in the left valve and single in the right; lateral teeth large, rather long, slightly curved and separated from the cardinal teeth; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices large and placed in the centre of the cavity of the beaks; cavity of the shell deep and rounded; cavity of the beaks small; nacre very white and iridescent at the posterior portion.

Remarks.—This is remarkable for its perfectly elliptical margin, its white nacre and roundness of the umbonial slope. It has somewhat the aspect of *U. stramineus* (Conrad) but differs from it in being a more perfect ellipse, in having less polish, and in the wrinkles being larger and more regular. It was taken by Mr. Edgar in Stone's River near Nashville, and I owe to that gentleman's kindness the specimen described.—The beaks in this are eroded, but they are perfect enough to present an appearance of radiate folds diverging from the tip of the beaks, like *U. delodontus* Lam. (*lacteolus*, Lea, Trans. Am. Phil. Soc. Vol. 5, page 8, Fig. 19,) and other South American species. Should these folds be found really to exist, when perfect specimens are had, this species will exhibit the only case yet observed among our *Uniones* with that character which is so common to those of South America.

UNIO AMŒNUS. Plate 10, Fig. 12.

Testâ ellipticâ, subcompressâ, valdè inæquilaterali; valvulis subcrassis; natibus subprominentibus; epidermide tenebrosâ, densè radiatâ; dentibus cardinalibus parvis, erectisque; lateralibus longis subcurvisque; margaritâ albâ et iridescente.

Shell elliptical, somewhat compressed, very inequilateral; valves rather thin; beaks somewhat prominent; epidermis dark, very much radiate; cardinal teeth small and erect; lateral teeth long and curved; nacre white and iridescent.

Hab. Holston River, Tenn. S. M. Edgar.
My Cabinet.

Diam. .7, Length 1.1, Breadth 1.9 inches.

Shell elliptical, somewhat compressed, very inequilateral, sub-emarginate at base; substance of the shell rather thick, thinner behind; beaks somewhat prominent; ligament rather long and thin; epidermis dark, with numerous green rays over nearly the whole disk; cardinal teeth small, double in both valves, erect and pointed; lateral teeth long and curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in the centre of the cavity of the beaks; cavity of the shell shallow; cavity of the beaks shallow and angular; nacre very pearly and iridescent.

Remarks.—A single specimen only of this species was taken by Mr. Edgar. It perhaps most nearly resembles *U. Medellinus* (nobis,) and *U. radiatus*. It is smaller and more transverse than the latter. Its pearly lustre is unusually fine. —In the individual before me the rays are thick and large.

UNIO OBTUSUS. Plate 11, Fig. 13.

Testâ obovatâ, inflatâ, posticè rotundatâ; valvulis subcrassis; natibus subprominentibus; epidermide luteâ, nitida; dentibus cardinalibus subgrandibus; lateralibus longis subrectisque; margaritâ albâ et iridescente.

Shell obovate, inflated, rounded behind; valves rather thick; beaks rather prominent; epidermis yellow, shining; cardinal teeth rather large; lateral teeth long and nearly straight; nacre white and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .9, Length 1.3, Breadth 2.2 inches.

Shell obovate, inflated, rounded behind; substance of the shell rather thick; beaks rather prominent; ligament rather short and thin; epidermis smooth, shining, yellow over the whole disk except on the posterior slope, which is dark brown; cardinal teeth rather large, double in both valves, erect, pointed; lateral teeth long and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices on the plate near to the cardinal tooth; cavity of the shell deep and rounded; cavity of the beaks rather deep and angular; nacre white and beautifully iridescent.

Remarks.—Three specimens of this species now under my examination differ but little from each other. The nacre of one on the posterior part is golden and very rich. This specimen has an indistinct ray upon it, the others are rayless, having a rich yellow surface. It has some resemblance to *U. cariosus*, Say, but is a more transverse shell, and differs in having the posterior slope entirely dark, while the *cariosus* is usually rayed on this part.

UNIO FATUUS. Plate 11, Fig. 14.

Testâ transversâ, compressâ, emarginatâ; valvulis subcrassis; natibus parvis; epidermide subviridi, radiatâ; dentibus cardinalibus parvis; lateralibus longis, subcurvisque; margaritâ albâ et iridescente.

Shell wide, compressed, emarginate; valves rather thick; beaks small; epidermis greenish, radiated; cardinal teeth small; lateral teeth long and somewhat curved; nacre white and iridescent.

Hab. Holston River, Tennessee. Dr. Currey.
My Cabinet, and Cabinet of Dr. Currey.

Diam. .8,	Length 1.3,	Breadth 2.7 inches.

Shell wide, compressed, emarginate; substance of the shell thin behind and thicker before; beaks small, rather compressed and placed near to the anterior margin; ligament long and thin; epidermis greenish with numerous obscure rays over the whole disk; umbonial slope rounded; cardinal teeth small, pointed, double in the left valve and single in the right; lateral teeth long, somewhat curved, separated from the cardinal teeth; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices nearly in the centre of the cavity of the beaks; cavity of the shell very shallow; cavity of the beaks very small; nacre white and iridescent.

Remarks.—This species has somewhat the aspect of a large *U. iris* (nobis,) and the outline of a young *U. subtentus* (Say.) The beaks are placed very near to the anterior margin. A single specimen came into my possession. More perfect ones may be found to possess more beautiful rays.

UNIO GEDDINGSIANUS. Plate 11, Fig. 15.

Testâ ellipticâ, subinflatâ; valvulis subtenuibus; natibus prominulis; epidermide fuscâ, radiatâ; dentibus cardinalibus compressis erectisque; lateralibus longis rectisque; margaritâ albâ vel salmonis colore tinctâ.

Shell elliptical, somewhat inflated; valves rather thin; beaks somewhat prominent; epidermis brown, radiated; cardinal teeth compressed and erect; lateral teeth long and straight; nacre white or salmon-coloured.

Hab. Congaree River, South Carolina. Prof. Ravenel.
My Cabinet, and Cabinet of Prof. Ravenel.

Diam. .8,	Length 1.3,	Breadth 2.4 inches.

Shell elliptical, somewhat inflated, biangulate behind; substance of the shell rather thin; beaks somewhat prominent; ligament long and thin; epidermis brown with numerous dark green rays over the whole disk; cardinal teeth compressed, elevated, deeply divided in the left valve; lateral teeth very long and straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed under the plate between the cardinal and lateral teeth; cavity of the shell rather shallow; cavity of the beaks small and somewhat angular; nacre white or salmon-coloured.

Remarks.—Professor Ravenel sent me two specimens of this species some time since. I have delayed describing it under the impression that it might prove to be only a variety of *confertus* (nobis.) After a careful examination, however, it appears to me to be distinct, and I propose to give it the name of my friend Prof. Geddings of Charleston. It is a more transverse shell than *confertus*, is less inflated, and less elevated on the umbonial slope. The older specimen is partly salmon-coloured, the younger white in the nacre.

UNIO STRIATUS. Plate 12, Fig. 16.

Testâ ellipticâ, compressâ; valvulis tenuibus; natibus subprominentibus; epidermide striatâ, rubiginis colore; dentibus cardinalibus parvis; lateralibus sublongis subrectisque; margaritâ salmonis colore tinctâ et iridescente.

Shell elliptical, compressed; valves thin; beaks rather prominent; epidermis striate, rust-coloured; cardinal teeth small; lateral teeth rather long and nearly straight; nacre salmon-coloured and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .3, Length .9, Breadth 1.3 inches.

Shell elliptical, compressed; substance of the shell thin, thicker behind; beaks rather prominent; epidermis striate in thin laminæ; ligament short and thin; cardinal teeth small, double in the left valve and single in the right; lateral teeth rather long and nearly straight; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices very small and placed nearly under the cardinal tooth; cavity of the shell shallow; cavity of the beaks very shallow and nearly angular; nacre salmon-coloured, more intense under the beaks, iridescent.

Remarks.—A small species having some resemblance to *U. Ravenelianus*, (nobis,) but not so thick, and more transverse. It is remarkable for the close laminæ of the epidermis which give the whole disk (except at the beaks) a rough appearance. The epidermis is lighter about the beaks.

Unio tortivus. Plate 12, Fig. 17.

Testâ ellipticâ, compressâ, emarginatâ; valvulis subtenuibus; natibus subprominentibus, compressis; epidermide tenebroso-fuscâ, striatâ; dentibus cardinalibus parvulis; lateralibus longis curvisque; margaritâ purpureâ et iridescente.

Shell elliptical, compressed, emarginate; valves rather thin; beaks somewhat prominent, compressed; epidermis dark brown, striate; cardinal teeth very small; lateral teeth long and curved; nacre purple and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .6, Length .1, Breadth 1.9 inches.

Shell elliptical, compressed, emarginate at base; substance of the shell rather thin; beaks somewhat prominent, compressed; ligament rather long and thin; epidermis dark brown, striate; cardinal teeth very small and lobed; lateral teeth long and curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in the centre of the cavity of the beaks; cavity of the shell very shallow; cavity of the beaks very shallow; nacre purple and iridescent.

Remarks.—This species belongs to that group of which the *U. complanatus*, may be considered the type, the nacre of which is usually purple, but sometimes white and salmon. The four specimens which are before me have all more or less purple, one being deeply coloured with it and tinged with purple, while another is almost white. It differs from the *complanatus* in being more compressed and in having a very small cardinal tooth. It is also a much smaller species. At the posterior margin there is a disposition to bi-angulation.

Unio lenior. Plate 12, Fig. 18.

Testâ obovatâ, inflatâ; valvulis tenuibus; natibus vix prominentibus, ad apices undulatis; epidermide luteâ, densissimè radiatâ; dentibus cardinalibus compressis; lateralibus parvis; margaritâ albâ et iridescente.

Shell obovate, inflated; valves thin; beaks scarcely prominent, at the tips undulated; epidermis yellow, thickly rayed; cardinal teeth compressed; lateral teeth small; nacre white and iridescent.

Hab. Stone's River, Tenn. S. M. Edgar.
My Cabinet, and Cabinet of Mr. Edgar.
Diam. .5, Length .7, Breadth 1 inch.

Shell obovate, inflated; substance of the shell thin; beaks scarcely prominent, with minute undulations at the tip; ligament very small and thin; epidermis yellow, with numerous capillary rays over nearly the whole disk; cardinal teeth compressed; lateral teeth small and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed on the under side of the plate between the cardinal and lateral teeth; cavity of the shell deep and rounded; cavity of the beaks rather deep and angular; nacre white and iridescent.

Remarks.—One perfect individual and an odd valve were all which were taken by Mr. Edgar. Both these specimens are evidently females having the umbonial slope enlarged, and the dentate margin which so well characterizes the sex. These specimens may not be of full growth, but I doubt if they occur much larger. This species has some resemblance to a young *U. brevidens,* (nobis,) but is a very much smaller and thinner shell, and differs in the rays.

UNIO NITENS. Plate 12, Fig. 19.

Testâ ellipticâ, transversâ, subinflatâ; valvulis subtenuibus; natibus subprominentibus; epidermide tenebroso-fuscâ; dentibus cardinalibus parvis, elevatis; lateralibus longis subrectisque; margaritâ cupreâ, splendidissimâ et iridescente.

Shell elliptical, wide, somewhat inflated; valves rather thin; beaks somewhat prominent; epidermis dark brown; cardinal teeth small, erect; lateral teeth long and nearly straight; nacre copper-coloured, very splendid and iridescent.

Hab. Long Creek, Cocke Co., Tenn. S. M. Edgar.
My Cabinet, and Cabinets of Mr. Edgar, Dr. R. O. Currey and Prof. Troost.
Diam. .7, Length 1.2, Breadth 1.9 inches.

Shell elliptical, transverse, somewhat inflated, substance of the shell thin, thicker before; beaks rather prominent and slightly undulate at tip; ligament rather short and thin; epidermis dark brown, obscurely rayed; umbonial slope rounded; cardinal teeth small, erect, pointed, double in the left and single in the right valve; lateral teeth long, nearly straight, separated from the cardinal tooth; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed directly in the cavity of the beaks; cavity of the shell rather deep; cavity of the beak shallow and angular; nacre of a very splendid copper-colour, whitish on the anterior basal margin, dark in the cavity and posterior part, beautifully iridescent.

Remarks.—The bright and splendid hue of the nacre of this species is superior to any other which has come under my notice. In outline it is closely allied to *U. obscurus* (nobis,) but its fine nacre easily distinguishes it. In young specimens may be observed indistinct small rays over the posterior part of the disk. Two of the specimens before me are enlarged at the posterior basal margin, indicating their being females.

UNIO LINEATUS. Plate 12, Fig. 20.

Testâ ellipticâ, inflatâ; valvulis tenuibus; natibus subprominentibus, ad apices undulatis; epidermide luteâ, radiatâ, politâ; dentibus cardinalibus parvis, lamellatis; lateralibus parvis, subcurvisque; margaritâ salmonis colore tinctâ et iridescente.

Shell elliptical, inflated; valves thin; beaks rather prominent, undulate at the tip; epidermis yellow, radiated, polished; cardinal teeth small, lamellar; lateral teeth small and somewhat curved; nacre salmon-coloured and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .6, Length .9, Breadth 1.4 inches.

Shell elliptical, inflated, with distinct linear rays over the whole disk except on the posterior slope; substance of the shell thin; beaks rather prominent, undulate at the tip; ligament short and rather thick; epidermis yellow and finely polished; cardinal teeth small, compressed, disposed to be double in both valves; lateral teeth small and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices on the plate between the cardinal and lateral teeth; cavity of the shell large; cavity of the beaks rather deep and angular; nacre salmon-coloured and iridescent.

Remarks.—This species is allied to the *U. occidens*, (nobis,) but is a much smaller shell. The three specimens under my examination are all the same size, and might easily be mistaken for young individuals of the *occidens*. It differs in the rays, the undulation of the beaks and the size. The rays are slightly interrupted and are visible through the beautiful and delicate nacre.

UNIO ATRO-MARGINATUS. Plate 13, Fig. 21.

Testâ plicatâ, oblongâ, compressâ; valvulis subtenuibus; natibus prominulis; epidermide tenebrosâ; dentibus cardinalibus parvis; lateralibus longis subrectisque; margaritâ purpureâ et valdè iridescente.

Shell plicate, oblong, compressed; valves rather thin; beaks somewhat prominent; epidermis very dark; cardinal teeth small; lateral teeth long and nearly straight; nacre purple and very iridescent.

Hab. Chattahooche River, Columbus, Geo. Dr. Boykin.
My Cabinet.

Diam. .5, Length 1.2, Breadth 1.9 inches.

Shell folded over the whole disk, oblong, compressed; substance of the shell rather thin; beaks somewhat prominent; ligament rather short and thin; epidermis very dark, almost black; posterior slope carinate and covered with regular, nearly parallel folds; cardinal teeth small, double in the left and single in the right valve; lateral teeth long and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed nearly in the centre of the cavity of the shell; cavity of the shell very shallow; cavity of the beaks very small; nacre purple and very iridescent.

Remarks.—Two specimens only of this distinct and interesting species were received among the shells from Dr. Boykin. In outline and in the folds it resembles the *Margaritana rugosa*, (*Alasmodonta rugosa*, Barnes.) It differs from it not only generically in the teeth, but in the colour of the epidermis, in the nacre and in having folds over the whole disk. The two specimens before me have a beautiful purple nacre shading off into white towards the cavity of the beaks. The folds causing undulations within the cavity display the fine iridescence of the nacre. The margin is remarkably broad and black. It is very likely that, when numerous specimens are examined, the nacre may be found to vary, and some prove entirely white and some salmon-coloured as in the *Unio complanatus*.

UNIO BOYKINIANUS. Plate 13, Fig. 22.

Testâ alatâ, plicatâ, triangulari, subcompressâ; valvulis crassis; natibus prominulis; epidermide tenebroso-fuscâ; dentibus cardinalibus parvis; lateralibus sublongis; margaritâ albâ et iridescente.

Shell winged, folded, triangular, rather compressed; valves thick; beaks somewhat prominent; epidermis dark brown; cardinal teeth small; lateral teeth rather long; nacre white and iridescent.

Hab. Chattahoochee River, Columbus, Geo. Dr. Boykin.
My Cabinet.

Diam. .1.2, Length 2.2, Breadth 2.8 inches.

Shell winged, folded all over the disk, triangular; rather compressed; substance of the shell thick; beaks somewhat prominent; ligament short and thin; epidermis dark brown; cardinal teeth small, apparently divided into three lobes in each valve; lateral teeth rather long and slightly curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices on the under side of the plate near to the cardinal tooth; cavity of the shell rather deep; cavity of the beak angular; nacre white and iridescent.

Remarks.—I owe to the kindness of Dr. Boykin this fine species, as well as many others herein described from the same locality. It has perhaps more resemblance to *U. Nicklinianus* (nobis,) than to any other species in its outline, and its folds, which latter are, however, larger. On the posterior slope the folds are very regular, on the other part, less so. I have had in my possession many years a young individual from the late Judge Tait, much resembling this, and it may prove to be the same species. The geographical distribution of the species of this family is of great interest and very important in many respects, as we find a marked distinction in nearly all the different species respectively inhabiting the waters east and west of the mountains, as I have elsewhere observed. For many years I have been exceedingly desirous of obtaining the shells inhabiting the approximating waters which fall respectively into the Atlantic on one side, and the Gulf of Mexico east of the Mississippi, on the other. The Chattahoochee is the first river of magnitude rising in the mountains which descends to the gulf, unless the Flint river be excepted. Among the species from this locality now under examination, I find three with folds (none with tubercles,) which, as we do not possess any in our eastern rivers, may be considered to have the western character. The remainder in part resemble our eastern species, but others again resemble the smooth ones of the West. I have made many attempts to obtain the shells of Ocmulgee river, the most southern of the Atlantic basin, without success. It would be exceedingly desirable to compare the species of the two basins, in order to designate the characters of those so nearly placed together in waters of so wide a drainage.

UNIO SUBANGULATUS. Plate 13, Fig. 23.

Testâ ellipticâ, subinflatâ, posticè subangulatâ; valvulis tenuibus; natibus subprominentibus; epidermide luteâ, radiatâ, politâ; dentibus cardinalibus subgrandibus, erectisque; lateralibus sublongis subrectisque; margaritâ salmonis colore tinctâ et iridescente.

Shell elliptical, somewhat inflated, subangulate behind; valves thin; beaks rather prominent; epidermis yellow, rayed, polished; cardinal teeth rather large and erect; lateral teeth rather long and nearly straight; nacre salmon-coloured and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .6, Length .1, Breadth 1.7 inches.

Shell elliptical, somewhat inflated, subangulate behind; substance of the shell thin; beaks rather prominent, slightly undulate at the tip; ligament rather short and thin; epidermis yellow, rayed over the whole disk, polished; cardinal teeth double in both valves, erect, pointed; lateral teeth rather long and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed on the under side of the cardinal tooth; cavity of the shell rather deep; cavity of the beaks small and angular; nacre salmon-coloured and iridescent.

Remarks.—In the examination of seven specimens of this species one proved to have a white nacre and another to have obsolete rays. The whole disk is usually covered with rays; the colour of the epidermis is of an ochry yellow.

UNIO PILARIS. Plate 14, Fig. 24.

Testâ rotundatâ, inflatâ; valvulis crassis; natibus elevatis; epidermide striatâ, tenebroso fuscâ; dentibus cardinalibus subgrandibus; lateralibus longulis subrectisque; margaritâ albâ.

Shell rounded, inflated; valves thick; beaks elevated; epidermis striate and dark brown; cardinal teeth rather large; lateral teeth rather long and nearly straight; nacre white.

Hab. French, Broad and Holston Rivers, East Tenn. S. M. Edgar.
My Cabinet, and Cabinets of Mr. Edgar and Dr. Troost.

Diam. .1, Length 1.4, Breadth 1.6 inches.

Shell rounded, inflated, solid; substance of the shell very thick; beaks elevated; ligament rather short and thick; epidermis with indistinct rays, striate, dark brown, becoming squamose towards the margin; lines of growth approximate; cardinal teeth rather large; lateral teeth rather long, thick, nearly straight; anterior cicatrices distinct; posterior cicatrices distinct, the smaller one being placed on the end of the lateral tooth; dorsal cicatrices placed on the under side of the cardinal tooth; cavity of the shell shallow, rounded; cavity of the beaks rather deep and angular; nacre milky white.

Remarks.—Mr. Edgar brought this species from East Tennessee, and kindly submitted several specimens to me. It seems to be naturally placed between *U. ebenus* and *U. subrotundus* (nobis,) and to resemble *U. maculatus*, Con. Mr. Edgar informs me that the animal is colourless.

UNIO TUBEROSUS. Plate 14, Fig. 25.

Testâ nodosâ, triangulari, emarginatâ; valvulis crassis; natibus elevatis; epidermide luteâ, striatâ; dentibus cardinalibus magnis; lateralibus parvis rectisque; margaritâ albâ.

Shell nodulous, triangular, emarginate; valves thick; beaks elevated; epidermis yellow, striate; cardinal teeth large; lateral teeth small and straight; nacre white.

Hab. Cany Fork and Cumberland Rivers, Middle Tenn. S. M. Edgar.
My Cabinet, and Cabinets of Mr. Edgar and Dr. Troost.

Diam. .1, Length 1.9, Breadth 2.2 inches.

Shell tuberculate nearly all over, triangular, emarginate at the posterior margin, depressed behind the umbonial slope; substance of the shell very thick before, thinner behind; beaks elevated; ligament rather short and thick; epidermis yellow, striate; cardinal teeth very large and double in both valves; lateral teeth very short, thick and straight; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed on the under side of the cardinal tooth; cavity of the shell shallow; cavity of the beaks very deep and angular; nacre white and silvery.

Remarks.—This is a very interesting species, and so closely resembles the *U. Metanever*, Raf. on one side, and *U. intermedius*, Con. on the other, that I at first, on seeing a single specimen, had doubts of the propriety of proposing for it a new name. I have before me five individuals brought by Mr. Edgar from Middle Tennessee, and also five specimens of *U. intermedius* which came from East Tennessee. The latter are all smaller than the *tuberosus*, and differ in having very few and very small tubercles, while the *tuberosus* is crowded with large ones. From the *metanever* it differs totally, in being without the large and regular tubercles of the umbonial slope, and the slope is less elevated. The nacre is very silvery, and with little or no iridescence. In one specimen there are a few indistinct green spots in the epidermis, which in fine young specimens may resemble the arrow-headed marks of the *metanever*.

UNIO PLENUS. Plate 14, Fig. 26.

Testâ triangulari, inflatâ; valvulis crassissimis; natibus elevatis, crassis; epidermide luteo-fuscâ, rugosâ; dentibus cardinalibus magnis; lateralibus brevibus subrectisque; margaritâ albâ et iridescente.

Shell triangular, inflated; valves very thick; beaks elevated and thick; epidermis yellowish-brown, wrinkled; cardinal teeth large; lateral teeth short and nearly straight; nacre white and iridescent.

Hab. Ohio River, near Cincinnati. T. G. Lea.
My Cabinet and Cabinet of T. G. Lea.

Diam. 1.1, Length 1.8, Breadth 1.6 inches.

Shell triangular, inflated, flattened before the umbonial slope, nearly equilateral, emarginate at base; substance of the shell very thick; beaks elevated, very thick and incurved, at the tip slightly undulate; ligament very short and rather thick; epidermis yellowish-brown, wrinkled, obscurely radiated on the umbones, the rays being lost in the wrinkles nearly half-way from the beaks; umbonial slope carinate; posterior slope much flattened; cardinal teeth large, single in the left and double in the right valve; lateral teeth short, nearly straight and disposed to be double in both valves; anterior cicatrices distinct; posterior cicatrices distinct, the smaller one being placed on the end of the lateral tooth; dorsal cicatrices placed on the under side of the cardinal tooth; cavity of the shell rather deep; cavity of the beaks deep and angular; nacre white and iridescent.

Remarks.—This species has embarrassed me for some time, as I have had, until recently, but few specimens. There is a close resemblance in the specimens before me both to the *U. obliquus*, Lam., and *U. trigonus*, (nobis.) It differs from both in being more rounded at the base, the emargination being very small. It is higher in the beaks than the *trigonus*, and more flattened there than the *obliquus*. In colour it approaches more to the former. The rays are less distinct than in the *obliquus*, rarely reaching more than half-way to the base. They vary very little in all the specimens I have examined. In two specimens out of fourteen before me, the nacre in the cavity of the shell is pale salmon colour.

UNIO HOLSTONENSIS. Plate 15, Fig. 27.

Testâ triangulari, solidâ, inflatâ; valvulis crassis; natibus magnis, elevatis; epidermide tenebroso-fuscâ, radiatâ; dentibus cardinalibus subgrandibus; lateralibus crassis brevibusque; margaritâ albâ et iridescente.

Shell triangular, solid, inflated; valves thick; beaks large and elevated; epidermis dark brown, radiated; cardinal teeth rather large; lateral teeth thick and short; nacre white and iridescent.

Hab. Holston River, Tenn. S. M. Edgar.
My Cabinet and Cabinet of Mr. Edgar.

Diam. .8, Length 1.1, Breadth 1.5 inches.

Shell triangular, solid, inflated; substance of the shell very thick, thinner behind; beaks elevated, large and solid; ligament short and rather thick; epidermis dark brown with several large interrupted rays over the umbones; cardinal teeth rather large; lateral teeth oblique, short, thick and nearly straight; anterior cicatrices distinct; posterior cicatrices distinct, the smaller one being placed on the end of the lateral tooth; dorsal cicatrices scarcely perceptible, placed on the inferior part of the cardinal tooth; cavity of the shell very shallow; cavity of the beaks shallow and rounded; nacre white and iridescent.

Remarks.—A single specimen only of this shell was received with those sent by Mr. Edgar. It is a well characterized little species. In outline it is somewhat like *U. trigonus*, (nobis,) but is more rounded, has not so sharp a carina and may be distinguished by its broad rays.

UNIO BOURNIANUS. Plate 15, Fig. 28.

Testâ triangulari, compressâ; valvulis crassis; natibus elevatis, incurvis, ad apices undulatis; epidermide luteâ, densè radiatâ; dentibus cardinalibus subgrandibus; lateralibus subcurvis; margaritâ albâ et iridescente.

Shell triangular, compressed; valves thick; beaks elevated, incurved and undulated at the tip; epidermis yellow, much radiated; cardinal teeth rather large; lateral teeth somewhat curved; nacre white and iridescent.

Hab. Scioto River, near Chillicothe, Ohio. A. Bourne.
My Cabinet, and Cabinet of Mr. Bourne.

Diam. .7, Length 1.2, Breadth 1.2 inches.

Shell triangular, very much compressed behind the umbonial slope, swollen over the umbones; substance of the shell very thick, thinner towards the posterior basal margin; beaks elevated, very thick and solid, incurved and undulated at the apex; ligament short and thin; epidermis yellow with numerous interrupted rays nearly over the whole disk, the lines of growth being very distinct; cardinal teeth rather large and broad; lateral teeth thick and somewhat curved; anterior cicatrices distinct, the superior one very deep; posterior cicatrices distinct, and placed on the end of the lateral tooth; dorsal cicatrices placed rather under the cardinal tooth; cavity of the shell shallow; cavity of the beaks shallow and angular; nacre white and iridescent.

Remarks.—This species seems only to have been observed by Mr. Bourne, by whose kindness I have before me the two specimens found by him. In outline, general form and solidity it resembles most *U. pyramidatus*, (nobis.) It differs entirely in the epidermis being yellow and having rays, and in the nacre which has no appearance of colour whatever in either specimen. In one individual beautiful green rays cover the disk—in the other they do not reach to the anterior margin. The epidermis in both is remarkably yellow. I name it after the naturalist Mr. Bourne, who has first observed it.

UNIO PAULUS. Plate 15, Fig. 29.

Testâ ellipticâ, inflatâ, minimâ; valvulis crassis; natibus subprominentibus; epidermide subnigrâ; dentibus cardinalibus parvis; lateralibus longis curvisque; margaritâ albâ et iridescente.

Shell elliptical, inflated, very small; valves thick; beaks somewhat prominent; epidermis nearly black; cardinal teeth small; lateral teeth long and curved; nacre white and iridescent.

Hab. Chattahoochee River, Columbus, Georgia. Dr. Boykin.
My Cabinet.

Diam. .4, Length .6, Breadth .9 inches.

Shell elliptical, inflated, very small; substance of the shell thick, thinner behind; beaks somewhat prominent; ligament short and thin; epidermis nearly black; cardinal teeth small, disposed to be double in both valves; lateral teeth long and curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed on the inferior part of the tooth; cavity of the shell deep; cavity of the beaks very small; nacre white, pearly and beautifully iridescent on the posterior part.

Remarks.—A single specimen only of this species was received. It seems to be most nearly allied to *U. parvus,* Barnes, but differs in being a smaller species and having a thicker nacre.

More recently I received from J. H. Couper, Esq., of Hopeton near Darien three specimens of this species, one of which is sub-carinate on the umbonial slope. A second one is enlarged posteriorly exhibiting the female character. All of the three are rather smaller than that received from Dr. Boykin.

UNIO EDGARIANUS. Plate 15, Fig. 30.

Testâ triangulari, compressâ, emarginatâ; valvulis crassis, natibus elevatis; epidermide luteâ, valdè radiatâ; dentibus cardinalibus magnis, lateralibus rectis; margaritâ albâ et iridescente.

Shell triangular, compressed, emarginate; valves thick; beaks elevated; epidermis yellow, much radiated; cardinal teeth large; lateral teeth straight; nacre white and iridescent.

Hab. Holston River, Tenn. Prof. Troost and Dr. Currey.
" Tennessee River, at Florence, Ala. Mr. Dutton.
My Cabinet, and Cabinets of Mr. Edgar, Dr. Currey and Prof. Troost.

Diam. .8, Length 1.2, Breadth 1.3 inches.

Shell triagular, compressed, emarginate at base, flattened or widely furrowed before the umbonial slope; substance of the shell thick; beaks elevated and thick; ligament small, linear; epidermis yellow, with numerous or large dark green rays over nearly the whole disk; umbonial slope carinate; cardinal teeth large, pointed; lateral teeth oblique and straight; anterior cicatrices distinct; posterior cicatrices distinct, the smaller one being placed on the end of the lateral tooth; dorsal cicatrices small, placed on the upper side of the cavity of the beaks; cavity of the shell very shallow; cavity of the beaks small and angular; nacre white and iridescent.

Remarks.—Two specimens only were received by me from Mr. Edgar, to whom I dedicate it. It is an interesting little species, and is remarkable for its form and the dark green rays, which almost cover the yellow ground. The larger specimen has a wide furrow nearly down the centre of the valve from the beak—the smaller one is only flattened there. In both specimens the posterior slope is devoid of rays.

UNIO DOLABELLOIDES. Plate 15, Fig. 31.

Testâ subrotundâ, subinflatâ; valvulis crassissimis; natibus valdè elevatis; epidermide fuscâ, radiatâ; dentibus cardinalibus minimis; lateralibus brevibus rectisque; margaritâ albâ et iridescente.

Shell rather round, somewhat inflated; valves very thick; beaks much elevated; epidermis brown, radiated; cardinal teeth very small; lateral teeth short and straight; nacre white and iridescent.

Hab. Holston River, Tenn. S. M. Edgar.
My Cabinet, and Cabinet of Mr. Edgar.

Diam. .9, Length 1.3, Breadth 1.3 inches.

Shell rather round, somewhat inflated, flat before the umbonial slope; substance of the shell very thick; beaks very much elevated and thick; ligament very short; epidermis brown, with broad interrupted rays behind the umbonial slope; umbonial slope sub-carinate; cardinal teeth very small and rather flattened; lateral teeth short and straight, with a broad plate intervening between them and the cardinal tooth; anterior cicatrices distinct; posterior cicatrices distinct, the smaller one being placed on the end of the lateral tooth; dorsal cicatrices very small and placed on the upper side of the cavity of the beaks; cavity of the shell shallow; cavity of the beaks angular; nacre white and iridescent.

Remarks.—Mr. Edgar procured this species when on a geological tour with Professor Troost up the Holston River. A single specimen only is in my possession, but its characters are so distinct that I do not hesitate to propose it as a new species. It seems to be between *U. undatus*, (Barnes,) and *U. Cor*, (Conrad.) The specimen before me is remarkable for the broad rays extending to the basal margin behind the umbonial slope on the flattened part of the side of the valve. The beaks of the specimen being eroded, it is impossible to say if the tips be undulated or not.

UNIO BOYDIANUS. Plate 16, Fig. 32.

Testâ obovatâ, subinflatâ, valdè inæquilaterali; valvulis subtenuibus; natibus subprominentibus, ad apices undulatis; epidermide luteo fuscâ; dentibus cardinalibus compressis; lateralibus longis subrectisque; margaritâ albâ et iridescente.

Shell obovate, rather inflated, very inequilateral; valves rather thin; beaks rather prominent, undulate at the tip; epidermis yellowish-brown; cardinal teeth compressed; lateral teeth long and nearly straight; nacre white and iridescent.

Hab. Oak Orchard Creek, Orleans County, N. Y. Dr. Boyd.
My Cabinet, and Cabinet of Dr. Jay.

Diam. .8, Length 1.2, Breadth 1.9 inches.

Shell obovate, rather inflated, very inequilateral, subangulate before, with regular, rather close and nearly equidistant marks of growth; substance of the shell rather thin, thicker before; beaks rather prominent, with small undulations at the tip; ligament rather short and thin; epidermis yellowish-brown, striate; cardinal teeth compressed, double in both valves; lateral teeth long and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices on the under side of the cardinal tooth; cavity of the shell rather deep and rounded; cavity of the beaks shallow and subangular; nacre white and iridescent.

Remarks.—Dr. Jay kindly sent me two specimens of this shell some time since. They were collected by Dr. Boyd, Assistant State Geologist. One of them has a few rays behind, the other is without rays. The anterior slope in both specimens is truncate, so much so in the smaller one, as to induce me to believe it to be deformed. It is perhaps most nearly allied to *U. ochraceus*, Say.

Unio Sloatianus. Plate 16, Fig. 33.

Testâ plicatâ, oblongâ, subcompressâ, valdè inæquilaterali; valvulis crassis; natibus subprominentibus; epidermide subnigrâ; dentibus cardinalibus subgrandibus; lateralibus crassis longisque; margaritâ albâ et purpureâ.

Shell plicate, oblong, rather compressed, very inequilateral; valves thick; beaks somewhat prominent; epidermis nearly black; cardinal teeth rather large; lateral teeth thick and long; nacre white and purple.

Hab. Chattahoochee River, Georgia. L. W. Sloat.

My Cabinet, and Cabinets of Dr. Jay and Mr. Sloat of Mobile.

Diam. 1.5, Length 2.3, Breadth 4.2 inches.

Shell folded, oblong, rather compressed, very inequilateral, biangular behind; substance of the shell thick; beaks somewhat prominent; ligament long and thick; epidermis nearly black; cardinal teeth rather large and striate; lateral teeth thick and long; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed under the plate between the cardinal and lateral teeth; cavity of the shell shallow; cavity of the beaks shallow and angular; nacre white with purple tints, iridescent behind.

Remarks.—The specimen described was kindly lent to me by Dr. Jay, who received it of Mr. Sloat, the latter gentleman having found but two specimens. The specimen quoted as being in my Cabinet, was sent to me by Dr. Boykin of Columbus, Georgia. I have classed it with the *Sloatianus*, with some hesitation, as it differs in being a thicker and more inflated shell, in being more plicate, and in having an angle on the umbonial slope. The specimen is a depauperated one, and when more perfect ones are observed, other characters may be found, which would render it necessary to make a distinct species of it.

Unio incrassatus. Plate 16, Fig. 34.

Testâ plicatâ, triangulari, subinflatâ; valvulis crassis; natibus subprominentibus; epidermide subnigrâ; dentibus cardinalibus parvis; lateralibus longis subrectisque; margaritâ salmonis colore tinctâ, vel purpureâ vel albâ et iridescente.

Shell plicate, triangular, rather inflated; valves thick; beaks somewhat prominent; epidermis nearly black; cardinal teeth small; lateral teeth long and nearly straight; nacre salmon-coloured, purple or white and iridescent.

Hab. Chattahoochee River, near Columbus, Georgia. Dr. Boykin.
My Cabinet, and Cabinet of Mr. Nicklin.
Diam. .9, Length, 1.4 Breadth 2.2 inches.

Shell folded on the posterior slope, triangular, rather inflated; substance of the shell thick, thinner behind; beaks somewhat prominent; ligament short and thick; epidermis nearly black; cardinal teeth small, lobed and striate; lateral teeth long and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed on the under side of the plate between the cardinal and lateral teeth; cavity of the shell rather shallow; cavity of the beaks shallow and subangular; nacre salmon-coloured, purple or white, and very iridescent behind.

Remarks.—Specimens of various ages of this species were kindly sent to me by Dr. Boykin. In general outline and appearance it closely resembles *U. crassidens,* Lam., but is a much smaller species. It belongs to that great group of which the *U. complanatus,* may be considered the type. Among the numerous specimens before me, the salmon colour prevails greatly, purple being the rarest. In the young specimens obscure rays may be observed, in the adults the umbonial slope is usually angular, and bounds the folds, which are not numerous.

UNIO DELPHINUS. Plate 17, Fig. 35.

Testâ alatâ, latâ, compressâ, posticè biangulatâ, valdè inæquilaterali; alâ elevata, acuminatâ, duplici; valvulis subcrassis; natibus vix prominentibus; epidermide tenebroso-fuscâ; dentibus cardinalibus parvis, crenulatis; lateralibus longissimis rectisque; margaritâ albâ et iridescente.

Shell winged, wide, compressed, biangular behind, very inequilateral; wing high, acuminate and double; valves somewhat thick; beaks scarcely prominent; epidermis dark brown; cardinal teeth small, crenulate; lateral teeth very long and straight; nacre white and iridescent.

Hab. New Holland.? G. Von den Busch, M. D.
My Cabinet, and Cabinets of Dr. Von den Busch and Mr. Gruner of Bremen.
Diam. 1.2, Length 3.6, Breadth 5.5 inches.

Shell winged, wide, compressed, biangular behind, subangular on the umbonial slope, with numerous very minute granulations over the disk, very inequilateral; wing high, duplex, terminating in two points, the anterior one being the highest and acutely pointed; substance of the shell rather thick; beaks scarcely prominent; ligament concealed, except the posterior part, which is spread out on the valve; epidermis very dark brown; cardinal teeth small, crenulate; lateral teeth very long and straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in a row in the cavity of the beaks; cavity of the shell very shallow; cavity of the beaks exceedingly small; nacre white and beautifully iridescent.

Remarks.—Since I described the *U. cucumoides*, from New South Wales, I have received the above described species from Dr. Von den Busch, and by his kindness I am permitted to place it in my Cabinet. It is certainly among the most curious and interesting species which have been observed. The duplex form of the wing is very remarkable. The early growth rises almost perpendicularly above the beaks to a point, the succeeding growth forming its symphynote fold in a horizontal line, sets off much below the apex of the first growth. The whole presents the appearance of a part being broken out. This, however, is by no means the case. It is a character, and we may observe it in a less degree, but still in a perfect manner in the very young of the *U. lævissimus*, (nobis,) which usually if not always at the second growth on the wing, takes a new starting point to form the fold over the ligament. The cardinal teeth are very remarkable, presenting but a small cleft, while the crenulations fill up the space connected with the lateral tooth, in this resembling the *Iridina*. The margin anterior to the beaks presents the appearance of there having been a wing. Immediately before the cardinal tooth there is a remarkable angular notch in the nacre filled up with laminated epidermal matter. The anterior cicatrices have the peculiarity mentioned in the *U. cucumoides*, but the three cicatrices are here perfectly distinct. The epidermis is minutely striate over most of the disk; but over the middle part, and on the wing, there may be observed with a lens numerous very remarkable, minute, round granulations.

Dr. Von den Busch informs me, that he obtained this shell from his friend Mr. Gruner, who, from "its similarity with a dolphin," proposed the name of *delphinus*, which I have adopted. As the vessel which brought this shell also visited some of the islands of the Indian Ocean, Mr. Gruner thinks there may be some doubt of its inhabiting New Holland.*

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* Since this paper went to press, a letter received from Dr. Von den Busch, informs me that this shell came from the "river Souzi, on the coast of Malacca."

UNIO PUSILLUS. Plate 18, Fig. 36.

Testâ ellipticâ, subcompressâ, posticè angulatâ; valvulis subtenuibus; natibus subprominentibus; epidermide tenebroso-fuscâ, politâ; dentibus cardinalibus minimis; lateralibus longis subcurvisque; margaritâ albâ et iridescente.

Shell elliptical, rather compressed, angular behind; valves rather thin; beaks rather prominent; epidermis dark brown, polished; cardinal teeth very small; lateral teeth long and somewhat curved; nacre white and iridescent.

Hab. Ogechee River, Georgia, Major Le Conte.
My Cabinet, and Cabinet of Major Le Conte.

Diam. .5, Length .7, Breadth 1.2 inches.

Shell elliptical, rather compressed, angular behind; umbonial slope angular; substance of the shell rather thin; beaks rather prominent; ligament small and thin; epidermis dark brown, darker on the posterior slope; polished, furnished with small obscure rays; cardinal teeth very small; lateral teeth long and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed on the under side of the plate between the cardinal and lateral teeth; cavity of the shell small; cavity of the beaks very shallow and angular; nacre white and iridescent.

Remarks.—Some years since several specimens of this shell were kindly sent to me by Major Le Conte. Fearing that they were young shells of some known species, I deferred describing them. I have not since been able to place them with any known species, and am now persuaded that they are distinct. This species is somewhat allied to *U. complanatus.*

UNIO JAVANUS. Plate 18, Fig. 37.

Testâ ellipticâ, subinflatâ, valdè inæquilaterali, posticè subbiangulatâ; valvulis subcrassis; natibus vix prominentibus; epidermide luteo-fuscâ; dentibus cardinalibus minimis; lateralibus longis curvisque; margaritâ albâ et iridescente.

Shell elliptical, rather inflated, very inequilateral, subbiangular behind; valves rather thick; beaks scarcely prominent; epidermis yellowish-brown; cardinal teeth very small; lateral teeth long and curved; nacre white and iridescent.

Hab. Java. G. Von den Busch, M. D.
My Cabinet, and Cabinet of Dr. Von den Busch of Bremen.

Diam. .8, Length 1.3, Breadth 2.2 inches.

Shell elliptical, rather inflated, very inequilateral, subbiangular and compressed behind; substance of the shell rather thick; beaks scarcely prominent; ligament rather short and thin; epidermis smooth, shining, yellowish brown, very dark on the posterior slope; cardinal teeth very small, double in the right, and single in the left valve; lateral teeth long and curved; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices placed under the plate between the cardinal and lateral teeth; cavity of the shell rather deep; cavity of the beaks rather shallow; nacre white and iridescent.

Remarks.—This species has in its exterior somewhat the appearance of a small *Anodonta fluviatilis*, (nobis.) The posterior and dorsal margins are sinuous. The first grown is large. The second and third are approximate. The beaks of the only specimen I have before me are eroded, but the small undulations visible on the posterior slope induce me to believe that when perfect individuals are observed, the tip will be found to be finely undulate. The cardinal teeth are remarkably small.

UNIO ORIENTALIS. Plate 18, Fig. 38.

Testâ transversâ, subinflatâ, valdè inæquilaterali; valvulis subcrassis; natibus subprominentibus, ad apices undulatis; epidermide luteâ, nitidâ; dentibus cardinalibus longis; lateralibus longis subcurvisque; margaritâ albâ et iridescente.

Shell wide, somewhat inflated, very inequilateral; valves somewhat thick; beaks slightly prominent, undulate at the tip; epidermis yellow, shining; cardinal teeth long; lateral teeth long and somewhat curved; nacre white and iridescent.

Hab. Java.? G. Von den Busch, M. D.
My Cabinet, and Cabinet of Dr. Von den Busch.

Diam. .4, Length .7, Breadth 1.5 inches.

Shell wide, somewhat inflated, very inequilateral, angular on the umbonial slope, substance of the shell somewhat thick; beaks slightly prominent, with small undulations at the tip; umbonial slope with two raised lines and two yellow rays on each valve diverging from the beak; ligament rather long and thin;

epidermis yellow, inclining to greenish brown, smooth and shining; cardinal teeth long and compressed; lateral teeth long and somewhat curved; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices placed on the centre of the cavity of the beaks; cavity of the shell rather shallow; cavity of the beaks shallow and subangular; nacre pearly white and very iridescent.

Remarks.—This species in outline resembles the *U. pictorum*, Lam. and *Unio Corrianus*, nobis. It was sent to me from Bremen by Dr. Von den Busch, who thinks it came from Java, but is not sure of its *habitat*. In the two specimens before me the rays on the posterior portion are very distinct.

MARGARITANA VONDENBUSCHIANA. Plate 18, Fig. 39.

Testâ obovatâ, compressâ, inæquilaterali; valvulis tenuibus; natibus subprominentibus; epidermide luteo-fuscâ; dentibus cardinalibus parvis, tuberculatis; margaritâ albâ et iridescente.

Shell obovate, compressed, inequilateral; valves thin; beaks somewhat prominent; epidermis yellowish-brown; cardinal teeth small, tuberculate; nacre white and iridescent.

Hab. Java. G. Von den Busch, M. D.
My Cabinet, and Cabinet of Dr. Von den Busch of Bremen.

Diam. .8, Length 1.8, Breadth 2.8 inches.

Shell obovate, compressed, inequilateral; substance of the shell thin; beaks somewhat prominent; ligament long and thin; epidermis yellow, brown, obscurely rayed, darker on the posterior slope and lighter towards the basal margin; cardinal teeth small, consisting of an irregular tubercle; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices placed in a row across the cavity of the beaks; cavity of the shell shallow; cavity of the beaks very small; nacre white and iridescent.

Remarks.—The form of the teeth in this shell places it near to the genus *Anodonta*. The enlargement of this part is greater than in the *Alasmodonta edentula*, Say, (*Anodon areolatus*, Swainson,) which I have, in my synopsis, placed with the *Anodontæ*. It, in fact, falls into that division which d'Orbigny has made under the name of *Monocondylæa*, and is somewhat like his species *fossiculifera*. I name it after Dr. Von den Busch, to whose kindness I am indebted for the specimen now described.

MARGARITANA CURREYIANA. Plate 18, Fig. 40.

Testâ triangulari, subcompressâ, emarginatâ, sulcatâ; valvulis crassis; natibus subprominentibus, ad apices undulatis; epidermide luteo-fuscâ; dentibus cardinalibus magnis; margaritâ albâ et iridescente.

Shell triangular, somewhat compressed, emarginate, sulcate; valves thick; beaks rather prominent, undulated at the tip; epidermis yellowish brown; cardinal teeth large; nacre white and iridescent.

Hab. Stone's River, Tenn. Dr. Currey of Nashville.

My Cabinet, and Cabinets of Dr. Currey, Dr. Troost and Mr. Edgar.

Diam. .5, Length .7, Breadth 1 inch.

Shell triangular, somewhat compressed or flattened on the side, emarginate at the basal and posterior basal margins, furrowed on the posterior slope; substance of the shell thick, thinner before; beaks rather prominent, with large undulations at the tip, nearly medial; ligament short and rather thick; epidermis yellowish brown; umbonial slope carinate; posterior slope flattened; cardinal teeth large, one closing in behind the other; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed under the cardinal tooth; cavity of the shell very small; cavity of the beaks angular and shallow; nacre white and iridescent.

Remarks.—A single specimen of this species of *Margaritana* was among the shells from Dr. Currey. He had found two or three only, all of which were of the same diminutive size, and, like mine, much eroded. It is about the size of the *U. fabalis*, (nobis,) and has some resemblance to it. If it were not separated generically from it, the furrow on the posterior slope causing two oblique folds would at once distinguish it. It is a very solid shell, and the teeth are robust. I name it after Dr. Currey, to whose kindness I am indebted for the possession of the shell.

ANODONTA ARGENTEA. Plate 19, Fig. 41.

Testâ ellipticâ, inflatâ, transversâ; valvulis tenuibus; natibus prominulis; apicibus minutè undulatis; epidermide fuscâ, radiatâ; margaritâ argenteâ et iridescente.

Shell elliptical, inflated, wide; valves thin; beaks rather prominent; apices minutely undulate; epidermis brown, radiated; nacre silvery and iridescent.

Hab. Stone's River, Tenn. Dr. Currey.
My Cabinet, and Cabinet of Dr. Currey.

Diam. 1.2, Length 1.5, Breadth 2.9 inches.

Shell elliptical, inflated, wide; substance of the shell thin; beaks rather prominent, with two or three small undulations at the tip; ligament thin and rather long; epidermis brown with dark green rays over the disk; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell very deep; cavity of the beak very shallow; dorsal line slightly curved, being in the left valve elevated under the beak in the form of a lamellar tooth; nacre silvery and iridescent.

Remarks.—In form this species is closely allied to *An. Ferussaciana,* (nobis.) Its nacre is, however, more silvery and thicker, and it has dark rays.

ANODONTA HARPETHENSIS. Plate 19, Fig. 42.

Testâ ellipticâ, inflatâ, carinatâ; valvulis tenuibus; natibus subprominentibus; apicibus undulatis; epidermide luteâ et viride; margaritâ salmonis colore tinctâ; margine lato.

Shell elliptical, inflated, carinate; valves thin; beaks rather prominent; apices undulated; epidermis yellow and green; nacre salmon-coloured; margin broad.

Hab. Harpeth River, Tenn. S. M. Edgar.
My Cabinet, and Cabinets of Mr. Edgar and Dr. Troost.

Diam. 1.8, Length 2.3, Breadth 4.2 inches.

Shell elliptical, inflated, carinate; substance of the shell thin; beaks rather prominent, with a double undulation at the apices; ligament very small and thin; epidermis yellow with green bands; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell deep and rounded; cavity of the beaks very shallow; dorsal line irregularly curved; nacre beautifully salmon-coloured, having a deep margin.

Remarks.—But a single specimen of this species has come under my notice. In its general form it resembles *An. decora,* (nobis.) It is, however, a smaller species, has a broader margin, and is less inflated. The alternate bands of yellow and green give it an agreeable aspect. The nacre is of a delicate colour and very satin-like.

ANODONTA FERRUGINEA. Plate 19, Fig. 43.

Testâ ellipticâ, inflatâ; valvulis tenuibus; natibus prominentibus, ad apices minutè undulatis, ferrugineis; epidermide tenebroso-fuscâ, politâ; margaritâ cœruleo-albâ et iridescente.

Shell elliptical, inflated; valves thin; beaks prominent, minutely undulate at the tips, ferruginous; epidermis dark brown and polished; nacre bluish-white and iridescent.

Hab. Simon's Creek, Indiana. T. G. Lea.
My Cabinet, and Cabinet of T. G. Lea.

Diam. .1, Length 1.3, Breadth 2.4 inches.

Shell elliptical, inflated, posterior margin biangular; substance of the shell thin; beaks ferruginous, prominent, with three or four nearly concentric small folds at the tip; ligament long and thin; epidermis dark brown and shining; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices placed nearly in the centre of the cavity of the beaks; cavity of the shell deep and rounded; cavity of the beaks shallow; dorsal line slightly curved under the beaks; nacre bluish-white and iridescent.

Remarks.—This is a small species with remarkably ferruginous beaks, and dark brown, sometimes greenish epidermis. Indistinct rays may be observed on some individuals. The lines of growth are dark, and in some specimens the basal margin is disposed to be emarginate. It is somewhat allied to *An. undulata*, Say, but differs very much in colour and undulations of the beaks.

ANODONTA FOOTIANA. Plate 20, Fig. 44.

Testâ ellipticâ, inflatâ, inæquilaterali; valvulis subtenuibus; natibus subprominentibus, ad apices undulatis; epidermide luteo-fuscâ; margaritâ cœruleo-albâ et iridescente.

Shell elliptical, inflated, inequilateral; valves thin; beaks rather prominent, undulate at the tips; epidermis yellowish-brown; nacre bluish white and iridescent.

Hab. Vicinity of Fort Winnebago. Dr. Foot.
My Cabinet.

Diam. 1.2, Length 1.9, Breadth 3.3 inches.

Shell elliptical, inflated, inequilateral, angular behind; substance of the shell rather thin; beaks rather prominent, undulate at the tip; ligament rather short and thin; epidermis yellowish-brown; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell rather deep and rounded; cavity of the beaks shallow; dorsal line rather curved; nacre bluish-white and iridescent.

Remarks.—Two perfect individuals, and two valves of this species were received among other specimens of the *Naïades* from Dr. Foot of the United States Army. This species seems to be allied to *An. fragilis*, Lam., but is a larger and stronger shell. The lines of growth are distinct and very close together.

Anodonta Maryattana. Plate 20, Fig. 45.

Testâ transversâ, valdè inflatâ, gibbosâ, valdè inæquilaterali; valvulis tenuibus; natibus prominentibus, ad apices undulatis; epidermide virido-luteâ; margaritâ argenteâ et iridescente.

Shell wide, very much inflated, gibbous, very inequilateral; valves thin; beaks prominent, undulated at the tip; epidermis greenish yellow; nacre silvery and iridescent.

Hab. Vicinity of Fort Winnebago. Capt. Maryatt, R. N.
My Cabinet.

Diam. 1.8, Length 2.2, Breadth 4 inches.

Shell wide, very much inflated, gibbous, very inequilateral; substance of the shell very thin and transparent; beaks prominent and doubly undulate at the tip; ligament thin and long; epidermis greenish-yellow; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell very deep; cavity of the beaks rather deep and rounded; dorsal line slightly curved; nacre silvery and iridescent.

Remarks.—Among many fine specimens of the *Naïades* brought by Capt. Maryatt from a tour up the Mississippi, &c., was a single specimen of this *Anodonta*. It is more inflated than any species I am acquainted with except the *An. gibbosa*, Say. Like it, it has that irregular swelling over the portion embracing the umbonial slope. It differs in being more transverse, and being devoid of rays. The nacre is remarkably thin, silvery and iridescent. The marks of growth are very distinct and widely separate.

ANODONTA COUPERIANA. Plate 20, Fig. 46.

Testâ ellipticâ, valdè inflatâ, gibbosâ; valvulis tenuibus; natibus planulatis, undulatis; epidermide virido-luteâ, obsoletè radiatâ; margaritâ cœruleo-albâ et iridescente.

Shell elliptical, very much inflated, gibbous; valves thin; beaks flattened and undulated; epidermis greenish-yellow, obsoletely radiate; nacre bluish-white and iridescent.

Hab. Hopeton, near Darien, Georgia. J. H. Couper, Esq.
My Cabinet.

Diam. .9, Length 1.5, Breadth 2.1 inches.

Shell elliptical, smooth, polished, very much inflated, gibbous and swollen from the beaks to the basal margin, flattened behind the beaks; basal margin much rounded; substance of the shell very thin; beaks flattened and finely undulate; ligament rather long and very thin; epidermis greenish-yellow, with numerous small rays, darker on the posterior slope, where the rays are very distinct and capillary; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell very deep and rounded; cavity of the beaks very small; dorsal line slightly curved; nacre bluish-white and iridescent.

Remarks.—This is a very distinct species, and I dedicate it to my friend Mr. Couper, who has done much to elucidate the Natural History of his vicinity. It is remarkable in its form, and more nearly allied to *An. gibbosa*, Say, than any other species with which I am acquainted. It differs in being more transverse, being less inflated, having flatter beaks, in being smaller and in having the swell of the inflation more towards the basal margin. Indistinct capillary rays covering the whole disk, diverge from the beaks, and are more distinct on the posterior slope where there are generally two yellow rays. The beaks are so much flattened as scarcely to rise above the dorsal margin.*

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* Accompanying this species I received from Mr. Couper several specimens of an *Anodonta* which so closely resembles my specimens of *Anodonta incerta*, from the Ohio, that I conclude they must be the same species. If it prove so, it will be the first which I have seen coming from the eastern side of the Allegheny range.

MELANIA BOYKINIANA. Plate 6, Fig. 59.

Testâ granulatâ, elevatâ, subturritâ, ad carinam tuberculatâ; suturis impressis; aperturâ elongatâ, ovatâ.

Shell granulate, elevated, somewhat turrited, at the carina tuberculate; sutures impressed; aperture long, ovate.

Hab. Chattahoochee River, Columbus, Geo. Dr. Boykin.
My Cabinet.

Diam. 3.8, Length 9.4 of an inch.

Remarks.—This is a very distinct and remarkable species. Although many individuals differ, the prevailing character is to have the whole of the whorls covered with numerous granulate, revolving lines, generally bearing a purple or brown line. In some the tubercles of the carina assume the character of folds.

MELANIA CATENOIDES. Plate 6, Fig. 60.

Testâ granulatâ, elevato-conoideâ, lineatâ; apice plicatâ; suturis parvis; aperturâ ovatâ.

Shell granulate, elevated, conoidal, lined; apex folded; sutures small; aperture ovate.

Hab. Chattahoochee River, Columbus, Geo. Dr. Boykin.
My Cabinet.

Diam. .43, Length .93 of an inch.

Remarks.—This species differs from the *M. Boykiniana,* in being without tubercles and carina. The coloured revolving hair-like lines are numerous, and being pitted, present the appearance of a chain. Some of the old specimens are quite black, while the younger ones are green or yellow. In some cases where the apex is eroded or worn off and the shell black and old, it looks like *M. Virginica,* (Say,) as no grains can be observed.

CAROCOLLA CUMBERLANDIANA. Plate 6, Fig. 61.

Testâ lenticulatâ, carinatâ, striatâ, albidâ, fusco-notatâ, latè umbilicatâ, ad carinam supernè et infernè impressâ; anfractibus quinis; aperturâ angulatâ, intus sulcatâ; labro acuto.

Shell lenticular, carinate, striate, whitish, brown-spotted, widely umbilicate, impressed above and below the carina; whorls five; aperture angular, within furrowed; lip acute.

Hab. Cumberland Mountains, near Jasper, Tenn. Dr. Currey.
My Cabinet, and Cabinets of Dr. Currey and Mr. Edgar.
Diam. .54, Length .14 of an inch.

Remarks.—Among many species of land shells which I owe to Dr. Currey's kindness, were two individuals of this Carocolla, which does not appear to have been before noticed. It has some resemblance to *H. alternata,* (Say,) but may at once be distinguished by its depressed, flat, lenticular form and carina. It is a very interesting species, and has a remarkable furrow above and below the carina: all the whorls, are visible in the umbilicus, and are striate all over.

CYCLOSTOMA CINCINNATIENSE. Plate 6, Fig. 62.

Testâ elevato-conicâ, lævi, nitidâ, diaphanâ, umbilicatâ; anfractibus senis; apice obtuso; labro margine reflexo.

Shell elevated in the form of a cone, smooth, shining, transparent, umbilicate; whorls six; apex obtuse; margin of the lip reflected.

Hab. Vicinity of Cincinnati. T. G. Lea.
My Cabinet, and Cabinet of T. G. Lea.
Diam. .13, Length .22 of an inch.

Remarks.—A small species which has been sent to me several times by my brother, who seems first to have observed it. It is about the size and nearly of the colour of *Paludina limosa,* Say. It is found on wet earth and roots of trees, on the margin of a small stream near Cincinnati.

Continuation of Mr. Lea's Paper on Fresh Water and Land Shells. *Read February 19th,* 1841.

In a paper read before the Society July 15th, 1837, I gave the result of some observations made in regard to the anatomy, gestation and geographical distribution of the family *Naïades,* and I mentioned at the time that it was my intention to pursue the subject. Circumstances, however, have prevented my undertaking the thorough examination of the habits of the species and their structure, which I intended. At my request, however, my brother T. G. Lea has made some valuable observations during the last three years at Cincinnati, where these shells are numerous, and the size often large. A digest of these observations has been made by him, and the result, though not entirely satisfactory, will make some advance towards a knowledge of the periods of some of the species.

Sexual difference is no longer a matter of doubt,* but the period and mode of *impregnation,* as well as the length of *gestation* and the time of *parturition,* are either unknown or but partially understood.

At page 52, Vol. 6, of the Transactions, I mentioned having seen in a single instance the ejectment of a number of sacciform oviducts in quite a rapid succession from the *Unio complanatus.* Dr. Kirtland has since, as he informs me by letter, "twice seen the females of *Unio cylindricus* throw off their ova *per saltum,* or with a kind of jet. The portions discharged were collections of a vast number of individuals, aggregated in oblong masses, conforming with the shape of the cells of the ovarium. Soon after they were discharged, they appeared to crumble to pieces, and the several individuals fell down among the sand."

These observations corroborate mine, and we may conclude that we have one fact established in two species in regard to parturition.

The *Anodontæ,* so far as I have been able to observe them, are ovoviviparous, but, whether they, as some species of the *Uniones* do, attach themselves when young by a byssus, I have not had the means to determine. In Silliman's Journal for July, 1840, Dr. Kirtland published an interesting account of this

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* Transactions, vol. vi. page 49.

attachment with figures. He had communicated the fact of his observations to me by letter several years before, and I then informed him that I had in a single instance some years before observed it in the Schuylkill.

The following tabular view and notes form the matter digested by my brother, from his extensive notes during the years 1838, '39, and '40, mentioned above.

No. 1.

No ova found in the oviducts. The ovaria not examined except in *Unio Æsopus*, which had ova in the ovarium. Examined in the Autumn of 1838.

	Specimens.
Unio Æsopus,	1
varicosus,	16
metanever,	26
cornutus,	40
cylindricus,	18
cuneatus,	20
gibbosus,	19
sulcatus,	25
pileus,	7
triangularis,	5
pustulatus,	5
pustulosus,	18
asperrimus,	19
tuberculatus,	7
trigonus,	6
elegans,	12
formosus,	9
ebenus,	14
fragosus,	15
Cooperianus,	40
monodontus,	7
verrucosus,	7
undatus, and pyramidatus,	30
lachrymosus,	5
dehiscens,	7
plicatus,	8

No. 2.

Ova in the ovarium in the Autumn of 1839.

U. cylindricus,	6
pyramidatus,	2
undatus,	5
varicosus,	2
tuberculatus,	3
gibbosus,	2
pustulosus,	7
pustulatus,	3
cornutus,	6
asperrimus,	3
plicatus,	1
metanever,	1
cuneatus,	2
Æsopus,	2

In March, 1840.

U. parvus,	10
lachrymosus,	7

In July.

U. rubiginosus,*	1

* Six others of this species, taken at the same time, had ova in the oviducts. See column, No. 4.

No. 3.

Ova in the oviducts in the Autumn of 1838.

U. perplexus,	16
foliatus,	18
irroratus,	12
retusus,	7
securis,	8
phaseolus,	8
ovatus,	1
gracilis,	3
alatus,	1
lævissimus,	4
tenuissimus,	5
ridibundus,	3
ellipsis,	4
circulus,	1
crassus,	7
rectus,	1
personatus,	1
multiplicatus,	4
occidens,	3
compressus,	1
camelus,	4
orbiculatus,	3
multiradiatus,	1
Marg. complanata,	1
rugosa,	2
An. edentula,	6
Ferussaciana,	4

In Autumn, 1839.

U. lævissimus,	2
multiplicatus,	1
alatus,	1
rectus,	3
plicatus,	3
crassus,	1
ovatus,	1
An. plana,	21
incerta,	3

No. 4.

Ova in the oviducts, at various dates in 1840.

March.

U. circulus,	1
occidens,	4
compressus,	10
luteolus	11
tenuissimus,	1
Marg. rugosa,	1
calceola,	1
complanata,	2
An. Wardiana,	2
incerta,	2

May 16.

U. lachrymosus,	2

Some minute ova were also found in the ovaria of these two specimens.

July and August.

U. plicatus,	1
patulus,	5
rubiginosus,	6
multiradiatus,	2
fabalis,	1
circulus,	1
gibbosus,	1
luteolus,	1
An. plana,	2

Sept. 5th.

U. compressus,	2

Oct. 12th.

U. occidens,	4
luteolus,	2
Marg. rugosa,	1
An. edentula,	1
Ferussaciana,	2

"In column No. 1, no ova were found in the oviducts of any of the enumerated species. They were carefully examined, as regards the oviducts, but as to the ovaria, they were not, except in the single specimen of *Unio Æsopus.* If the ovaria had been examined, no doubt the ova would have been found in all of them, exclusive of *sulcatus, pileus* and *formosus.* They were all taken from September 19th, to November 13th, 1838.

"In column No. 2, many of the species contained in column No. 1, were examined again in the Autumn of 1839, and found to have ova in the ovaria and none in the oviducts. The others in column No. 1, that I had not an opportunity to examine would, I think, have been found in the same condition. In this column it may be observed, that *U. parvus* and *lachrymosus* had ova in the ovaria in March, also a single specimen of *U. rubiginosus* taken at Waynesville in July. As this was not as advanced as six others taken at the same time, their period is probably irregular.

"Column No. 3, contains the species observed with the oviducts charged with young in the Autumn of 1838 and '39.

"Column No. 4, contains the species with oviducts charged with young at various periods of 1840.—In columns No. 1, and 2, no ova were found in the oviducts.

"I have not been able to come to a satisfactory conclusion respecting the gestation and period at which the *Uniones* discharge their young; that it varies between some groups of the species, I have no doubt.—For instance, take all those in columns No. 1 and 2, which late in the Autumn have no ova transferred to the oviducts, while other groups, in columns No. 3 and 4, have the oviducts charged with young at the same season. The latter probably discharge in the Spring, or early Summer, and the former later.

"In column No. 2, is a *U. plicatus* with ova in the ovarium in Autumn; in No. 4, is one with ova in the ducts in July. Suppose this to have discharged in August, it makes a very long gestation.

"In column No. 4, is a *U. circulus,* with ova in the oviducts, in March, and another with ova in the oviducts, in July. The same species also in column No. 3, with ova in the oviducts, in Autumn. From this I would infer that it is irregular, or breeds more than once a year. In column No. 4, is a *U. luteolus,* with ova in the oviducts, in March, in August and in October. Some that I observed in August had their *branchiæ* so swollen, that they could not shut the valves close. In this case the animal would have discharged in a short time. The same inference applies to this as to *circulus*. Of *U. occidens*, in column No. 4, you will see the same in March and October.

"Few of the species in columns 1 and 2 were found with ova in the oviducts. This is owing to the period at which they must be transferred from the ovarium, which, most likely, is in the spring. I have observed them until the end of November. After that, our river continues too high to take them until July or August. In the interval the young must be perfected and discharged. By reference to my notes, you will find the above facts in detail. The columns are arranged and generalized from them. My observations in 1838–39 and '40, are included in them, and only differ as the economy of the species itself may differ. There will not be found any contradiction.

"The ovarium constitutes much the largest portion of the body. It lies immediately above the foot, forming all the solid part of the body between it and the viscera. In a letter I sent you November 26th, 1838, were three views of a *U. multiplicatus*, the ovarium extending from the superior part of the foot *nearly* to the intestinal canal, and from behind and a little below the stomach to the connexion of the posterior muscle, forming, with the exception of the foot, the larger portion of the whole body. The integuments are thick, and on laying it open it has a fibrous interior with a gelatinous substance, in which are disseminated numerous ova.

"You will find in the notes sent to you in 1838 a description of *both* lobes of the branchiæ on each side, of two specimens of *U. multiplicatus* being charged. In the other specimens examined, but *one* lobe on each side was charged as usual. In another examination, in September, 1839, *both* lobes were charged. Thus, it appears they vary in this species, as they probably do also in *U. rubiginosus*."*

UNIO SAPOTALENSIS. Plate 21, Fig. 47.

Testâ ellipticâ, subinflatâ, inæquilaterali, posticè subbiangulatâ; valvulis crassis; natibus vix prominentibus; epidermide luteâ, densè radiatâ; dentibus cardinalibus subgrandibus; lateralibus magnis subrectisque; margaritâ subaureâ et valdè iridescente.

Shell elliptical, somewhat inflated, inequilateral, subbiangular behind; substance of the shell thick; beaks scarcely prominent; epidermis yellow, very much radiated; cardinal teeth rather large; lateral teeth large and nearly straight; nacre somewhat golden-coloured and very iridescent.

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* The *U. rubiginosus* and *multiplicatus*, are the only species observed by my brother to be possessed of oviducts, in both pairs of the *branchiæ*.

Hab. Sapotal River, near Tlocatalpam, Mexico. Dr. Burrough.
Cabinet of Dr. Burrough.

Diam. .1, Length 1.4, Breadth 2.2 inches.

Shell elliptical, somewhat inflated, inequilateral, subbiangular behind, enlarged and somewhat carinate on the umbonial slope, flattened on the umbones and sub-emarginate at base; substance of the shell thick, thinner behind; beaks scarcely prominent; ligament rather short and thick; epidermis yellow, the whole disk being marked with green rays, darker on the posterior slope; cardinal teeth rather large, erect, single in the right and double in the left valve; lateral teeth large and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in the centre of the cavity of the beaks; cavity of the shell shallow; cavity of the beaks small and angular; nacre somewhat golden-coloured and finely iridescent.

Remarks.—A single specimen only is before me. Its fine rich pearly lustre and beautiful iridescence are very remarkable. I have rarely seen any iridescence in a *Unio* so rich. It has some resemblance to *U. radiatus*, and *U. interruptus*, (nobis,) but may be distinguished from both by the flatness of the umbones and the raised umbonial slope.*

Unio Tecomatensis. Plate 21, Fig. 48.

Testa ellipticâ, inflatâ, inæquilaterali, posticè subbiangulatâ; valvulis crassis; natibus subprominentibus; epidermide subnigrâ, nitida; dentibus cardinalibus magnis; lateralibus magnis subcurvisque; margaritâ vel purpureâ vel salmonis colore tinctâ et iridescente.

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* In addition to the knowledge of the fresh water shells inhabiting the rivers and lakes of the southern part of North America, so assiduously obtained by Dr. Burrough, I am indebted to another friend, Dr. Blanding, for the interesting fact, that the species which I described under the names of *U. Nicklinianus*, (see Trans., vol. 5, page 28,) and *U. discus*, (see vol. 6, page 74,) inhabit the River Moctezuma, in Central America, with the *U. Tampicoensis*. I am indebted to Dr. Blanding, for specimens of these, and his Cabinet may be referred to, as well as Mr. Nicklin's, and Mr. Phillips'; these gentlemen having also received specimens from Dr. B. The *Nicklinianus* seems always to be white in its nacre, while the *discus* varies, some individuals being perfectly white, some rich salmon-coloured, and others of a deep purple. A single valve in my Cabinet displays all these colours.

In some of the specimens of *U. Nicklinianus*, there is a remarkable elevated line on the posterior slope, which in some cases interrupts the folds.

Shell elliptical, inflated, inequilateral, subbiangular behind; substance of the shell thick; beaks somewhat prominent; epidermis nearly black, shining; cardinal teeth large; lateral teeth large and somewhat curved; nacre purple or salmon-coloured and iridescent.

Hab. Tecomate River, near Tlocatalpam, Mexico. Dr. Burrough.
My Cabinet, and Cabinet of Dr. Burrough.

Diam. 1.6, Length 2.5, Breadth 3.5 inches.

Shell elliptical, inflated, inequilateral, subbiangular behind; substance of the shell thick, thinner behind; beaks rather prominent; ligament long and thick; epidermis very dark, nearly black, shining, wrinkled towards the margin; cardinal teeth large, erect and double in both valves; lateral teeth large and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices large and placed in a row immediately under the cardinal tooth; cavity of the shell rather deep and rounded; cavity of the beak rather deep and subangular; nacre purple or salmon-coloured and iridescent.

Remarks.—Two specimens only of this species were brought by Dr. Burrough, one of a fine salmon colour, the other of a deep purple. It probably occurs also perfectly white, resembling in this variety of colour many other species, particularly the *U. complanatus.* In form it resembles *U. crassus,* Say, but differs altogether in the colour of the epidermis and the colour of the nacre. I have seen no young specimens, and the beaks of those before me, being much eroded, their character cannot be ascertained. In the colour of the epidermis it resembles old individuals of *U. pliciferus,* (nobis,) but being without the folds and being less transverse, ought not to be confounded with that shell.

UNIO GEORGIANUS. Plate 21, Fig. 49.

Testâ ellipticâ, subcompressâ, inæquilaterali, posticè subangulatâ; valvulis subtenuibus; natibus subprominentibus; epidermide luteo-fuscâ; dentibus cardinalibus parvis; lateralibus brevibus rectisque; margaritâ albâ.

Shell elliptical, rather compressed, inequilateral, subangular behind; substance of the shell rather thin; beaks somewhat prominent; epidermis yellowish brown; cardinal teeth small; lateral teeth short and straight; nacre white.

Hab. Stump Creek, Geo. T. R. Dutton.
Cabinet of Mr. Dutton.

Diam. .6, Length 1.1, Breadth 1.6 inches.

Shell elliptical, rather compressed, inequilateral, subangular behind, somewhat carinate on the umbonial slope; substance of the shell thin, thicker before; beaks somewhat prominent; ligament short and thin; epidermis yellowish brown, finely striate, and with numerous marks of growth, apparently without rays; cardinal teeth small, single in the right and double in the left valve; lateral teeth short and straight with a direction over the cardinal tooth; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed under the posterior part of the cardinal tooth; cavity of the shell small; cavity of the beaks rather shallow and angular; nacre white.

Remarks.—A single specimen only of this shell is before me. It possesses no remarkable characters, but is obviously distinct from any shell with which I am acquainted. It has some resemblance on one side to *U. Ravenelianus*, (nobis,) and on the other to *cariosus*, Say. The beaks being eroded, I am unable to say what kind of undulations, if any, they may have possessed.

Unio Duttonianus. Plate 22, Fig. 50.

Testâ valdè transversâ, cylindraceâ, valde inæquilaterali, posticè angulatâ; valvulis subcrassis; natibus vix prominentibus; epidermide tenebroso-fuscâ, obsoletè radiatâ; dentibus cardinalibus minimis; lateralibus longissimis rectisque; margarita albâ et iridescente.

Shell very wide, cylindrical, very inequilateral, angular behind; substance of the shell rather thick; beaks scarcely prominent; epidermis dark brown, obsoletely radiated; cardinal teeth very small; lateral teeth very long and straight; nacre white and iridescent.

Hab. Ogechee Canal, Savannah, Geo. T. R. Dutton.
Cabinet of Mr. Dutton.

Diam. .7, Length .1, Breadth 2.8 inches.

Shell very wide, cylindrical, very inequilateral, angular behind; posterior slope wide, flattened, with two lines from the beaks to the posterior margin; substance of the shell rather thick; beaks scarcely prominent; ligament rather thick and long; epidermis dark brown and very obscurely rayed; cardinal teeth very small, tubercular; lateral teeth very long, thin and straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices small and placed in the centre of the cavity of the beaks; cavity of the shell deep and rounded; cavity of the beaks very small and subangular; nacre white and iridescent.

Remarks.—In its outline this species resembles *U. folliculatus*, (nobis.) It differs in being more cylindrical and in having a much smaller cardinal tooth. The cardinal tooth is very remarkable for its small size, being little more than two small tubercles on the dorsal line. The only specimen before me is white: others may differ in colour. On the sides are a few obscure transverse folds. The breadth and flatness of the posterior slope is very remarkable.

UNIO BIGBYENSIS. Plate 22, Fig. 51.

Testâ subtriangulari, compressâ, inæquilaterali, posticè angulatâ; valvulis subcrassis; natibus prominentibus; epidermide luteâ, valdè radiatâ; dentibus cardinalibus magnis erectisque; lateralibus magnis subrectisque; margaritâ vel albâ vel salmonis colore tinctâ.

Shell sub-triangular, compressed, inequilateral, angular behind; substance of the shell rather thick; beaks somewhat prominent; epidermis yellow, very much rayed; cardinal teeth large and erect; lateral teeth large and nearly straight; nacre white or salmon-coloured.

Hab. Big Bigby Creek, Maury Co., Tenn. T. R. Dutton.
My Cabinet, and Cabinet of Mr. Dutton.

Diam. .8, Length 1.5, Breadth 2.1 inches.

Shell sub-triangular, compressed, inequilateral, angular behind; substance of the shell rather thick, thinner behind; beaks somewhat prominent, undulated at the tip; ligament rather long and thick; epidermis yellow, with numerous broad green rays; posterior slope somewhat carinate and free from rays; cardinal teeth large and erect, disposed to be double in both valves; lateral teeth large, thick and nearly straight; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed under the plate, posterior to the cardinal tooth; cavity of the shell very shallow; cavity of the beaks shallow and angular; nacre white or salmon-coloured.

Remarks.—This species has a strong resemblance to *U. rubiginosus*, (nobis,) in its outline and in its nacre. They are both found occasionally white. When I described *rubiginosus*, I had not seen a specimen with a white nacre. The *Bigbyensis* differs from it in having numerous broad rays, while those on the *rubiginosus*, when it is rayed at all, are usually very obscure. In the cardinal teeth they differ also; those of the *rubiginosus* being flatter, and more spread out. In its yellow epidermis and rays, the *Bigbyensis* resembles the *U. oviformis*, Con. That shell, however, is more oblique, and it may at once be distinguished by the large ovate lunule; the *Bigbyensis* apparently possessing none.

UNIO CROCATUS. Plate 22, Fig. 52.

Testâ ellipticâ, inflatâ, inæquilaterali, posticè angulatâ; valvulis tenuibus; natibus prominentibus; epidermide croceâ, radiatâ, nitidâ; dentibus cardinalibus parvis; lateralibus longis curvisque; margarita salmonis colore tinctâ et iridescente.

Shell elliptical, inflated, inequilateral, angular behind; substance of the shell thin; beaks prominent; epidermis saffron-coloured, radiated, shining; cardinal teeth small; lateral teeth long and curved; nacre salmon-coloured and iridescent.

Hab. Savannah River, Geo. T. R. Dutton.
My Cabinet, and Cabinet of Mr. Dutton.

Diam. .8, Length 1.2, Breadth 1.8 inches.

Shell elliptical, inflated, inequilateral, angular behind, substance of the shell thin, thicker before; beaks prominent; ligament rather thin and short; epidermis saffron-coloured, smooth and shining, with linear rays and numerous regular lines of growth; cardinal teeth small, single in the right and double in the left valve; lateral teeth long and curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed in the centre of the cavity of the beaks; cavity of the shell deep; cavity of the beaks deep and angular; nacre salmon-coloured and iridescent.

Remarks.—Two specimens of this species are before me. One has numerous capillary lines radiating from the beak, while the other has but few and very indistinct ones. It is most nearly allied perhaps to *U. ochraceus*, Say; but may be distinguished by the colour of the epidermis, by the teeth being thicker, and by the inflation of the umbones. The posterior slope is without rays, and is somewhat rough.

UNIO RAJAHENSIS. Plate 23, Fig. 53.

Testâ triangulari, inflatâ, inæquilaterali, posticè angulatâ; valvulis crassis; natibus valdè prominentibus; epidermide tenebroso-fuscâ; dentibus cardinalibus magnis; lateralibus sublongis curvisque; margaritâ albâ et valdè iridescente.

Shell triangular, inflated, inequilateral, angular behind; substance of the shell thick; beaks very prominent; epidermis dark brown; cardinal teeth large; lateral teeth rather long and curved; nacre white and very iridescent.

Hab. The Rajah's Tank, Calcutta. Dr. Jay.

My Cabinet, and Cabinets of Dr. Jay and Dr. B. W. Budd of N. Y.

Diam. .8, Length 1.1, Breadth 1.4 inches.

Shell triangular, inflated, inequilateral, angular behind; posterior slope much flattened, cordate, with two curved impressed lines; umbonial slope carinate; beaks very prominent and solid; ligament short, thick and light brown; epidermis dark brown; cardinal teeth large, double in both valves; lateral teeth curved, being more bent near the cardinal tooth, disposed to be double in the right and to be treble in the left valve; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed under the plate between the cardinal and lateral teeth; cavity of the shell rather deep and triangular; cavity of the beaks deep and triangular; nacre beautifully pearly white and very iridescent.

Remarks.—Two specimens of this species only were received from Calcutta by Dr. Jay. One is rather large and more inflated than the other. The beaks of both are eroded. When perfect they may be found to be undulate at tip like *U. corrugatus,* Lam. In the nacre it is very much like that shell, but differs totally in the outline, in its beaks and in being more inflated and more solid. The cleft of the cardinal tooth is nearly parallel with the dorsal line; the lateral teeth are remarkable for their duplication in one valve and triplication in the other.

UNIO CALLOSUS. Plate 23, Fig. 54.

Testâ ellipticâ, compressâ, inæquilaterali, posticè angulatâ; valvulis crassis; natibus prominentibus; epidermide luteo-fuscâ, nitidâ; dentibus cardinalibus parvis; lateralibus longis curvisque; margaritâ albâ et iridescente.

Shell elliptical, compressed, inequilateral, angular behind; substance of the shell thick; beaks prominent; epidermis yellowish brown, shining; cardinal teeth small; lateral teeth long and curved; nacre white and iridescent.

Hab. Ohio Canal, twelve miles below Columbus. Dr. Jay.

Cabinet of Dr. Jay.

Diam. .9, Length 1.4, Breadth 2.2 inches.

Shell elliptical, compressed, inequilateral, angular behind, carinate on the umbonial slope; substance of the shell thick; beaks prominent, ligament rather short and thick; epidermis yellowish brown, darker and wrinkled on the posterior slope; cardinal teeth small, double in both valves; lateral teeth very long and curved; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed under the plate between the cardinal and lateral teeth; cavity of the shell shallow; cavity of the beaks small and angular; nacre white and iridescent.

Remarks.—A single specimen of this shell only is before me. It is without rays. The eroded state of the beaks prevents our knowing if it be undulate at the tip. In outline it resembles some varieties of *U. complanatus*. In the flatness of the sides it is allied to *U. phaseolus*, Hild. But it differs entirely from that species in not being flattened towards the beaks and in being without rays.

ANODONTA MONTEZUMA. Plate 23, Fig. 55.

Testâ obovatâ, subinflatâ, valdè inæquilaterali; valvulis tenuibus; natibus prominentibus; epidermide luteâ viridique, rugosâ; margaritâ albâ et iridescente.

Shell obovate, rather inflated, very inequilateral; substance of the shell thin; beaks prominent; epidermis yellow and green, rough; nacre white and iridescent.

Hab. Central America. Dr. Jay.

Cabinet of Dr. Jay.

Diam. .6, Length 1.1, Breadth 1.6 inches.

Shell obovate, rather inflated, very inequilateral, rounded before and behind; substance of the shell thin; beaks prominent; ligament short and thin; epidermis yellow and green, rough; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell rather deep and rounded; cavity of the beaks very shallow; nacre white and iridescent.

Remarks.—The specimen for which the above description was made appears to be mature. It may, however, sometimes occur larger. The beaks are too much eroded to observe if they were undulated. The green predominates in the epidermis in the superior part of the disk,—the inferior part is yellow. The epidermis is rough from frequent crimping.

ANODONTA GLOBOSA. Plate 24, Fig. 56.

Testâ rotundâ, valdè inflatâ, inæquilaterali; valvulis tenuibus; natibus prominentibus, undulatis; epidermide viridi, obsoletè radiatâ; margaritâ cæruleo-albâ et iridescente.

Shell rounded, very much inflated, inequilateral; valves thin; beaks prominent and undulated; epidermis green, obscurely radiated; nacre bluish-white and iridescent.

Hab. Concha Lake near Tlocatalpam, Mexico. Dr. Burrough.
My Cabinet, and Cabinet of Dr. Burrough.

Diam. 2.2, Length 2.9, Breadth 4 inches.

Shell rounded, very much inflated, globose, much swollen under the beaks, inequilateral, subangular behind; lines of growth distinct and distant; substance of the shell very thin; margin broad; beaks very prominent, much inflated, and finely undulated at the tip; ligament rather long and thin; epidermis green with occasional interruptions of yellow; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell very deep and rounded; cavity of the beak large; dorsal line very slightly curved; nacre bluish-white and finely iridescent.

Remarks.—This is the most globose *Anodonta* which has been described. The margin is not quite so rounded as *An. suborbiculata,* Say, but the shell is much more inflated. It has some resemblance to *An. gibbosa,* Say, yet cannot be mistaken for that species, on account of its being devoid of the gibbous character and being more orbicular. It is somewhat angular at the anterior dorsal margin. The undulations at the beaks are small and duplicate. Dr. Burrough brought three specimens only, one of which is much older and larger than that figured. Concha Lake is about twenty leagues south of Vera Cruz.

Read June 18th, 1841.

UNIO ARGENTEUS. Plate 25, Fig. 57.

Testâ obliquâ, oviformis, valdè compressâ, valdè inæquilaterali, posticè subangulatâ; valvulis subcrassis; natibus subprominentibus; epidermide luteo-fuscâ, politâ; dentibus cardinalibus subgrandibus; lateralibus longis subcurvisque; margaritâ argenteâ et iridescente.

Shell oblique, oviform, much compressed, very inequilateral, subangular behind; valves rather thick; beaks somewhat prominent; epidermis yellowish brown, polished; cardinal teeth rather large; lateral teeth long and somewhat curved; nacre silver white and iridescent.

Hab. Holston River, East Tenn. Dr. Troost and Mr. S. M. Edgar.
My Cabinet, and Cabinets of Dr. Troost and Mr. Edgar.

Diam. .8, Length 1.6, Breadth 2.5 inches.

Shell oblique, oviform, much compressed, very inequilateral, subangular behind, and regularly rounded before, with two compressed lines behind the umbonial slope, substance of the shell rather thick, thinner behind; beaks somewhat prominent; ligament rather long and thick; epidermis brown, polished and shining on the superior portion, with regular and somewhat distant lines of growth; cardinal teeth rather large, not much elevated; lateral teeth long, rather thick and slightly curved; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed on the under side of the plate between the cardinal and lateral teeth; cavity of the shell very shallow, cavity of the beaks very shallow and angular; nacre silver white and iridescent.

Remarks.—In a box sent to me by Dr. Troost and Mr. Edgar from the waters of East Tennesseee, there was a single specimen of this shell. In form it is most nearly allied to *U. oviformis*, Con., but it differs in being rather more compressed. In colour it differs entirely, being much darker and being devoid of rays.

UNIO SPARSUS. Plate 25, Fig. 58.

Testâ sparsim tuberculatâ, triangulari, subinflatâ, subequilaterali, posticè emárginatâ, ad latus planulatâ; valvulis crassis; natibus elevatis; epidermide luteolâ; dentibus cardinalibus grandibus, lateralibus brevissimus rectisque; margaritâ albâ et iridescente.

Shell sparsely tuberculate, triangular, rather inflated, subequilateral, emarginate behind, flattened at the side; valves thick; beaks elevated; epidermis yellowish; cardinal teeth large; lateral teeth small and straight; nacre white and iridescent.

Hab. Holston River, East Tenn. Dr. Troost and S. M. Edgar.
My Cabinet, and Cabinets of Dr. Troost and Mr. Edgar.

Diam. .8, Length 1.3, Breadth 1.5 inches.

Shell sparsely tuberculate, triangular, rather inflated, subequilateral, emarginate behind, flattened on the side from the beak to the margin, carinate on the umbonial slope and sulcate posteriorly; substance of the shell very thick, thinner behind; beaks elevated; ligament very short and rather thick; epidermis yellowish; cardinal teeth very large; lateral teeth very short and straight; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed on the inferior part of the cardinal tooth; cavity of the shell rather deep; cavity of the beak deep and angular; nacre white and iridescent.

Remarks.—Several specimens of this species have at different times been brought to my attention by Dr. Troost and Mr. Edgar. I hesitated for some time separating it from *U. metanever*, Rafin., which in outline it closely resembles, as well as in the arrow-headed markings. It may be distinguished from that species by the size and rarity of its tubercles, having none of the large ones on the umbonial slope which so well characterize the *metanever*. It is also closely allied to *U. tuberosus*, (nobis,) but that shell differs in being thickly covered with tubercles.

UNIO REGULARIS. Plate 25, Fig. 59.

Testâ regulariter ellipticâ, subinflatâ, inæquilaterali; valvulis subtenuibus; natibus vix prominentibus; epidermide luteo-fuscâ, radiatâ; dentibus cardinalibus minutis, lateralibus longis curvisque; margaritâ cæruleâ et iridescente.

Shell regularly elliptical, somewhat inflated, inequilateral; valves rather thin; beaks scarcely prominent; epidermis yellowish brown, radiated; cardinal teeth very small; lateral teeth long and curved; nacre bluish and iridescent.

Hab. French Broad River, East Tenn. Dr. Troost and S. M. Edgar.
My Cabinet, and Cabinets of Dr. Troost and Mr. Edgar.

Diam. .8, Length 1.3, Breadth 2.3 inches.

Shell regularly elliptical, somewhat inflated, inequilateral, rounded on the umbonial slope; substance of the shell rather thin, thicker before; beaks scarcely prominent; epidermis yellowish brown with rather regular rays over the whole disk; cardinal teeth very small, single in the right and double and deeply cleft in the left valve; lateral teeth long and curved along the dorsal margin; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed within the cavity on the under side of the cardinal teeth; cavity of the shell rather deep and rounded, cavity of the beaks very shallow and slightly angular; nacre bluish and iridescent.

Remarks.—In its regular elliptical form this shell resembles *U. radiatus*. It also resembles *U. pictus*, nobis, in some degree, but is more inflated and a much darker-coloured shell. The teeth are remarkably small, and in the three specimens before me disposed to be carious.

UNIO MÆSTUS. Plate 26, Fig. 60.

Testâ ellipticâ, subinflatâ, valdè inæquilaterali; valvulis subcrassis; natibus prominulis; epidermide tenebroso-fuscâ, rugoso-striatâ; dentibus cardinalibus parvis, lateralibus longis curvisque; margaritâ atro-purpureâ et iridescente.

Shell elliptical, somewhat inflated, very inequilateral; valves somewhat thick; beaks somewhat prominent; epidermis dark brown, roughly striate; cardinal teeth small; lateral teeth long and curved; nacre dark purple and iridescent.

Hab. French Broad River, East Tenn. Dr. Troost and S. M. Edgar.
My Cabinet, and Cabinets of Dr. Troost and Mr. Edgar.

Diam. .8, Length 1.1, Breadth 2 inches.

Shell elliptical, inflated, rounded on the umbonial slope, equally rounded before and behind, very inequilateral; substance of the shell somewhat thick, thinner behind; beaks somewhat prominent, placed near to the anterior margin; ligament rather short and thin; epidermis dark brown, nearly black and roughly striate; cardinal teeth small, single in the right and double and deeply cleft in the left valve; lateral teeth long, thin and somewhat curved; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed across the cavity of the beaks; cavity of the shell rather deep and rounded; cavity of the beaks very small; nacre dark purple and iridescent.

Remarks.—This species is most nearly allied to *U. glans*, nobis, but is larger, more transverse, and has a rougher epidermis. In the purple nacre they resemble each other—The beaks of the two specimens before me are eroded, and therefore the character of the tips cannot be given. One of the specimens is less elliptical than the other, and disposed to be angular behind.

UNIO BRUMBYANUS. Plate 26, Fig. 62.

Testâ ellipticâ, inflatâ, inæquilaterali, posticè subbiangulatâ; valvulis crassis; epidermide nigrâ, politâ; dentibus cardinalibus subgrandibus, lateralibus brevibus subrectisque; margaritâ albâ et iridescente.

Shell elliptical, inflated, inequilateral, subbiangular behind; valves thick; epidermis black, polished; cardinal teeth rather large; lateral teeth short and straight; nacre white and iridescent.

Hab. Warrior River, Tuscaloosa, Alabama. Prof. Brumby.
Cabinet of Dr. Griffith.

Diam. .6, Length .8, Breadth 1.2 inches.

Shell elliptical, inflated, inequilateral, subbiangular behind, disposed to be biangular on the umbonial slope, raised on the umbones; substance of the shell thick, thinner behind; ligament thin and short; epidermis black, polished and shining on the superior portion; cardinal teeth rather large, conical, single in the right and double in the left valve; lateral teeth short and straight; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices placed on the under side of the plate between the cardinal and lateral teeth; cavity of the shell rather deep; cavity of the beaks rather deep and angular; nacre pearly white and iridescent.

Remarks.—This little species exteriorly resembles *U. glans*, nobis, but is rather more angular, and is higher on the umbones,—interiorly it differs in having a white nacre. It is to be regretted that the only specimen sent is in the beaks quite imperfect. This is the only *Unio* sent to Dr. Griffith by Prof. Brumby, and to him I dedicate it.

Read October 21st, 1842.

UNIO DARIENSIS. Plate 26, Fig. 61.

Testâ oblongâ, subinflatâ, inæquilaterali, posticè perangulatâ, ad laterâ planulatâ; valvulis subcrassis; natibus prominulis; epidermide luteo-fuscâ; dentibus cardinalibus compressis, lateralibus longissimis lamellatisque; margaritâ albâ.

Shell oblong, subinflated, inequilateral, angular behind, flattened on the sides; valves somewhat thick; beaks rather prominent; epidermis yellowish brown; cardinal teeth compressed; lateral teeth long and lamellar; nacre white.

Hab. Near Darien, Georgia. J. H. Couper, Esq.
My Cabinet, and Cabinet of Mr. Couper.

Diam. 1.2, Length 1.8, Breadth 2.3 inches.

Shell oblong, rather inflated, inequilateral, with an elevated, rather acute angle on the umbonial slope, and flattened on the sides; substance of the shell rather thick, thinner behind; beaks rather prominent and flattened; ligament rather long and somewhat thick; epidermis yellowish brown, and obsoletely rayed; posterior slope elevated into a prominent carina and corrugate; cardinal teeth rather small, compressed; lateral teeth long, lamellar and nearly straight; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed under the plate posterior to the cardinal tooth; cavity of the shell deep and angular; cavity of the beaks rather shallow; nacre white.

Remarks.—This shell is remarkable for its high, acutely angular umbonial slope, and its flattened sides. Having but a single specimen before me, and that with eroded beaks, I am unable to say any thing respecting the undulations of the beaks. On the sides near to the basal margin there are four or five indistinct folds, but this may not be found to be permanent with the species. In its acute angle and flattened side it has a strong resemblance to *An. angulata*, (nobis.) It seems to be more nearly allied to *U. Congaræus*, (nobis,) than to any other *Unio*.

UNIO HALEIANUS. Plate 27, Fig. 63.

Testâ ellipticâ, subinflatâ, inæquilaterali; valvulis subtenuibus; natibus prominulis, ad apicem undulatis; epidermide tenebroso-fuscâ, striatâ; dentibus cardinalibus magnis, compressis, lateralibus longis subcurvisque; margaritâ albâ et iridescente.

Shell elliptical, subinflated, inequilateral; valves rather thin; beaks rather prominent, undulated at the tip; epidermis very dark brown, striate; cardinal teeth large, compressed; lateral teeth long and somewhat curved; nacre white and iridescent.

Hab. Mississippi River, thirty miles above N. Orleans. Josiah Hale, M. D.
My Cabinet.

Diam. .1, Length 1.5, Breadth 2.8 inches.

Shell elliptical, rather inflated, inequilateral, with a thin, depressed line from the beak to the posterior margin; substance of the shell rather thin; beaks rather prominent, with nearly concentric undulations at the tip; ligament rather long and thin; epidermis very dark brown, nearly black, striate in thin laminæ on the inferior portion of the valves; cardinal teeth large, compressed, elevated, disposed to be double in both valves; lateral teeth long, somewhat curved and lamellar; anterior cicatrices distinct; posterior cicatrices confluent; dorsal cicatrices placed across the centre of the cavity of the beaks; cavity of the shell rather deep; cavity of the beaks shallow and subangular; nacre pearly white and iridescent.

Remarks.—This shell is of a very regular ellipse, and has more resemblance to the *U. parvus*, Barnes, than any other species with which I am acquainted. It is, however, much larger, being quite four times the size of the largest *parvus* I have seen from the vicinity of New Orleans, where they occur largest. Its beaks have nearly the same kind of undulations. A single specimen was given to my brother T. G. Lea by Dr. Hale of Alexandria, Louisiana, after whom I name it. This specimen is now in my Cabinet. I do not know if Dr. Hale got other specimens.

UNIO FOREMANIANUS. Plate 27, Fig. 64.

Testâ triangulari, compressâ, inæquilaterali, posticè angulatâ, ad latera planulatâ; valvulis crassis; natibus prominentibus; epidermide luteâ, valdè radiatâ; dentibus cardinalibus crassis, lateralibus crassis rectisque; margaritâ albâ.

Shell triangular, compressed, inequilateral, angular behind; valves thick; beaks prominent; epidermis yellow, much radiated; cardinal teeth thick; lateral teeth thick and straight; nacre white.

Hab. Coosa River, Alabama. Dr. Brumby.
My Cabinet, and Cabinets of Dr. Foreman and Dr. Brumby.
Diam. .7, Length 1.2, Breadth 1.6 inches.

Shell triangular, compressed, inequilateral, angular on the umbonial slope and flattened on the sides; substance of the shell very thick, thinner behind; beaks very prominent and angular; epidermis yellow with numerous capillary wavy rays; ligament short and thick; posterior slope slightly elevated; cardinal teeth thick; lateral teeth short and straight, the plate between these teeth being abruptly arched; anterior cicatrices distinct; posterior cicatrices distinct; dorsal cicatrices placed under the plate posterior to the cardinal tooth; cavity of the shell shallow and angular; cavity of the beaks very shallow and angular; nacre white.

Remarks.—This is an interesting species somewhat allied to *U. formosus*, and *U. securis*. It differs from the former in being more compressed, and in having capillary rays,—from the latter in not being so much compressed, and being destitute of the catenoid rays. I owe to Dr. Foreman's kindness the examination of two specimens which he received among other fine shells from Dr. Brumby, of Tuscaloosa, Alabama. Neither of the specimens are perfect enough on the beaks to ascertain what kind of undulations they may have in a perfect state. The older and more worn specimen is by no means as triangular as the other. The capillary wavy rays cover nearly the whole disk.

ANODONTA DUNLAPIANA. Plate 27, Fig. 65.

Testâ ellipticâ, inflatâ, subcylindraceâ, transversè vittatâ; valvulis tenuibus; natibus prominulis, undulatis; epidermide nitidâ, luteolâ, obsoletè radiatâ; margaritâ albâ et iridescente.

Shell elliptical, inflated, subcylindrical, transversely banded; valves thin; beaks slightly prominent and undulated; epidermis shining, yellowish, obsoletely rayed; nacre white and iridescent.

Hab. South Carolina. Mrs. Dunlap.
My Cabinet, and Cabinet of Mrs. Dunlap of Salem, Mass.
Diam. 1.5, Length 1.6, Breadth 3.4 inches.

Shell elliptical, smooth, polished, very much inflated, somewhat cylindrical, having transverse green bands; substance of the shell thin; beaks slightly prominent and undulate at the tip; ligament long and very thin; epidermis polished, yellowish, interrupted by green transverse bands, with numerous small rays darker on the posterior slope, where they are very distinct and capillary; anterior cicatrices confluent; posterior cicatrices confluent; dorsal cicatrices none; cavity of the shell deep and rounded; cavity of the beaks very small; dorsal line nearly straight; nacre white and iridescent.

Remarks.—Mrs. Dunlap, whose name it gives me pleasure to place to this shell, has favoured me with three specimens of this beautiful *Anodonta*, all of which have the remarkable green bands mentioned. It has some resemblance to *An. fluviatilis*, with some of the characters of *An. Couperiana*, (nobis.) It is less oblique than the former species, and more cylindrical, and has the peculiar capillary rays of the latter species. It differs from *An. Couperiana*, in being a larger species, in being without the gibbous character, in being less rayed and in being thicker,—the nacre is also less blue, there being a slight pinky hue in the *Dunlapiana*. On the posterior slope on each valve there are two distinct green rays passing from the beaks to the posterior margin.

SYSTEMATIC INDEX.

CONTENTS.

CORRIGENDA.

Page 165. For *Melania lævigata*, read *Melania lævis; lævigata* being preoccupied by Lamarck,

Do. 167. For *Melania rufa*, read *Melania rufescens.* The specific name *rufa*, being preoccupied by Dr. Philippi, for a Sicilian species.

Do. 177. For *Melania corrugata*, read *Melania rugosa; corrugata* being preoccupied by Lamarck.

Do. 186. For *Melania striata*, read *Melania striatula; striata* being preoccupied by Mr. Sowerby, for a fossil species.

ARTICLE XIII.

Description and Notices of new or rare Plants in the natural Orders Lobeliaceæ, Campanulaceæ, Vaccinieæ, Ericaceæ, collected in a Journey over the Continent of North America, and during a Visit to the Sandwich Islands, and Upper California. By Thomas Nuttall. Read December 3, 1841.

ORDER LOBELIACEÆ. (JUSSIEU.)

TRIBE I. DELISSEACEÆ, (PRESL.)

CLERMONTIA. (GAUDICHAUD.)

CLERMONTIA **macrophylla;* arborescent; leaves very long, oblong, lanceolate, shortly acuminate, glandulosely serrulate, attenuated with a rather long petiole; beneath minutely pilose along the veins; peduncles stout, mostly two-flowered, much longer than the lanceolate, acuminate bractes, about the length of the petioles; tube of the calyx turbinate, about twice the length of the connivent lobes; lobes of the corolla linear, the length of the calyx; the upper segments connate.

HAB. Oahu. A spreading tree about twelve feet high. The ripe fruit a rather solid berry, about the size of a small Siberian crab, of a bright orange, and frequently strung as necklaces and chaplets by the natives of the Island. It is also said to be eaten by the birds. The leaf with the petiole about eleven inches to a foot long; near two and a half inches wide.

CYANEA. (GAUD.)

CYANEA *Grimesiana.*—A tree or large shrub, about ten feet high, very lactescent, sending out leaves chiefly at the extremities of the branches, which are smooth and deep green, from twelve to eighteen inches long and deeply pinnatifid; the petioles beset with spinulose tubercles; leaflets lanceolate, dentate, acuminate, about four to six inches long. Flowers in a short, fastigiate raceme, white, externally striped with dark reddish purple; the corolla falcate, about two and a half inches long, and the segments long and linear. Filaments connate to the summit, free at the base of the anthers; anthers with long, pencillate tufts of white coarse hairs. Berry turbinate; the seed even and lenticular, pale brown, very similar to that of *Clermontia*. It flowers in the winter season, and is indeed a splendid plant.

TRIBE II. CLINTONIEÆ, (PRESL. DECAND.)

CLINTONIA *elegans;* OBS.—This, like all the other species, is subaquatic, growing on the margins of perennial ponds: in such situations I found it abundant, near the outlet of the Wahlamet, where it appeared to be biennial or perennial, beginning to flower in April. The taste of the plant is nearly as sweet as that of young lettuce, and it is greedily cropped by deer and other animals. The sap is no ways milky.

CLINTONIA *corymbosa;* HAB. With the preceding, to which it is nearly allied. The lower lip presents a broad, nearly white centre. The capsule is sometimes almost smooth; the petiole one and a half inches long. The flower and its calyx green. Flower one and a half inches long.

SCÆVOLA. (LINNÆUS.)

SCÆVOLA **Plumerioides;* shrubby; axills sericeously bearded; leaves fastigiate, shortly petiolate, obovate-oblong, obtuse, entire and very smooth, subcoriaceous and attenuated at the base; peduncles pubescent, one or two-flowered, very short; bractes minute; limb of the calyx five-parted; corolla bearded within, the segments smooth and ciliate.

HAB. Near the shores of the Island of Atooi. A stout shrub sending up numerous branches, which, as in *Plumeria*, present leaves only at the extremities. These are somewhat fleshy, four or five inches long and about one and a half wide, rounded at the summit, below attenuated, but scarcely petiolate. The axills with a long silky pubescence. Flowers small, white, or pedicels of less than half an inch in length. Divisions of the calyx lanceolate, acute. Indusium of the stigma hairy and bearded. Nut scarcely more than one-seeded. Berry allied, apparently, to *S. montana*, but with a different inflorescence.

SCÆVOLA **coriacea;* shrubby, low and decumbent, branches ascending; axills sericeous; leaves short, oboval, obtuse, entire, thick and coriaceous, attenuated below; peduncles axillary and terminal, one to three-flowered, the germ bibracteolate; calyx almost an entire margin, corolla bearded within, externally smooth.

HAB. On the island of Atooi, near the sea. A very low decumbent shrub, with cuneate-oval, very thick, coriaceous leaves, not much larger than those of Box. Flower white, larger than the last, uniformly bearded within. Stile or stigma hirsute, the latter densely bearded. Drupe two-celled, two-seeded. The calyx a slightly crenate cup. The leaf scarcely an inch long, and about half an inch wide. Branches with a white and rough bark, the ascending ones about half a foot high.

SCÆVOLA **ligustrifolia;* shrubby and smooth, with slender leafy branches; axills of the young leaves shortly bearded; leaves lanceolate, at either end acuminate, serrulate or nearly entire; peduncles axillary, dichotomal, filiform and compressed, as long or longer than the leaves; flower very long, and nearly smooth externally; calyx very shortly and obtusely five-toothed, pubescent; bractes linear, persistent; indusium of the stigma smooth and ciliate, the style pubescent.

HAB. In Oahu; common in the mountains near Honolulu. Flowers rather showy and elegant, white, continuing in a long succession. Every part of the plant smooth, except the calyx, axills, and the exterior of the flower-bud, which are slightly pubescent. Leaves about two and a half inches long, and three quarters of an inch wide. Flower more than an inch long, internally pubescent on the tube. Calyx with five shallow teeth; anthers smooth. The stigma pubescent within the smooth margin. Nut two-celled. Allied to *S. Chamisgoniana,* but the leaves are never toothed, and the older leaves have naked axills.

SCÆVOLA **pubescens;* shrubby, leaves and branches pubescent; and axills shortly pilose; leaves lanceolate, acuminate at either end, sessile, repandly dentate, the dentures glandular, peduncles dichotomal, compressed, nearly as long as the leaves, bractes linear, lanceolate; corolla elongated, the tube smooth, bearded within as well as the style; berry smooth, two-celled, two-seeded.

HAB. Woods of Oahu, near Honolulu: rare. Apparently allied to *S. mollis.* Leaves thinly pubescent, except when young, green; about three and a half inches long and about an inch wide; the axills minutely bearded. Flower white, a little more than an inch long. The border a little pubescent externally. Calyx of five pubescent short teeth. Bractes longer than the berry, persistent, the former bluish when ripe; peduncles about two and a half inches long, twice forked, six to nine or more flowered. A very elegant and ornamental species.

ORDER *NEMACLADACEÆ. Character the same as that of the genus. Allied to GOODENOVIEÆ.

*NEMACLADUS.

Tube of the calyx turbinate, adnate to the ovary, the border five-cleft, nearly equal; corolla ringent, gibbous, five-cleft, without tube, upper lip vaulted, bifid, segments wholly membranaceous, with a nearly valvular æstivation; stamina five, the filaments distinct but connivent, into a tube, with the hair adnate to the corolla; anthers oval, free, or nearly connivent in a circle; stigma annular, bi-lobed, without a proper indusium; capsule semi-superior, many-seeded, below two-celled, the apex dehiscent by four valves; seeds spherical, impressed, punctate and striate, albumen carnose and oily.—A small, much-branched, lactescent, annual or biennial of Upper California; leaves alternate, rarely toothed, above linear and entire; branches dichotomous; flowers minute, white, axillary, on long, filiform peduncles. (The name employed is given in allusion to its numerous and slender branches.)

NEMACLADUS **ramosissimus*.

HAB. In sandy soils, near St. Diego, Upper California. Lower part of the stem and radical leaves a little hirsute. Primary leaves spathulate, incisely toothed, the rest of the leaves linear, entire and sessile, somewhat carnose and very smooth, about half a line wide; branches very numerous, procumbent and rigid, dichotomous and terete. Peduncles axillary, solitary, filiform and very slender, near half an inch in length. The whole plant spreading out about five or six inches. Calyx with the turbinate base embracing the adnate ovarium; the border five-cleft, somewhat ringent, the segments linear. Corolla monopetalous, small, white, and membranaceous, gibbous, bilabiate, but without tube; upper lip formicate, bifid, the segments falcate and acuminate; the lower lip three-toothed, very short; the dentures ovate, obtuse. Stamens five, with the filaments connivent into a tube, connected at base to the corolla, filaments very slender; anthers free, but connivent into a circle round the stigma, oval, acute, two-celled, white and short. Style one, stigma glandular, hirsute, two-lobed, without any proper indusium, capsule two-celled below, semi-superior, gibbous, the summit fragile, somewhat irregularly four-valved. Seeds numerous, brown and spherical, punctate and rough as in most of the *Lobelias*, but with the punctures arranged in rows or ribs.

OBS. A plant apparently without any proper affinities, constituting a very distinct order, probably between the true LOBELIACEÆ and GOODENOVIEÆ proper. It has the milky sap, resupinate corolla with membranaceous laminæ, and nearly the capsule and seeds of Lobeliaceæ; the free stamens of Goodenovieæ, though of a very different character, and with a stigma without indusium, nearly as in the Cyphiaceæ, but the corolla gamosepalus, and divested of tube.

Order CAMPANULACEÆ. (Decand.)

Heterocodon.

Calyx foliaceous, five-cleft, or by abortion three or four-cleft, the adnate tube roundish and turbinate. Corolla campanulate, five-lobed, in the lower flowers wanting or minute stamina, five, free, shorter than the anthers. Stigmas three, short. Capsule roundish, membranaceous, with salient angles; three-celled, dehiscing irregularly at the base. Seeds compressed, triquetrous, even. A slender, divaricately-branching annual of Oregon, scattered with almost retrorse, flat hairs, with the aspect of *Campanula perfoliata.* Leaves alternate, short, roundish, toothed and amplexicaule. Flowers solitary, sessile, the terminal ones only perfectly corolliferous. Corolla strictly campanulate, blue, and small, the stigma and style included. (The name alludes to the unequal character of the flower.)

Heterocodon **rariflorum.*⊙

Hab. Grassy plains of the Wahlamet and Oregon. Root very small, with a few simple fibres. The plant six to twelve inches high, slender, with few branches, often wholly simple; the stem angular, and pilose. Leaves numerous on the lower part of the stem, roundish-cordate, elegantly and very equally dentate, amplexicaule. Flowers solitary, axillary. Segments of the calyx foliaceous, wide and somewhat toothed; in the lower subapetalous flowers only three or four-cleft. Corolla about the size and form of that of *Campanula hederacea*, segments acute. This plant appears intermediate in genus between *Campanula* and *Dysmicodon.*

DYSMICODON, as a section of Specularia, *Endlicher.* *Gen. Plant. p.* 518.

Triodallus. (*Rafinesque.*)

Calyx in the upper flowers five-cleft, in the lower imperfect, or apetalous ones three or four-cleft, the adnate tube cylindric-obconic, compressed, even and without prominent angles. Corolla pelviform, five-lobed. Stamens five, free, filaments smooth, not dilated at base, much shorter than the anthers.

Stigmas three, filiform, revolute. Capsule linear-obconic, even, and compressed, two and three-celled, opening laterally by a small deciduous operculum. Seeds even, sublenticular. North American and Californian annuals, with alternate, amplexicaule roundish or ovate denticulate leaves. Flowers axillary, sessile, blue. Nearly allied to *Specularia*, but with a different habit, calyx and seed; and with the lower flowers apetalous and reduced in the number of their parts.

DYSMICODON *perfoliatum*, stem simple, erect, with the angles hirsute, leaves amplexicaule, broad, ovate or roundish, denticulate; flowers axillary, solitary, or by three's; lobes of the calyx in the lower flowers three and four lanceolate, acute, nearly half the length of the adnate tube. *Campanula perfoliata*, LINN. *Specularia perfoliata.* DECAND. 7. p. 491.

HAB. Throughout the United States, to the shores of the Pacific. Capsule opening about the middle.

DYSMICODON *Californicum;* stem erect, nearly simple, branching from the base, nearly without angles, and somewhat hirsute with spreading or retrorse hairs; radical leaves roundish and petiolate; cauline amplexicaule, ovate obtuse, obscurely crenulate, nearly entire, ciliate; flowers solitary, sessile; the calyx lobes about one-fourth the length of the adnate tube; capsule opening towards the summit.

HAB. In shady woods near Santa Barbara, Upper California. A very slender species allied to the preceding, but perfectly distinct. Lateral capsules two-celled, with three calyx-lobes. The perfect flower I have not seen.

DYSMICODON *ovatum;* stem erect, simple, smooth or somewhat hirsute on the angles; leaves ovate, acute, with very shallow crenatures, amplexicaule, radical ones spathulate-oblong; flowers one to three in the axills, sessile; the calyx lobes about one-fourth the length of the adnate tube; capsule opening towards the summit. *Campanula intermedia*, Dr. ENGELMANN, (non R. and Schultz.) Near Fort Gibson, Arkansas.

Specularia. TORREY, MSS.

HAB. Arkansas and Louisiana. With all the aspect of the first species, producing perfect pelviform blue flowers at the extreme summit only; in these the lobes of the calyx are lanceolate, acute, and as long or longer than its adnate tube. In the lower flowers the capsules are two-celled, and the lobes of the calyx three or four, rarely five. Some plants occur entirely smooth; in others the angles of the stem and the veins of the leaves beneath are pulvulous.

*CAMPYLOCERA.

Calyx in the upper flowers five-cleft, in the lower, apetalous ones unequally three-cleft, with the adnate tube long, cylindric and curved; tube of the perfect flowers, subterete and compressed. Corolla pelviform, five-cleft. Stamens five, filaments very short, equal and smooth. Stigmas two, oval and short. Capsule in the perfect flowers two-celled, subterete, usually opening with one deciduous operculum. Capsule of the imperfect flowers terete, one-celled, with a single parietal placenta, or a trifid, valvular dehiscence at length from the summit to the base, nearly as in *Clintonia*. Seeds even, elliptic, compressed, contorted. An annual of Arkansas, with much the habit of the preceding genus. Stems simple or branching from the base; leaves alternate, lanceolate, nearly entire; flowers solitary, axillary. (The name alludes to the curved, horn-like appearance of the lower capsules.)

Campylocera *leptocarpa;* stem hirsute at the angles, leaves ciliate.

β. glabella; stem and leaves nearly smooth. *Campanula leptocarpa.* Dr. Engelmann, MSS.

Hab. Arkansas; five to ten inches high. Except the upper surface of the leaves, covered with a minute hirsute pubescence. Leaves lanceolate and linear-lanceolate, the radical ones slightly crenulate. Calyx in the lower apetalous flowers cylindric and curved, with three ringent or unequal lobes, the capsule one-celled, with one of the three valves only placentiferous, and that parietal, as in the rare examples in this order of *Clintonia* and *Lisipoma.* The perfect two-celled capsules three quarters of an inch long, two-celled, linear and compressed, rounded at the sides, somewhat narrower at the base and summit, usually opening with but one opercular valve. In these flowers the five divisions of the calyx border become rigid and spreading, linear and acute. Corolla blue, conspicuous, rather deeply and acutely five-cleft, wholly like that of *Specularia.* The affinities of this plant, indeed, appear to be in the perfect flowers to *Specularia*, and the imperfect ones, in the absence of the corolla, might be mistaken for those of *Clintonia:* the valves are also almost equally as much contorted. The imperfect flowers appear a long time previous to those which are corolliferous. β. Fort Gibson, Arkansas. [*Engelmann.*]

* GITHOPSIS.

Calyx five-cleft, the segments long and linear, about the length of the adnate, obconic, cylindric tube. Corolla cylindric-campanulate, deeply five-cleft. Stamens five, free, filaments smooth, very short, not dilated. Stigmas three, revolute. Capsule three-celled, obconic, cylindric, striated, opening *within* the calyx by terminal pores. Seeds acute, ovate, subtriangular. An annual of Oregon. Stems branching from the base, dichotomous; flowers solitary, terminal and lateral, opposite the leaves, small and blue, scarcely exserted beyond the long, leafy lobes of the calyx. Leaves alternate, sessile, serrated, below very small. (Named in allusion to the resemblance of the flowers with those of *Githago segetum.*)

GITHOPSIS * *Specularioides.*

HAB. Plains of the Oregon, near the outlet of the Wahlamet; common. Flowering in May and June, four to ten inches high, more or less branched from the base; above dichotomal, with the upper part of the plant smooth. The flowers terminal or lateral, solitary: a branch usually issues, from the same axill with the lower flowers, producing a sort of irregular straggling cyme. Leaves oblong, or oblong-ovate, sharply serrate, the lower ones minute, the upper from a quarter to half an inch long, one to two lines wide. Adnate tube of the calyx about one-third of an inch long with ten striæ, attenuated below into a thick pedicel; the leaf-like, linear, and sometimes serrulated segments, about the same length. Corolla tubular-campanulate, scarcely longer than the calyx, border rather deeply five-cleft, the segments acute, deep blue, the base whitish. Stamens included, with long linear anthers, and very short, slender, equal filaments. Stigma trifid, short and revolute. Capsule three-celled, opening at the summit *within* the calyx, by the shrinking of the base of the corolla. Seeds numerous and minute, subtriangular, even and brown. Allied to *Specularia,* but with a cylindric capsule, opening only on the inner summit, a corolla approaching campanulate; angular seeds, and a very peculiar habit.

GITHOPSIS **Specularioides; β. hirsuta.* Every part of the plant, except the corolla, more or less hirsute: the capsule with reflected hairs.

HAB. With the above.

* XYLOCOCCUS.

Calyx five-parted, persistent, corolla cylindric-ovate, smooth within, the border five-toothed. Stamina ten, included; filaments long and subulate, pilose; anthers short and compressed, opening by two truncated pores, the summit biaristate, with the awns reflected. Ovarium globose, the base surrounded by a thick circular nectary. Style short, stigma obtuse. Drupe even, globular, dry, with a very thick, hard and even, spherical nut, by abortion one-seeded. A shrub of California, with alternate, entire leaves, tomentose beneath. Flowers on terminal racemes, red. Drupes smooth, and spherical. (The name derived from *ξυλον*, *wood*, and *κοκκος*, a *berry;* the berry or drupe being of a woody hardness.)

Xylococcus *bicolor.*

Hab. Monterey, Upper California. A fine shrub three or four feet high, with a smooth brown bark. Leaves nearly the form and size of those of *Rhododendron punctatum*, about two inches long and about three quarters of an inch wide, elliptic, acute, entire, above green and shining, beneath whitely tomentose, young branches pubescent. Racemes erect; pedicels and bractes, as well as the calyx, villous; bractes short. Corolla large, red, internally smooth. Anthers short, the awns about the same length. Drupes spherical, about the size of a grain of black pepper, yellowish, smooth, and shining, with a thin coating of dry insipid pulp, wholly juiceless; the nut spherical and even, without striation, occupying nearly the whole front, the shell exceedingly thick and hard, with a vestige of five cells, all obliterated but one, and that containing a single, oblong, compressed seed. Distinguished from *Arctostaphylos*, by the flower and habit, no less than the fruit: the filaments of the stamina are also proportionably longer, not suddenly dilated at base, but gradually subulate and pilose throughout.

Order. VACCINIEÆ. (Decand.)

DECAMERIUM. (Vaccinium, species *Linn.* and *Willd.*)

Calyx adnate to the ovary, the border five-toothed. Corolla subcampanulate, five-toothed, stamina ten, included; anthers without dorsal awns, bifid at the apex, with oblique pores; the filaments dilated at base, nearly as long as the anthers. Style scarcely exserted, the stigma capitate-annular. Drupe globose, invested by the calyx, partly ten-celled with ten pyrenæ, or only one-celled; nuts angular, one-seeded, about ten. Seed subelliptic, punctate. North American shrubs, with alternate, entire, oblong, or obovate leaves, flowers in lateral, leafy elongated bracteolate racemes, white, more or less tinged with red, arising from independent buds. Leaves and bractes sprinkled with resinous atoms. The fruit black or glaucous, subacid, and rather agreeable; but often disliked on account of their indurated nuciform carpels. Allied to *Gaylussacia,* but the habit and geographical range is wholly different; the drupe also not grooved, nor truly ten-celled, but with ten distinct pyrenæ, and the leaves deciduous. (The name alludes to the number and structure of the fruit.)

DECAMERIUM *frondosum. Vaccinium frondosum.* WILLD. sp. 2. p. 352. DECAND. 7. p. 566. *V. decamerocarpon.* IBID.

HAB. Common throughout the United States, from Canada to Florida. The drupe of this species appears to be five or ten-celled, with ten nuciform carpels. Berries rather large, blue, and globular, of a pleasant subacid flavour, but disagreeable from the occurrence of the hard nuciform carpels. Flowers small and campanulate, the border reflected. Filaments of the stamina smooth. Albumen large and fleshy. Embryo small and terete.

DECAMERIUM *resinosum. Vaccinium resinosum,* AITON. Kew. 2. p. 12. [ed. 1.] DECAND. 7. p. 566.

HAB. Common throughout the United States, and from Canada to Florida. In this species, the bractes and bracteoles are small, the former mere bud scales. Flowers mostly red. The filaments of the anthers somewhat pilose. The drupe or berry one-celled, with a circle of ten angular rough pyrenæ, attached internally to a sort of narrow axis or placenta. Leaves remarkably covered with resinous atoms beneath. Berries black and agreeable, but disesteemed from the presence of the bony carpels.

DECAMERIUM *hirtellum. Vaccinium hirtellum,* AIT. Kew. 2. p. 357. DECAND. 7. p. 566.

HAB. The Southern States of the Union, from S. Carolina to Florida. The young leaves before expansion are sometimes almost comescently tomentose. This variety may be deserving of notice as β.* tomentosum. Filaments of the stamina smooth.

DECAMERIUM *dumosum. Vaccinium dumosum.* ANDREWS. Bot. Rep. t. 112. DECAND. 7. p. 566.

HAB. From Massachusetts to Florida. A low running shrub, with leafy independent lateral bracteolate racemes. The corolla perfectly campanulate, white, with tints of red, the teeth erect. Berries black, conspicuously crowned with the erect, enlarged border of the calyx; at first glandularly pubescent; not unpleasant, but with the same fault as the preceding, the ten bony carpels being thick and hard, and disposed in a circle without any locular divisions. Filaments of the stamens pubescent, with something of the habit of a *Gaylussacia.*

Obs. This group appears to form a very natural genus. The structure of the fruit is extremely different from that of *Vaccinium myrtillus*, or the true Vacciniums; and all the species, peculiar to the United States, have, again, a different seed from the European type, the spermoderm being impress-punctate. In the present genus, the seeds within the bony putamen, are also similarly punctate.

* BATODENDRON. (Vaccinium, species of Authors.)

Calyx adnate to the ovary, the border five-toothed. Corolla campanulate, five-cleft. Stamens ten, included, anthers with dorsal awns, bifid at the apex, opening by long oblique foramina, the filaments smooth, short, and equal. Style exserted, stigma minute, truncated. Berry globose, invested by the calyx, umbilicate, ten-celled, cells three to five-seeded; the seeds sublenticular, puncticulate, imbedded in an indurated granular pulp. Albumen large and fleshy. Embryo small.—A small evergreen tree of the southern parts of the United States, intricately branched; leaves lucid, obovate, subserrulate. Racemes lateral and terminal; leafy. Flowers white, long, pedunculate, without bracteoles. Berries black and rather dry, but sweetish, and nearly inedible from the presence of a rough indurated granular pulp. Allied to the preceding genus, but with a very different fruit, and somewhat distinct habit. The name is derived from *βατος*, a *bramble*, the *blackberry* or *bilberry*, and *δενδρον*, a *tree.*)

Batodendron *arboreum, Vaccinium arboreum.* Marshall, Mich. Flor. Bor. Amer. 1. p. 230. Presl. 1. p. 285. Decand. 7. p. 567. Vaccinium *Diffusum.* Aiton. Hort. Kew. vol. 2. p. 11.

Hab. From North Carolina or Virginia to Florida and west of the Mississippi in Arkansas known by the name of the Farkleberry. A small tree 10 to 20 feet high, with roundish and obovate leaves. Berries black and smooth, but scarcely edible, being filled with a granular pulp almost as coarse as saw-dust. The spermoderm thick, impress-punctate and indurated. The bark of the root is very astringent, and a decoction of it is employed in dysentery and diarrhœa, as well as the dried fruit. *(Elliott.)* Perhaps *Vaccinium leucanthum* of Chamisso may form a second species of this genus.

* PICROCOCCUS. (VACCINIUM, Species LINN. and Authors.)

Calyx adnate to the ovary, the border five-toothed. Corolla pelviform, five-lobed, shorter than the stamens. Stamens ten, exserted; anthers with short dorsal awns, deeply bifid and very long, opening by elongated, oblique foramina, with bifid or lacerated points; filaments short, pubescent and dilated. Style exserted; stigma an even truncated point. Berry large, globose and pyriform, invested by the calyx, umbilicate, eight to ten-celled, by abortion six to eight-seeded. Seeds roundish and elliptic, puncticulate. North American shrubs, with alternate entire deciduous elliptic leaves. Racemes lateral, leafy, peduncles usually without bracteoles, sometimes axillary. Flowers white. Berries juicy, pale green or purplish, bitter and inedible. (The name alludes to the bitter fruit.)

Picrococcus stamineus. Vaccinium staminium, LINN.

HAB. From Canada to Florida, common. *(Deerberry.)*

Picrococcus elevatus. Vaccinium elevatum. BANKS and SOLANDER, Decand. 7. p. 567.

HAB. New Jersey to South Carolina and west to the Mississippi, in Ohio, &c. β. In the woods of Mexico between Pachuca and Real del Monte.

*Picrococcus *Floridanus;* leaves ovate or cordate-ovate, acute, at length smooth, peduncles axillary, one-flowered, subbracteolate; corolla but little longer than the five-cleft calyx; dorsal awns of the stamina minute. *Vaccinium Floridanum.* Herb. SCHWEINITZ.

HAB. Florida. (Mr. Cooper.) I have seen only a single branch, in which the flowers appear truly axillar. The calyx is unusually large, corolla small and contracted. The leaves about two inches long, and more than an inch wide.

OBS. There is a remarkable abortion of seeds in the berries of this genus. Sometimes we find scarcely more than one or two, rarely more than six or eight, although the berry is uncommonly large, (near half an inch in diameter sometimes.) The seeds are about the size of those of Mignionette, or a little larger, elliptic-ovate and convex, brown, with a pitted epidermis, and a large, conformable, oily, and fleshy white albumen. In all the seeds I have now had an opportunity of examining, the embryo is wanting. The species here brought together, and proposed as a genus, are, again, a very natural group.

VACCINIUM. (Linn. in part.)

§ I. *Seeds angular, impunctate. Anthers biaristate.* † *Leaves deciduous.*

Vaccinium *Myrtillus,* Linn. Near the line of perpetual snow, in the central chain of the Rocky Mountains. (Thornberg's ravine.) *β. microphyllum,* Hooker, Flor. Bor. Am. 2. p. 33. Exactly the European plant, but smaller.

Vaccinium *ovalifolium.* Smith.

Hab. In the shady woods of the Oregon, near Fort Vancouver.

Vaccinium *parvifolium.* Smith.

Hab. With the above.

Vaccinium *cæspitosum β.* **cuneifolium.* Stem low and branching, not cæspitose; leaves all obtuse.

Hab. Plains of the Oregon, near the Wahlamet, common, forming extensive tufts. Six to eight inches high. The berries covered with a dense bloom, but not agreeable.

Vaccinium *uliginosum.* Linn.

Hab. The White Mountains of New Hampshire. In this species the seeds are numerous, much curved, and acute at each extremity.

† *Leaves sempervirent. Anthers unawned.*

Vaccinium Vitis Idæa.

Hab. Canada, the White Mountains and North-West coast, but I have not met with it in the latter locality.

§ II. *Seeds somewhat oval and rounded, impressed-punctate. Cells of the berry about ten-seeded.*

Anthers unawned; leaves more or less deciduous.

Vaccinium *corymbosum,* Linn. also *V. Pennsylvanicum,* Lamarck. *V. virgatum,* Aiton. *V. Canadense,* Richardson. *V. Ligustrinum,* Mich. *V. galezans,* Mich. *V. tenellum,* Aiton. *V. myrsinites,* Mich.

* METAGONIA.

Calyx adnate to the ovary, the border four or five-cleft. Corolla conic or ovoid, pentangular, of a thick consistence, the border four or five-cleft. Stamens eight to ten included, the anthers bifid, with or without awns, dehiscing by terminal oblique pores. Style included, stigma minutely five-lobed. Berry sub-pyriform or globose, fleshy, conspicuously crowned by the enlarging calyx, five-celled, with a five-lobed placenta, the lobes separated by the dissepiments. Seeds small and exceedingly numerous, angular and somewhat cuboid, impressed-punctate.—Small evergreen shrubs of South America, extending to Oregon, Mexico, the West Indies, and the southern States of the American Union: a distinct section exists in the Sandwich and Friendly Islands, and perhaps in Madagascar. Leaves generally serrate and small. Flowers usually scarlet or red, as well as the calyx and fruit. Berries of a fleshy consistence, as in those of *Aronia*, usually edible, not juicy or glaucous, as in the whortleberry. Probably a divided genus. But I have no materials for its investigation beyond the limits of the United States, the Sandwich Islands, and a single species from Peru. (The name given is in allusion to the angular form of the corolla.)

§ I. *Berry subpyriform, anthers awned.*

† *Peduncle solitary, axillary, ebracteate.*

METAGONIA *cerea! Vaccinium cereum.* FORSTER. Flor. ins. Austral. prod. p. 28.

HAB. Tahiti.

METAGONIA *calycina, Vaccinium calycinum.* SMITH. Cyc. no. 7.

HAB. On shelving rocks at the Pari, Oahu. A very humble shrub, with scarlet flowers, calyces and fruit. The berry has exactly the appearance and consistence of that of the *Aronia botryapium*, being crowned with a very conspicuous calyx: its taste is agreeably subacid, and it is frequently employed as a preserve by the missionaries. This, or the preceding species, is the *Ohelo* of the natives, so abundant in the volcanic mountains of Owhyhee.

METAGONIA *penduliflora. Vaccinium penduliflorum,* (GAUDICHAUD.) Probably nothing more than a variety of *M. cerea.* Corolla in all the species conic and pentangular.

†† *Flowers racemose.*

METAGONIA *meridionale. Vaccinium meridionale.* SWARTZ.

HAB. The mountains of Jamaica.

METAGONIA *corymbodendron. Vaccinium corymbodendron.* (DUNAL.)

HAB. In Alpine situations, near the city of Pillao, Peru. The calyx bibracteate. Corolla conic.

§ II. *Anthers awnless, with nearly erect terminal pores. Fruit pyriform or globose.*

METAGONIA PYXOTHAMNUS, *ovata, Vaccinium ovatum.* PURSH. 1. p. 290. *V. lanceolatum.* DUNAL. A numerous leaved variety.

HAB. Common on the banks of the Oregon, near the sea. An evergreen, elegant shrub, three to five feet high, and erect. Also in Upper California near Santa Barbara, but with the stems more hirsute. Fruit dry and scarcely edible.

METAGONIA *myrtifolia, Vaccinium myrtifolium.* MICH. Flor. Bor. Am. 1. p. 229. *V. crassifolium,* ANDREWS.

HAB. North Carolina to Florida. Flowers small, subcampanulate, pentangular, in contracted bracteolate racemes. Berries rather dry and insipid.

METAGONIA *terniflora, Vaccinium terniflorum,* DUNAL. in DECAND. 7. p. 575.

HAB. In Peru, (Pavon.) Calyx four-parted.

METAGONIA *didymantha, Vaccinium didymanthum,* DUNAL. in DECAND. ibid.

HAB. In Peru. Calyx five-parted.

METAGONIA? *alaternoides, Vaccinium alaternoides.* (HUMB. *β.* and KUNTH. nov. gen. 3. p. 265.)

HAB. In the Andes of Peru.

METAGONIA *Penæoides, Vaccinium penæoides.* (H. B. and KUNTH. 3. p. 264.)

HAB. On the mountain Tanguragua, in Quito. Corolla tubular-campanulate, quadrifid.

METAGONIA **prostrata;* Stem prostrate, pubescent; leaves crowded, oblong-lanceolate, at either end acute, serrulate, beneath strongly nerved, subciliate; petioles pubescent, minute; peduncles short, thick and axillary, one to three-flowered; calyx bibracteolate; corolla conic-ovoid, pentangular, five-cleft; berry pyriform.

HAB. In Peru, between Cuenca and Loxa. (Dr. Jamison.) A prostrate shrub; stems eight to twelve inches long, terete. Leaves very numerous, secund, thick, small and coriaceous, near half an inch long and about two lines wide, serrulations distant and shallow, the lower portion of the leaf subciliate on the margin. Peduncles short and approximate, thick and very smooth, clad with several pairs of bractes, indicating so many abortive flowers. Germ and berry pyriform, smooth, wrinkled and fleshy: segments of the calyx triangular, acute, conspicuously crowning the berry. Corolla conic, pentagonal, about the length of the germ, the border connivent and five-cleft. Every part of the inflorescence, apparently scarlet. Style included; the stigma minutely five-lobed, subcapitate. Filaments pubescent, anthers awnless, short, with terminal and not oblique pores. Berry five-celled, insipid, the cells each containing many more seeds than in the true *Vacciniums,* the seeds brown, puncticulate, angular and somewhat cuboid, closely allied apparently to *G. penæoides.* The general colour of the plant, when growing, is purple.

METAGONIA *empetrifolia, Vaccinium empetrifolium.* (H. B. and KUNTH. nov. gen. et spec. 3. p. 263. t. 248.)

HAB. In Peru on the mountain Antigoma. Corolla tubular-campanulate, four-cleft, scarlet.

METAGONIA? *acuminata, Vaccinium acuminatum.* (H. B. and K. ibid.)

HAB. In the mountains of New Grenada and Peru, in Alpine elevations. Flowers white, corolla four-cleft.

METAGONIA *crenulata, Vaccinium crenulatum.* (DUNAL. in DECAND. 7. p. 570.)

HAB. In Peru.

METAGONIA *marginata, Vaccinium marginatum.* (DUNAL. ibid.)

HAB. In Peru.

METAGONIA? *villosa, Vaccinium villosum.* SMITH in Rees' Cycl. no. 29.;

HAB. In Mexico (MUTIS.) Corolla purple, pentagonal, with the angles villous.

METAGONIA? *Schlechtendalii, Vaccinium Schlechtendalii.* G. DON. Gen. Syst. 3. p. 856.

HAB. Mexico. Calyx bracteolate. Berry globose, umbonate.

OBS. The Madagascar species may also, in all probability, be referred to this group of species, with several others; but the whole must now be left to the decision of future observers.

ORDER ERICACEÆ.

TRIBE ARBUTEÆ. DECAND.

ARBUTUS *Menziesii;* not uncommon on the banks of the Oregon, below Fort Vancouver, in rocky places, where it becomes a tree thirty to forty feet high. The flowers abundant, yellowish-white; the berries orange yellow, dry and coated with a thin layer of granular tubercular pulp. Very nearly allied to *A. Andrachne.*

ARCTOSTAPHYLOS. (GAL. DECAND.)

† *Fruit even, berried. Leaves coriaceous, persistent, mostly entire.*

ARCTOSTAPHYLOS *uva-ursi.*

HAB. Around Vancouver, and the hills of the Oregon to the Pacific.

ARCTOSTAPHYLOS **pumila;* glaucous, dwarf and erect; somewhat closely pubescent; leaves obovate, obtuse, entire, lucid above, below narrowed with a petiole; flowers on short terminal bracteate racemes; pedicels obtusely bibracteolate at base; corolla bearded within; awns of the anthers slenderly hirsute, nearly twice their length, filaments sparingly bearded, twice the length of the anthers; calyx ciliate.

Hab. Round Monterey, Upper California. Flowering in March and April, very much like *A. uva-ursi*, but a low erect shrub about half a foot high, branching from the base and forming tufts. Stems brown and smooth, branches villous as well as the young leaves beneath, the leaves at length smooth. Flowers white, in short rounded racemes. Corolla verticose-ovate, the border reflected, densely bearded within towards the orifice. Segments of the calyx slenderly ciliate: bractes linear, reflected, about the length of the villous short petioles. Awns of the anthers very long and hirsute; the filaments with a few straggling hairs at the base.

Arctostaphylos **acuta;* glaucous, dwarf and erect, pubescent, leaves obovate or oblanceolate, with a short acute point, at length nearly smooth, below narrowed with a petiole; flowers in short terminal bracteate racemes, the pedicels minutely bibracteolate at base; corolla pubescent within; awns of the anthers slenderly hirsute, about their length, filaments smooth.

Hab. With the above, for which it might be mistaken as a variety, but the leaves are usually broader, and the flowers smaller and striated with pink.

*XEROBOTRYS.

Arctostaphylos, but the corolla four or five-toothed. Stamens eight to ten. Ovarium subglobose, the base surrounded by a thick, circular, entire nectary. Berry globose, dry and farinaceous, containing three to five triangular grooved nuts, the nuts one, two or three-seeded; one, two or three-celled. The cells tortuous. Seeds curved and elongated, sempervirent.—Shrubs of Upper California, leaves entire or serrated; racemes contracted, terminal, flowers white or rosaceous. Berries yellow, spherical, dry, juiceless and insipid. Nearly allied to *Xylococcus*, but the flower that of *Arctostaphylos*, and the structure of the fruit distinct from both. (The name from *ξηρος dry*, and *βοτρυς, a grape or berry*, in allusion to the nature of the fruit.)

Xerobotrys *tomentosus, Arbutus tomentosa.* Pursh. Flor. Bor. Am. 1. p. 282. Hooker, Flor. Bor. Am. 2. p. 36. Fig. 130. *Arctostaphylos tomentosa.* Doug. Decand. 7. p. 585. *Andromeda? bracteosa,* Decand. Prod. 7. p. 607.

Hab. Monterey, Upper California; common. A bush growing in tufts about three feet high. Flowers white, or with a slight rose tinge; leaves generally entire. Berries yellow, as large as pepper corns, spherical and pilose, with a dry, perfectly insipid farinaceous pulp, containing mostly about three obtusely three-sided nuts, with two other abortive ones, each containing two or three cells, with a single elongated seed, in each filling the tortuous cavity of the nut. Our plant is nearly ferruginous.

XEROBOTRYS. *argutus.* *Arctostaphylos tomentosa β? arguta,* DECAND. ib. Certainly not our species, which is very rarely even minutely serrulate.

XEROBOTRYS? *cordifolius.* *Arctostaphylos cordifolia.* LINDL. DECAND. Prod. 7. p. 586.

XEROBOTRYS? *glaucus.* *Arctostaphylos glauca.* IBID. DECAND. Ib.

XEROBOTRYS * *venulosus;* erect; branchlets, petioles and margins of the leaves pubescent; leaves elliptic, or elliptic-ovate, acute, sometimes subserrulate, rather long petiolate, thick, smooth and shining; racemes terminal, corymbose; bractes scale-like, very short; calyx ciliate; corolla bearded within; filaments pilose; awns of the anthers very long; the berry globose and smooth. *Andromeda? venulosa.* DECAND. Prod. 7. p. 607.

HAB. Round Monterey, Upper California. A shrub about a foot high, at length wholly smooth. Branches brown and smooth, those of the young shoots, hoary and villous, clad with the persisting brown bud scales. Leaves about an inch long, half to three quarters of an inch wide, thick and mostly acute at base, green on both sides, even and reticulated, so that both surfaces appear similar. Flowers white, in short crowded fastigiate racemes. Bractes almost imbricated, ovate, acute, pubescent, not half as long as the short peduncles, which are bibracteolate at base. Berries smooth, depressed-spherical, of a similar form and structure with those of *X. tomentosus*, corolla short and ovate.

TRIBE ANDROMEDEÆ. (Ital.)?

GAULTHERIA *Shallon.*

HAB. In shady woods, Oregon, very common. About two feet high, and filling up extensive tracts. The berries black, and somewhat agreeable.

*PORTUNA. (ANDROMEDA, PURSH.)

LEUCOTHÖE, but with the anthers bifid, biporous, and dorsally awned at the base, the filaments smooth. Capsule globose. Seeds six to ten in a cell, oblong, flat and alated or membranaceous, imbricated longitudinally, with a terminal hylum.—An evergreen shrub of the Southern States, with coriaceous, elliptic, ciliate serrulate leaves, and terminal panicles of white flowers, the corolla ovate-cylindric. (The name alludes to its proximate relation to *Leucothöe.*)

PORTUNA *floribunda.* *Andromeda floribunda.* PURSH. Flor. Bor. Am. 1. p. 488. CURT. Bot. Mag. t. 1566. Bot. Reg. 807. *Leucothöe floribunda,* D. and G. Don. *Zenobia floribunda,* Decand. 7. p. 598. Capsule as large as a pepper corn. The five lobes of the placenta, at the summit of the capsule. Seeds longitudinally arranged, unusually large.

*EUBOTRYS. (ANDROMEDA, LINN.)

Calyx five-parted, bibracteolate at base. Corolla cylindric subovate, the border five-toothed, reflected. Stamens ten, filaments lanceolate, flat and smooth, about the length of the anthers; anthers bifid, the summit four-awned. Style filiform. Stigma truncate, subcapitate. Capsule five-celled, five-valved, depressed-globose, dissepiment medial. Seeds minute, numerous, angular and flatly compressed.—Deciduous leaved shrubs of the United States, with the flowers in secund, cauline, or axillary simple racemes. Flowers white. (The name alludes to the remarkable racemose inflorescence.) Somewhat allied to *Zenobia*, but very different in habit, and inflorescence: the seeds also minute and flat, while in Zenobia they are rather large, roundish and angular.

EUBOTRYS *racemosa;* nearly smooth; leaves oblong, acute or acuminate serrulate; racemes elongated lateral; bractes none, or deciduous. *Andromeda racemosa*, LINN. *Lyonia racemosa*, DON. 11. cc. *Zenobia racemosa*, DECAND. 7. p. 598.

HAB. From Canada to Georgia. Divisions of the calyx lanceolate, acute, the base subtended by two similar bracteoles. Flowers white.

EUBOTRYS **bracteata;* smooth leaves, oblong-lanceolate, coriaceous, acute, serrulate; racemes axillar and terminal, bracteate; bractes linear.

HAB. East Florida, (Mr. Ware.) A very imperfect specimen, not advanced to flowering. The leaves thick and rigid.

PHYLLODOCE. (SALISBURY.)

PHYLLODOCE *Grahamii, Menziesia Grahamii.* HOOKER, Flor. Bor. Amer. 2. p. 40. *M. empetriformis*, GRAH. in Bot. Mag. t. 3176.

HAB. Near the summit of the central range of the Rocky Mountains in Thornberg's ravine. Many specimens differ in the paucity of flowers, there being only three or four together; the peduncles are also somewhat glandularly pubescent. The corolla is campanulate and pale red, The general aspect and size is that of *P. laxifolia*, but the flowers are smaller.

MENZIESIA *ferruginea.*

HAB. Around Fort George, near the estuary of the Oregon.

LEDUM. (LINN.)

* LEDADENDRON. *Capsule subglobose; filaments pilose towards the base; stigma annulate, five-lobed.* A tall sempervirent shrub, with alternate entire leaves, smooth on both surfaces, beneath covered with resinous scales. Flowers umbellate, white.

LEDUM **glandulosum;* a tall and stout shrub, leaves elliptic, entire, mostly obtuse, but mucronulate, long petiolate, smooth on both surfaces, beneath paler and resinosely atomiferous; capsule globose-ovate.

HAB. In the central chain of the Rocky Mountains, on the sides of the mountains which close up Thornberg's ravine, growing in extensive thickets, the bushes four to six feet high, and as large as those of *Kalmia latifolia*. Bark brown and smooth. Branches coming out in circles at length from the base of former corymbs. Leaf an inch to an inch and a half long, three quarters of an inch wide; petiole half an inch long. Every part of the plant in a young state, except the corolla and upper surface of the leaves, scattered with shining yellow resinous scales. Leaf paler beneath, dark green above. Peduncles one half to three quarters of an inch long, corymbose. Calyx five-lobed, small, the segments oval, obtuse, ciliated. Corolla of five white, broad, oval petals. Stamens ten, filaments long, subulate, pilose below; anthers oblong biporose. Style about the length of the stamens, thickened above, annulate with five linear lobes within. Capsule roundish ovoid, pubescent as well as glandular and scaly, five-celled, five-valved, the axis pentangular, dehiscing at the base. Seeds numerous, subulate, alated at either end. Quite similar, but smaller than in *L. latifolium*. The habit of this plant approaches to that of *Kalmia*.

ORDER EPACRIDEÆ. (B. BROWN.)

CYATHODES *Tameiameiæ* and *C. Banksii.*

HAB. On high hills near Kolao in the Island of Atooi.

ORDER PYROLACEÆ. (LIND.)

PYROLA. (SALISBURY, DECAND.)

PYROLA **elata;* leaves round or oval, obtuse, attenuated below, minutely crenulate, about the length of the petiole; stipules long, lanceolate, acuminate; scape angular and very tall; calyx lobes lanceolate, acute; corolla spreading; stigma five-lobed.

HAB. Shady woods of the Oregon, near the confluence of the Wahlamet. Caudex creeping and extensive, remarkable for its numerous, long, narrow stipules. Leaves two inches or more long, about an inch and a half wide, very dark green. Sometimes as round as in those of *P. rotundifolia*, to which it is very closely related. Scapes eighteen to twenty inches high! with about two free scales. Bractes lanceolate, acuminate, about the length of the pedicels. Flowers bright, rose red and fragrant, rather smaller than in *P. rotundifolia*. Petals elliptic-oblong. The crenulations of the leaves scarcely sensible. A majority of the leaves are oval.

PYROLA *bracteata.*

HAB. Dark fir woods of the Oregon, near Fort Vancouver. As the flowers advance the bractes appear, as in other species, no longer than the pedicel. The flower of this species is also strongly tinged with red, and very similar to that of *P. rotundifolia;* the stipules are acuminate, as in the preceding.

PYROLA *minor.*

HAB. Base of the White Mountains of New Hampshire. (Pickering.)

PYROLA *secunda; β.* * leaves roundish-ovate, minutely crenulate, obtuse.

HAB. Blue Mountains of Oregon, not far from the River Oregon.

§ * SCOTOPHILA.—*Seeds minute, nearly spherical, terminated at either extremity by a small reticulated roundish membrane. Anthers with short wide basal inverted pores.*

PYROLA *aphylla.*

HAB. In the shady pine woods, round Fort Vancouver. Occasionally it produces, near the root, and on infertile shoots, a few small, ovate or lanceolate greenish leaves, but it is generally clad only with whitish scales. By the seed, this species makes a near approach to *Pterospora.* A variety also occurs with lanceolate, acuminate divisions to the calyx, which may be called β. * *leptosepala.*

MONESES. (SALISB. DECAND. PYROLÆ. LINN.)

MONESES * *recticulata;* leaves roundish-ovate, dentate, reticulately and prominently veined; calyx ciliate; anthers as long as the filaments. *Pyrola uniflora.* HOOKER, Flor. Bor. Am. (in part.) 2. p. 45.

HAB. Shady fir woods of the Oregon, not far from the sea. Nearly allied to *M. grandiflora* DECAND.; but the leaves are strongly toothed, with elevated reticulations.

CHIMAPHILA *umbellata.*

HAB. In the shady woods of the Oregon, towards the sea. Larger than usual, and with the leaves acute. The flowers I have not seen.

PTEROSPORA *Andromedea.*

HAB. The forests of the Blue Mountains in Oregon. Seed nearly spherical, acute at each end, striated, terminated above by a very broad, scale-like, dilated, round, reticulated, transparent membrane, many times broader than the seed.

HYPOPITYS *Americana.* (*H. multiflora β. Americana*, DECAND.)

HAB. Shady forests of the Oregon.

MONOTROPA *uniflora.* (LINN.)

HAB. With the above.

ARTICLE XIV.

Observations on the Geology of the Western Peninsula of Upper Canada, and the Western Part of Ohio. By William B. Rogers, Prof. of Natural Philosophy in the University of Virginia and Henry D. Rogers, Prof. of Geology in the University of Pennsylvania. Read December 3, 1841.

To determine the exact position of the wide-spread formations of the Ohio River and the western Lakes in the general system of the Appalachian rocks, as developed in New York, Pennsylvania, Virginia and Tennessee, is a problem of much interest in the geology of the United States. It is indeed an essential preliminary to some of the most important inquiries of a scientific kind which can engage American geologists. The gradations of type in these ancient sedementary deposits, which extend, we believe, more or less to their included organic remains, and which must be first studied before we can clearly understand the physical changes that have marked the history of these strata, will not be reduced to their true laws until the continuity of the eastern and western rocks shall have been fully established.

But this determination is attended with many difficulties, since the very variations of type referred to, are often of a nature to mislead; their true value not being recognised until the investigation is nearly over. Besides these liabilities to error from changes of type imperfectly ascertained, there are others incident to the region before us where the unsupplied links between the eastern and western strata are to be sought. These are the horizontality of the rocks, the deep covering of drift which generally conceals them and the interruption of their range by the interposed waters of Lake Erie.

To compare directly the formations as they appear in the Appalachian chain with their western and northern outcrop in Ohio and New York, would not, we believe, furnish satisfactory identifications; for we already know the great alterations in type which most of them undergo in passing northward and westward under the broad bituminous coal field of Pennsylvania and Ohio. To trace them *continuously* by their lithological and fossil characters, north-eastward to the Mohawk, and thence westward through New York, seemed to us to be rendered necessary by the thinning out of some formations, the coming in of others, and the suspected partial changes in the organic remains of all; and to be, in fact, the only method compatible with the caution essential in such researches.

After devoting considerable pains to a preliminary study of the formations of western New York, we resolved, if possible, to keep in view some easily recognised horizon among the strata, and by working round Lake Erie through Upper Canada and Michigan, form a junction with the rocks of Ohio.

Believing that by this procedure we have ascertained the place, approximately at least, of the rocks of parts of Upper Canada, Michigan and Ohio, we propose in the present paper to give a concise account, first, of their range from the Niagara river to Lake Huron, and, secondly, of the course of some of them from Lake Huron into Ohio.

PART I.

OF THE RANGE OF THE NIAGARA RIVER ROCKS THROUGH UPPER CANADA.

RANGE OF THE NIAGARA LIMESTONES.—This group of rocks, in its extension across Upper Canada, continues, as in New York, to form a great part of the escarpment of the Mountain Ridge. Its line of outcrop, thus marked, follows a nearly west course from Queenstown and the Niagara river, to the head of Lake Ontario; then bending in a rapid curve around the head of the Lake to near the foot of Burlington Bay, it strikes off in a N. N. W. direction towards Lake Iroquois, or the Georgian Bay of Lake Huron, the southern shore of which it reaches in the neighbourhood of Penetangasheen. From the Niagara river to the head of Lake Ontario, the arenaceous rocks composing the Grey-band and the other strata immediately beneath the Niagara limestone group, form, as in the neighbouring parts of New York, a low bench adjoining the base of the main terrace, while the red shales and sandstones still lower in the series overspread the plain which stretches northwards, from the margin of this bench to the Lake shore; the whole of this series of strata, from the red shales upwards, having a gentle dip towards the south.

In passing from the Niagara river to the head of the Lake, we remarked a gradual but slight change in the lithological character of some of the strata of the Niagara limestone, the nature and degree of which will be best indicated by the annexed sketch of a vertical section of these rocks, as they are displayed in the mountain ridge at a point west of Hamilton, and upwards of fifty miles west of the Niagara river.

SECTION WEST OF HAMILTON ON THE ROAD TO ANCASTER, IN THE DESCENDING ORDER.

1. Brownish, subcrystalline, bituminous limestone.
2. Siliceous limestone of a brownish and gray colour, containing distinct courses of flint or cherty nodules.
3. Rather soft siliceous sandstone, occurring in thick slabs.
4. Hard siliceous limestones and sandstones with the vesicular structure, and hollow encrinal impressions characteristic of similar strata at Niagara Falls.
5. Lead-coloured shales and calcareous slates.

Comparing the above series of strata, in detail, with a section of the rocks at the falls and whirlpool, obtained by repeated examinations, we find that while the general character and order of succession of the principal beds remain unaltered, the calcareous and siliceous portions are more defined in their composition, the geodes are much less frequent in all the beds, and the cherty matter of the higher strata is more entirely collected into regular layers or courses. The whole group is also considerably thicker than on the Niagara river.

For some distance westward of the escarpment of these rocks, the upper plain formed by the mountain ridge is in general deeply covered with drift composed of the rolled fragments of the siliceous and bituminous limestones and sandstones, together with some of the materials of the red shale and sandstone of the formation next below; but almost entirely unmixed with the fragments of other higher calcareous rocks. Between Ancaster and Brandtsford, about thirty miles west of Hamilton, the drift contains a gradually lessening proportion of the materials of the red shale and sandstone, while to the west and northwest of Brandtsford it ceases altogether.

In the vicinity of Paris, however, about thirty-eight miles west of Hamilton, rolled fragments of the upper group of limestones begin to make their appearance in the streams and on the surface; and, growing more frequent as we proceed westward, prove, near London, the predominant material of the drift. It need scarcely be remarked, that the N. N. W. trend of the terrace formed by the Niagara limestone would, in connexion with the admitted southerly course of the drift, give rise to the distribution of the materials here described.

RANGE OF THE GYPSEOUS SHALES.—Crossing the Niagara river in the neighbourhood of the Tonewanta, this group of strata stretches in a narrow belt some distance south of the terrace, and parallel with it. It intersects the Welland canal, and follows the course of Grand river to the vicinity of Paris. From this point these shales sweep towards the north to conform with the flexure of the mountain ridge, and passing a little east of Guelph range towards the southern end of Lake Iroquois. The gypseous shales are well exposed, in excavations for plaster, in two places on the Grand river. One of these is near the Welland canal and the other at Paris, where the top of the formation rises perhaps forty feet above the level of the stream. The shales here contain the curious hopper-shaped cavities familiarly known as a distinctive feature of the upper part of the formation in New York. They are accompanied, likewise, by the remarkable vesicular or pitted limestone, which, throughout the western counties of that state furnishes so good a guide to the gypseous beds.

RANGE OF THE VESICULAR LIMESTONE.—This is ordinarily an impure, buff-coloured, subcrystalline limestone, abounding in small lenticular cavities, having very much the shape of tabular crystals of selenite, to which they probably owe their origin. Remarkable for the permanency of its peculiar features and for its wide diffusion, this stratum has proved of the utmost service in our researches, as a safe and convenient base in establishing the super-position of the other more variable formations. Tracing the less easily identified strata by it, it served us as a grand lithological horizon from the Niagara river through Upper Canada into Michigan and Ohio.

At Paris it is associated, we have already said, with the gypsum-bearing shales. From that neighbourhood it may be traced northward to the vicinity of Guelph, in obedience to the general northern strike of all the rocks as they follow the trend of the great terrace. Westward and south-westward from Guelph the stratum very gently declines in level, in accordance with the general dip. At Beachville, on the south branch of the Thames, it is below the level of the water, the river bed, both here and at intervals for many miles north-eastward, exposing a higher limestone, and on the north branch of the same river we ascend the stream nearly forty miles northward from London before the pitted rock emerges to the surface. South of a nearly east and west line, drawn from Guelph to Goderich, rounded and weather-worn fragments of the pitted rock abound in the general drift, composed of the limestones and other beds that outcrop to the north and north-east. But in the Maitland river of Lake Huron, it is found *in situ*, well exposed with a group of overlying limestones both at Goderich and for several miles up the stream.

In no instance either among the rolled fragments or in the beds seen in place, did we detect any organic remains; but its position at the top of the gypseous shales, and its singularly well marked features, leave us in no uncertainty as to the formation to which it belongs.

Of the Rocks overlying the Vesicular Limestone in Upper Canada.—The strata which repose upon the pitted, or vesicular limestone in the western portions of Upper Canada, do not accord, exactly, with those which overlie this rock in New York. Important changes in the group take place, in fact, within the limits of that State, and other modifications will be shown to arise westward of the Niagara River. In the central counties of New York, the following strata, according to Mr. Vanuxem, intervene between the pitted rock and the Marcellus shales. 1. Hydraulic limestone; 2. Pentamerus limestone; 3. Delthyris shaly limestone; 4. Scutella limestone; 5. Oriskany sandstone; 6. Fucoides Cauda Galli beds; 7. Onondaga limestone; 8. Corniferous limestone; 9. Seneca limestone.* But in the counties west of the Genessee River the only strata not thinned away are, 1. Hydraulic limestone. 5. Oriskany sandstone. 7. Onondaga limestone. 8. Corniferous limestone, and 9. Seneca limestone.† Some of these remaining strata are much lessened in thickness,

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* See Vanuxem's fourth Annual Report, General Survey of New York.

† See Hall's fourth Annual Report, General Survey of New York.

and the Oriskany sandstone is altogether absent at the Niagara River. The Rocks which have thus disappeared in going westward through New York, comprise, with the exception of the Hydraulic limestone, all the members of formations six and seven of the Appalachian System of Pennsylvania and Virginia.

In approaching the interior of the Peninsula of Upper Canada, we have evidences of a further change in the formations; the Corniferous and Onondaga limestones appearing to cease altogether before we mark the eastern shores of Lake Huron, and the Hydraulic and Seneca limestones either, likewise, disappearing, or so changing their type, as to make their recognition uncertain.

A group of limestones resting on the pitted rock about thirty miles above London, on the north branch of the Thames, seems to embrace a stratum referable to the Onondaga rock; but on the Maitland River near Goderich, where the series is well exposed, none of the formations developed east of Buffalo, excepting the well characterized pitted limestone, could be identified.

The following section of the strata exposed in the cliffs of the Maitland, conveys, we believe, a correct idea of the general order of superposition of the limestones of the south-western part of the peninsula of Upper Canada.

1. Ascending the River from the bridge near Goderich, the lowest stratum seen near the water's edge is a fawn-coloured slaty limestone of fine texture, containing hopper-shaped cavities, and a few fossils. This rock was recognised as belonging to the upper part of the gypseous shales.

2. A buff-coloured arenaceous limestone, striped with various shades. It is often merely a calcareous sandstone, of variable composition, occurring in layers from six inches to two feet thick. It contains a delthyris, but not in considerable numbers.

3. Above the last occurs an arenaceous and argillaceous rock of a yellow or buff-colour, and very rough worm-eaten aspect. It is soft, and contains geodes or nests of carbonate of lime and sulphate of strontian, the removal of which has caused its cavernous structure. This bed is several feet thick.

4. The next higher mass is a bed about two feet thick of the pitted rock of the gypsum. This is an impure buff-coloured soft limestone which breaks at right angles to the bedding. It corresponds in all respects to the rock seen at Paris, Syracuse and other places, in association with the gypseous shales. This is the highest layer exposed near the bridge; but, ascending the stream, we find excellent exposures along both its banks.

5. At the Canada Company's Mills, about two miles above the bridge, a higher set of strata appear. These consist of dove-coloured and fawn-coloured limestone, abounding in characteristic fossils, overlaid by a bluish limestone, weathering with a mealy surface, often coarser than the preceding, and sometimes slightly sparry. This also is very full of fossils.

Though the determination of the precise date of these limestones overlying the pitted rock, would supply the best link for establishing the connexion of the western and eastern strata, an approximation to it is all that we have yet been able to effect. That they constitute a new formation, not found in New York, we think is evident; but these horizontal limestones are so extensively overspread with drift, and, when, seen, expose so small a depth, as to make it impossible to find their actual contact with the Onondaga or Seneca strata; though they occur on the north branch of the Thames under circumstances that intimate their close connexion with those rocks. We cannot, therefore, assign to them their exact position; nor is it practicable to designate the neighbourhood where the Maitland limestone first appears or the Onondaga rock finally vanishes in going westward. The former originates probably east of the north branch of the Thames, while the last has an assignable thickness for some distance farther west. But if the exact horizon of the Maitland limestone cannot now be defined, there is reason, on two accounts, to place it high in the calcareous group which underlies the Marcellus shales. One motive for assigning it this position, is its obvious identity with the Sandusky limestone, the infra-position of which to the Marcellus shales can readily be shown.

That this identity exists we are persuaded from a comparison of fossils, and from actually tracing the pitted rock and Maitland limestone, from Canada round the head of Lake Erie. Another inducement for thus referring the Maitland stratum, is the affinity which prevails between its fossils and those of the Onondaga and Seneca rocks. Of the species examined, it contains in common with those formations, Atrypa affinis, also an Atrypa common at Schoharie, Strophomena lineata, a delthyris common to the Onondaga limestone and to the shales next above the equivalent of that rock in Pennsylvania, (Marcellus shales,) also Cyathophylum Ceratites and a Trilobite of the Onondaga limestone. Though these links indicate a near approximation in date, they are not regarded as proving the rock an equivalent of any of the formations mentioned. They are the more interesting from the fact that not even this much relationship prevails between the Maitland formation and any of the strata lower than the Onondaga limestone. What seems chiefly conclusive of the high position of the Maitland rock is its identity with the limestone of Sandusky, the plane of which is but little under the horizon of the Marcellus shales.

Rocks of the Detroit River, and of the Western end of Lake Erie. Having become satisfied of the persistence of the pitted rock through Upper Canada, it became a matter of leading interest to establish the relations of it and the overlying limestones to the strata widely developed around the head of Lake Erie; regarding this as the only certain mode of ascertaining the date of the rocks of Western Ohio. Combining our own observations of the dip and range of the strata in Upper Canada, with the data recorded in the annual reports of Dr. Houghton, the State geologist of Michigan,* we became convinced of the existence of a broad, but gentle axis of elevation passing in a S. S. W. direction somewhere near the lower end of lake Huron. A slight but obvious western dip is visible on the Maitland near Goderich, and is extensively seen on the opposite or Michigan shore, southward, the whole way from near Saginaw Bay to the outlet of the Detroit River. The eastern dip from this axis is evidenced by the southern trend of the limestones, which cross the upper end of Lake Erie, between Point Au Playe and Sandusky, where the dip itself, indeed, may be detected. It is indicated by the form of the Canadian Peninsula, and strikingly by the singular line of drainage of the River Thames, which, instead of seeking a short line either to Lake Huron or Lake Erie, pursues a much longer course, as if guided by the strike of the rocks, and empties into Lake St. Clair.

Persuaded of the existence of this anticlinal axis, which passes, probably, somewhere between Goderich and the head of the Thames, we adverted next to its probable connexion with the broad anticlinal elevation of the strata in the western part of Ohio, upon which the general features of the geology of that State and Indiana mainly depend. Guided by this conjecture, we foresaw that the rocks which we had been tracing from the Niagara River, in a W. N. W. direction to Lake Huron, must experience an important change in

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* See second and third Annual Reports on the Geology of Michigan.

their strike and range to the S. S. W., and that we might in all probability still meet with the pitted rock which had guided us so well in Upper Canada, on the Detroit River, and perhaps at the head of Lake Erie. Should this prove to be correct, we hoped to unite by *actual tracing* the rocks of Ohio and Michigan, with those of Upper Canada and New York. We therefore traced the formations south-westwardly, and exploring in our progress the borders of the Detroit River, and afterwards the Maumee, our anticipations were fully realized.

Rocks of the Detroit River.—The strata which border the Detroit River, both in Michigan and Canada, we readily identified by their aspect and organic remains with the beds which immediately overlie the pitted rock on the Maitland. Their exact identity, however, we were fortunate enough fully to establish by discovering the vesicular rock itself well exposed on Gros' Isle, an island at the mouth of the Detroit River, not far from the Michigan shore. The rock at this place consists of a very arenaceous cream-coloured limestone. It is seen in numerous small quarries formerly wrought, and is visible to a depth of about four feet. It abounds in the characteristic lenticular cavities, and contains geodes of sulphate of Strontian identical with those at Goderich. No organic remains seem to occur in it. The beds show an extremely gentle dip to the N. W., and their elevation above the level of the river cannot exceed eight feet.

The strata on the western side of the river are well seen in a series of quarries about one mile N. N. W. of the village of Truago or Monguagon. They are exposed in shallow excavations for several hundred yards to a depth of from five to eight feet. The prevailing rock is a light gray, somewhat sparry, very fossiliferous limestone. It is occasionally arenaceous and the weathered surfaces assume a yellowish mealy aspect. It is generally of a close texture and very pure. In the partings between the layers we detected the peculiar wavy or suture-like divisions, so abundant in another rock at the Falls of Niagara, and which we had before seen in the limestones above the pitted rock in Canada.

The rock at Truago strongly reminded us of that seen at Beachville on the Thames, and at the Mills near Goderich. An inconsiderable dip towards the north-west may here be seen.

Crossing the river here three miles broad, from Truago to Malden, on the

Canadian shore, we encounter the rock just described, in another series of quarries lying about two miles east of the river. Extensive openings, said to occupy an area of nearly forty acres, expose the strata to a moderate depth. The layers vary considerably in texture and aspect, some, when weathered, being of a yellowish tint, and arenaceous, while others are compact and comparatively pure, resembling exactly the purer variety met with at Truago. In these quarries it was difficult to establish any decided dip. If a general inclination of the beds does prevail, it is westward.

Neither at the Malden nor Truago quarries did we meet with any trace of the pitted rock, nor with any bed containing the hopper-shaped cavities seen in the limestone below the pitted rock on the Maitland. From these facts we are convinced that the Malden and Truago beds overlie the vesicular rock of Gros' Isle. They are therefore identical in position, as they obviously are in lithological character, and organic remains, with the limestones of the Maitland. These beds are highly fossiliferous, abounding in Strophomena lineata, S. rugosa, Delthyris, Atrypa, Leptæna, Cyathophillum ceratites, Favosites, Encrini, Orthoceratites, Trilobites, and several other fossils not yet specifically determined.

Rocks of the Maumee River, and of Sandusky Bay.—Near Maumee city, on the Maumee River in Ohio, we again meet with the well-marked pitted limestone, identical in all respects with that already described as occurring at Gros' Isle and Goderich. Its exposure in this position on a line drawn through Goderich and Gros' Isle, is a fact of the highest interest; for it goes to establish unequivocally, both the existence and direction of the extensive anticlinal axis which we had conjectured to pass from Upper Canada into western Ohio. The position of this important axis, is probably some distance east of the Maumee, for the rocks on that river have a visible western dip. It crosses Lake Erie most probably nearly midway between the western head of the Lake, and the chain of Islands which stretch from Point Sandusky to Point Au Playe.

Comparing the rock laid open in the quarries at Marblehead, near Sandusky Bay, with that seen at the head of the Lake, we cannot hesitate to refer them to the same formation, the opposite direction of their dips resulting from the axis above mentioned. An examination of the fossils most prevalent in the Sandusky limestone establishes, beyond a question, the identity of this formation with that of Malden and Goderich. To this last identification we attach the more importance, as the Sandusky rock, under the name of the cliff limestone of Ohio, has been of late variously regarded by geologists, some conceiving it to be the equivalent of the European carboniferous, or mountain limestone. That its closest foreign relations are to the Wenlock rocks of the English Silurian strata, and not to those of the carboniferous date, is obvious from an inspection of its organic remains alone. But there exists in Tennessee and Virginia a higher limestone not developed in either Ohio or New York, much more nearly related to the mountain limestone of Europe, to which it has been referred by Professor Troost. This rock, characterized by its oolitic structure and the beautiful genus Pentremites, appears, as we infer from some descriptions given by Troost, to be underlaid by blue limestones, identical, seemingly, with the cliff rock of Ohio.

Rocks of the Anticlinal region in Ohio.—The broad anticlinal axis which we have traced from the western side of Canada into Ohio, crosses the Ohio River somewhere in the neighbourhood of Louisville, and terminates probably in Kentucky. It imparts a general S. S. W. strike to all the strata of western Canada, eastern Michigan, Ohio, and parts of Indiana and Kentucky. The lowest formation near Lake Erie which the axis brings to the surface, is the pitted rock already traced. But that still lower formations are elevated by it more to the S. W., is apparent from the descriptions given by Dr. Locke, and other geologists, of the geology of the south-western part of Ohio.*

The cliff limestone at the base of which we place the pitted rock is there underlaid by marly shales that rest upon an extensive formation of blue limestone, well exhibited in the region of Cincinnati. These shales probably represent the gypseous shales of New York, for it is fair to conclude that so thick a mass of fine sedementary matter as they constitute on the Niagara River, can hardly have thinned away at this distance westward.

But to what formation shall we assign the blue limestones of Cincinnati? Do they correspond with the Niagara limestone next under the gypseous shales, or to some yet inferior formation? or do they belong to a new and interpolated group not met with farther east? Influenced by a certain degree of correspondence in the fossils, and by the known progressive thickening westward of the Niagara limestone, which seems to preclude a belief of its thinning out

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* See first and second Annual Report of Geological Survey of Ohio.

before reaching the axis in Ohio, we are disposed to regard it and the Cincinnati limestone, which both occupy the same position under the shales beneath the pitted rock, as approximately contemporaneous. In thus viewing the limestone of Cincinnati, we regret to find our conclusions apparently at variance with those of Mr. Conrad, now decidedly the first authority in our country, in questions of Palæontology. He expresses the opinion in his last annual report, that the limestone of Cincinnati is "the equivalent or continuation of the black limestone of Trenton Falls," in New York. But to bring up a formation so low in the Appalachian series, the anticlinal axis must previously elevate not only the gypseous and Niagara strata, but the prodigiously thick groups of shales, limestones, slates and sandstones, which rest above the Trenton limestone, and which, if thus elevated, would have conferred upon Ohio, Indiana, and Kentucky a wholly different geology, mineral wealth, and physical geography from that which we now behold.

To present, in conclusion, a simple generalization of the results aimed at, respecting the range and distribution of the rocks which cross the Niagara river, let us conceive the strata forming the expanded plain bounded by the Mountain terrace, gently to decline to the S. W., in upper Canada and Ohio, while the flat but extensive anticlinal axis traverses the slope from Kentucky to the western side of Upper Canada. In these two conditions we discern the cause first of the general north-western strike of the pitted limestone, which carries it in the direction of Cabot's Head, and the Manitoulin Islands, and secondly of that long south-western strike which affects the same stratum in another outcrop, as far south as the Maumee, and expands the overlying and next subjacent rocks, in a broad zone across the Ohio river into Kentucky and Tennessee.

ARTICLE XV.

Observations of the Magnetic Dip in the United States. Fourth Series. By Elias Loomis, Professor of Mathematics and Natural Philosophy in Western Reserve College. Read May 6, 1842.

Although my dipping needle might be regarded as tolerably well tested by the observations in different azimuths, contained in the Society's Transactions, Vol. VIII., p. 66, still, as this examination was limited to a portion of the axis of each needle, I was disposed to institute another trial. For this purpose I resorted to the method of Mayer, loading the needles with sealing-wax. The following tables exhibit a summary of the observations. Columns second and third show the observed angles with a vertical, when a mark on the face of the needle was turned successively to the east and west; columns fourth and fifth show the same with the polarity reversed. The last column shows the dip deduced by Mayer's formula.

NEEDLE No. 1.

DATE.	POLES DIRECT.		POLES REVERSED.		DIP DEDUCED.
	Mark East.	Mark West.	Mark West.	Mark East.	
1841, April 27, 8— 9, A. M.	17° 8′.4	+ 17° 17′.9	17° 22′.3	+ 16° 56′.6	72° 48′.7
May 13, 7— 8, A. M.	39 27 .8	— 9 57 .9	37 48 .9	— 10 12 .0	44 .5
May 15, 7—12, A. M.	41 39 .5	— 13 22 .5	38 11 .3	— 10 44 .0	42 .7
" " " "	49 6 .6	— 26 34 .9	45 54 .2	— 23 45 .8	44 .6
" " " "	51 52 .0	— 31 42 .0	46 2 .7	— 24 1 .3	46 .7
" " " "	61 28 .3	— 49 19 .7	56 1 .2	— 42 29 .2	53 .2
" " " "	59 32 .6	— 45 55 .2	56 20 .5	— 42 57 .1	51 .9
" " 1— 6, P. M.	60 23 .9	— 47 25 .5	57 39 .2	— 45 22 .8	52 .6
" " " "	34 10 .6	— 1 49 .4	39 25 .1	— 13 17 .8	42 .8
" " " "	27 20 .2	+ 6 41 .8	27 25 .1	+ 5 11 .6	42 .7
" " " "	24 44 .4	+ 10 18 .5	23 30 .6	+ 9 11 .2	47 .4
" " " "	17 11 .1	+ 17 22 .6	16 52 .4	+ 17 23 .3	47 .6
Mean of 12 observations, Needle No. 1, (960 readings,)					72° 47′.1

NEEDLE No. 2.

DATE.	POLES DIRECT.		POLES REVERSED.		DIP DEDUCED.
	Mark East.	Mark West.	Mark West.	Mark East.	
1841, May 18, 7—12, A. M.	56° 34′.5	— 42° 49′.9	63° 9′.2	— 52° 36′.0	72° 43′.4
" " " "	57 31 .7	— 44 52 .4	61 30 .6	— 49 22 .8	43 .1
" " " "	53 47 .2	— 38 20 .6	55 56 .2	— 39 17 .3	52 .2
" " " "	47 43 .2	— 27 55 .8	53 58 .5	— 34 49 .1	49 .6
" " " "	43 9 .5	— 19 43 .4	44 12 .6	— 17 29 .4	48 .8
" " " "	40 8 .1	— 14 24 .2	39 55 .2	— 10 19 .0	43 .8
" " " "	36 24 .2	— 8 33 .2	34 57 .2	— 3 13 .8	51 .3
" " 1— 4, P. M.	31 3 .1	— 0 54 .1	30 2 .3	+ 3 32 .3	53 .4
" " " "	25 52 .7	+ 6 20 .6	25 2 .0	+ 9 41 .9	47 .3
" " " "	22 43 .0	+ 10 35 .2	21 3 .3	+ 13 23 .3	52 .5
" " " "	15 36 .3	+ 18 48 .3	15 55 .2	+ 18 35 .8	46 .1
Mean of 11 observations, Needle No. 2, (880 readings,)					72° 48′.3

The discordances between the individual results are somewhat greater than had been expected, nevertheless the average agrees very closely with the dip formerly obtained. This method of observing has the advantage of testing successively every part of the axis of the needle, yet, otherwise, it is much inferior to the common method, for the load serves to increase the friction of the axis, and the same error in the observations produces greater influence on the results. In order to determine what correction should be applied to observations made in the usual method, we need first to know the annual change of dip. For this purpose I have compared observations made at this place since 1838. The following table exhibits the materials for comparison. In the equations of condition, δ represents the mean dip for January 1, 1838, and Δ the annual change of dip.

OBSERVATIONS.		EQUATIONS OF CONDITION.	DIFFERENCES.
1838, Sept. 8,	72° 48′.2	$\delta + .684\,\Delta = 8'.2$	+ 0′.1
1839, April 22,	46 .8	$\delta + 1.304\,\Delta = 6\,.8$	— 1 .4
Aug. 17,	48 .4	$\delta + 1.624\,\Delta = 8\,.4$	+ 0 .2
1840, Jan. 11,	49 .5	$\delta + 2.027\,\Delta = 9\,.5$	+ 1 .2
Aug. 31,	49 .5	$\delta + 2.665\,\Delta = 9\,.5$	+ 1 .1
1841, May 10,	47 .4	$\delta + 3.353\,\Delta = 7\,.4$	— 1 .2
Nov. 4,	48 .7	$\delta + 3.841\,\Delta = 8\,.7$	0 .0

These equations, being solved by the method of minimum squares, give $\delta = 7'.95$, or the mean dip, January 1, 1838, 72° 47′.95, $\Delta = +\,0'.18$, from which we obtain the differences between the observed and computed dips, as given in the last column above. The dip obtained August, 1840, by observations in different azimuths, was 72° 49′.6, being 1′.2 greater than is computed from the above data; the dip, May, 1841, by Mayer's method, was 72° 47′.7, being 0′.9 less than we obtain from the same data. Mean error of observations by the usual method + 0′.1, a quantity so small that it has been neglected.

The following observations were made by the usual method.

Magnetic Dip at Brooklyn, Ohio. Latitude 41° 30′ *N.; Longitude* 81° 43′ *W.*

Place of observation one mile west of Ohio city.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, April 23,	11—1, P. M.	No. 1,	40	73° 10′.2
"	"	No. 1, poles reversed,	40	18 .9
"	"	Mean of No. 1,	80	14 .6
"	"	No. 2,	40	19 .7
"	"	No. 2, poles reversed,	40	16 .3
"	"	Mean of No. 2,	80	18 .0
"	"	Mean of both needles,	160	73 16 .3

Magnetic Dip at Tallmadge, Ohio. Latitude 41° 6′ *N.; Longitude* 81° 27′ *W.*

Place of observation nearly the same as formerly.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, April 26,	8—10, A. M.	No. 1,	40	72° 55′.6
"	"	No. 1, poles reversed,	40	49 .1
"	"	Mean of No. 1,	80	52 .4
"	"	No. 2,	40	52 .4
"	"	No. 2, poles reversed,	40	63 .5
"	"	Mean of No. 2,	80	58 .0
"	"	Mean of both needles,	160	72 55 .2

Magnetic Dip at Cleveland, Ohio. Latitude 41° 30′ *N.; Longitude* 81° 41′ *W.*

Place of observation one mile east of the city.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 12,	4—1, P. M.	No. 1,	40	73° 7′.9
"	"	No. 1, poles reversed,	40	2 .0
"	"	Mean of No. 1,	80	5 .0

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 12,	4—1, P. M.	No. 2,	40	73° 3 .4
"	"	No. 2, poles reversed,	40	3 .9
"	"	Mean of No. 2,	80	3 .7
"	"	Mean of both needles,	160	73 4′.3

I have now made four observations for the dip near Cleveland. First, upon the north side of the city; then upon the south side; next upon the west; and, last, upon the east. The dip at Cleveland, according to observations made in the neighbouring towns, should be 73° 4′.0. The station error, then, of the first observation was + 22′.0; of the second, + 8′.0; third, + 12′.3; fourth, + 0′.3. Corresponding anomalies have been detected in observations for the variation of the needle in this vicinity.

Magnetic Dip at Monroe, Michigan. Latitude 41° 55′ *N.; Longitude* 83° 28′ *W.*

Place of observation a half mile north of the court house.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 14,	2—4, P. M.	No. 1,	40	73° 15′.9
"	"	No. 1, poles reversed,	40	22 .7
"	"	Mean of No. 1,	80	19 .3
"	"	No. 2,	40	19 .2
"	"	No. 2, poles reversed,	40	18 .4
"	"	Mean of No. 2,	80	18 .8
"	"	Mean of both needles,	160	73 19 .0

Magnetic Dip at Ypsilanti, Michigan. Latitude 42° 14′ *N.; Longitude* 83° 38′ *W.*

Place of observation sixty rods east of the rail-road depôt.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 16,	7—9, A. M.	No. 1,	40	73° 24′.1
"	"	No. 1, poles reversed,	40	15 .5
"	"	Mean of No. 1,	80	19 .8
"	"	No. 2,	40	17 .4
"	"	No. 2, poles reversed,	40	18 .1
"	"	Mean of No. 2,	80	17 .8
"	"	Mean of both needles,	160	73 18 .8

Magnetic Dip at Ann Arbor, Michigan. Latitude 42° 18′ *N.; Longitude* 83° 45′ *W.*

Place of observation twenty rods south of the rail-road depôt.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 16,	11—1, P. M.	No. 1,	40	73° 14′.3
"	"	No. 1, poles reversed,	40	19 .3
"	"	Mean of No. 1,	80	16 .8
"	"	No. 2,	40	17 .4
"	"	No. 2, poles reversed,	40	15 .0
"	"	Mean of No. 2,	80	16 .2
"	"	Mean of both needles,	160	73 16 .5

As the results obtained in 1839, at the last three stations, seemed quite anomalous, I was desirous of verifying them. The stations of observation were purposely taken at some distance from the former ones, to avoid any local influence of limited extent. The results at Ann Arbor and Ypsilanti are almost identically the same as before; at Monroe the last result accords much better with what might be expected from the general course of the isoclinal lines. Some indications of disturbing influences are apparent in the geological character of this section. Throughout most of it is found a deposite of blue clay, containing nearly two per cent. of iron. Iron ore is also quite common.

Magnetic Dip at Detroit, Michigan. Latitude 42° 19′ *N.; Longitude* 83° 3′ *W.*

Place of observation one mile west of the city.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 17,	8—10½, A. M.	No. 1,	40	73° 40′.9
"	"	No. 1, poles reversed,	40	30 .0
"	"	Mean of No. 1,	80	35 .5
"	"	No. 2,	40	34 .4
"	"	No. 2, poles reversed,	40	38 .5
"	"	Mean of No. 2,	80	36 .5
"	"	Mean of both needles,	160	73 36 .0

Observations repeated ten Rods North of former Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 17	10½—12½, A. M.	No. 1,	40	73° 30′.8
"	"	No. 1, poles reversed,	40	39 .0
"	"	Mean of No. 1,	80	34 .9

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 17,	10½—12½, A. M.	No. 2,	40	73° 38′.0
"	"	No. 2, poles reversed,	40	33 .4
"	"	Mean of No. 2,	80	35 .7
"	"	Mean of both needles,	160	73 35 .3

Observations repeated three Rods West of last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 17,	3—5, P. M.	No. 1,	40	73° 35′.3
"	"	No. 1, poles reversed,	40	30 .1
"	"	Mean of No. 1,	80	32 .7
"	"	No. 2,	40	32 .1
"	"	No. 2, poles reversed,	40	38 .7
"	"	Mean of No. 2,	80	35 .4
"	"	Mean of both needles,	160	73 34 .1

Observations repeated near the second Locality.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 18,	8½—10, A. M.	No. 1,	40	73° 30′.2
"	"	No. 1, poles reversed,	40	38 .5
"	"	Mean of No. 1,	80	34 .4
"	"	No. 2,	40	40 .6
"	"	No. 2, poles reversed,	40	34 .8
"	"	Mean of No. 2,	80	37 .7
"	"	Mean of both needles,	160	73 36 .0

Observations repeated on the same Spot.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 18,	10—12, A. M.	No. 1,	40	73° 39′.9
"	"	No. 1, poles reversed,	40	29 .6
"	"	Mean of No. 1,	80	34 .8
"	"	No. 2,	40	34 .4
"	"	No. 2, poles reversed,	40	41 .2
"	"	Mean of No. 2,	80	37 .8
"	"	Mean of both needles,	160	73 36 .3

Mean of 800 readings at Detroit, with both needles, ... 73 35 .5

The close agreement of the results in the five preceding series of observations shows that very little is gained, in point of accuracy, by multiplying the observations beyond the usual number of a single series.

Magnetic Dip at Mackinac, Michigan. Latitude 45° 51′ *N.; Longitude* 84° 41′ *W.*

Place of observation a quarter of a mile south-west of the fort.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 21,	8—10, A. M.	No. 1,	40	76° 33′.4
“	“	No. 1, poles reversed,	40	42 .2
“	“	Mean of No. 1,	80	37 .8
“	“	No. 2,	40	43 .4
“	“	No. 2, poles reversed,	40	35 .2
“	“	Mean of No. 2,	80	39 .3
“	“	Mean of both needles,	160	76 38 .5

Observations repeated on the same Spot.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 21,	10—12, A. M.	No. 1,	40	76° 43′.0
“	“	No. 1, poles reversed,	40	37 .6
“	“	Mean of No. 1,	80	40 .3
“	“	No. 2,	40	34 .6
“	“	No. 2, poles reversed,	40	40 .5
“	“	Mean of No. 2,	80	37 .5
“	“	Mean of both needles,	160	76 38 .9

Observations repeated fifteen Rods North-East of last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 21,	2—3½, P. M.	No. 1,	40	76° 36′.3
“	“	No. 1, poles reversed,	40	41 .5
“	“	Mean of No. 1,	80	38 .9
“	“	No. 2,	40	38 .7
“	“	No. 2, poles reversed,	40	32 .0
“	“	Mean of No. 2,	80	35 .4
“	“	Mean of both needles,	160	76 37 .1

Observations repeated on the same Spot.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 21,	3½—5, P. M.	No. 1,	40	76° 39′.4
“	“	No. 1, poles reversed,	40	31 .4
“	“	Mean of No. 1,	80	35 .4
“	“	No. 2,	40	33 .3
“	“	No. 2, poles reversed,	40	38 .4
“	“	Mean of No. 2,	80	76 35 .8
“	“	Mean of both needles,	160	76 35 .6

Mean of 640 readings at Mackinac, with both needles, ... 76 37 .5

The same conclusion might be derived from these observations as from those at Detroit, with regard to the inutility of multiplying beyond a certain point the observations at one place. If the observations are to be repeated, the object being to obtain the mean dip of the place, it seems better to change the locality, if it be only by a few rods, by which means any disturbing causes of limited extent will probably be detected.

Magnetic Dip at Fort Brady, Michigan. Latitude 46° 30′ *N.; Longitude* 84° 24′ *W.*

Place of observation fifty rods south-east of the south-east angle of the fort.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 25,	2—5, P. M.	No. 1,	40	77° 25′.3
“	“	No. 1, poles reversed,	40	33 .1
“	“	Mean of No. 1,	80	29 .2
“	“	No. 2,	40	28 .5
“	“	No. 2, poles reversed,	40	25 .4
“	“	Mean of No. 2,	80	27 .0
“	“	Mean of both needles,	160	77 28 .1

Observations repeated eighteen Rods South-West of the last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 25,	5—7, P. M.	No. 1,	40	77° 33′.0
“	“	No. 1, poles reversed,	40	25 .4
“	“	Mean of No. 1,	80	29 .2
“	“	No. 2,	40	25 .5
“	“	No. 2, poles reversed,	40	27 .2
“	“	Mean of No. 2,	80	26 .4
“	“	Mean of both needles,	160	77 27 .8

Observations repeated near the River, at the foot of the Rapids.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 27,	5—7, A. M.	No. 1,	40	77° 36′.9
“	“	No. 1, poles reversed,	40	30 .3
“	“	Mean of No. 1,	80	33 .6
“	“	No. 2,	40	29 .5
“	“	No. 2, poles reversed,	40	36 .2
“	“	Mean of No. 2,	80	32 .9
“	“	Mean of both needles,	160	77 33 .2

Mean of 480 readings with both needles, ... 77 29 .7

Magnetic Dip at Gros Cap, Canada. Latitude 46° 32′ *N.; Longitude* 84° 43′ *W.*

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 26,	1—3, P. M.	No. 1,	40	77° 4′.8
“	“	No. 1, poles reversed,	40	8 .9
“	“	Mean of No. 1,	80	6 .9
“	“	No. 2,	40	6 .9
“	“	No. 2, poles reversed,	40	0 .4
“	“	Mean of No. 2,	80	3 .6
“	“	Mean of both needles,	160	77 5 .3

The difference in the dip observed at Gros Cap, and at Fort Brady, is 24′.4, whereas the dip at the two places might have been anticipated to be nearly the same. At the Sault the red sandstone appears on the surface of the earth, and contains a large per centage of iron.

Magnetic Dip at South Manitou, Michigan. Latitude 45° 5′ *N.; Longitude* 85° 38′ *W.*

Place of observation near the eastern shore, about the middle of the island, as regards north and south.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Aug. 31,	9—10½, A. M.	No. 1,	40	75° 55′.4
“	“	No. 1, poles reversed,	40	62 .6
“	“	Mean of No. 1,	80	59 .0
“	“	No. 2,	40	67 .5
“	“	No. 2, poles reversed,	40	51 .9
“	“	Mean of No. 2,	80	59 .7
“	“	Mean of both needles,	160	75 59 .3

Magnetic Dip at Chicago, Illinois. Latitude 41° 53′ *N.; Longitude* 87° 44′ *W.*

Place of observation one mile north of the town.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 2,	8½—10½, A. M.	No. 1,	40	72° 50′.6
“	“	No. 1, poles reversed,	40	47 .0
“	“	Mean of No. 1,	80	48 .8
“	“	No. 2,	40	47 .8
“	“	No. 2, poles reversed,	40	46 .5
“	“	Mean of No. 2,	80	47 .1
“	“	Mean of both needles,	160	72 48 .0

Observations repeated five Rods West of last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 2,	10½—12¼, A. M.	No. 1,	40	72° 47′.6
“	“	No, 1, poles reversed,	40	50 .2
“	“	Mean of No. 1,	80	48 .9
“	“	No. 2,	40	45 .9
“	“	No. 2, poles reversed,	40	46 .3
“	“	Mean of No. 2,	80	46 .1
“	“	Mean of both needles,	160	72 47 .5
Mean of 320 readings with both needles,		. . . . .	. . .	72 47 .7

Magnetic Dip at Galena, Illinois. Latitude 42° 28′ *N.; Longitude* 90° 13′ *W.*

Place of observation on the hill back of the town.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 4,	8—10, A. M.	No. 1,	40	72° 64′.4
“	“	No. 1, poles reversed,	40	59 .1
“	“	Mean of No. 1,	80	61 .8
“	“	No. 2,	40	61 .4
“	“	No. 2, poles reversed,	40	61 .7
“	“	Mean of No. 2,	80	61 .6
“	“	Mean of both needles,	160	73 1 .7

Observations repeated four Rods East of last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 4,	10—12, M.	No. 1,	40	73° 1′.3
“	“	No. 1, poles reversed,	40	5 .6
“	“	Mean of No. 1,	80	3 .5
“	“	No. 2,	40	2 .5
“	“	No. 2, poles reversed,	40	0 .7
“	“	Mean of No. 2,	80	1 .6
“	“	Mean of both needles,	160	73 2 .5

Magnetic Dip at Mineral Point, Wisconsin. Latitude 42° 51′ *N.; Longitude* 89° 58′ *W.*

Place of observation eighty rods west of the Franklin House.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 6,	5—6½, P. M.	No. 1,	40	73° 26′.0
“	“	No. 1, poles reversed,	40	20 .2
“	“	Mean of No. 1,	80	23 .1

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 6,	5—6½, P. M.	No. 2,	40	73° 21′.8
"	"	No. 2, poles reversed,	40	25 .1
"	"	Mean of No. 2,	80	23 .4
"	"	Mean of both needles,	160	73 23 .2

Magnetic Dip at Blue Mounds, Wisconsin. Latitude 43° 0′ *N.; Longitude* 89° 36′ *W.*

Place of observation near Mr. Ebenezer Brigham's.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 7,	12—2, P. M.	No. 1,	40	73° 30′.6
"	"	No. 1, poles reversed,	40	40 .7
"	"	Mean of No. 1,	80	35 .6
"	"	No. 2,	40	19 .9
"	"	No. 2, poles reversed,	40	48 .3
"	"	Mean of No. 2,	80	34 .1
"	"	Mean of both needles,	160	73 34 .9

In fording a creek, this morning, near Mineral Point, the compass got wet. It was carefully dried as soon after as possible, and is thought to have experienced no serious injury. This is probably the cause of the inequality in the weight of the arms of No. 2, as shown in the last observation. Nevertheless, the mean results of the two needles accord as well as usual.

Magnetic Dip at Madison, Wisconsin. Latitude 43° 3′ *N.; Longitude* 89° 11′ *W.*

Place of observation eighty rods south-east of the capital.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 8,	10—12, A. M.	No. 1,	40	73° 67′.6
"	"	No. 1, poles reversed,	40	59 .0
"	"	Mean of No. 1,	80	63 .3
"	"	No. 2,	40	77 .8
"	"	No. 2, poles reversed,	40	54 .2
"	"	Mean of No. 2,	80	66 .0
"	"	Mean of both needles,	160	74 4. 7

Observations repeated near the same Place.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 8,	1—3, P. M.	No. 1,	40	73° 62′.6
"	"	No. 1, poles reversed,	40	73 .3
"	"	Mean of No. 1,	80	68 .0
"	"	No. 2,	40	57 .1

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 8,	1—3, P. M.	No. 2, poles reversed,	40	73° 80′.0
"	"	Mean of No. 2,	80	68 .6
"	"	Mean of both needles,	160	74 8 .3
Mean of 320 readings of both needles, ...				74 6 .5

Magnetic Dip at Campbell's, Wisconsin. Latitude 43° 1′ *N.; Longitude* 89° 26′ *W.*

Fifteen miles from Madison; ten miles from Blue Mounds.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 9,	5—7, A. M.	No. 1,	40	73° 31′.8
"	"	No. 1, poles reversed,	40	25 .0
"	"	Mean of No. 1,	80	28 .4
"	"	No. 2,	40	42 .3
"	"	No. 2, poles reversed,	40	13 .3
"	"	Mean of No. 2,	80	27 .8
"	"	Mean of both needles,	160	73 28 .1

Between this place and Madison, distant only fifteen miles, and near the same parallel, the difference of dip is 38′.4, whereas they might have been anticipated to have nearly the same dip. There seems to be powerful local attraction near Madison. Iron ore has been found on the lake shore, close to the village, and the surveyor who laid out the town complained that the direction of his compass needle was exceedingly irregular.

Magnetic Dip at Hickok's, Wisconsin. Latitude 42° 58′ *N.; Longitude* 89° 47′ *W.*

Ten miles from Blue Mounds; nine miles from Dodgeville.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 9,	11—1, P. M.	No. 1,	40	73° 35′.0
"	"	No. 1, poles reversed,	40	45 .7
"	"	Mean of No. 1,	80	40 .4
"	"	No. 2,	40	26 .2
"	"	No. 2, poles reversed,	40	51 .2
"	"	Mean of No. 2,	80	38 .7
"	"	Mean of both needles,	160	73 39 .5

Magnetic Dip at Mineral Point, Wisconsin. Latitude 42° 51′ *N.; Longitude* 89° 58′ *W.*

Place of observation a few rods back of Franklin House.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 10,	10—12, A. M.	No. 1,	40	73° 27′.8
"	"	No. 1, poles reversed,	40	21 .9

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 10,	10—12, A. M.	Mean of No. 1,	80	73° 24′.9
“	“	No. 2,	40	33 .9
“	“	No. 2, poles reversed,	40	7 .1
“	“	Mean of No. 2,	80	20 .5
“	“	Mean of both needles,	160	73 22 .7
Mean of 320 readings of both needles, Sept. 9, and 10, -				73 23 .0

Magnetic Dip at Platteville, Wisconsin. Latitude 42° 43′ *N.; Longitude* 90° 14′ *W.*

Place of observation a few rods south of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 11,	7—9, A. M.	No. 1,	40	73° 16′.1
“	“	No. 1, poles reversed,	40	21 .9
“	“	Mean of No. 1,	80	19 .0
“	“	No. 2,	40	0 .5
“	“	No. 2, poles reversed,	40	29 .9
“	“	Mean of No. 2,	80	15 .2
“	“	Mean of both needles,	160	73 17 .1

Observations repeated six rods south of the last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 11,	9—11, A. M.	No. 1,	40	73° 22′.0
“	“	No. 1, poles reversed,	40	15 .1
“	“	Mean of No. 1,	80	18 .5
“	“	No. 2,	40	28 .8
‘	“	No. 2, poles reversed,	40	4 .5
“	“	Mean of No. 2,	80	16 .7
“	“	Mean of both needles,	160	73 17 .6
Mean of 320 readings with both needles, ...				73 17 .4

Magnetic Dip at Galena, Illinois. Latitude 42° 28′ *N.; Longitude* 90° 13′ *W.*

Place of observation nearly the same as formerly.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 13,	2—5, P. M.	No. 1,	40	72° 61′.9
“	“	No. 1, poles reversed,	40	70 .5
“	“	Mean of No. 1,	80	66 .2
“	“	No. 2,	40	49 .4
“	“	No. 2, poles reversed,	40	77 .2
“	“	Mean of No. 2,	80	63 .3
“	“	Mean of both needles,	160	73 4 .8
Mean of 480 readings of both needles, ...				73 3 .0

Magnetic Dip at Peru, Illinois. Latitude 41° 23′ *N.; Longitude* 89° 5′ *W.*

Place of observation near the landing.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 16,	1—3, P. M.	No. 1,	40	71° 55′.9
"	"	No. 1, poles reversed,	40	47 .1
"	"	Mean of No. 1,	80	51 .5
"	"	No. 2,	40	67 .4
"	"	No. 2, poles reversed,	40	39 .3
"	"	Mean of No. 2,	80	53 .3
"	"	Mean of both needles,	160	71 52 .4

Observations repeated on the hill back of the Landing.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 16,	3—5, P. M.	No. 1,	40	71° 41′.3
"	"	No. 1, poles reversed,	40	52 .7
"	"	Mean of No. 1,	80	47 .0
"	"	No. 2,	40	38 .6
"	"	No. 2, poles reversed,	40	66 .3
"	"	Mean of No. 2,	80	52 .5
"	"	Mean of both needles,	160	71 49 .8
Mean of 320 readings with both needles,	. . .	. . .	.	71 51 .1

Magnetic Dip at Pekin, Illinois. Latitude 40° 35′ *N.; Longitude* 89° 36′ *W.*

Place of observation a few rods below the steamboat landing.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 18,	9—11, A. M.	No. 1,	40	71° 12′.9
"	"	No. 1, poles reversed,	40	9 .3
"	"	Mean of No. 1,	80	11 .1
"	"	No. 2,	40	29 .9
"	"	No. 2, poles reversed,	40	0 .8
"	"	Mean of No. 2,	80	15 .3
"	"	Mean of both needles,	160	71 13 .2

Magnetic Dip at mouth of Copperas Creek, Illinois. Latitude 40° 30′ *N.; Longitude* 89° 48′ *W.*

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 18,	2—3, P. M.	No. 1,	40	70° 56′.4

The observations were here interrupted, but from a comparison of preceding and following observations at Pekin and Alton, the dip at Copperas Creek may be inferred to be 71° 4′.0.

September 21.—One end of No. 2 was rubbed on a hone, to reduce the inequality in the weight of the arms.

Magnetic Dip at Alton, Illinois. Latitude 38° 54′ *N.; Longitude* 90° 4′ *W.*

Place of observation in Middletown, a half mile from the landing.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 22,	8—10, A. M.	No. 1,	40	69° 24′.2
“	“	No. 1, poles reversed,	40	36 .3
“	“	Mean of No. 1,	80	30 .2
“	“	No. 2,	40	37 .3
“	“	No. 2, poles reversed,	40	43 .6
“	“	Mean of No. 2,	80	40 .4
“	“	Mean of both needles,	160	69 35 .3

Observations repeated six Rods East of the last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 22,	10—12, M.	No. 1,	40	69° 36′.4
“	“	No. 1, poles reversed,	40	23 .0
“	“	Mean of No. 1,	80	29 .7
“	“	No. 2,	40	40 .2
“	“	No. 2, poles reversed,	40	37 .8
“	“	Mean of No. 2,	80	39 .0
“	“	Mean of both needles,	160	69 34 .3
Mean of 320 readings of both needles, ...				69 34 .8

Magnetic Dip at Upper Alton, Illinois. Latitude 38° 55′ *N.; Longitude* 90° 3′ *W.*

Place of observation a few rods east of the college.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 22,	2—4, P. M.	No. 1,	40	69° 34′.0
“	“	No. 1, poles reversed,	40	46 .5
“	“	Mean of No. 1,	80	40 .3
“	“	No. 2,	40	49 .2
“	“	No. 2, poles reversed,	40	50 .0
“	“	Mean of No. 2,	80	49 .6
“	“	Mean of both needles,	160	69 44 .9

Observations repeated a few rods south of former station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 25,	2—4, P. M.	No. 1,	40	69° 39′.8
“	“	No. 1, poles reversed,	40	50 .8

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 25,	2—4, P. M.	Mean of No. 1,	80	69° 45′.3
"	"	No. 2,	40	59 .1
"	"	No. 2, poles reversed,	40	35 .9
"	"	Mean of No. 2,	80	47 .5
"	"	Mean of both needles,	160	69 46 .4
Mean of 320 readings of both needles, ...				69 45 .7

Magnetic Dip at Edwardsville, Illinois. Latitude 38° 50′ *N.; Longitude* 89° 53′ *W.*

Place of observation a few rods west from the court house.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 23,	10—12, M.	No. 1,	40	69° 57′.6
"	"	No. 1, poles reversed,	40	46 .4
"	"	Mean of No. 1,	80	52 .0
"	"	No. 2,	40	63 .9
"	"	No. 2, poles reversed,	40	62 .9
"	"	Mean of No. 2,	80	63 .4
"	"	Mean of both needles,	160	69 57 .7

Magnetic Dip at Bunker Hill, Illinois. Latitude 39° 4′ *N.; Longitude* 89° 53′ *W.*

Place of observation one mile north of the village.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 24,	12—2, P. M.	No. 1,	40	69° 37′.9
"	"	No, 1, poles reversed,	40	49 .0
"	"	Mean of No. 1,	80	43 .4
"	"	No. 2,	40	53 .5
"	"	No. 2, poles reversed,	40	56 .1
"	"	Mean of No. 2,	80	54 .8
"	"	Mean of both needles,	160	69 49 .1

Magnetic Dip at Monticello, Illinois. Latitude 38° 57′ *N.; Longitude* 90° 5′ *W.*

Place of observation near the Female Seminary.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 25,	9—11, A. M.	No. 1,	40	69° 50′.2
"	"	No. 1, poles reversed,	40	34 .8
"	"	Mean of No. 1,	80	42 .5
"	"	No. 2,	40	20 .4
"	"	No. 2, poles reversed,	40	50 .1
"	"	Mean of No. 2,	80	35 .2
"	"	Mean of both needles,	160	69 38 .9

Magnetic Dip at St. Louis, Missouri. Latitude 38° 38′ *N.; Longitude* 90° 4′ *W.*

Place of observation one mile west of the city.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Sept. 29,	9—11, A. M.	No. 1,	40	69° 31′.5
“	“	No. 1, poles reversed,	40	20 .8
“	“	Mean of No. 1,	80	26 .1
“	“	No. 2,	40	16 .5
“	“	No. 2, poles reversed,	40	33 ,2
“	“	Mean of No. 2,	80	24 .9
“	“	Mean of both needles,	160	69 25 .5

Magnetic Dip at Vincennes, Indiana. Latitude 38° 43′ *N.; Longitude* 87° 29′ *W.*

Place of observation a half mile above the lower ferry, near the bank of the river.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 1,	10—12, M.	No. 1,	40	69° 45′.9
“	“	No. 1, poles reversed,	40	55 .0
“	“	Mean of No. 1,	80	50 .4
“	“	No. 2,	40	63 .1
“	“	No. 2, poles reversed,	40	43 .4
“	“	Mean of No. 2,	80	53 .3
“	“	Mean of both needles,	160	69 51 .9

Observations repeated three rods north-east of the last Station.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 1,	1—3, P. M.	No. 1,	40	69° 55′.6
“	“	No. 1, poles reversed,	40	47 .1
“	“	Mean of No. 1,	80	51 .3
“	“	No. 2,	40	43 .7
“	“	No. 2, poles reversed,	40	68 .5
“	“	Mean of No. 2,	80	56 .1
“	“	Mean of both needles,	160	69 53 .7
Mean of 320 readings of both needles, ...				69 52 .8

Magnetic Dip at Cincinnati, Ohio. Latitude 39° 6′ *N.; Longitude* 84° 27′ *W.*

Place of observation, Mr. Longworth's garden, on the east side of the city.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 5,	10—12, M.	No. 1,	40	70° 19′.2
“	“	No. 1, poles reversed,	40	35 .9
“	“	Mean of No. 1,	80	27 .5

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 5,	3—5, P. M.	No. 1,	40	70° 35′.7
"	"	No. 1, poles reversed,	40	20 .0
"	"	Mean of No. 1,	80	27 .8
Mean of both sets of observations,	. . .	. . .	160	70 27 .7

I have always taken the greatest pains to preserve my compass and needles free from injury; nevertheless, in travelling a great distance by public conveyances, especially in a new country, some exposure seems unavoidable. The mean results with the two needles agreed very well down to September 22d, at Alton, since which time the results with No. 2 have been quite anomalous. At Edwardsville and Bunker Hill the dip by No. 2 was 11′.4 greater than with No. 1, and at Monticello 7′.3 less. At Cincinnati the difference was still greater, so that from this time I discarded No. 2 altogether. These anomalies I ascribe to rust upon the axis. It was not great, but distinctly visible by a magnifier. I have alluded to such an imperfection in my former paper, p. 67. This rust had doubtless increased during the exposure of the present journey. I have detected no such imperfection in No. 1, and perhaps its indications alone, since September 22d, would be more trustworthy than when united with those of No. 2.

Magnetic Dip at Columbus, Ohio. Latitude 39° 57′ *N.; Longitude* 83° 3′ *W.*

Place of observation ninety rods east of the new State House yard.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 7,	2—3, P. M.	No. 1,	40	70° 57′.4
"	"	No. 1, poles reversed,	40	70 .5
"	"	Mean of No. 1,	80	71 4 .0

Observations repeated ten rods farther east.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 7,	3—4, P. M.	No. 1,	40	70° 69′.7
"	"	No. 1, poles reversed,	40	57 .1
"	"	Mean of No. 1,	80	63 .4
Mean of both sets of observations,	. . .	. . .	160	71 3 .7

Magnetic Dip at Hebron, Ohio. Latitude 39° 59′ *N.; Longitude* 82° 29′ *W.*

Place of observation a hundred rods north of the stage house.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 8,	1—2, P. M.	No. 1,	40	71° 8′.2
"	"	No. 1, poles reversed,	40	11 .3
"	"	Mean of No. 1,	80	9 .8

Observations repeated ten rods farther north.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 8,	2—3, P. M.	No. 1,	40	71° 14′.4
"	"	No. 1, poles reversed,	40	6 .4
"	"	Mean of No. 1,	80	10 .4
Mean of both sets of observations,			160	71 10.1

At the last two stations the dip is materially less than might have been anticipated; nevertheless, I consider the observations entitled to as much confidence as the others.

Magnetic Dip at Frasersburgh, Ohio. Latitude 40° 9′ *N.; Longitude* 82° 8′ *W.*

Place of observation near canal lock No. 16.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 9,	10—11, A. M.	No. 1,	40	71° 44′.1
"	"	No. 1, poles reversed,	40	50 .2
"	"	Mean of No. 1,	80	47 .1

Observations repeated near Canal Lock No. 17.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 9,	4½—5½, P. M.	No. 1,	40	71° 54′.3
"	"	No. 1, poles reversed,	40	46 .2
"	"	Mean of No. 1,	80	50 .3
Mean of both sets of observations,			160	71 48 .7

Magnetic Dip at Dover, Ohio. Latitude 40° 33′ *N.; Longitude* 81° 30′ *W.*

Place of observation near canal lock, two miles north of the town.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 11,	9—10, A. M.	No. 1,	40	72° 20′.9
"	"	No. 1, poles reversed,	40	18 .7
"	"	Mean of No. 1,	80	19 .8
"	10—11, A. M.	No. 1,	40	16 .0
"	"	No. 1, poles reversed,	40	21 .3
"	"	Mean of No. 1,	80	18 .7
Mean of both sets of observations,			160	72 19 .2

Magnetic Dip at Fulton, Ohio. Latitude 40° 55′ *N.; Longitude* 81° 38′ *W.*

Place of observation near the canal lock.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 12,	9—10, A. M.	No. 1,	40	72° 40′.4
"	"	No. 1, poles reversed,	40	37 .4
"	"	Mean of No. 1,	80	72 38 .9

Magnetic Dip at Clinton, Ohio. Latitude 40° 58′ *N.; Longitude* 81° 40′ *W.*

Place of observation near the canal lock.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 12,	1—2, P. M.	No. 1,	40	72° 43′.2
"	"	No. 1, poles reversed,	40	44 .7
"	"	Mean of No. 1,	80	72 44 .0

Magnetic Dip at Tallmadge, Ohio. Latitude 41° 6′ *N.; Longitude* 81° 27′ *W.*

Place of observation twenty rods north of station April 26, 1841.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 13,	11—12, M.	No. 1,	40	72° 52′.2
"	"	No. 1, poles reversed,	40	50 .8
"	"	Mean of No. 1,	80	72 51 .5

Magnetic Dip at Hudson, Ohio. Latitude 41° 15′ *N.; Longitude* 81° 27′ *W.*

Place of observation, magnetic block formerly used.

Date.	Hour.	Needle.	No. Readings.	Dip.
1841, Oct. 27,	10½—11½, A. M.	No. 1,	40	72° 46′.7
"	"	No. 1, poles reversed,	40	55 .0
"	"	Mean of No. 1,	80	50 .9
Nov. 13,	1½—2½, P. M.	No. 1,	40	43 .3
"	"	No. 1, poles reversed,	40	49 .8
"	"	Mean of No. 1,	80	46 .5
Mean of both sets of observations,	.	, ...	160	72 48. 7

ARTICLE XVI.

Supplementary Observations on the Storm which was experienced throughout the United States about the 20th of December, 1836. *By Elias Loomis, Professor of Mathematics and Natural Philosophy in Western Reserve College, Ohio. Read May* 6, 1842.

SINCE my article on the storm of December 20th, 1836, was communicated to the society, I have obtained two additional meteorological registers, embracing barometric observations for the same period, namely, from Fort Snelling, by Mr. J. N. Nicollet, and from Cincinnati, by Professor Joseph Ray.

Fort Snelling, 845 *Feet above the Sea. Latitude* 44° 53′ *N.; Longitude* 93° 12′ *W.*

1836.	Barometer.	At. Therm.	Ex. Therm.	REMARKS.
Dec. 18, 9, A. M.	29.160	60.0	+ 3.4	South wind. Clear sky.
Noon,	.155	60.0	+ 18.0	“ Cloudy.
3, P. M.	.100	58.0	+ 22.5	“ “
9, P. M.	.065	43.4	+ 18.4	Strong south wind. Cloudy.
19, 9, A. M.	28.990	60.0	+ 23.0	Calm. “
Noon,	.962	61.0	+ 25.0	South wind. “
3, P. M.	.950	63.0	+ 25.0	“ “
$9\frac{1}{4}$, P. M.	.875	64.0	+ 24.0	Cloudy, accompanied with sleet.
20, 9, A. M.	.850	52.0	— 5.0	N. W. wind. Snow, with sleet.
Noon.	.746	34.5	— 5.6	Strong N. W. wind. Storm begins $11\frac{1}{4}^{h}$.
3, P. M.	.740	50.0	— 5.6	“ “ “ Snow storm increases.
9, P. M.	.840	43.5	— 8.7	Very strong N. W. wind; hard snow; tempestuous; storm over at 10 o'clock.
21, 9, A. M.	29.342	58.2	— 21.6	N. W. wind, very moderate. Clear sky.
Noon,	.350	48.0	— 10.5	S. W. wind; moderate; 2 inches snow on the ground.
3, P. M.	.380	56.0	— 2.4	S. W. wind. Clear sky.
9, P. M.	.410	42.0	— 19.5	No wind. “
22, 9, A. M.	.180	52.0	— 4.4	S. E. wind. Cloudy.
Noon,	.000	49.4	+ 2.3	Strong S. E. wind. Cloudy.
3, P. M.	28.845	43.0	+ 5.4	“ “ “ “
9, P. M.	.662	52.0	+ 14.4	Calm. Snow commenced at 6, P. M.

Cincinnati. Latitude 39° 6′ *N.; Longitude* 84° 27′ *W.*

	THERMOMETER.			BAROMETER.			WIND.		RAIN.	WEATHER.			REMARKS.
	Sunrise.	2, P. M.	9, P. M.	5, A. M.	1, P. M.	9, P. M.	A. M.	P. M.		Sunrise.	2, P. M.	9, P. M.	.
19	8	43	36	29.56	29.53	29.51	S. W.	S. W.		clear	hazy	variable	
20	41	43	49	.23	28.97	28.71	E.	E.	1.00	cloudy	rainy	cloudy	Wet day; sudden change; strong East wind.
21	60	11	8	.43	29.54	29.76	W.	N.W.		clear	clear	clear	Strong wind.
22	3	25	20	.82	.64	.47	S.	S. E.		clear	hazy	hazy	

From these observations it appears that at Fort Snelling the barometer did not begin to rise till about 3, P. M., of the 20th, although the wind had changed to north-west before 9, A. M. This is similar to what I have several times observed at Hudson. In the eastern states the barometric minimum coincided, in the present instance, almost exactly with the change of wind, and, in the absence of evidence to the contrary, I had inferred that the same rule was general. It appears, however, not to have been true; for the north-west part of the United States, and the lines of barometric minimum in this vicinity, should be represented with greater curvature than they are given on my chart. The atmospheric wave, then, in latitude 45°, travelled with nearly twice the velocity it did in latitude 30°. The entire range of the barometer at Fort Snelling was .67 inch, about half what it was in longitude 72°, on the same parallel. At the same rate, the oscillation would be reduced to about one-third of an inch in the neighbourhood of the Rocky Mountains.

ARTICLE XVII.

Astronomical Observations, made at several Places in the United States. By J. N. Nicollet. Read May 6, 1842.

BALTIMORE, (Md.,) at the Botanical Garden of St. Mary's College.

Latitude 39° 17′ 55″. Longitude $5^h\ 6^m\ 30^s$. (?)

I. A transit of Mercury, observed May 4, 1832, by J. N. Nicollet.

Beginning of the transit; invisible in the United States.

End of the transit,	Interior contact of limbs,	$22^h\ 28^m\ 37^s.2$	Mean time of the place.
	Centre of Mercury,	29 33 .9	
	Exterior contact of limbs,	30 46 .6	

Remark.—The morning was generally cloudy, but, still, successive openings of several minutes' duration afforded ample opportunities of following up the progress of the transit, during which the planet was very distinct, and its outline well defined. The disc of the sun, during the second and third observations, was very clear, which circumstance leads me to believe that the times of these last are very correct. The observations were made with a Dollond telescope, having a magnifying power of about 100.

The Rev. Mr. A. Verot, Professor of Mathematics and Natural Philosophy in St. Mary's College, recorded the time and other circumstances of the observations.

II. Immersion by Moon's dark limb of γ. Libræ, observed July 7, 1832, at $10^h\ 00^m\ 04^s$ .63, mean time, by J. N. Nicollet. Sky cloudy at intervals, but clear at the moment of the observation. A Dollond telescope, having a magnifying power of about 100.

III. A solar eclipse, observed July 26, 1832, by J. N. Nicollet, and the Rev. Mr. A. Verot.

	Nicollet.	Verot.	
Beginning of the eclipse,	18^h 47^m 35^s .95	18^h 47^m 48^s .95	Mean time.
End of the eclipse,	20 31 48 .05	20 31 35 .07	

Beautifully clear sky. N. W. wind, tolerably strong. The Dollond telescope used by Mr. Nicollet for the beginning of the eclipse, had only a magnifying power of about seventy or eighty; but for the observation of the end, this power was replaced by another of about one hundred and ten or one hundred and twenty. Rev. Mr. Verot's telescope's power was but twenty-five or thirty. Professor Julius T. Ducatel counted the time by the chronometer, and recorded the observations.

IV. Immersion γ. Capricorni by Moon's dark limb, observed November 28, 1832, at 6^h 12^m 10^s .25, mean time, by J. N. Nicollet.

Clear sky. A Dollond telescope, having a magnifying power of about one hundred.

V. Immersion ν. Piscium, observed March 12, 1834, at 7^h 26^m 50^s, mean time, by the Rev. Mr. Verot.

VI. Immersion χ. Capricorni, September 14, 1834, at 8^h 13^m 41^s, mean time, observed by the Rev. Mr. Verot.

VII. Immersion γ^2. Aquarii, November 9, 1834, at 5^h 43^m 00^s, mean time, observed by the Rev. Mr. Verot.

VIII. A solar eclipse, November 30, 1834, observed by the Rev. Mr. Verot.

Beginning of the eclipse,	0^h 51^m 58^s .8	Mean time.
End " "	3 31 31 .2	

IX. Immersion χ. Geminorum, May 3, 1835, at 10^h 27^m 45^s, mean time, observed by the Rev. Mr. Verot.

X. A transit of Mercury, November 7, 1835, observed by the Rev. Mr. Verot.

Beginning of the transit,	Exterior contact not observed.		
	Centre of Mercury,	0^h 27^m 12^s	Mean time.
	Interior contact,	0 28 08	

XI. A solar eclipse, May 14, 1836, observed by the Rev. Mr. Verot.

Beginning of the eclipse,	$18^h\ 53^m\ 45^s$	Time by the chronometer.
End, " "	21 19 32	

	Chronometer.	Sun's centre's altitude.	
For the calculation of the time,	$19^h\ 5^m\ 9^s$	25° 42′ 32″ .7	Thermometer 55° 0.
	20 39 39	43 52 35 .1	

Error of the sextant 15″ additive to the sun's altitude.

XII. A solar eclipse, September 18, 1838, observed by the Rev. Mr. Verot.

Beginning of the eclipse,	$3^h\ 7^m\ 22^s$	Mean time.
Formation of ring,	4 25 33	
Rupture of ring,	4 30 54	
End of the eclipse,	5 40 41	

XIII. Milledgeville, (Geo.,) State House, Senate Hall.

Latitude 33° 4′ 30″, (?) Longitude $5^h\ 33^m\ 20^s$, (?)

A total eclipse of the sun, November 30, 1834, observed by J. N. Nicollet.

Beginning of the eclipse,	$0^h\ 15^m\ 07^s$ .0 ?	Mean time of the State House.
Beginning of total darkness,	1 42 36 .7	
End of total darkness,	1 43 52 .0	
End of the eclipse,	3 5 28 .1	

Remark.—Mr. Nicollet was supplied with a telescope kindly procured for him by Dr. Milton Antony, and was zealously assisted by Doctors Dugas and Ford, of the Medical College of Augusta, (Ga.)

XIV. June 30, 1838. Red pipe stone quarry, on the Coteau des Prairies, Sioux Indian Country, Iowa Territory.

Latitude 44° 00′ 52″. Longitude $6^h\ 25^m\ 17^s$.

Immersion α. Virginis, at $10^h\ 43^m\ 7^s$ .28, mean time, observed by J. N. Nicollet, and his assistant Lieutenant, Charles Tremont, of the Corps Topographical Engineers.

XV. September 18, 1838. Ti tanka Taminan Lake, (east shore of,) on Lahontan River, Sioux Country, Iowa Territory.

Latitude 44° 16′ 41″. Longitude $6^h\ 13^m\ 23^s$.

A partial eclipse of the sun, observed by J. N. Nicollet.

Beginning of the eclipse not observed.
End, " " $4^h\ 18^m\ 6^s$ .85, Mean time.

Clear sky. Dollond telescope, having a magnifying power of about 100.

XVI. September 18, 1838. Goebel's residence, near Newport, Franklin County, Missouri.

Latitude 38° 33′ 58″. Longitude $6^h\ 4^m\ 28^s.6$

A partial eclipse of the sun, observed by Mr. D. W. Goebel.

$$\left.\begin{array}{llll}\text{Beginning of the eclipse} & 1^h & 53^m & 16^s.77 \\ \text{End,} \quad \text{“} \quad \text{“} & 4 & 40 & 42\ .22\end{array}\right\}\ \text{Mean time.}$$

The magnifying power of Mr. Goebel's telescope was about forty.

XVII. July 6, 1839. At Mr. Nicollet's encampment, on the Coteau du Missouri, Yanktonan Indian country.

Latitude 44° 51′ 11″. Longitude $6^h\ 36^m\ 18^s$

An Immersion η. Tauri, at $15^h\ 49^m\ 35^s.5$, mean time, observed by Mr. Nicollet.

XVIII. November 20, 1839. City of St. Louis, Missouri, at the Garden of the Cathedral.

Latitude 38° 37′ 28″. Longitude $6^h\ 1^m\ 0^s.7$

Immersion η. Tauri at $6^h\ 12^m\ 14^s.7$, P. M., mean time, observed by Mr. Nicollet.

XIX. June 5, 1841. At Goebel's Residence, near Newport, Franklin County, Missouri.

Latitude 38° 33′ 58″. Longitude $6^h\ 4^m\ 28^s.6$

Immersion σ. Sagittarii at $15^h\ 40^m\ 7^s.94$, mean time, observed by Mr. D. W. Goebel.

XX. June 26, 1842. Fort Charlotte, old American trading house, north-west shore of Lake Superior, at the west end of the Grand Portage.

Latitude 47° 58′ 34″. Longitude 89° 59′ 31″.

A partial eclipse of the sun.

$$\left.\begin{array}{llll}\text{Beginning of the eclipse} & 6^h & 7^m & 1^s.0 \\ \text{End,} \quad \text{“} \quad \text{“} & 7 & 13 & 19\ .2\end{array}\right\}\ \text{Mean time.}$$

Observation made by James Ferguson, then the astronomer to the American commission for determining the northern boundary; now one of the distinguished assistants of the United States coast survey, under the superintendence of Mr. Hassler.

The telescope used by Mr. Ferguson was of two and a half feet focal length, and the magnifying power of about sixty.

J. N. NICOLLET.

ARTICLE XVIII.

Observations of Encke's Comet, at the High School Observatory, Philadelphia, March and April 1842, *with the Fraunhofer Equatorial, by Sears C. Walker, and E. Otis Kendall. Read May* 20, 1842.

THE following observations were made with a Fraunhofer Filarmicrometer, with illuminated wires, applied to the nine feet Equatorial. The value of a revolution of the Micrometer screw is 25″.626, as determined by several hundred transits of stars over the wires, the interval being varied from time to time, and measured on different parts of the scale. The magnifying power used for all these observations was seventy-five. On all the evenings except the 31st of March and 11th of April, the distance and position of the comet were measured from some known star or stars. On these two evenings this method was impracticable; there being no star visible in the same field of view with the comet, transits of the comet and stars preceding or following it, nearly on the same parallel, over the wires of the micrometer were observed, giving us of course only the correction of the ephemeris in right ascension for those two evenings. On all the others the corrections in right ascension, and declination were obtained.

No.	Observation.	Philadelphia Siderial Time. μ	Position. S′.	Turns of Micrometer Screw. m.	Measured Distance. s′	Remarks.
1	Comet from Star a 9th mag.	7^{h} 36^{m} $0^{s}.3$		8.665	222″.06	1842, March 27.
2	b	7 40 53 .3		11.080	283 .94	Bar. 29.83.
3	a	7 50 5 .3	114° 55′			Att. therm. 56.
4	b	7 50 35 .2	51 35			No. 1 doubtful.
5	b	7 51 35 .2	53 35			
6	a	7 52 35 .2	113 7			
7	"	7 54 57 .2		9.827	251 .83	
8	b	7 59 21 .2		13.047	334 .35	
9	"	8 4 29 .1		13.954	357 .60	
10	a	8 7 50 .1		11.153	285 .82	
11	"	8 10 25 .1	108 40			
12	b	8 12 20 .1	55 40			

No.	Observation.	Philadelphia Siderial Time.	Position.	Turns of Micrometer Screw.	Measured Distance.	Remarks.
		μ	S′.	m.	s′.	
13	Comet from Star c 8th mag.	7^h 37^m $55^s.1$		27.054	693″.31	1842, March 28.
14	"	40 51 .1		27.687	709 .53	Bar. 30.11.
15	"	44 14 .1	50° 34′			Att. therm. 44°.5
16	"	45 17 .1	50 16			The comet had a tail 3′ 16″ in length, very faint.
17	d 10th "	49 16 .1		12.006	307 .67	
18	"	50 54 .0		12.078	309 .52	
19	"	51 50 .0	76 45			
20	"	52 55 .0	76 25			Position 55°.
21	e 11th "	8 0 2 .0		11.402	*292 .20	* Comet from star e, position 167° nearly.
22	"	4 23 .0		10.707	274 .39	
23	"	7 23 .0		12.872	329 .87	
24	"	8 47 .0		12.928	331 .30	
25	c	13 27 .9		29.875	765 .60	
26	"	19 46 .9		29.537	756 .93	
27	"	21 39 .9		30.666	785 .87	
28	"	23 25 .9	53 15			
29	"	25 32 .9	53 8			
30	"	29 5 .9	53 58			
						1842, March 31.
31	Comet from Star f 10th mag.	7^h 52^m $14^s.8$	232° 19′			Bar. 30.03.
32	"	54 34 .8		6.704	171″.81	Att. therm. 46°.
33	"	56 38 .8		6.628	169 .86	No. 32 doubtful.
34	"	8 0 18 .8		6.983	178 .95	
35	"	3 58 .7		6.348	162 .68	
36	"	5 33 .7	225 44			
37	"	8 23 .7	223 57			
38	Diameter of nebula.	11 47 .7		1.253		
		* $\mu' = (\mu + 22^s.412)$				Clock's rate+$6^s.7$.
39	Star g 7, 8 mag. on m=30	8 32 30 .4				* μ' is time by clock, fast $22^s.41$ of sid. time.
40	Comet on m=30	34 26 .4				
41	Star g on m=30	35 59 .4				
42	" on m=37.424	36 11 .8				
43	Comet on m=30	37 52 .6				
44	" on m=37.424	38 6 .1				
						1842, April 1.
45	Comet from Star h 10th mag.	7^h 50^m $51^s.1$		20.667	529″.63	Bar. 30.16 in.
46	"	53 51 .1		20.817	533 .47	Att. therm. 50°.
47	"	55 46 .1	91° 39′			Comet had a tail 7′ in length, faint.
48	"	59 21 .1	91 37			
49	"	8 11 24 .0		21.233	544 .13	Position 56°
						1842, April 5.
50	Comet from Star i 9.10 mag.	8^h 22^m $47^s.5$	139° 10′.5			Bar. 29.94.
51	"	24 20 .5	139 40			Att. therm. 57°.
52	"	26 10 .5	138 0			
53	"	42 12 .4		36.670	939″.73	

No.	Observation.	Philadelphia Siderial Time.	Remarks.
		* $\mu' = (\mu + 37^{s}.817)$	1842, April 11.
54	Comet on m = 30	8^{h} 53^{m} 23^{s}.6	Clock's rate $+7^{s}.2$.
55	" " m = 40	53 40 .9	Bar. not noted.
56	Star k 8, 9 mag. " m = 30	55 5 .0	Att. therm. 68°.
57	" " m = 40	55 22 .5	* μ' is clock time, fast 37^{s}.82 of sid. time.
58	Star l 9th mag. " m = 30	55 53 .4	
59	" " m = 40	56 10 .3	
60	Comet " m = 30	57 47 .2	
61	" " m = 40	58 0 .2	
62	Star k " m = 30	59 24 .6	
63	" " m = 40	59 42 .8	
64	Star l " m = 30	9 0 12 .5	
65	" " m = 40	0 31 .7	

The true right ascensions and declinations of the stars of comparison, on the evenings of observation, were as follows:—

a	= 1^{h}	46^{m}	11^{s}.18,	*a′* = +	16°	46′	26″,04,	* 9	mag., Bessel's Zone,	394
"	1	46	11 .28,	"	16	46	31 .26,	9	, Lalande, H. C., p.	192
b	1	46	10 .55,	*b′*	16	41	24 .72,	9	, Bessel's Zone,	394
c	1	49	25 .88,	*c′*	16	46	1 .69,	8	, " "	"
"	1	49	25 .51,	"	16	46	8 .32,	8, 9	, Lalande, H. C., p.	192
d	1	49	41 .70,	*d′*	16	52	32 .70,	10	, Anonym, Approx,	
e	1	50	5 ,	*e′*	16	59	20 ,	11	, " "	
f	2	1	4 .60,	*f′*	17	15	12 .90,	10	, " "	
g	1	59	6 .71,	*g′*	17	16	29 .60,	7, 8	, Bessel's Zone,	394
"	1	59	6 .51,	"	17	16	33 .80,	7, 8	, " "	332
"	1	59	6 .01,	"	17	16	29 .60,	7, 8	, Piazzi.	
h	2	3	52 .90,	*h′*	17	16	51 .50,	10	, Anonym. Approx.	
i	2	17	18 .20,	*i′*	17	17	0 .70,	9,10	, " "	
k	2	31	58 .31,	*k′*	15	0	18 .69,	8, 9	, Bessel's Zone,	394
"	2	31	58 .10,	"	15	0	20 .83,	8, 9	, " "	141
l	2	32	46 .87,	*l′*	14	57	48 .28,	9	, " "	141
"	2	32	47 .35,	"	14	57	51 .90,	9	, " "	32

The measures and transits observed with the filarmicrometer have been reduced by the formulæ of Bessel in the Astr. Nachr., No. 69, and in the Königsberg Observations, Vol. XV., p. 22. Those of the same star have been referred to a common epoch by means of Encke's Ephemeris. The probable errors are computed from a comparison of the single results in the usual manner. The true places of the comet in right ascension and declination have thus been obtained, free from the effect of aberration, parallax, and refraction.

Date.	Siderial Time at Philadelphia.	Comet's place freed from Aberration, Parallax, and Refraction.		No. of Single Results.
1842.	μ	α = Comet's true R. A.	δ = Comet's true Dec.	
March 27	$7^h\ 54^m\ 57^s$	$a + 0^m\ 18^s.358 \pm 0^s.06$	$a' - 1'\ 29''.38 \pm 1''.9$	3
—	7 59 21	$b + 0\ \ 20.404 \pm 0.60$	$b' + 3\ \ 29.28 \pm 2.3$	3
28	7 37 55	$c + 0\ \ 39.279 \pm 0.16$	$c' + 7\ \ 43.22 \pm 2.1$	5
—	7 50 54	$d + 0\ \ 22.790 \pm 0.03$	$d' + 1\ \ 20.91 \pm 0.3$	2
31	7 54 35	$f - 0\ \ 7.860 \pm 0.12$	$f' - 1\ \ 46.13 \pm 1.6$	4
—	8 36 34	$g + 1\ \ 56.222 \pm 0.65$		3
April 1	7 50 51	$h + 0\ \ 38.149 \pm 0.34$	$h' - 0\ \ 8.51 \pm 0.4$	3
5	8 42 12	$i + 0\ \ 45.608$	$i' - 11\ \ 26.31$	1
11	8 53 36	$k - 1\ \ 41.525 \pm 0.19$		4
—	8 54 1	$l - 2\ \ 29.715 \pm 0.28$		4

By applying the places of the known stars in the above collection, we obtain:

Date.	Siderial Time at Philadelphia.	Comet's true Right Ascension and Declination from Observation.		Correction of Encke's Ephemeris.		No. of Results.	Authority for star's place.
1842.	μ.	α	δ	Cos. $\delta\ \Delta\ \alpha$.	$\Delta\ \delta$.		
March 27	$7^h\ 54^m\ 57^s$	$1^h\ 46^m\ 29^s.54$	$+ 16\ 44\ 56.7$	$+ 0^s.57$	$+ 5''.4$	3	Bessel's Zone.
—		1 46 29.64	$+ 16\ 45\ 1.9$	$+ 0.67$	$+ 10.6$	3	Lalande, H. C.
—	7 59 21	1 46 30.95	$+ 16\ 44\ 54.0$	$+ 1.30$	$+ 0.9$	3	Bessel's Zone.
28	7 37 55	1 50 5.16	$+ 16\ 53\ 44.9$	$+ 2.75$	$+ 2.6$	5	" "
—		1 50 4.79	$+ 16\ 53\ 51.5$	$+ 2.40$	$+ 9.3$	5	Lalande, H. C.
31	8 36 34	2 1 2.83		$+ 0.33$		3	Bessel's Zone.
—		2 1 2.23		$- 0.24$		3	Piazzi.
April 11	8 53 36	2 30 16.67		$- 1.85$		4	Bessel Zones.
—	8 54 1	2 30 17.40		$- 1.16$		4	" "

Mean of 33 results, cos. $\delta\ \Delta\ \alpha = + 0^s.65 \pm 0^s.32$.
" 19 " $\Delta\ \delta = + 5''.8 \pm 1''.2$.

The High School observatory is $5^h\ 0^m\ 41^s.9$ west of Greenwich. Latitude N. 39° 57′ 8″.

We take occasion to acknowledge, with pleasure, the assistance of Dr. Patterson, Messrs. Franklin A. Dick, and John Downes, in making and reducing the observations.

ARTICLE XIX.

Observations of the Magnetic Dip, made in the United States, in 1841. *By J. N. Nicollet. Read September* 16, 1842.

THE following observations were made with a dipping instrument constructed by Robinson, of London, and procured for me by Professor A. D. Bache of Philadelphia. The whole instrument is made of brass; but the vertical circle is plated with silver, upon which the dip is read directly to ten minutes, which, by estimation, may be easily divided to one or two minutes. The horizontal circle, which serves for the measurement of the azimuthal motions of the vertical plane, is graduated to degrees, and the position of the magnetic meridian is determined, either by the usual method of measuring the position of the plane perpendicular to that meridian; or, a horizontal needle mounted upon a pivot with a cylindrical handle of brass having an axis, may be used instead of the dipping needle, being placed in the magnetic meridian, and by the aid of the azimuthal motion of the vertical circle, is found to answer the purpose even better than the other mode. The two dipping needles which accompany the instrument are each of them six inches in length, and in the form of rhombs, terminated very acutely towards each extremity. The breadth across the shorter diagonal of the rhombs is four-tenths of an inch. The axis, when the observation of the dip is made, rests upon agate supports, and its uniform central position upon them is secured by two brass Y's, which can be gently raised and lowered at will, so as to relieve the needle from the supports, or restore it to its bearing upon them, and affords by that process the facility of measuring the dip of the needle several times in each position. For the purpose of designating the magnetic poles, the two ends on one side of each needle, are marked A and B. A spirit level is attached to the uppermost normal point of the vertical circle, and is levelled by three foot screws.

The method of observation is as follows:

1. The plane of the vertical circle being in the magnetic meridian, the graduated face of the instrument and the marked side of the needle to the east, I wait for the needle to come to a state of rest, and then read off its position at its two extremities for the purpose of correcting the eccentricity of the needle. Should the observation be unexpectedly disturbed a little, by a brisk or strong wind, as is sometimes the case, then I measure the position of the needle when the arc of vibration is reduced to about ten or fifteen minutes, taking the mean of the extreme oscillations at both ends.

Without disturbing the position of the instrument, I now, by the aid of the brass Y's, lift up the needle and gently let it down to bear again on its agate supports. When at rest, I read off again as before. I repeat the same operation three times, and each time take the mean of both ends; thus obtaining three mean readings, the sum of which being divided by three, gives the mean of six readings in the same position of the instrument and needle. The three mean readings generally differ but by very few minutes; the extreme difference, so far, with my instrument, very seldom goes to ten minutes.

2. I correct the want of parallelism of the zero line and level, by turning slowly the vertical circle 180° azimuth, which brings the face of the instrument and the marked side of the needle from the east to the west, and there I make six readings, the mean of which taken as before, gives the dip in this second position of the instrument and needle.

Now, was the needle of a perfect construction, the mean of the two results obtained in the two preceding positions would be the true magnetic dip at the place of observation. But, as such perfection cannot be expected, it becomes necessary to recur to the following operations for the purpose of compensating all the errors arising from the position of the magnetic axis of the needle.

3. Leaving the instrument in its second position, I proceed to correct the want of coincidence between the magnetic axis, and the axis of figure of the needle, by turning in the brass Y's, the marked side of the needle from the west to the east, and repeating the six readings as above stated.

4. Turning again the face of the vertical circle to the east, (leaving the needle as in the preceding position,) and reading off six times as before, it makes twenty-four readings for the first magnetic state of the needle, which I designate by the words *poles direct.*

A second magnetic state of the needle is required for correcting the errors resulting from the centre of gravity being out of the axis of the needle. To that effect, the poles are reversed by the action of two magnetic bars of nearly seven inches in length, and the entire observation of the dip repeated in the same order as to the four positions described above, which gives twenty-four readings, the result of which I call *poles reversed.* The second needle furnishes the same number of readings, making ninety-six readings in all. This is the number actually taken at each of the places recorded in this paper, with the exception of No. II. and III. where only two readings, one of each pole, were made in each position of the instrument and needle.

The instrument was placed upon a very convenient tripod, to which was fixed a square table, with an azimuthal instrument to bring the vertical circle in the magnetic meridian when on the zero of the vertical circle; and the whole being well adjusted, stood firmly and steadily during the observation, as proved by the spirit level, which very seldom required to be corrected.

I was induced to adopt the preceding method by analogy with what is practised in taking altitudes with an astronomical circle, in which case, to complete an observation, it is required to take one altitude with the face of the instrument on one side, and then a conjugate observation on the opposite side. I was not aware at that time that the mode of observing the dip I have followed had undergone a slight modification on the part of many observers, who, instead of turning the vertical circle 180°, to bring it to the second position, prefer leaving it in its original position, and change only the marked side of the needle in its brass Y's, with the view, I suppose of saving one turning of the face of the vertical circle, in the observation of any one of the magnetic states of the needle. But there can be no objection to the mode I have followed, for, if for fear of disturbing the instrument it be thought proper to save one turning of it, this is only avoiding one cause of disturbance to introduce another, which is perhaps as great, since it compels them to open twice the glass door, to change the face of the needle, with a manipulation, it would seem, more likely to bring on a disturbance, than the simple and smooth turning of the vertical circle. This, however, is a matter of very secondary importance, the spirit level attached to the instrument, being in all cases to be scrupulously consulted; and, I trust this will be shown by the results of my observations, compared with others.

During my late visits to the northern lakes and return, I was accompanied by my friend Professor Ducatel, who assisted me in recording the observations. We were both very particular in the selection of the stations of observations, retiring at convenient but sufficient distances from towns, settlements, or large establishments, and always consulting the geological formation of the surrounding country and spot. I need not say that we were also very particular as to the removal from our persons of all iron or steel, under any form whatever.

I. *Magnetic Dip at Philadelphia. Latitude* 39° 57′ 8″ *N.; Longitude* 75° 11′ 31″ *West of Greenwich.*

Place of observation the Girard College.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, April 26,	4—6, P. M.	Observed dip with Poles direct,	71° 55′ .1	71° 54′ .7
“	“	“ Poles reversed,	63 .4	59 .6
		Mean dip,	71 59 .25	71 57 .15
		Mean dip of both needles,		71 58 .20

These observations were made by Professor A. D. Bache, of Philadelphia, before sending the instrument to me in Baltimore, by way of comparison.

II. *Magnetic Dip at Baltimore, Maryland. Latitude* 39° 17′ 55″ *N.; Longitude* 76° 37′ 50″ *W.*

Place of observation, the second square N. E. of the Washington Monument. (The station of observation of Professor A. D. Bache.)

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, April 28,	9—12, A. M.	Observed dip, Poles direct,	71° 33′.00	71° 38′.75
“	“	“ Poles reversed,	36 .75	31 .00
		Mean dip,	71 34 .87	71 34 .87
		Mean dip of both needles,		71 34 .87.

III. *Magnetic Dip at Baltimore, Maryland.*

Place of observation the Botanical Garden of St. Mary's College.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, April 28,	3—6, P. M.	Observed dip, Poles direct,	71° 41′.37	71° 35′.37
“	“	“ Poles reversed,	33 .87	43 .75
		Mean dip,	71 37 .62	71 39 .56
		Mean dip of both needles,		71 38 .59

During the observations of this day at Baltimore, Professor John Locke, of Cincinnati, made at the same time, and places, and with his own dipping instrument, consentaneous observations.

IV. *Magnetic Dip at Washington city, D. C. Latitude* 38° 53′ 31″ *N.; Longitude* 77° 1′ 24″ *W.*

Place of observation the eastern garden of the capitol, at about the middle of the central avenue.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, June 5,	7—10, A. M.	Observed dip, Poles direct,	71° 11′.20	71° 17′.25
"	"	" Poles reversed,	19 .00	14 .00
		Mean dip,	71 15 .10	71 15 .62
		Mean dip of both needles,		71 15 .36

The observations of this day were made conjointly with Major J. D. Graham, he observing with an instrument of Gambey's construction, and I with my Robinson's.—Weather fine, light north-west wind, light clouds near the horizon. The temperature during the observations from 72° to 84°.

V. *Magnetic Dip at Washington city, D. C.*

Place of observation the same as the preceding.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, July 15,	7—9¼, A. M.	Observed dip, Poles direct,	71° 18′.75	71° 10′.50
"	"	" Poles reversed,	9 .50	21 .25
		Mean dip,	71 14 .12	71 15 .87
		Mean dip of both needles,		71 15 .00

Remarks.—Weather cloudy, calm and sultry. Last night, a heavy storm between 9 and 11 o'clock. The temperature during the observations from 79° to 81°.

VI. *Magnetic Dip at Washington city, D. C.*

Place of observation the same as the preceding.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, July 16,	6¾—9¼, A. M.	Observed dip, Poles direct,	71° 11′.00	71° 17′.75
"	"	" Poles reversed,	16 .75	9 .75
		Mean dip,	71 13 .87	71 13 .75
		Mean dip of both needles,		71 13 .81

Remarks.—Sky clear, N. W. wind, tolerably strong. The temperature during the observations from 73° to 76°.

VII. *Magnetic Dip at Washington city, D. C.*

Place of observation the garden of the Washington Observatory, on Capitol hill, (about 300 yards N. N. W. of the preceding station.?)

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Aug. 13,	1—3¼, P. M.	Observed dip,	Poles direct,	71° 17′.50	71° 13′.00
"	"	"	Poles reversed,	11 .52	17 .80
			Mean dip,	71 14 .51	73 15 .40
			Mean dip of both needles,		71 14 .95

Remarks.—Weather cloudy, light south wind. The temperature during the observations from 78° to 81°.

VIII. *Magnetic Dip at Baltimore, Md.*

Place of observation the second square north-east of the Washington monument, station of observation of Professor Bache, and occupied by myself and Dr. Locke, on the 28th April, 1841. (See No. II., above, in this paper.)

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Aug. 19,	9—11½, A. M.	Observed dip,	Poles direct,	71° 32′.40	71° 37′.22
			Poles reversed,	42 .00	32 .00
			Mean dip,	71 37 .20	71 34 .61
			Mean dip of both needles,		71 35 .90

Remarks.—Sky clear, light south wind. The temperature during the observations from 73° to 79°.

IX. *Magnetic Dip at Baltimore, Md.*

Place of observation the grove north of the Washington monument, (station of observation of Professor Loomis, as pointed out to me by Mr. T. Green, of Baltimore.)

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Aug. 19,	12—2, P. M.	Observed dip,	Poles direct,	71° 55′.50	71° 44′.95
"	"	"	Poles reversed,	46 .72	53 .10
			Mean dip,	71 51 .11	71 49 .02
			Mean dip of both needles,		71 50 .06

Remarks.—Sky clear, moderate south wind. The temperature during the observations from 83° to 85°.

X. *Magnetic Dip at Baltimore, Md.*

Place of observation the botanical garden of St. Mary's college.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Aug. 20,	9½—12, A. M.	Observed dip,	Poles direct,	71° 37′.58	71° 44′.82
"	"	"	Poles reversed,	41 .45	35 .17
			Mean dip,	71 39 .51	71 40 .00
			Mean dip of both needles,		71 39 .75

Remarks.—Weather cloudy, moderate south-west wind. The temperature during the observations from 87° to 95°.

These observations were made in a pavilion, constructed, at my suggestion, by the liberality of the Rev. Gentlemen of St. Mary's college. Observations No. III., made in a different part of the garden, show that the brick wall, which passes at the distance of seventy-eight feet from the pavilion, has no appreciable effect upon the magnetic dip.

XI. *Magnetic Dip at Albany, N. Y. Latitude* 42° 39′ 3″ *N.; Longitude* 73° 44′ 49″ *W.*

Place of observation out of the city, about half a mile west of the capitol, south corner of the Cemetery, near the Orphan Asylum.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Aug. 29,	4—6½, P. M.	Observed dip,	Poles direct,	74° 43′.55	74° 39′.17
"	"	"	Poles reversed,	41 .60	35 .37
			Mean dip,	74 42 .57	74 37 .27
			Mean dip of both needles,		74 39 .92

Remarks.—Weather cloudy and sultry, drizzling towards the close of the observations. The temperature during the observations from 77° to 73°.

The needle No. 2, (after reversing the poles,) very sluggish, although carefully magnetized.

XII. *Magnetic Dip at Oswego, N. Y. Latitude* 43° 28′ *N.; Longitude* 76° 30′ *W.*

Place of observation at Mr. G. H. Woodruff's garden, near the Baptist Church, the eastern end of the part of the town situated on the right side of Oswego River.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Sept. 1,	10—12½, A. M.	Observed dip,	Poles direct,	75° 7′.82	74° 59′.12
"	"	"	Poles reversed,	9 .87	75 15 .60
			Mean dip,	75 8 .84	75 7 .36
			Mean dip of both needles,		75 8 .10

Remarks.—Sky clear, light north-west wind. The temperature during the observations from 70° to 73°.

XIII. *Magnetic Dip at Niagara Falls, N. Y. side. Latitude* 43° 2′ *N.; Longitude* 79° 12′ *W.*

Place of observation on the skirt of the wood bordering on the Niagara River, east of the town of Niagara, about three hundred yards south-east of Cataract Hotel.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, Sept. 5,	9¼—11¾, A. M.	Observed dip, Poles direct,	74° 51′.72	74° 53′.05
"	"	" Poles reversed,	49 .62	45 .80
		Mean dip,	74 50 .67	74 49 .42
		Mean dip of both needles,		74 50 .04

Remarks.—Weather fine, calm. The temperature during the observations from 69° to 76°.

XIV. *Magnetic Dip at Niagara Falls, Canada side.*

Place of observation in the meadow, about thirty yards west of Clifton House.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, Sept. 5,	3—6, P. M.	Observed dip, Poles direct,	74° 56′ .7	74° 46′.55
"	"	" Poles reversed,	56 .6	59 .10
		Mean dip,	74 56 .65	74 52 .82
		Mean dip of both needles,		74 54 .73

Remarks.—Weather fine, light south wind. The temperature during the observations from 70° to 73°.

The two stations of this day at the Niagara Falls, one mile apart of each other, the second nearly north-west of the first.

XV. *Magnetic Dip at Detroit, Michigan. Latitude* 42° 19′ *N.; Longitude* 83° 3′ *W.*

Place of observation at Judge E. Farnsworth's Orchard, Jefferson avenue, upper end of the city.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, Sept. 10,	9½—11¼, A. M.	Observed dip, Poles direct,	73° 34′.60	
"	"	Poles reversed,	30 .90	
		Mean dip of No. 1,	73 32 .75	

Remarks.—Weather cloudy, south-west wind. The temperature during the observations from 76° to 78°.

The sudden arrival and departure of a steam-boat which I was expecting to furnish me a passage for Makinag, did not allow me time to observe the dip with needle No. 2.

XVI. *Magnetic Dip at Michillimakinag Island, Michigan. Latitude* 45° 51′ *N.; Longitude* 84° 23′ *W.*

Place of observation in the Juniper grove, on the Lake shore, about a quarter mile south-west from the new Fort Makinag, and out of the village.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, Sept. 12,	3¼—5¼, P. M.	Observed dip, Poles direct,	76° 32′.16	76° 37′.18
"	"	" Poles reversed,	35 .95	31 .70
		Mean dip,	76 34 .05	76 34 .44
		Mean dip of both needles,		76 34 .24

Remarks:—Weather, flying clouds, sun shining at intervals; brisk north-west wind, increasing during the observations. The temperature during the observations from 70° to 75°. The sky, which was overcast during the evening, cleared up about ten o'clock, at which time a beautiful aurora borealis made its appearance, with brilliant coruscations, and remained luminous part of the night.

XVII. *Magnetic Dip at Michillimakinag Island, Michigan.*

Place of observation west side of the ruin of old Fort Holmes, on the top of the hill, about two hundred and sixty feet above the level of the Lake.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, Sept. 13,	2¼—4, P. M.	Observed dip, Poles direct,	76° 37′.10	76° 32′.05
"	"	" Poles reversed,	30 .75	39 .75
		Mean dip,	76 33 .92	76 35 .90
		Mean dip of both needles,		76 34 .91

Remarks:—Weather cloudy, south-west wind, rather strong towards the close of the observations. The temperature during the observations from 76° to 70°. During the ensuing night the sky cleared up, and at about 11 o'clock was perfectly clear, the aurora borealis, as in the preceding night, appearing with great beauty. I was, unfortunately, so situated as not to be able to allow my magnetic apparatus to remain in position, whereby I might have ascertained any influence exercised by this phenomenon.

XVIII. *Magnetic Dip at Chicago, Illinois. Latitude* 42° 0′ *N.; Longitude* 87° 44′ *W.*

Place of observation in a small grove, near the borders of Lake Michigan, and north side of Chicago River.

Date.	Hour.		Needle No. 1.	Needle No. 2.
1841, Sept. 18,	9¾—11¾, A. M.	Observed dip, Poles direct,	72° 42′.22	72° 48′.75
"	"	" Poles reversed,	49 .60	42 .80
		Mean dip,	72 45 .91	72 45 .77
		Mean dip of both needles,		72 45 .84

Remarks:—Weather cloudy, strong south-east wind. The temperature during the observations from 60° to 59°.

XIX. *Magnetic Dip at Juliet, Illinois. Latitude* 41° 30′ *N.; Longitude* 88° 9′ *W.*

Place of observation in the oak grove, near the church upon the hill, on the west side of Illinois and Chicago Canal.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Sept. 26,	2½—4¼, A. M.	Observed dip,	Poles direct,	72° 21′.92	72° 10′.18
"	"	"	Poles reversed,	9 .55	22 .30
			Mean dip,	72 15 .73	72 16 .24
			Mean dip of both needles,		72 15 .98

Remarks:—Weather clear, light west wind. The temperature during the observations from 64° to 62°.

XX. *Magnetic Dip at Ottawa, Illinois. Latitude* 41° 15′ *N.; Longitude* 88° 50′ *W.*

Place of observation a quarter of a mile west of the town, near the wooden bridge, on the right bank of the creek, which consists of a soft sand stone.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Sept. 29,	8—11¾, A. M.	Observed dip,	Poles direct,	72° 14′.12	72° 23′.38
"	"	"	Poles reversed,	27 .40	16 .08
			Mean dip,	72 20 .76	72 19 .73
			Mean dip of both needles,		72 20 .24

Remarks:—Weather cloudy, sun shining at intervals, brisk north-west wind. The temperature during the observations from 44° to 56°.

XXI. *Magnetic Dip at Peru, Illinois. Latitude* 41° 13′ *N.; Longitude* 89° 3′ *W.*

Place of observation on the immediate right bank of Illinois River, in a willow grove, about eighty yards from the lower end of the town.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Sept. 30,	3¼—5½, P. M.	Observed dip,	Poles direct,	71° 51′.20	71° 46′.22
"	"	"	Poles reversed,	48 .35	54 .82
			Mean dip,	71 49 .77	71 50 .52
			Mean dip of both needles,		71 50 .14

Remarks:—Clouds gathering to the west, and the air almost calm at the beginning of the observation of Needle No. 1; north-west wind rises brisk and strong at intervals, needle restless; its positions are measured by means of its shortest vibrations. Calm weather succeeded again towards the close of the observation of needle No. 1, but, being afraid of being disturbed again by similar atmospheric changes, I moved the instrument to a ravine in the bluff, about one hundred yards north of the former station, and there I observed the needle No. 2.

The next morning I repeated the observations of both needles at the station of the needle No. 2, of this day, as will be seen in the following records.

XXII. *Magnetic Dip at Peru, Illinois.*

Place of observation in a ravine about eighty yards from the lower end of the town, and about one hundred yards north of the Illinois River, the same station as occupied yesterday for needle No. 2.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Oct. 1,	9¼—11½, A. M.	Observed dip,	Poles direct,	71° 45′.70	71° 53′.30
"	"	"	Poles reversed,	53 .23	44 .55
			Mean dip,	71 49 .46	71 48 .92
			Mean dip of both needles,		71 49 .19

Note.—The last three stations at Juliet, Ottawa, and Peru, whose latitudes differ but little, especially the last two named, yield, according to my observations, magnetic dips, which, as they are not justified by differences in longitude, so neither can they be accounted for on the supposition of any local attraction, as there are no indications of the occurrence of iron ore in the vicinity, the soil containing but the usual trifling proportion of oxide of iron belonging to nearly all regions, the influence of which is considered as inappreciable by our instruments. On the other hand, I have no reason to doubt the accuracy, within the usual limits, of my own observations, as they were made with a tried instrument, and with all the care of which I am capable. As, so far as I know, the true geographical position of these three places, has not been astronomically determined, it is possible that when this shall be done, there will be found more conformity in the relation existing between the difference of geographical position and that of the magnetic inclination. In reference to that subject, I have much regretted not to have been able to determine the position of these three places; the haste of my journey as well as the inclemency of the weather having prevented me, excepting at Ottawa. At all events, should any error have been made in determining the magnetic dip at any of these three stations, it cannot have happened at Peru, the result there having been confirmed during two consecutive days of observations. This error may arise from a repeated mistake in reading off the degrees of the two needles, which, though I cannot realize it to myself, is nevertheless possible, since, as at Ottawa, the different positions in which the needle is placed during a complete observation indicate degrees of different denominations. We should guard, however, against any preconceived notions in reference to phenomena so delicate and complicated as those relating to the laws that regulate the distribution of magnetism over the surface of the earth, and which are yet so little known to us.

The foregoing observations, therefore, are submitted for as much as they are worth for the present, in the hope that some future observer at Juliet, and Ottawa, will take the trouble to confirm or refute them.

Remarks:—Weather cloudy, light north-east wind. The temperature during the observations from 51° to 56°.

XXIII. *Magnetic Dip at St. Louis, Missouri. Latitude* 38° 37′ 28″ *N.; Longitude* 90° 15′ 10″ *W.*

Place of observation on the east side of the Mississippi River, in a grove opposite Bloody Island, near Illinois Town, about one mile east of St. Louis.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Oct. 6,	1¾—3¾, P. M.	Observed dip,	Poles direct,	69° 31′.05	69° 16′.98
"	"	"	Poles reversed,	24 .98	34 .08
			Mean dip,	69 28 .01	69 25 .33
			Mean dip of both needles,		69 26 .67

Remarks:—Sky clear, south-east wind, brisk at intervals. The temperature during the observations from 72° to 76°.

XXIV. *Magnetic Dip at St. Louis, Missouri.*

Place of observation in Mr. Henry Chouteau's orchard, on the west shore of Chouteau's pond, about half a mile west of the Mississippi River, or one and a half mile west of the preceding station.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Oct. 11,	2¼—4½, P. M.	Observed dip,	Poles direct,	69° 22′.90	69° 12′.62
"	"	"	Poles reversed,	29 .80	43 .18
			Mean dip,	69 26 .35	69 27 .90
			Mean dip of both needles,		69 27 .12

Remarks:—Weather cloudy and calm. The temperature during the observations, 67° to 65°.

XXV. *Magnetic Dip at Baltimore, Md.*

Place of observation the botanical garden of St. Mary's college.

Date.	Hour.			Needle No. 1.	Needle No. 2.
1841, Nov. 15,	11 A. M.—1½ P. M.	Observed dip,	Poles direct,	71° 46′.90	71° 49′.32
"	"		Poles reversed,	34 .12	33 .07
			Mean dip,	71 40 .51	71 41 .19
			Mean dip of both needles,		71 40 .85

Remarks.—Weather cloudy, sun shining at intervals, high south-west wind, not interfering with the observations as they were made in the Magnetic Pavilion recently constructed. (See the remarks No. X., above.)

This observation, which gives nearly the same result as that found at the same place on the 20th of August, before leaving Baltimore, shows that the needles have suffered no material changes during my magnetic tour.

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Department of State, Washington. A Fac Simile of the engrossed Copy of the Declaration of Independence.

Diver (Dr.) Twenty-one Copper Coins, chiefly Oriental.

Dunglison (Robley.) A Specimen of the Chinese Printing Blocks.

Gilpin (Joshua.) A Specimen of Rock from the highest pinnacle of Mont Blanc. This specimen had been presented to the donor by the celebrated Professor de Saussure, in 1798.—

Gilpin (Joshua.)—*continued.*

The Tusk of a Swordfish, which had been thrust into the bottom of an American Ship in the Chinese Sea.

Harlan (Richard.) A set of Casts, comprising twenty-eight pieces, of a new Fossil Genus, named by Dr. Harlan *Orycterotherium Missouriensis.*

Justice (George M.) A Fossil from the Island of Antigua.

Locke (Prof. John.) A Collection of Casts of Fossils, chiefly of Western Rocks.

M'Kennan (James.) Specimens of Wood taken from a Beam out of the Ruins of Uxmal, Central America. This wood is derived from a Tree called *Zapodillo*, and is said by the natives to be insusceptible of decay.—A specimen of Sponge, and nineteen specimens of Shells, from Central America.

Nicollet (J. N.) A large Specimen of the Red Pipe Stone, from the country of the Sioux Indians.

Patrullo (Nicholas.) A Specimen of Marble from Granada, in Spain.

—— A large Map of South America, by Olmedilla. Published by order of the Spanish Government, in 1775.

Penington (John.) An Engraved Portrait of Alexander Von Humboldt. Framed.

Saxton & Gobrecht (of the U. S. Mint.) An Engraved Seal for the use of the Secretaries of the A. P. S.

Schwarz (J. G.) Typographical Specimens, from the Typometry of Mr. Raffelsperger, of Vienna, including Maps, Portraits, &c.

Short (Prof. Charles W.) Dried Specimens of Western and Southern Plants of the United States; and a Collection of Dried Plants made in the State of Kentucky, containing some Species not included in any of the parcels formerly sent by the donor. These Herbariums were prepared by the donor himself; and are beautifully arranged and carefully preserved.

Turner (The Rev. C.) A Lithographic Drawing of the Statue of Sir Isaac Newton.

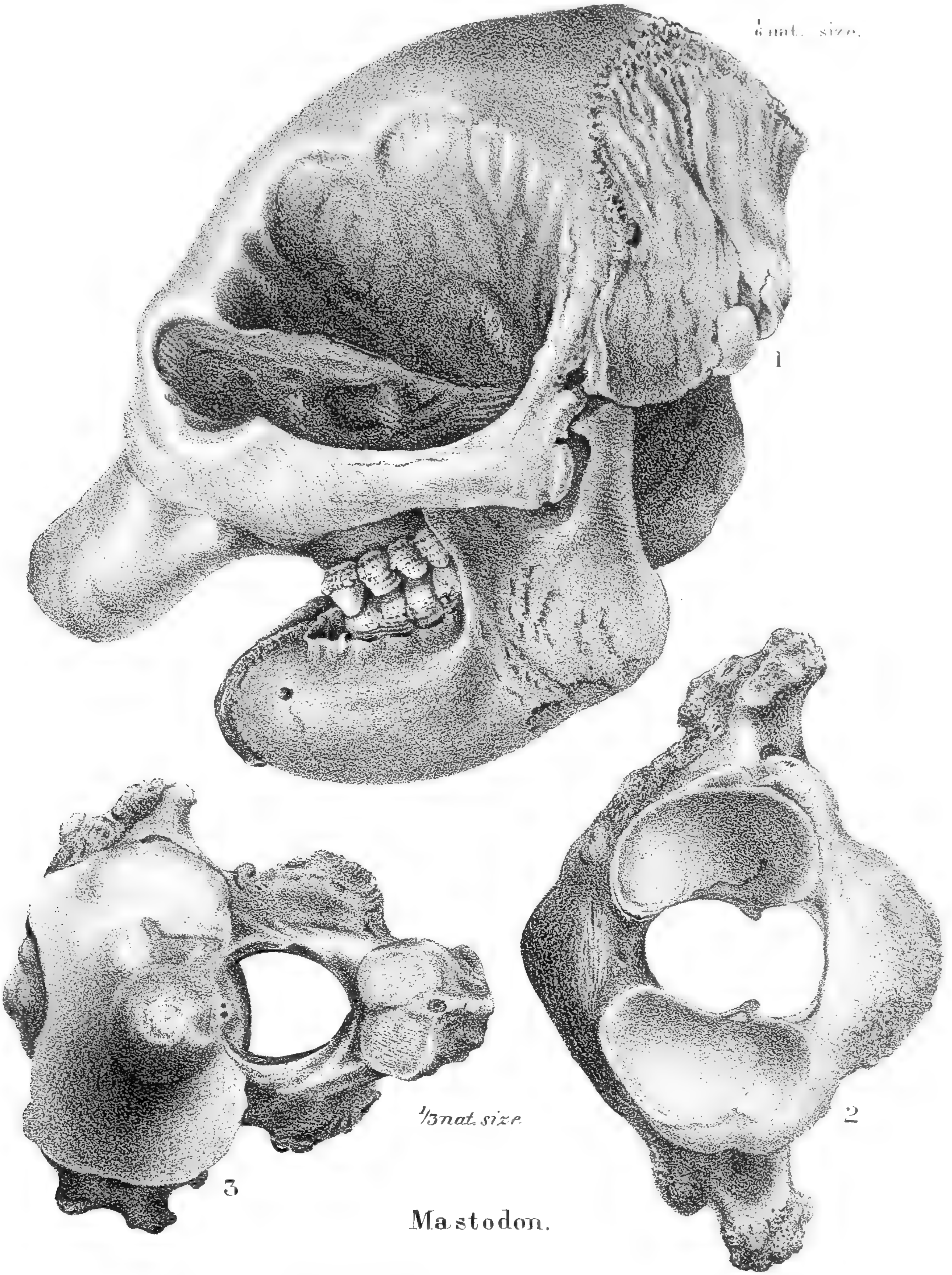
Welsh (T. B.) An Engraved Portrait of Dr. Philip Tidyman, by T. B. Welsh.

END OF VOL. VIII.

ERRATA IN MR. NICOLLET'S ARTICLE.

Page 309, seventh line from bottom, *for* "Lake Ti tanka Taminan," *read* Lake Ti tanka Tanninan: also, in the same page, ninth line from bottom, *for* "Lieut. Charles Tremont," *read* Lieut. Charles Fremont.

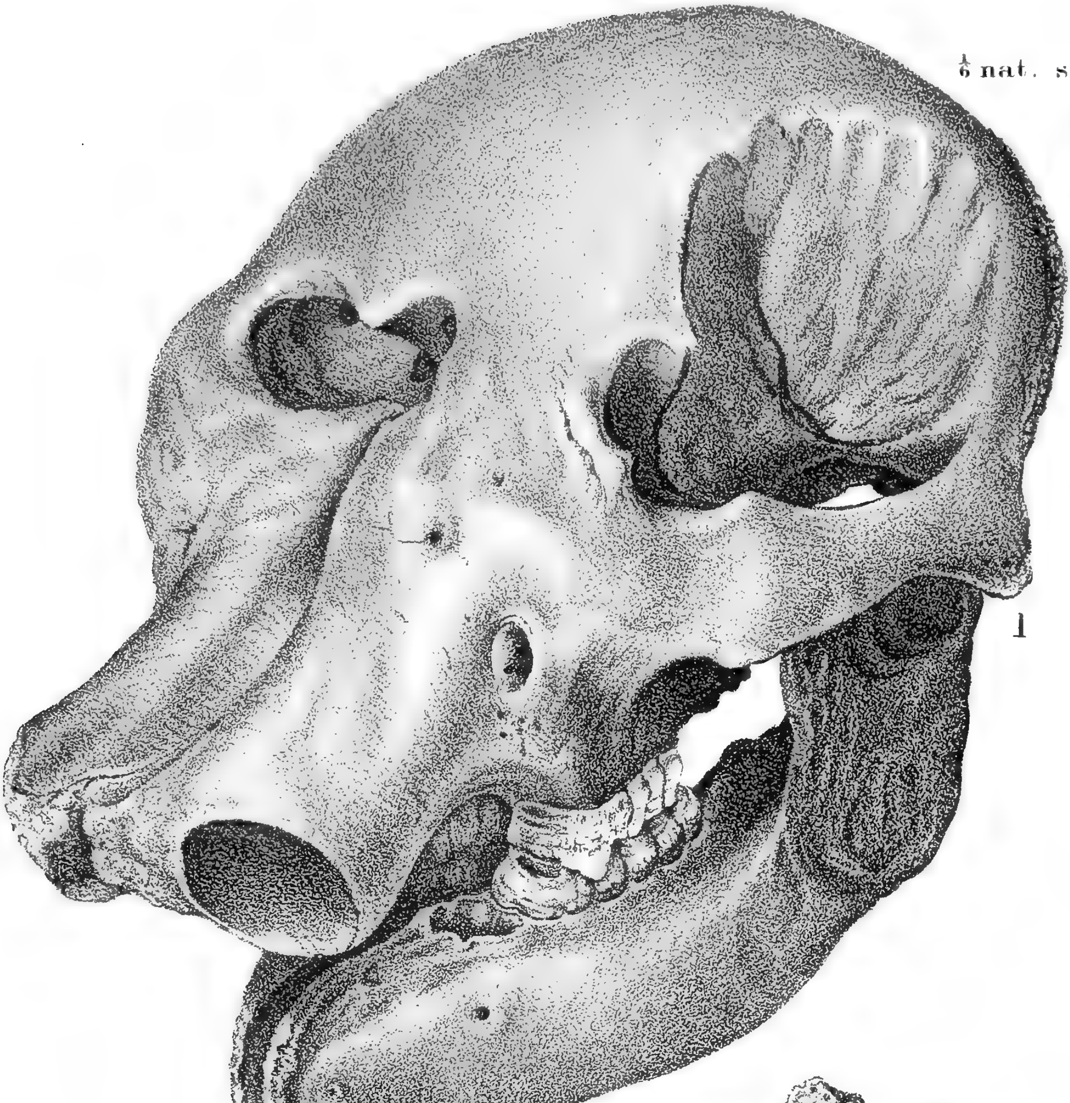
Trans. Am. Phil. Soc. 2d Series Vol. 8 Pl. 1



Mastodon.

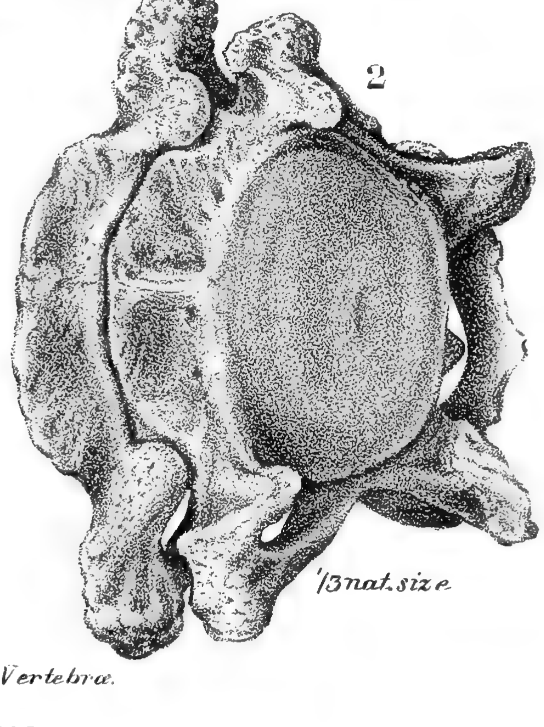
Fig 1. Head. *2 First Cervical Vertebra.* *3. Second Cervical Vertebra*

Drawn by Oscar A. Lawson On stone by M. S. Weaver. Lith. of T. Sinclair



$\frac{1}{6}$ nat. size.

1



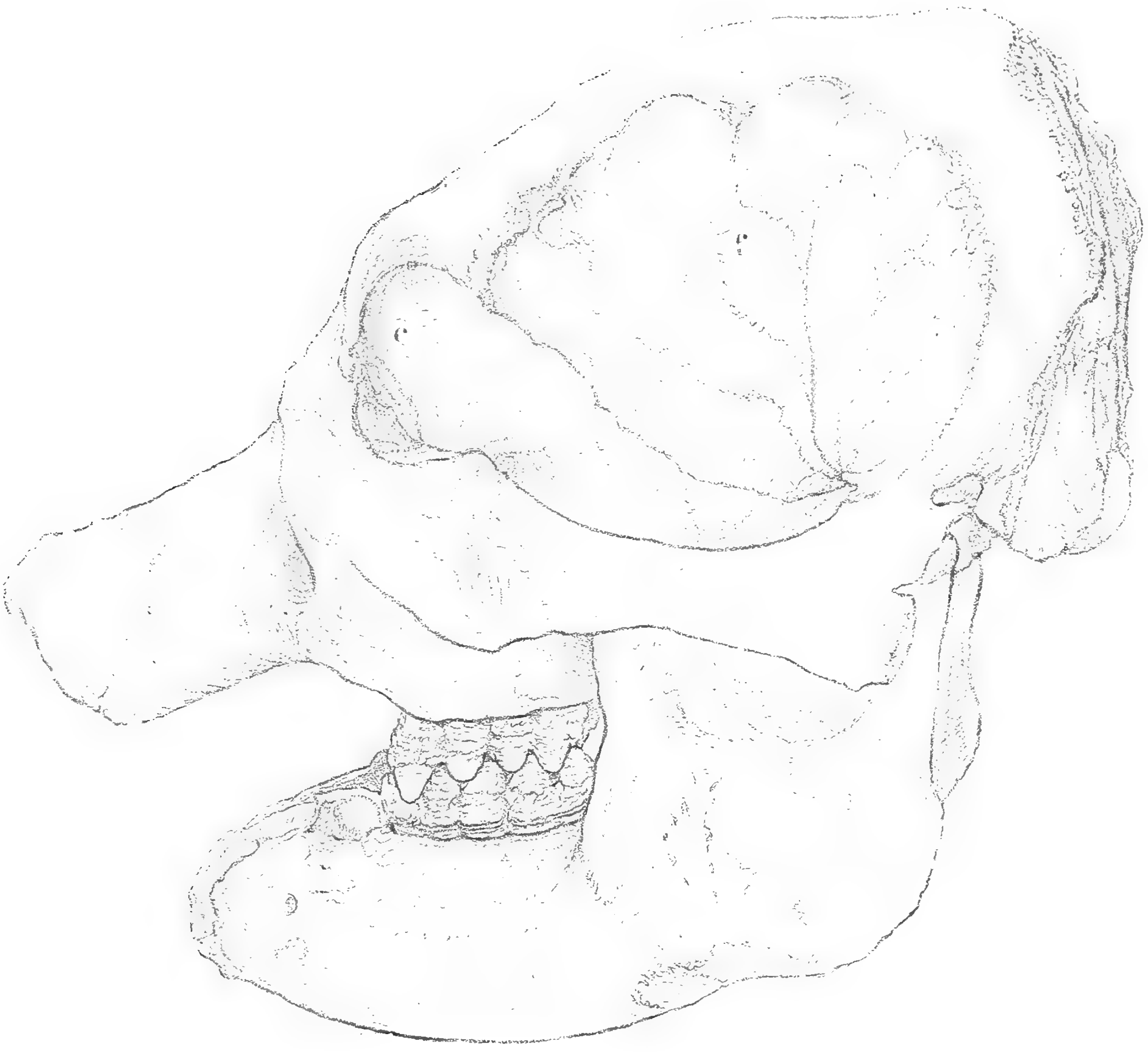
2

1/3 nat. size.

Mastodon.

Fig. 1 Head. *2. Two Cervical Vertebrae.*

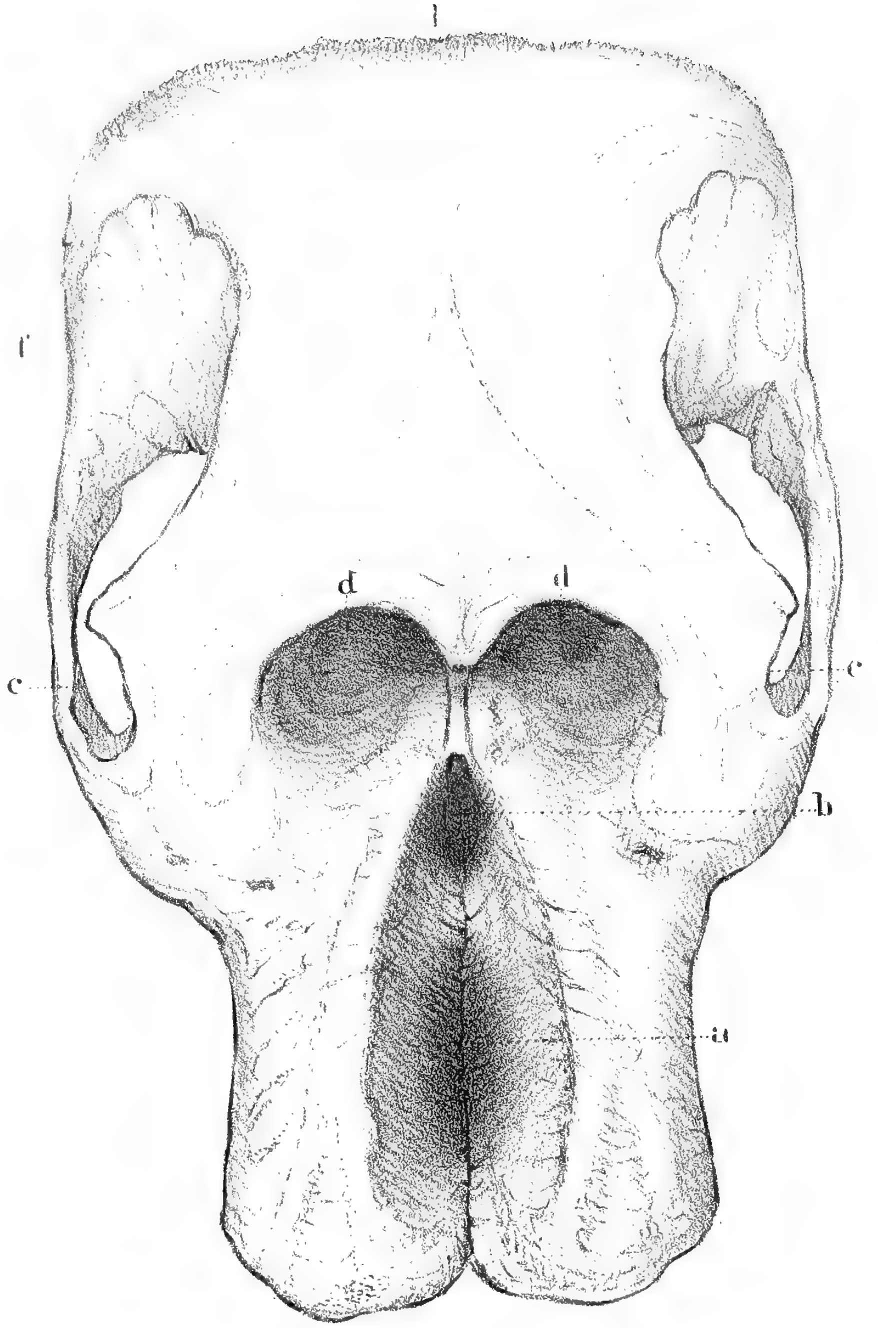
Drawn by Oscar A. Lawson. On stone by M. S. Weaver. Lith. of T. Sinclair.



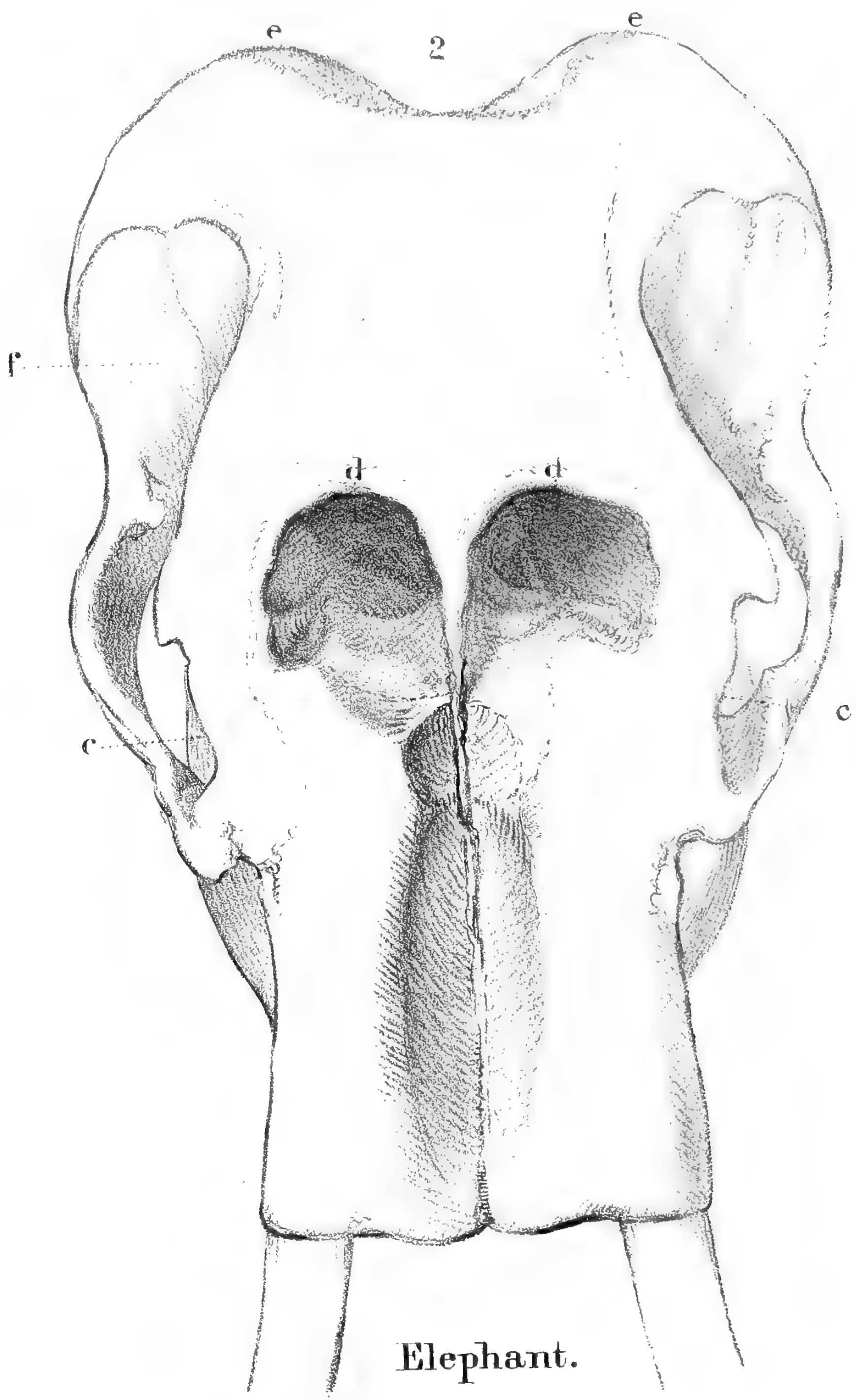
Mastodon.

c. *Orbit.* f *Temporal Fossa.*

Drawn by Oscar A. Lawson. On stone by M. S. Weaver. Lith. of T. Sinclair.



Mastodon.



Elephant.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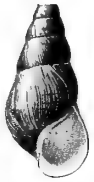
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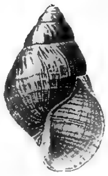
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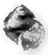
22


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1 *M. Hildrethiana*
2 ,, *castanea*
3 ,, *lævigata*
4 ,, *Kirtlandiana*
5 ,, *Taitiana*
6 ,, *dubiosa*
7 ,, *ebenum*

8 *M. rufa*
9 ,, *fusiformis*
10 ,, *clavæformis*
11 ,, *gracilis*
12 ,, *subsolida*
13 ,, *Ocoëensis*
14 ,, *subcylindracea*
15 ,, *sordida*

16 *M. regularis*
17 ,, *fuliginosa*
18 ,, *Nickliniana*
19 ,, *viridis*
20 ,, *occidentalis*
21 ,, *Niagarensis*
22 ,, *globula*
23 ,, *altilis*

24 *M. strigosa*
25 ,, *virgata*
26 ,, *tenebrosa*
27 ,, *teres*
28 ,, *obtusa*
29 ,, *Lecontiana*
30 ,, *corrugata*

MELANIDÆ &c.


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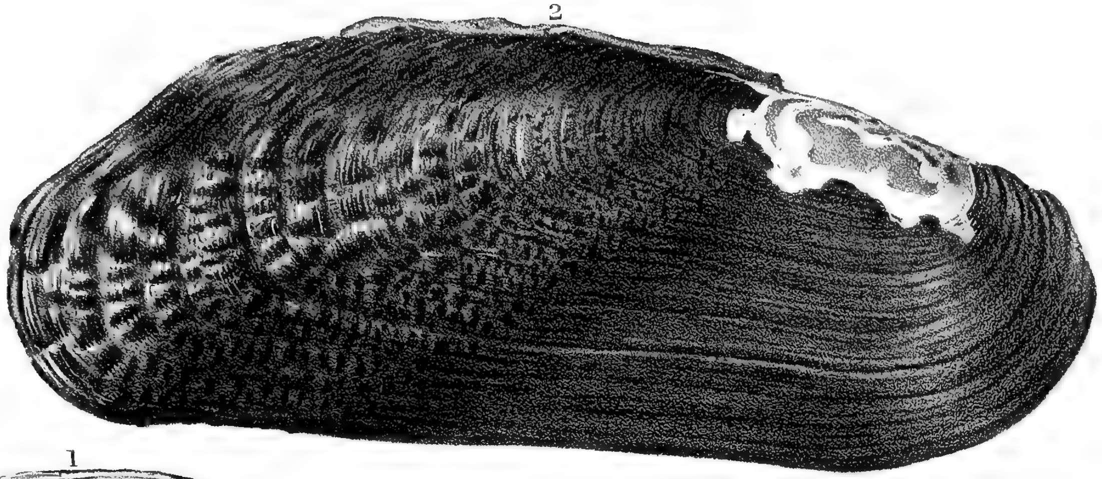
31 *M. monozonalis.*
32 .. *terebralis* .....
33 .. *columella* ....
34 .. *blanda* ....
35 .. *crebri-costata*
36 .. *Curreyana* ......
37 .. *Edgariana* ...
38 .. *decora* ....

39 *M. costulata* ....
40 .. *nitens* ....
41 .. *plicatula* ....
42 .. *concinna* ....
43 .. *Babylonica* ...
44 .. *exarata* ....
45 .. *Potosiensis* ......
46 .. *acuto carinata*

47 *M. Wardariana*
48 .. *sulcosa* ......
49 .. *striata* .. ..
50 .. *pilula* ....
51 .. *circincta* .. ....
52 .. *venusta* ....
53 .. *Florentiana*
54 .. *Duttoniana.*

55 *M. Holstonia* ....
56 .. *caliginosa*
57 .. *nodulosa*
58 .. *Cincinnatiensis*
59 .. *Boykiniana* ....
60 .. *catenoides* ....
61 .. *Carocolla Cumberlandiana*
62 .. *Cyclostoma Cincinnatiense*

2



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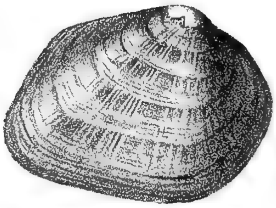
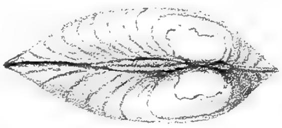
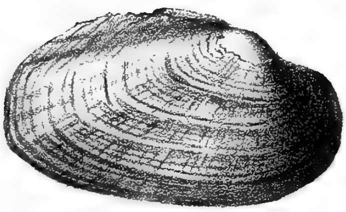
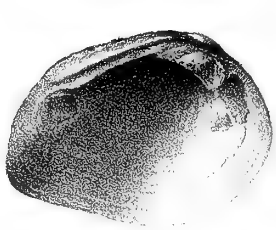




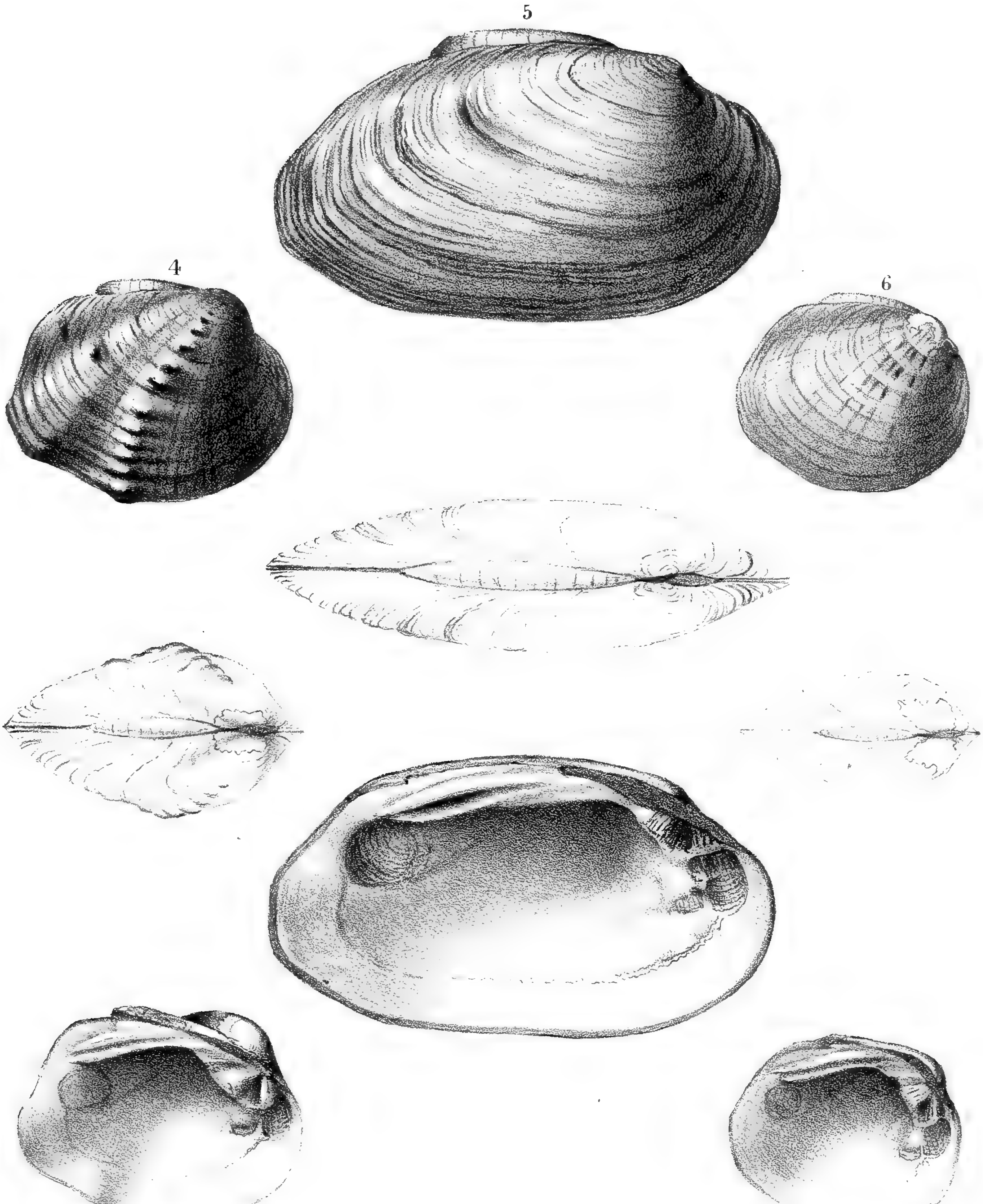




1. *Unio exiguus.*
2. *Unio cucumoides*
3. *Unio cuneolus.*

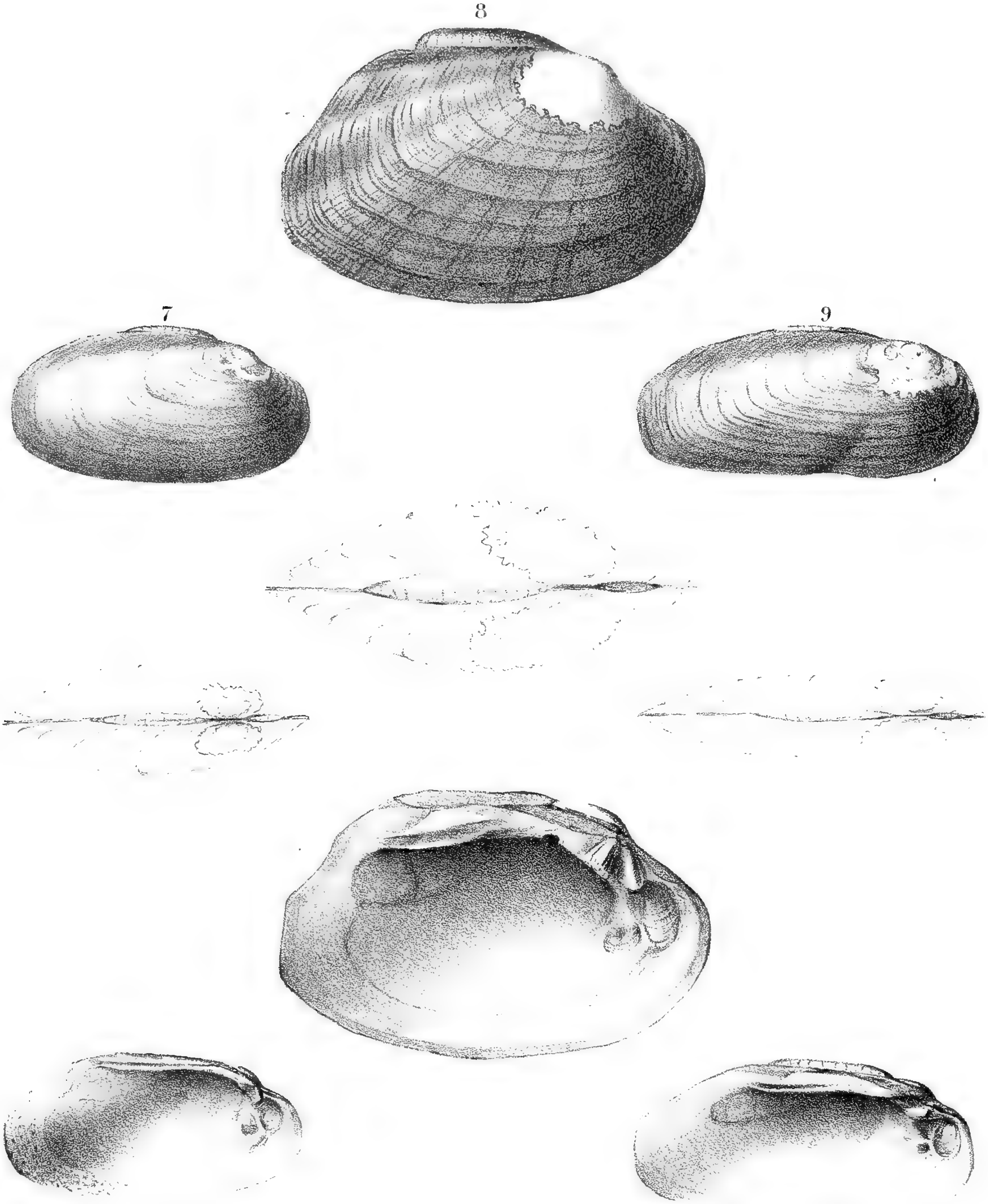
J.T.French del.

Sinclair's Lith. Phila



4. *Unio Cincinnatiensis.*
5. *Unio Stonensis.*
6. *Unio Lesueurianus.*

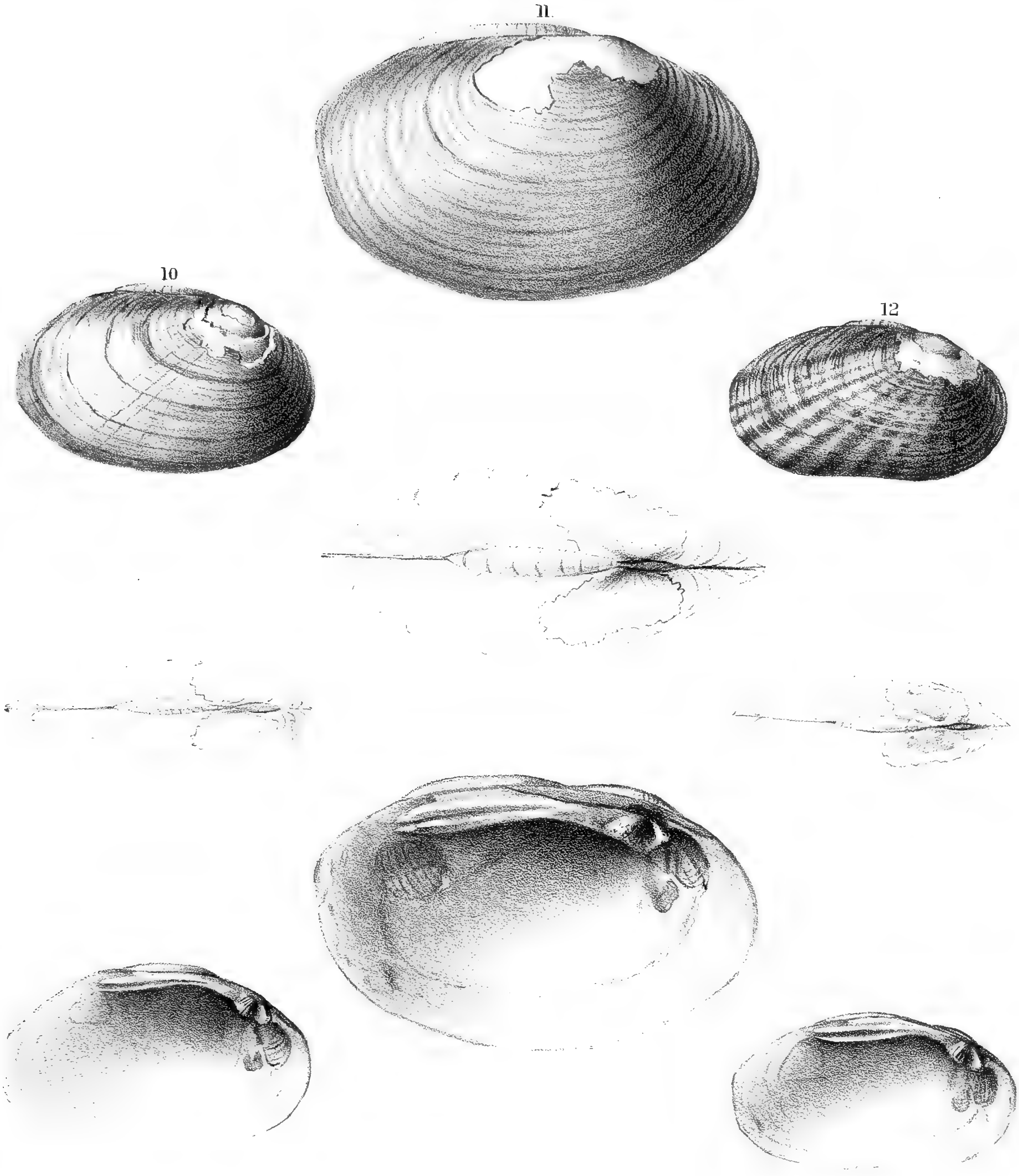
J.T. French del.
Sinclair's Lith. Phil^{a}



7. *Unio dactylus.*
8. *Unio biangulatus.*
9. *Unio strigosus.*

J. T. French del.

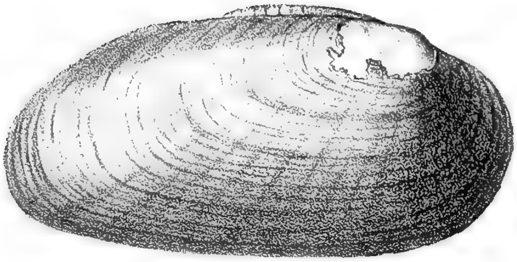
Sinclair's Lith. Phil^{a}.



10. *Unio tener.*
11. *Unio Tennesseensis.*
12. *Unio amœnus.*

H. C. Lea del.
Sinclair's Lith. Phil.
on stone by J. T. French.

14



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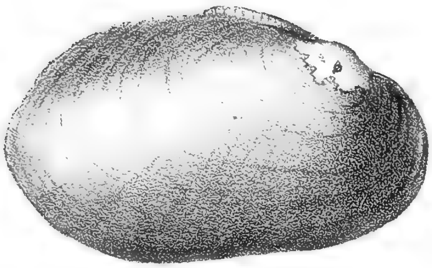

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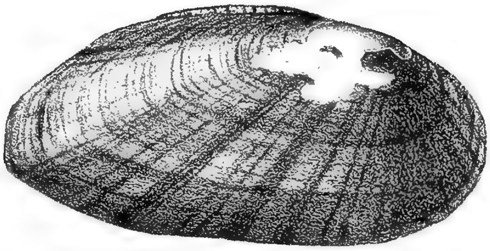
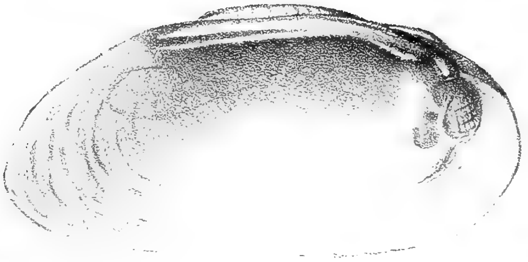
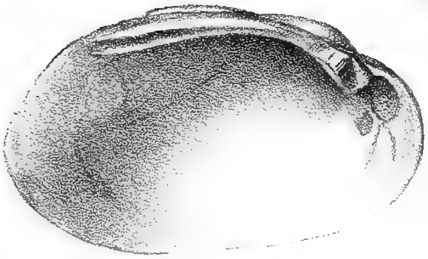
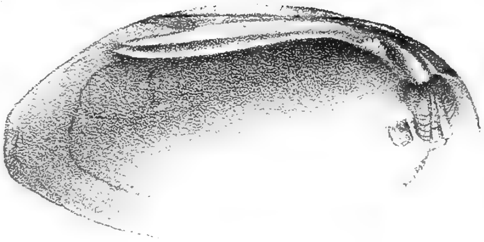








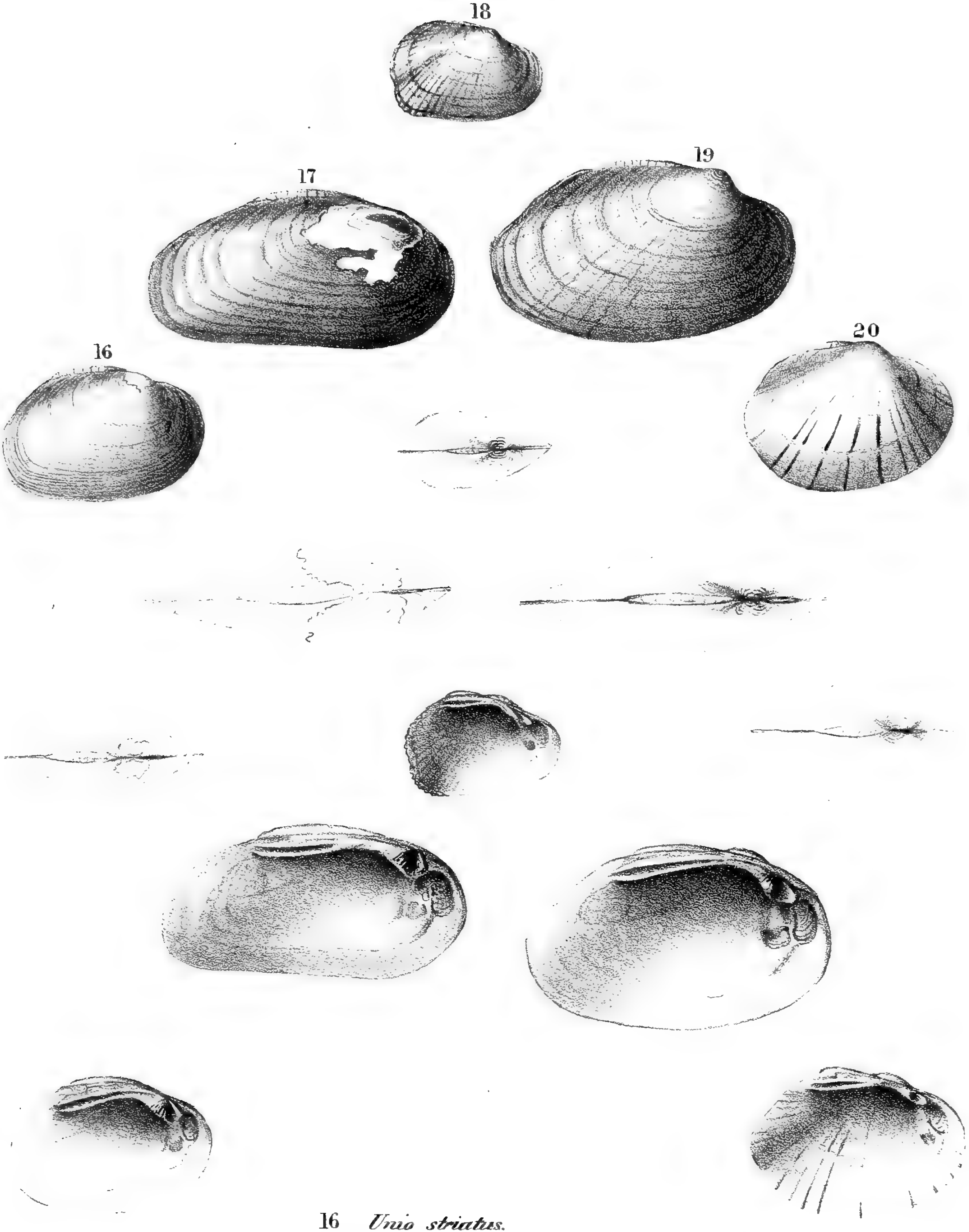
H. C. Lea del.

13 *Unio obtusus.*
14 *Unio fatuus.*
15 *Unio Geddingsianus.*

on stone by J. T. French.

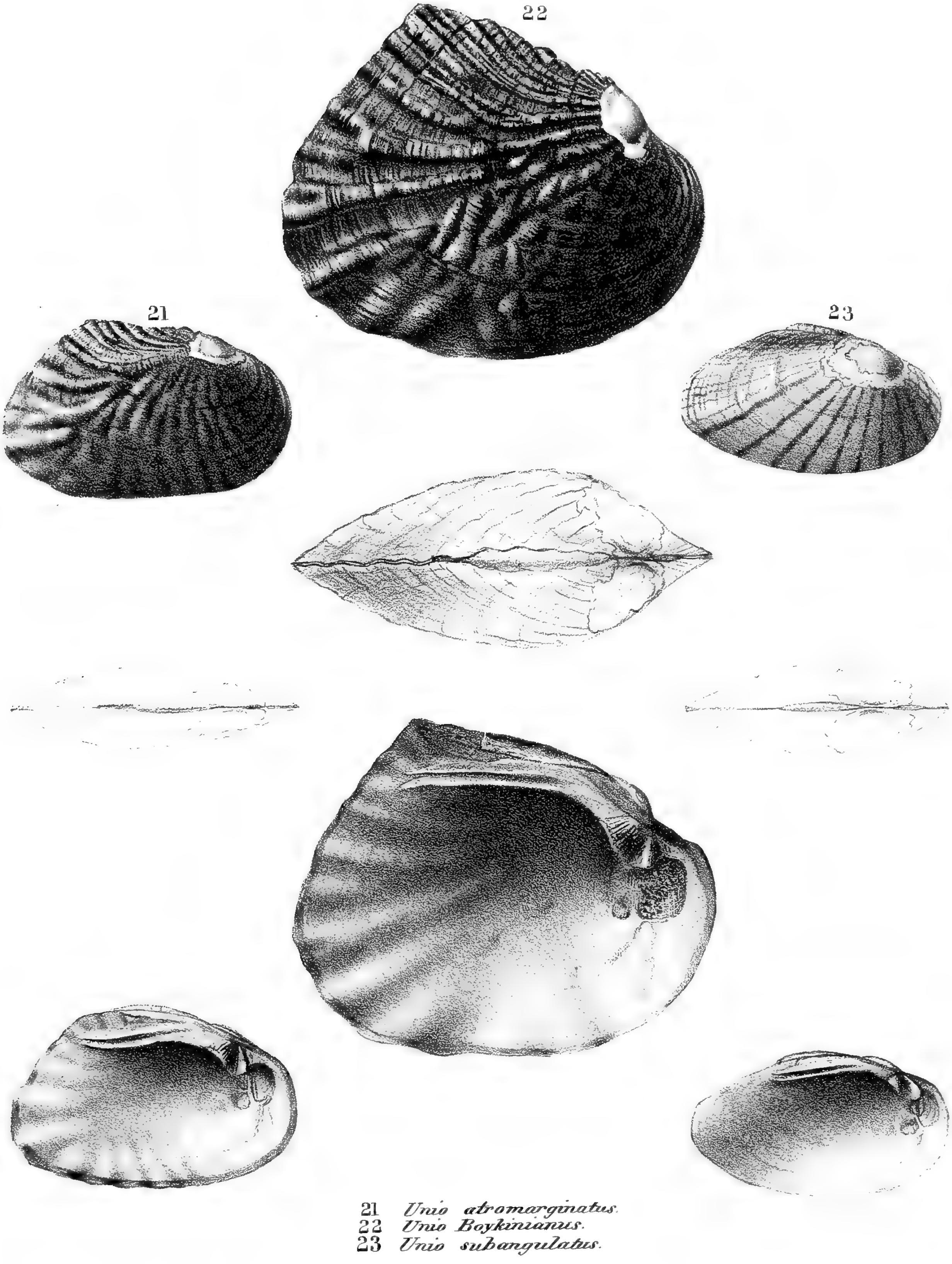
Sinclair's Lith. Phil.

Trans. Am. Phil. Soc. 2d Series Vol. 8 Pl. 12.



16 *Unio striatus.*
17 *Unio tortivus.*
18 *Unio lenior.*
19 *Unio nitens.*
20 *Unio lineatus.*

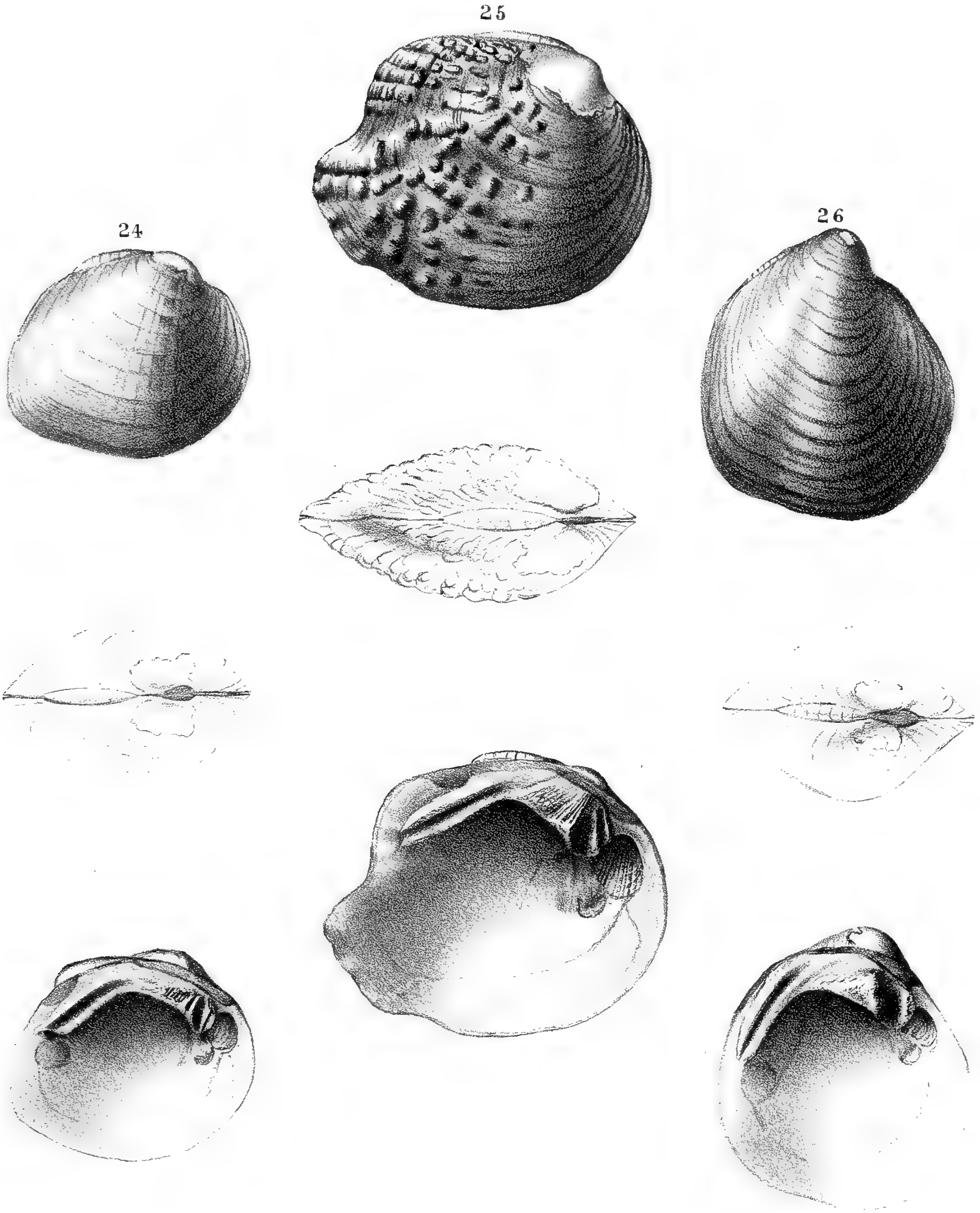
H.C.Lea del. on stone by J.T.French. Sinclair's Lith Phila.



21 *Unio atromarginatus.*
22 *Unio Boykinianus.*
23 *Unio subangulatus.*

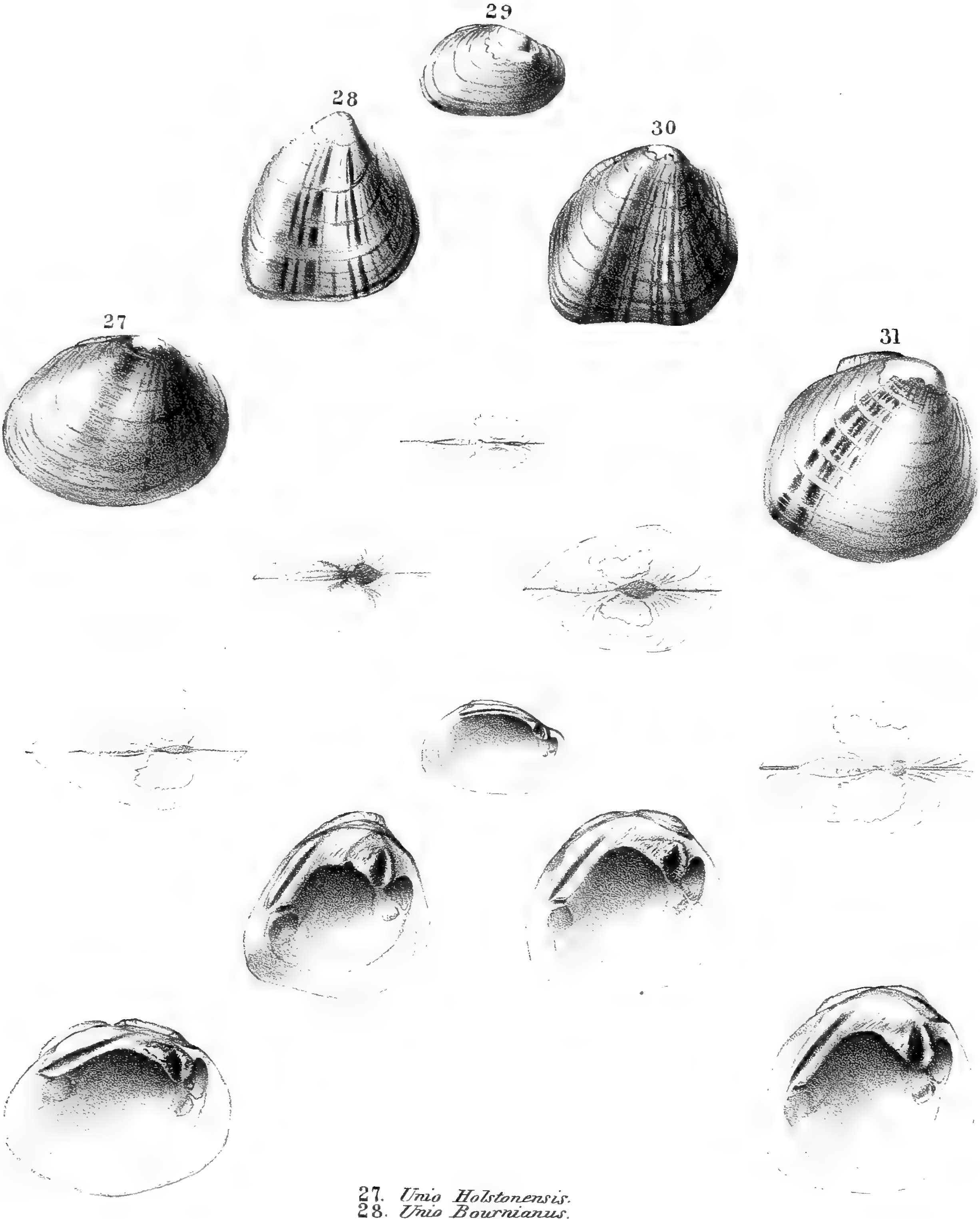
J.T.French del.

Sinclair's Lith Phila.



24. *Unio pilaris.*
25. *Unio tuberosus.*
26. *Unio plenus.*

M C. Lea del.
on stone by J.T. French.
Sinclair's Lith. Phila



27. *Unio Holstonensis.*
28. *Unio Bournianus.*
29. *Unio paulus.*
30. *Unio Edgarianus.*
31. *Unio dolabelloides.*

H. C. Lea del

on stone by J. T. French.

Sinclair's Lith. Phil^{a}

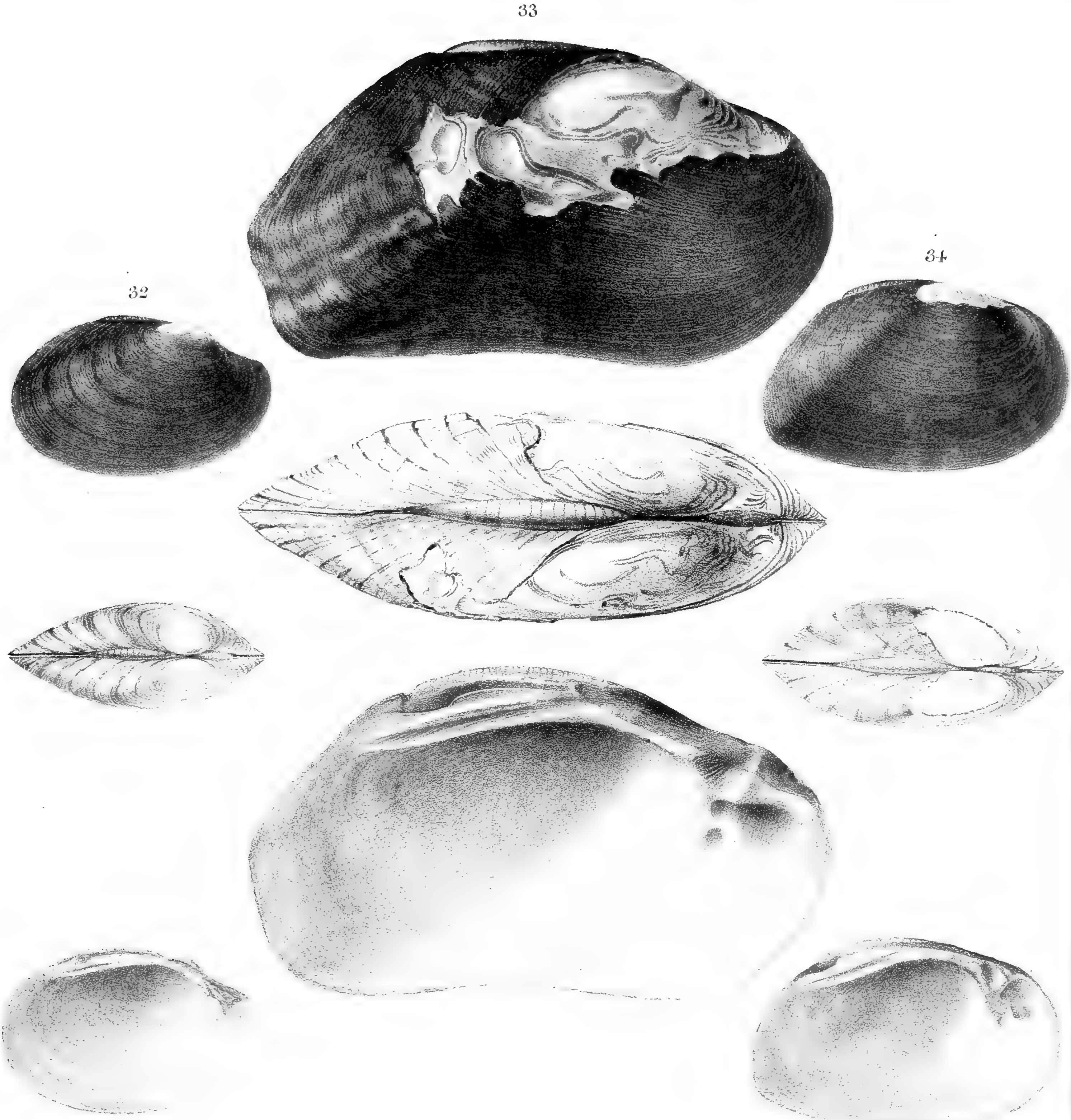
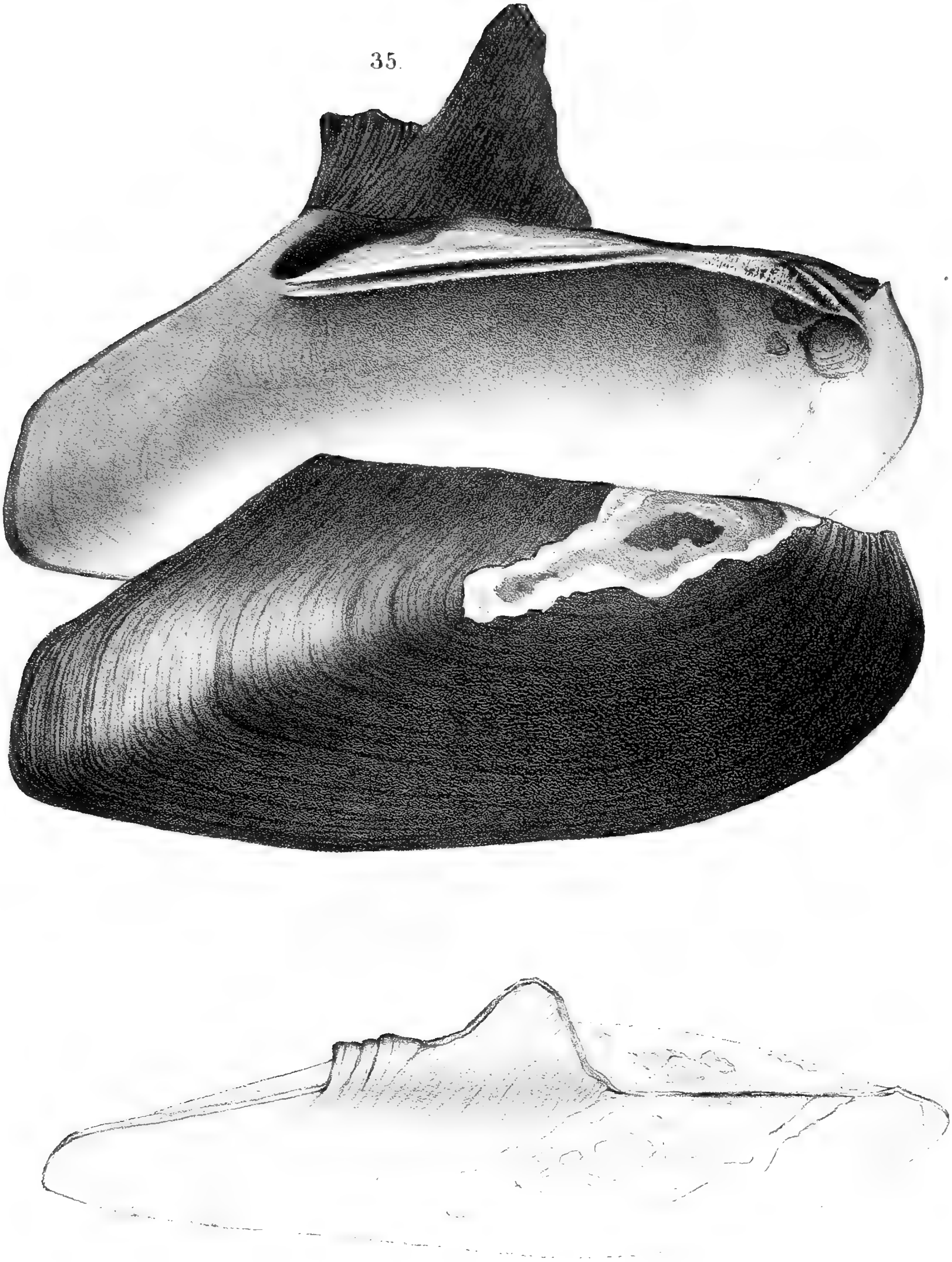


Fig. 32 *Unio Boydianus.*
" 33 " *Sloatianus.*
" 34 " *incrassatus.*

J. Queen del.

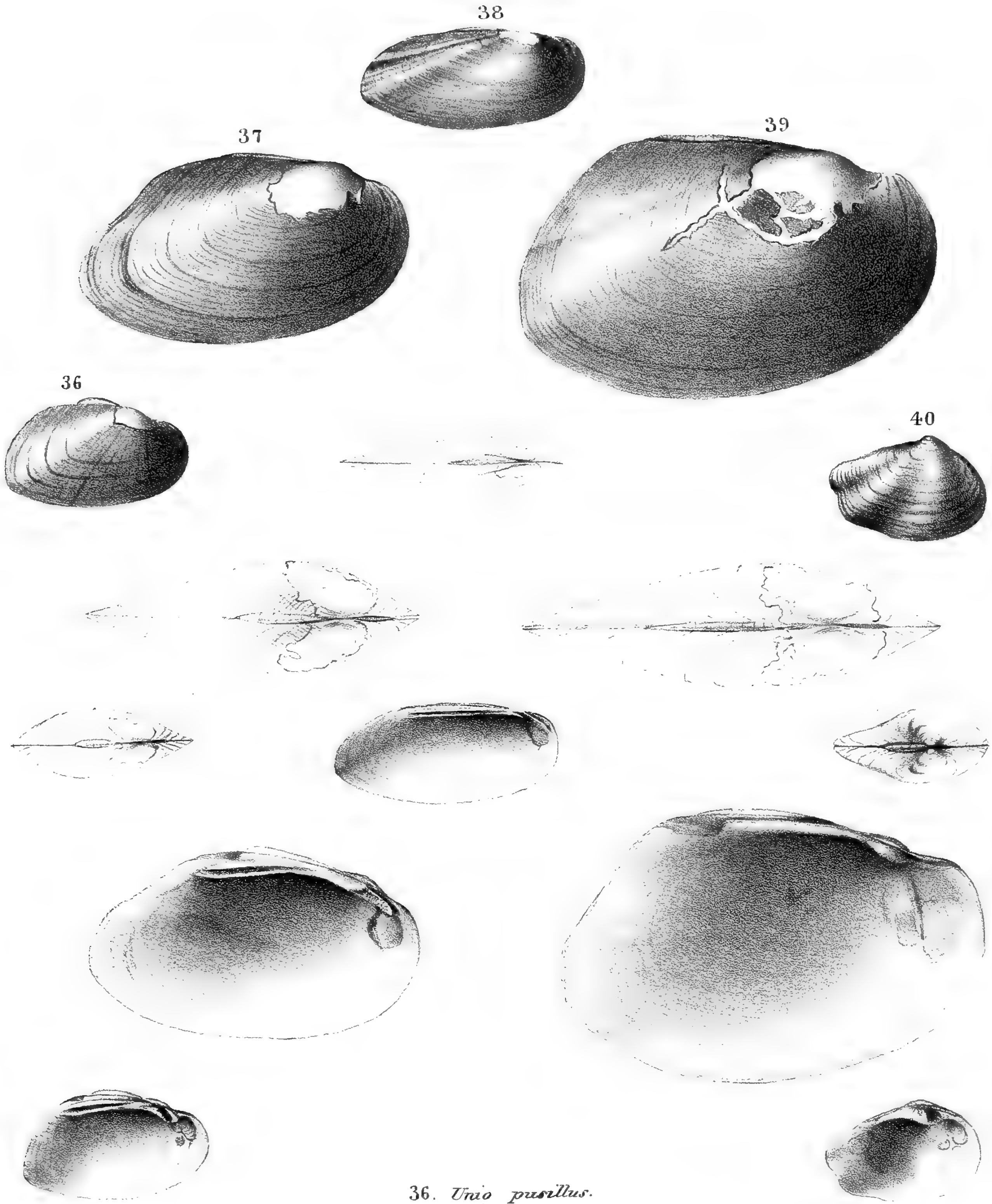
P.S. Duval, Lith. Phila

35.



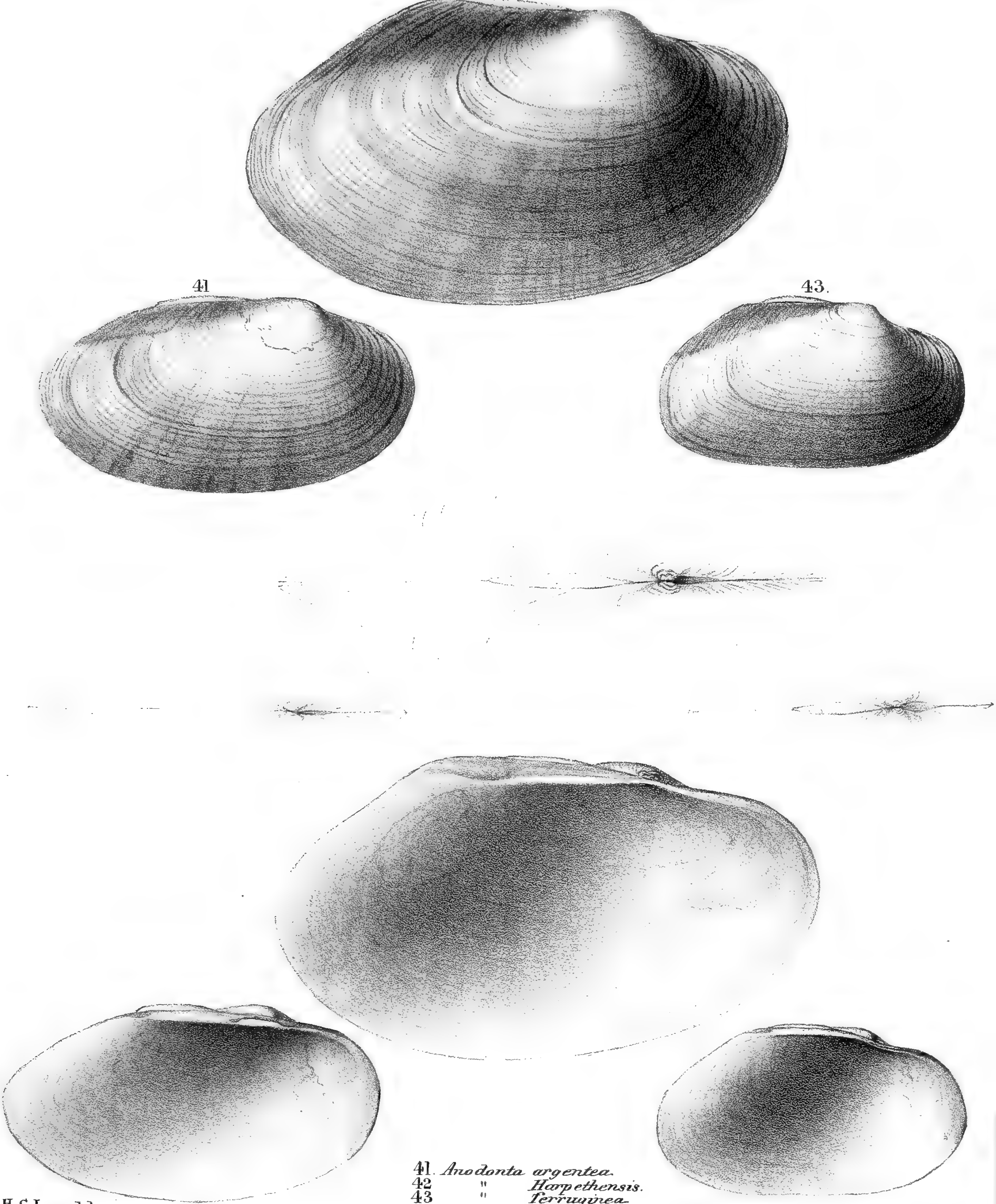
35. *Unio delphinus.*

H.C.Lea del. on stone by J.T.French. Sinclair's Lith. Phil^a



36. *Unio pusillus.*
37. *Unio Javanus.*
38. *Unio Orientalis.*
39. *Margaritana Vandenbuschiana.*
40. *Margaritana Curreyana.*

H. C. Lea del.
on stone by J. T. French.
Sinclair's Lith. Phil^a.

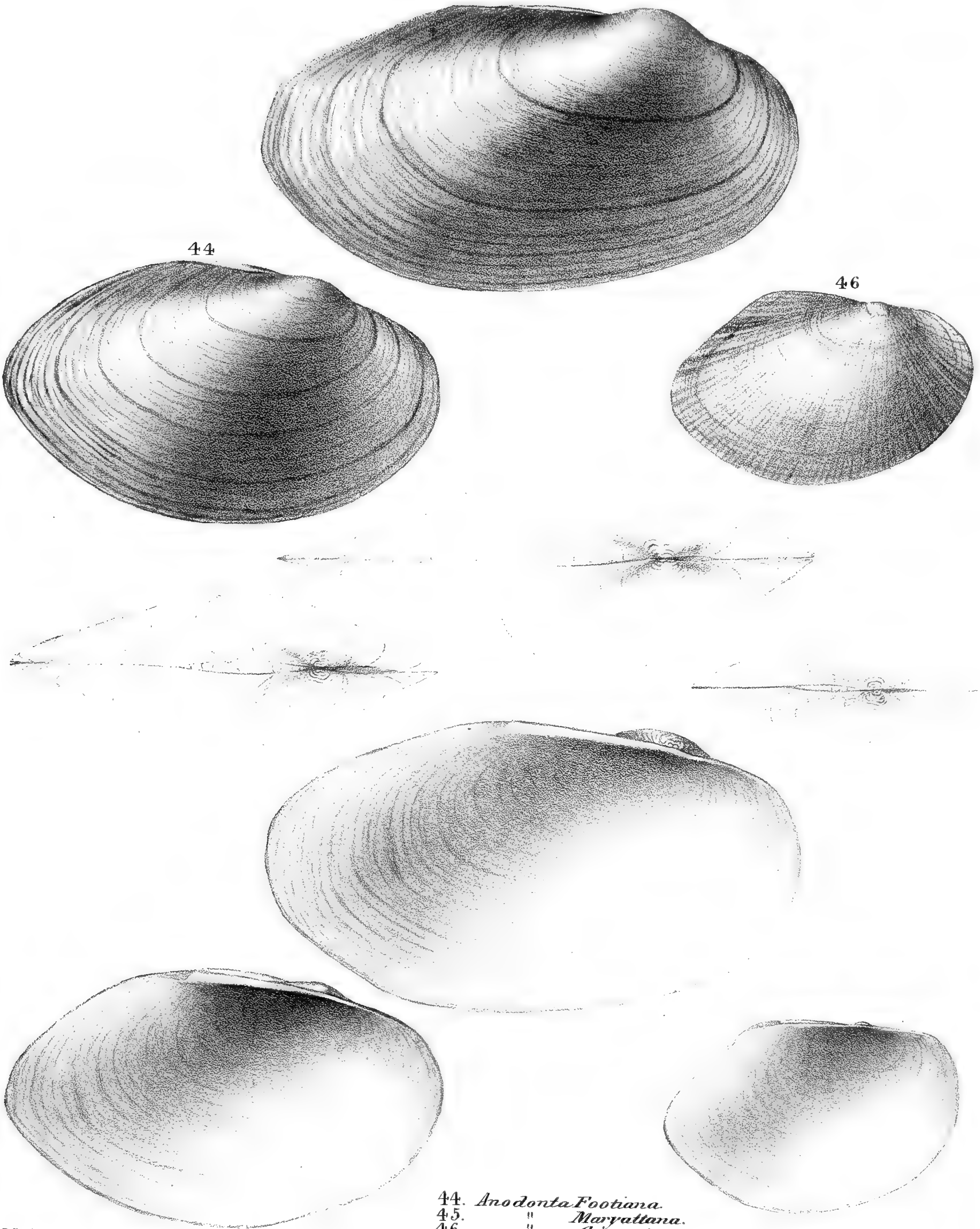


41. *Anodonta argentea.*
42 " *Harpethensis.*
43 " *ferruginea.*

H. C. Lea del.

on stone by J. T. French.

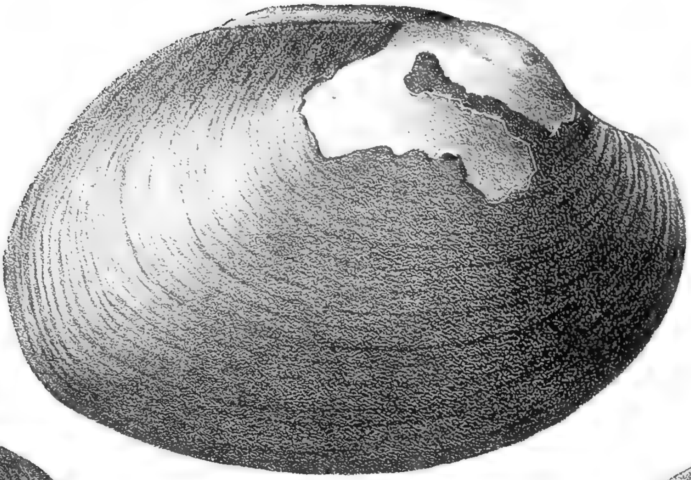
Sinclair's Lith. Phil^a



44. *Anodonta Footiana.*
45. " *Maryattana.*
46. " *Couperiana.*

M. C. Lea del
on stone by J. T. French.
Sinclair's Lith. Phila

48



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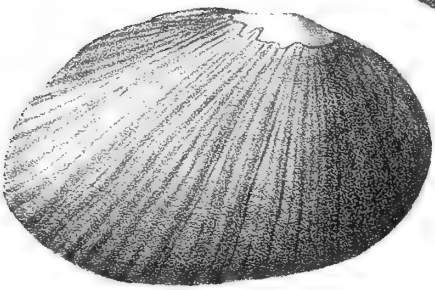

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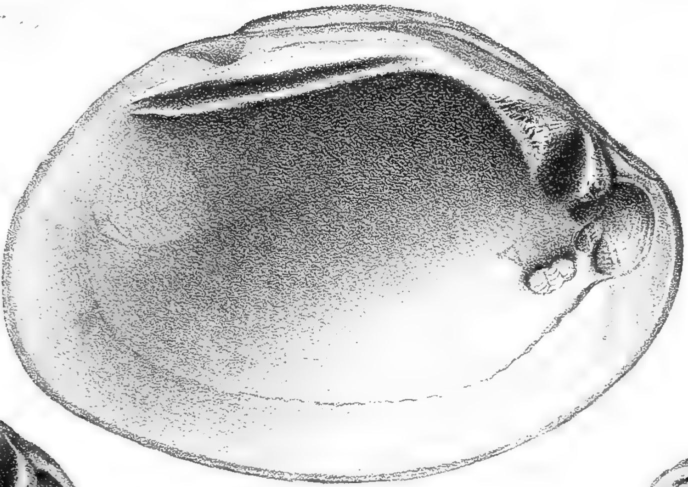
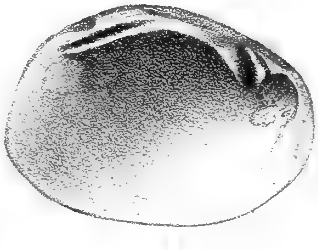
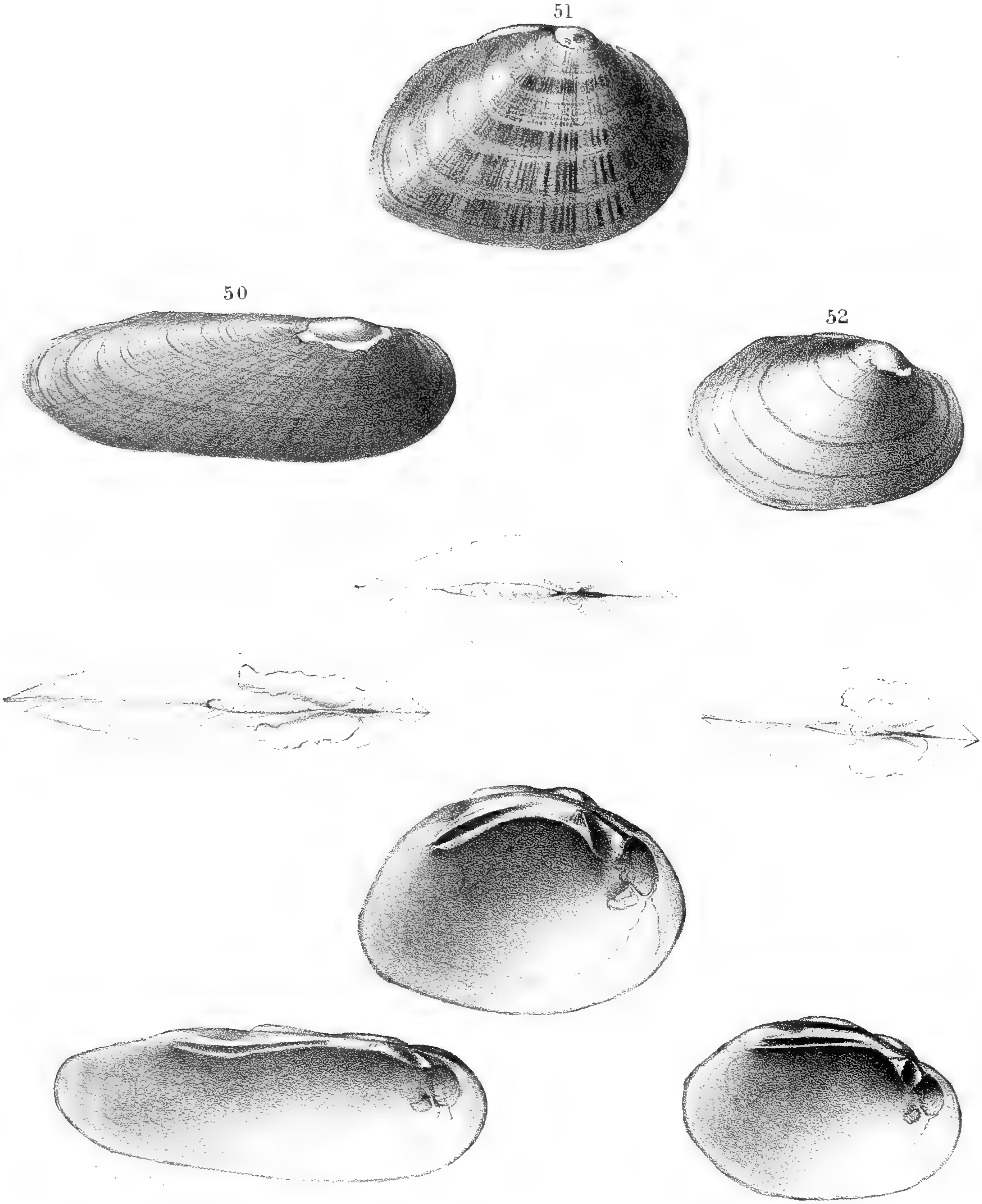




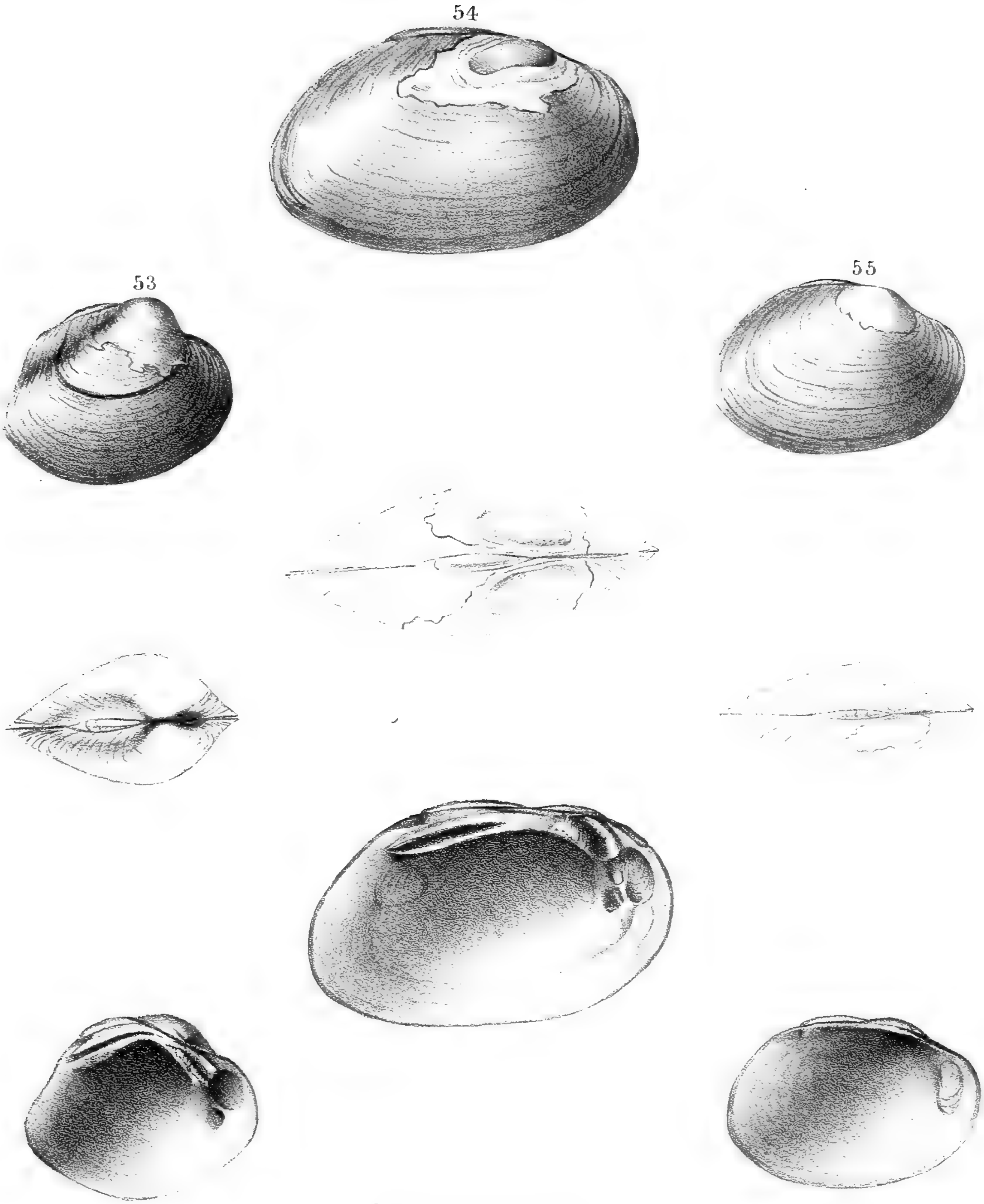
47. *Unio Sapotalensis.*
48 " *Tecomatensis.*
49 " *Georgianus.*

M. C. Lea del.
on stone by J. T. French.
Sinclair's Lith. Phila.



50. *Unio Duttonianus.*
51. " *Bigbyensis.*
52. " *crocatus.*

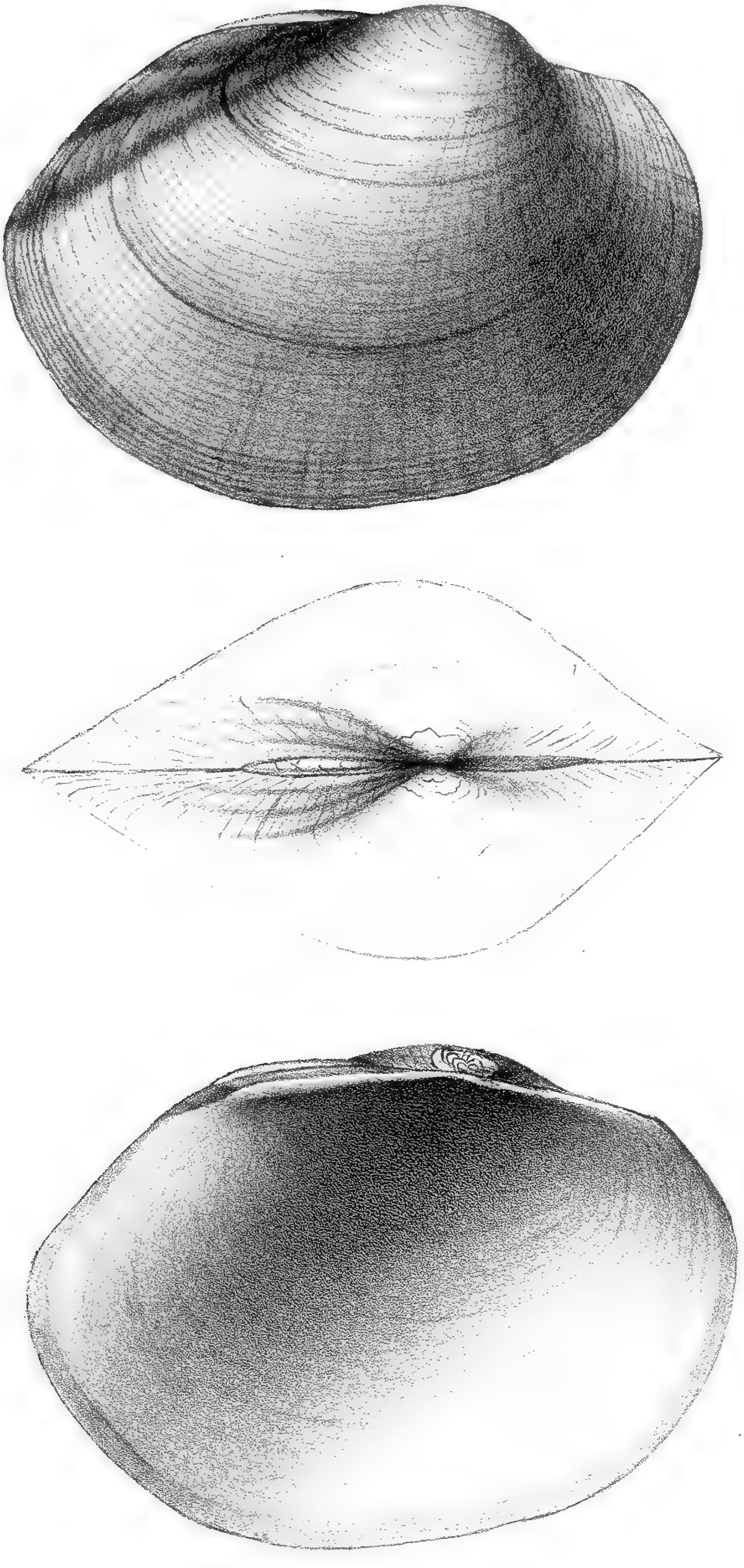
H. C. Lea. del.
on stone by J. T. French
Sinclair's Lith. Phila.



53. *Unio Rajahensis.*
54. *Unio callosus*
55. *Anodonta Montezuma.*

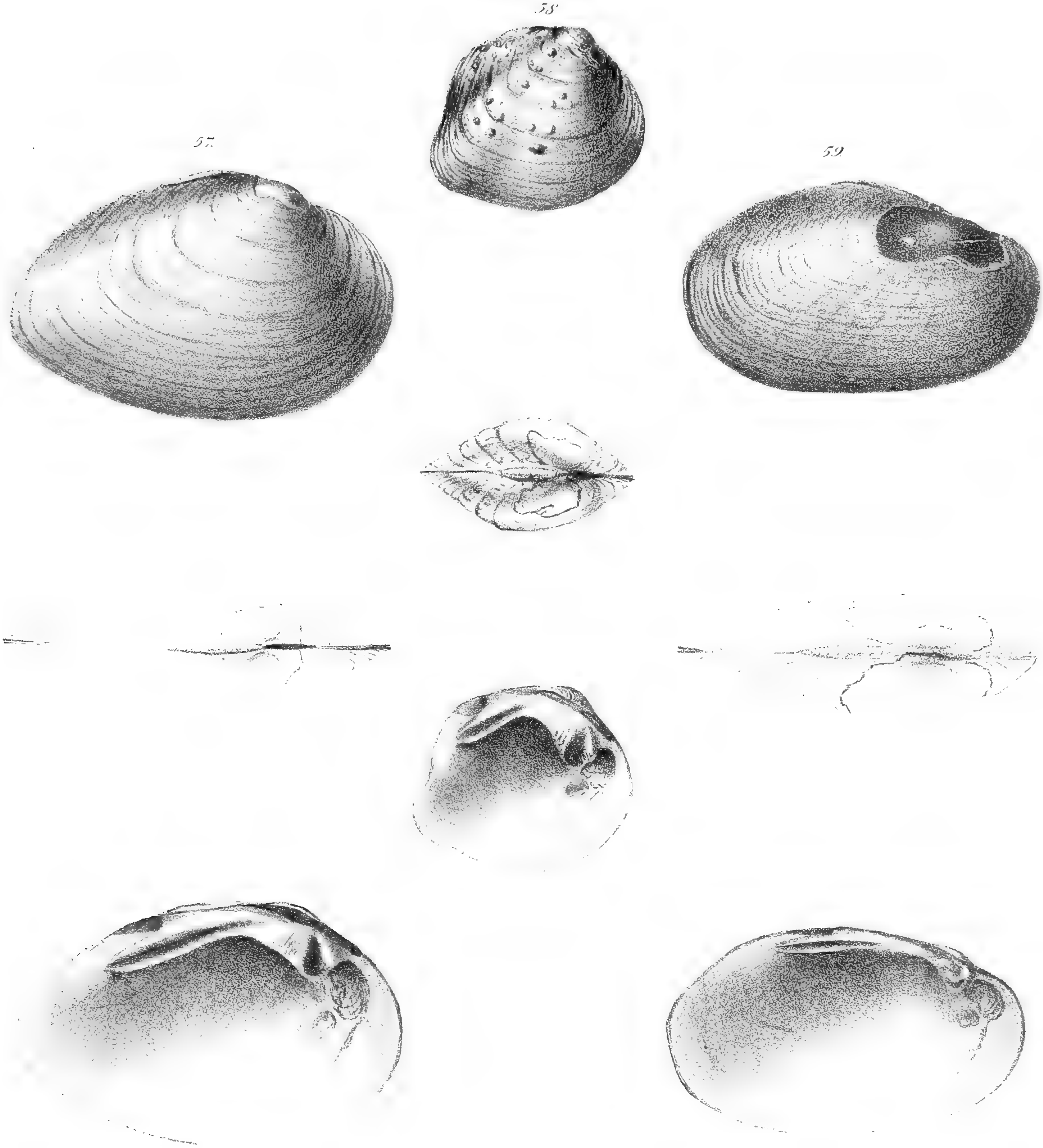
H.C.Lea del.
on stone by J.T.French.
Sinclair's Lith. Phil^a.

56



56. *Anodonta globosa.*

M.C. Lea del.
on stone by J.T. French.
Sinclair's Lith. Phila.



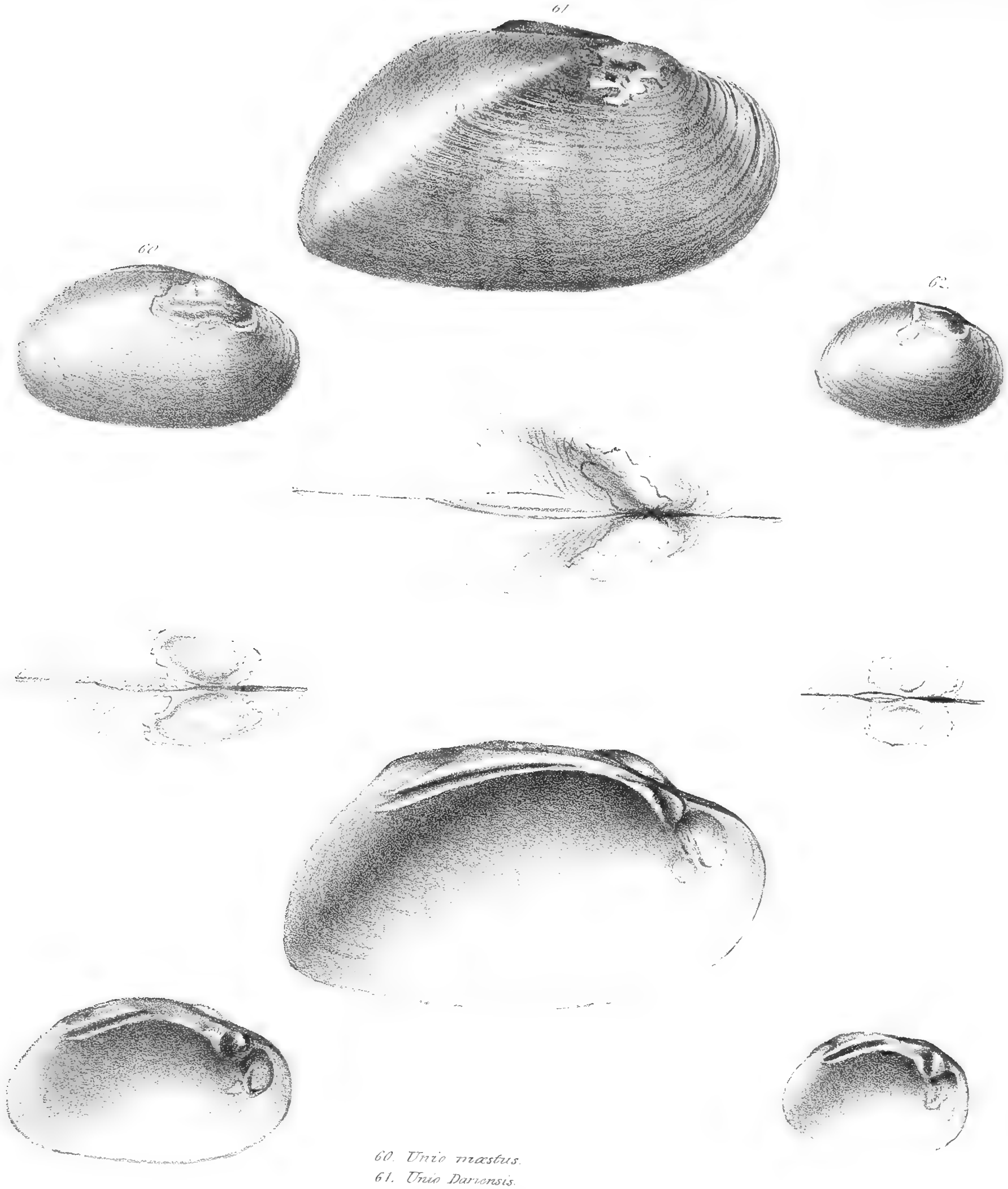
H. C. Lea. del

57. *Unio argenteus.*
58. *Unio sparsus*
59. *Unio regularis*

On stone by J. T. French

Sinclair's Lith. Phil^a

Trans. Am. Phil. Soc. 2d Series. Vol. 8. Pl. 26.

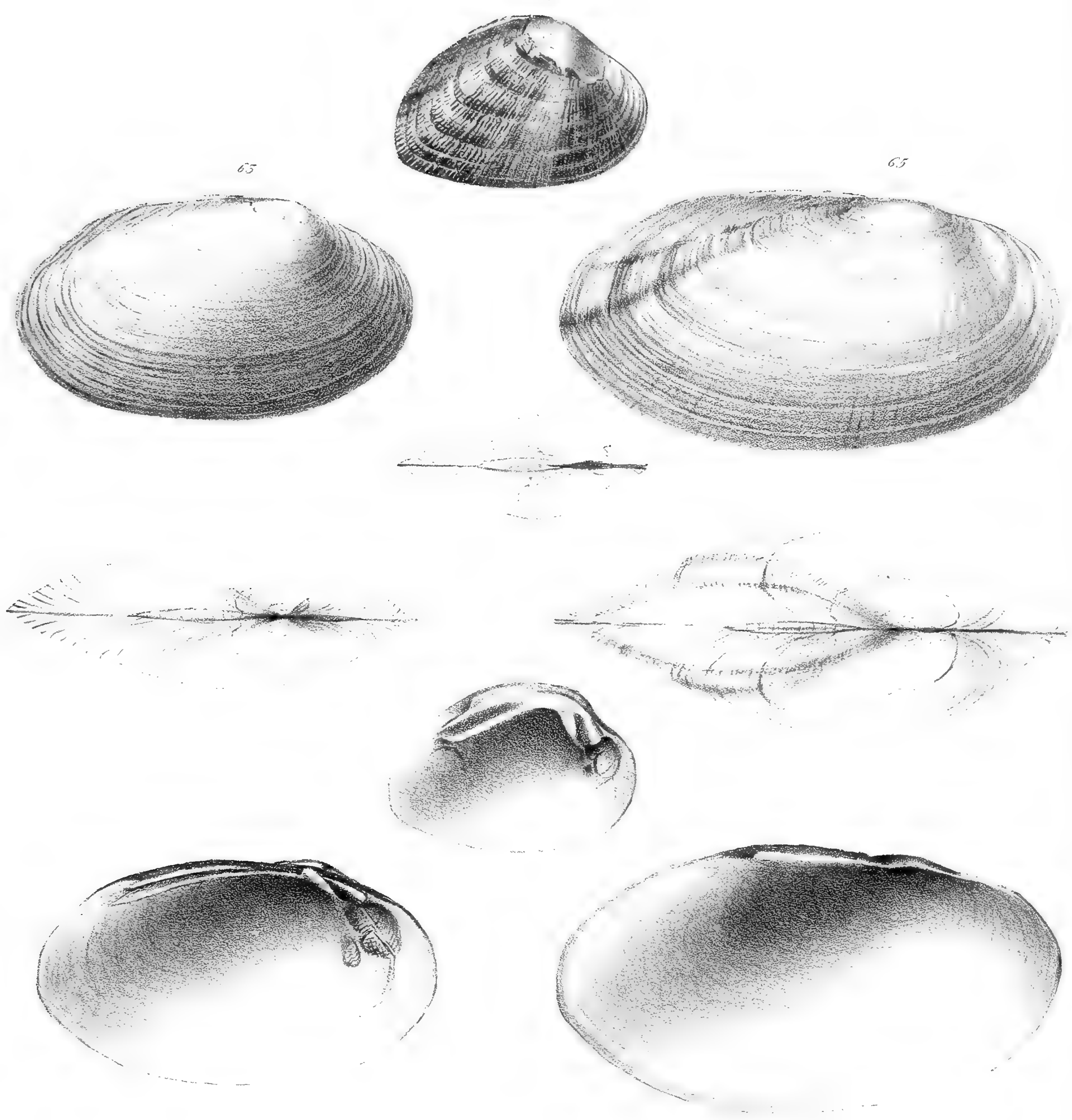


60. Unio mastus.
61. Unio Dariensis.
62. Unio Brumbyanus.

H. C. Lea. del.

On stone by J. T. French

Sinclair's Lith. Phil^a.



H. C. Lea del.

63. Unio Haleianus.
64 Unio Ebrenianus.
65. Anodonta Dunlapiana.

On stone by J. T. French

Sinclair's Lith. Philad.