

SMITHSONIAN

CONTRIBUTIONS TO KNOWLEDGE.

VOL. XXIII.



EVERY MAN IS A VALUABLE MEMBER OF SOCIETY, WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES
KNOWLEDGE FOR MEN.—SMITHSON.

CITY OF WASHINGTON:
PUBLISHED BY THE SMITHSONIAN INSTITUTION.

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ADVERTISEMENT.

THIS volume forms the twenty-third of a series, composed of original memoirs on different branches of knowledge, published at the expense, and under the direction, of the Smithsonian Institution. The publication of this series forms part of a general plan adopted for carrying into effect the benevolent intentions of JAMES SMITHSON, Esq., of England. This gentleman left his property in trust to the United States of America, to found, at Washington, an institution which should bear his own name, and have for its objects the "*increase and diffusion* of knowledge among men." This trust was accepted by the Government of the United States, and an Act of Congress was passed August 10, 1846, constituting the President and the other principal executive officers of the general government, the Chief Justice of the Supreme Court, the Mayor of Washington,¹ and such other persons as they might elect honorary members, an establishment under the name of the "SMITHSONIAN INSTITUTION FOR THE INCREASE AND DIFFUSION OF KNOWLEDGE AMONG MEN." The members and honorary members of this establishment are to hold stated and special meetings for the supervision of the affairs of the Institution, and for the advice and instruction of a Board of Regents, to whom the financial and other affairs are intrusted.

The Board of Regents consists of two members *ex officio* of the establishment, namely, the Vice-President of the United States and the Chief Justice of the Supreme Court, together with twelve other members, three of whom are appointed by the Senate from its own body, three by the House of Representatives from its members, and six persons appointed by a joint resolution of both houses. To this Board is given the power of electing a Secretary and other officers, for conducting the active operations of the Institution.

To carry into effect the purposes of the testator, the plan of organization should evidently embrace two objects: one, the increase of knowledge by the addition of new truths to the existing stock; the other, the diffusion of knowledge, thus increased, among men. No restriction is made in favor of any kind of knowledge; and, hence, each branch is entitled to, and should receive, a share of attention.

¹ This office has been abolished.

The Act of Congress, establishing the Institution, directs, as a part of the plan of organization, the formation of a Library, a Museum, and a Gallery of Art, together with provisions for physical research and popular lectures, while it leaves to the Regents the power of adopting such other parts of an organization as they may deem best suited to promote the objects of the bequest.

After much deliberation, the Regents resolved to divide the annual income into two parts—one part to be devoted to the increase and diffusion of knowledge by means of original research and publications—the other part of the income to be applied in accordance with the requirements of the Act of Congress, to the gradual formation of a Library, a Museum, and a Gallery of Art.

The following are the details of the parts of the general plan of organization provisionally adopted at the meeting of the Regents, Dec. 8, 1847.

DETAILS OF THE FIRST PART OF THE PLAN.

I. TO INCREASE KNOWLEDGE.—*It is proposed to stimulate research, by offering rewards for original memoirs on all subjects of investigation.*

1. The memoirs thus obtained, to be published in a series of volumes, in a quarto form, and entitled "Smithsonian Contributions to Knowledge."

2. No memoir, on subjects of physical science, to be accepted for publication, which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

3. Each memoir presented to the Institution, to be submitted for examination to a commission of persons of reputation for learning in the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

4. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision be made.

5. The volumes of the memoirs to be exchanged for the Transactions of literary and scientific societies, and copies to be given to all the colleges, and principal libraries, in this country. One part of the remaining copies may be offered for sale; and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

6. An abstract, or popular account, of the contents of these memoirs to be given to the public, through the annual report of the Regents to Congress.

II. TO INCREASE KNOWLEDGE.—*It is also proposed to appropriate a portion of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counsellors of the Institution.

2. Appropriations in different years to different objects; so that, in course of time, each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made:—

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, mathematical, and topographical surveys, to collect material for the formation of a Physical Atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analyses of soils and plants; collection and publication of articles of science, accumulated in the offices of Government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also explorations, and accurate surveys, of the mounds and other remains of the ancient people of our country.

I. TO DIFFUSE KNOWLEDGE.—*It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. Some of these reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators, eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch, can procure the parts relating to it, without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individuals for a moderate price.

The following are some of the subjects which may be embraced in the reports:—

I. PHYSICAL CLASS.

1. Physics, including astronomy, natural philosophy, chemistry, and meteorology.
2. Natural history, including botany, zoology, geology, &c
3. Agriculture.
4. Application of science to arts.

II. MORAL AND POLITICAL CLASS.

5. Ethnology, including particular history, comparative philology, antiquities, &c.
6. Statistics and political economy.
7. Mental and moral philosophy.
8. A survey of the political events of the world; penal reform, &c.

III. LITERATURE AND THE FINE ARTS.

9. Modern literature.
10. The fine arts, and their application to the useful arts.
11. Bibliography.
12. Obituary notices of distinguished individuals.

II. TO DIFFUSE KNOWLEDGE.—*It is proposed to publish occasionally separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises to be submitted to a commission of competent judges, previous to their publication.

DETAILS OF THE SECOND PART OF THE PLAN OF ORGANIZATION.

This part contemplates the formation of a Library, a Museum, and a Gallery of Art.

1. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies of the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

2. The Institution should make special collections, particularly of objects to verify its own publications. Also a collection of instruments of research in all branches of experimental science.

3. With reference to the collection of books, other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found elsewhere in the United States.

4. Also catalogues of memoirs, and of books in foreign libraries, and other materials, should be collected, for rendering the Institution a centre of bibliographical knowledge, whence the student may be directed to any work which he may require.

5. It is believed that the collections in natural history will increase by donation, as rapidly as the income of the Institution can make provision for their reception; and, therefore, it will seldom be necessary to purchase any article of this kind.

6. Attempts should be made to procure for the gallery of art, casts of the most celebrated articles of ancient and modern sculpture.

7. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union, and other similar societies.

8. A small appropriation should annually be made for models of antiquity, such as those of the remains of ancient temples, &c.

9. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit new objects of art; distinguished individuals should also be invited to give lectures on subjects of general interest.

In accordance with the rules adopted in the programme of organization, each memoir in this volume has been favorably reported on by a Commission appointed

for its examination. It is however impossible, in most cases, to verify the statements of an author; and, therefore, neither the Commission nor the Institution can be responsible for more than the general character of a memoir.

The following rules have been adopted for the distribution of the quarto volumes of the Smithsonian Contributions:—

1. They are to be presented to all learned societies which publish Transactions, and give copies of these, in exchange, to the Institution.

2. Also, to all foreign libraries of the first class, provided they give in exchange their catalogues or other publications, or an equivalent from their duplicate volumes.

3. To all the colleges in actual operation in this country, provided they furnish, in return, meteorological observations, catalogues of their libraries and of their students, and all other publications issued by them relative to their organization and history.

4. To all States and Territories, provided there be given, in return, copies of all documents published under their authority.

5. To all incorporated public libraries in this country, not included in any of the foregoing classes, now containing more than 10,000 volumes; and to smaller libraries, where a whole State or large district would be otherwise unsupplied.

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C. WOOD, M.D. Published December, 1880. 4to. pp. 266. Five plates.

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LUCERNARIÆ

AND THEIR ALLIES.

A MEMOIR ON THE ANATOMY AND PHYSIOLOGY

OF

HALICLYSTUS AURICULA,

AND OTHER LUCERNARIANS,

WITH A

DISCUSSION OF THEIR RELATIONS TO OTHER ACALEPHÆ; TO BEROIDS,
AND POLYPI.

BY

HENRY JAMES CLARK, B.S., A.B.

WASHINGTON:
SMITHSONIAN INSTITUTION.

1878.

ADVERTISEMENT.

THE following Memoir relates to a group of animals of a somewhat octagonal bowl-shaped form (not unlike that of a reversed umbrella), with tentacles clustered in groups at each of the angles. These animals, formerly regarded as a group of the Polyps, related to the sea-anemones, have in more recent times been associated with the Acalephs or sea-nettles and jelly-fishes, and either combined with one of the more comprehensive orders, or estimated as representatives of a peculiar and independent order. This group, which was the subject of Professor Clark's last studies, is in his judgment entitled to ordinal rank in the class of Acalephæ. The first part of the work is occupied with the "general and comparative morphology" of the Lucernariæ; and the second part is restricted to the "anatomy and physiology of *Halichystus auricula*." In the first part are three chapters; the first on "individuality," in which are considered the questions relating to "polarity and polycephalism," and "the hydroid and medusoid cephalisms." In the second, the thesis that "the type of form is not radiate" is defended, and the form is described as "the dorso-ventrally repetitive type." The third chapter is devoted to the consideration of "antero-posterior (cephalo-caudal) repetition," and under the heads of "the scyphostoma and ephyra varieties of the same morph" and "the individuality of Pelagia and Lucernariæ."

In the second part are four chapters, the third to seventh of the entire work. In the first (third of the work) are described the "general form and structure," including habitat, habits, form, and size, the proboscis, the umbrella, and the peduncle. In the second is considered the "organography, including the walls," "the muscular system," "the tentacles, the marginal adhesive bodies, or colletocystophoræ," "the caudal adherent disk," "the digitiform bodies, or digituli," "the digestive system," "the nervous system," and "the reproductive system."

In a third, are embraced the results of studies of the "embryology," or various stages of growth of the species, including observations on "the egg and the spermatozoa;" on "a young *Halichystus auricula*, nearly one-sixteenth of an inch in diameter;" on "a specimen three thirty-seconds of an inch across the umbrella;" on "a young specimen one-eighth of an inch across;" on the "special development

of a tentacle, a colletocystophore, and a genital sac;" on the "young one-fifth of an inch across;" and on the "young six twenty-fifths of an inch across."

In a fourth chapter, in an "histology of *Haliclystus auricula*," the tissues of the several parts of the body are considered—that is, "the umbellar and peduncular walls;" "histology of the tentacles;" "histology of the colletocystophores" (anchors); "histology of the caudal disk;" and "histology of the digituli" and "the prehensile cysts" (nematocysts and colletocysts).

With profound regret, we have to announce that before the completion of the engraving of the necessary plates to illustrate his work, Professor Henry James Clark was called from this life, in the flower of his age, and in the midst of a series of successful investigations.

The publication of this memoir has, consequently, been greatly delayed. The reading of the proofs and supervision of the work were kindly undertaken by Professor A. E. Verrill, of Yale College, who has, however, himself been much hindered in his work by ill-health and other causes. In editing this memoir he has not thought it desirable to make any changes, except verbal and typographical ones, which would not alter the meaning of the author. This has been carefully adhered to in all cases, even where changes would, perhaps, have been made by the author himself, had he lived, in consequence of the advance of knowledge during the several years that have elapsed since the memoir was written. Owing to the fact that the plates, with one exception, were engraved in Paris, and no proofs were submitted for correction, several errors, noticed in the explanations, were made in the lettering. These might lead to mistakes, in some cases, unless their existence be noted.

The following extracts from a Memoir of Mr. Clark, read by Professor A. S. Packard, Jr., before the National Academy of Sciences, in 1874, will be of interest to the readers of the present work:—

"Within the year past we have lost a member who may be said, without disparagement to others laboring in the same field, to have been the foremost American histologist and microscopist, and one of our most skilful and accomplished biologists; one the rule of whose scientific life was a practical application of experimental philosophy. A true naturalist, he was an enthusiast, and yet in his methods of study severe, exact, and in all respects scholarly.

Henry James Clark was born June 22, 1826, at Easton, Massachusetts. Of his early life little information has been obtained, except that he was fond of drawing, an art which proved of much service and credit to him in after years.

He received his collegiate education at the University of the City of New York, graduating in 1848.

His first love for science seems to have grown from his fondness for flowers. Immediately after leaving college he taught for some time at White Plains, New York. While there, in some of his out-of-door rambles—and he was fond of taking long walks—he found a flower which he thought was new. On returning home he ascertained that it was not described in Professor Gray's Botany. He at once began a correspondence with Professor Gray in regard to it, and eventually received an invitation from him to go to Cambridge. He went there as a student of botany, under Professor Gray, in 1850, and this may be regarded as the date of his scientific birth. While a student at the Botanic Garden, he taught in the Academy at Westfield, Massachusetts, for a single term, apparently achieving much success as a teacher, and forming life-long friendships.

Soon after this he became a student of Professor Agassiz; but his love for botany never diminished. He studied it in after years from the side of vegetable histology and morphology in connection with and as illustrating the histology and morphology of animals. The influence of his knowledge of botany on his zoological studies was marked. It prepared him for his studies on spontaneous generation, on the theory of the cell, on the structure of the Protozoa and the nature of protoplasm. In studying the lasso-cells of the Acalephs, he traced their analogical resemblance to the stinging hairs of the nettle. By his intimate knowledge of the spores of the smaller Algæ, he was able to point out some of the characters separating the lowest Protozoa from the spores of plants, and aid in the work of Thuret and others in eliminating from the animal kingdom certain vegetable spores which had been originally described as infusoria.

His first scientific paper was on a botanical subject, 'The peculiar growth of rings in the trunk of *Rhus toxicodendron*,' published in 1856, and this was supplemented by unpublished studies on the eccentricity of the pith in *Ampelopsis quinquefolia* and *Celastrus scandens*. In his walks he often botanized, and contributed in this way to Gray's botanical text-books. Thus with the training he received from Professors Gray and Agassiz, he looked upon the world of organized beings from both the botanical and zoölogical sides. He well deserves the name, *biologist*.

He graduated from the Lawrence Scientific School in 1854, taking the degree of B. S. He was for several years the private assistant of Professor Agassiz, who, early in 1857, spoke of him enthusiastically, remarking to a friend, 'Clark has become the most accurate observer in the country.' Between 1856 and 1863 he was associated with Agassiz in the preparation of the anatomical and embryological portions of the 'Contributions to the Natural History of the United States.' Here his great skill and delicacy in the use of the scalpel and pencil won much praise from naturalists. Nearly all the plates in the Contributions, illustrating the embryology and histology of the turtles and Acalephs, are signed with his name.

The drawings were not only beautifully worked up, but possessed the merit of extreme accuracy.

In the use of the microscope, Clark showed not only mechanical skill and ingenuity, but a patience, caution, and experience in difficult points in histology, which undoubtedly placed him at the head of observers in this country, and rendered him, perhaps, inferior to few in Europe. He used the highest powers with a skill that few if any living observers have surpassed. He suggested improvements, carried out by Spencer, at the instance of Professor Agassiz, in this instrument. After leaving Cambridge he studied the Infusoria and lower plants, and made drawings and notes, comprising descriptions of many new forms of Infusoria. He planned an extensive work upon this subject, portions of which are now in charge of the Boston Society of Natural History for publication. The drawings are of great delicacy and beauty, and, had he lived to complete the work, it would doubtless have been equal to if not in advance of Claparède and Lachman's famous work on the Infusoria. He did not dissociate the Protophyta from the Protozoa, regarding them as almost inseparable in nature; thus, as we have ascertained, in his lectures to his classes, well nigh anticipating Haeckel's classification of the lowest forms of the animal and vegetable kingdom into the Protista and Protozoa.

In June, 1860, he was appointed adjunct Professor of Zoölogy in the Lawrence Scientific School, which he held until the expiration of his term of office; and, in the spring and summer of 1861, gave a course of lectures on histology at the Museum of Comparative Zoölogy. In the spring of 1864 he delivered a course of twelve lectures at the Lowell Institute in Boston, which were published in the same year, under the title of 'Mind in Nature; or, the Origin of Life, and the Mode of Development of Animals.' This is, in all respects, for its usually sound and clear thinking, its breadth of view, and the amount of original work it contains, perhaps the most remarkable general zoölogical work as yet produced in this country. If the author had left us no other work, this alone would testify to years of the severest labor and independent thought. It anticipated certain points in histology, and the structure of the Protozoa and Sponges especially, which have made the succeeding labors of some European observers notable.

In December, 1866, he was appointed Professor of Botany, Zoölogy, and Geology in the Agricultural College of Pennsylvania. He resided at Centre County, Pennsylvania, the seat of the College, until April, 1869, when he was appointed to the Chair of Natural History of the University of Kentucky. He lived at Lexington, Kentucky, until February, 1872, when he was elected Professor of Veterinary Science in the Massachusetts Agricultural College.

During this period he suffered much from sickness; still he managed in intervals of college duties to produce some remarkable memoirs. In his first paper on

Actinophrys (1863), he discovered that 'all vibratile cilia originate in the amorphous intercellular substance,' and do not form direct prolongations of cells. In 1864, appeared a brief paper, in which he showed that Tubularia was not parthenogenous, having found, by the aid of Tolles' improved quarter of an inch objectives, that it produced eggs. Perhaps the most important work he has done is in his studies on the affinities of the sponges. In November, 1866, appeared, in the American Journal of Science and Arts, a brief paper, entitled 'Conclusive Proofs of the Animality of the Ciliate Sponges, and of their Affinities with the Infusoria Flagellata.' While he had in his Lowell Lectures endeavored to show that there was a unity of plan in the organization of the Protozoa, their bodies being arranged in the form of a helix, he now endeavored to show that the sponge did not depart from the protozoan type. By the discovery of a remarkable form (*Codosiga*) he was enabled in it to trace a link, in his opinion, uniting the sponges with the flagellate Infusoria, such as *Monas*, *Anthophysa*, and *Codosiga*. In the full memoir, which was published a year after, with numerous figures, under the title 'Spongiæ Ciliatæ as Infusoria Flagellata,' he attempted to establish the homology of the flagellate cells, constituting the tissues of the sponge, with the flagellate Infusoria. He demonstrated, by the use of the superior objectives made by Tolles, that these cells are like Monads, with contractile vesicles, nuclei, a collar, and flagellum; that the sponge was in fact a compound monad, and not a compound amœba, as insisted on by Carter in 1854-57, and Lieberkuhn in 1856 and 1857. This was a great step in advance of previous observers. Certainly an organism with cells so highly differentiated as those in the sponge cannot be a plant, and while, as Clark observes, Carter had 'been the first to present anything like decisive proofs of the animality of the sponges,' yet this was confirmed and demonstrated still more completely by Clark himself. In this memoir he insists upon the fact that these simple 'monas-like infusoria,' making up the compound body of the sponge, were undoubtedly endowed with a distinct mouth, afterwards, in 1871, distinctly seen; while Carter described them as engulfing food like an amœba, any part of the cell acting as a mouth. Of course it is necessary for our author to prove that *Monas* is an animal. This he does conclusively, showing it has a distinct mouth, with a 'lip,' into which food is thrown by the flagellum. The cells or zooids of the sponge (*Leucosolenia*) agree with *Monas* in all respects, except that he did not detect the mouth, though he saw currents of floating particles which 'are constantly whirled in by the flagella and made to impinge upon the area within the collar.'

The study of the sponges has since the publication of this important memoir been pursued by Oscar Schmidt, Miklucho Macleay, and Ernst Haeckel. Considerable advance has been made regarding the organization of the adult, while

the young of the sponge has been proved to be like the planula of a radiate, and made up of two layers of cells.

The last paper he published was entitled, 'The American Spongilla, a Craspedote, Flagellate Infusorian,' in which he criticizes Haeckel's views on the affinities of these animals, and insists upon their affinities to known Flagellate Infusoria. This was published in December, 1871, in the American Journal of Science and Arts.

Busy with his work at Amherst, and struggling with the fatal disease (tabes mesenterica) which was rapidly reducing his bodily strength, he wasted away, and died on the first day of July, 1873, in full possession of his mental faculties. He left a wife, seven surviving children, and many warm friends to mourn his loss.

He was a man of the warmest sympathies, a devoted and affectionate husband, a loving brother, and dutiful son; in many respects an admirable teacher, as a lecturer clear and systematic, with an enthusiasm that evinced the true naturalist. The secret of his success as an investigator may be stated in his own words taken from his diary, where he says he made it a rule to practise the 'utmost rigidity and thoroughness in his researches, without regard to time consumed or the value of the results.' He had the best of teachers, and he made the most of his opportunities. We may look upon the results of his work as elevating the standard of American scientific work.

He was a member of most of the learned societies in this country, while his works have been recognized and referred to by some of the leading zoölogists in Europe."

JOSEPH HENRY,

Secretary Smithsonian Institution.

WASHINGTON, D. C., APRIL, 1878.

PART I.

GENERAL AND COMPARATIVE MORPHOLOGY.

CHAPTER I.

INDIVIDUALITY.

§ 1. *Polarity and Polycephalism.*

1 To those readers who are acquainted with the literature of *Acalephæ* there will very naturally arise, first and foremost, the question as to our theory concerning the individuality of these polymorphic beings. This is a point upon which we feel necessitated at the outset to take a definite stand, in regard to the *Acalephæ* as a whole, and in reference to the *Lucernariæ* in particular. We have already, in a general work¹ upon the development, morphology, and classification of animals, entered our protest against that theory of individuality which assumes that the medusoid genitalia of Hydromedusæ should be considered as individuals in a higher sense than the hydræ are, no matter to how low a degree of development they descend nor at how high an elevation they arrive in the complexity and differentiation of their parts. We still adhere to that protest as far as the hydræ and medusoids are related to each other; but look upon them both in a modified light in reference to their individuality.

2 We suppose it will not be questioned that in the main, naturalists and physiologists have always defined in their own minds, and in their teachings, the zoological *individual* to be a *monocephalic* being; that they have taken as their standard the most highly developed creatures of the animal kingdom, whose *oneness* and independence place them on an equal footing with man in these respects. In the discussion, of late years, upon the individuality of the lower, compound, colonial denizens of the water, the main points at issue have always been to determine whether a certain form was, on one hand, an *individual*, either in its highest sense (a monomeric, independent integral) or one of several independent individuals which constitute a colony (a polymeric integer), or, on the other hand, was an *organ*, which formed only a part of an individual, whether the

¹ Mind in Nature, or the Origin of Life and the Mode of Development of Animals. New York, D. Appleton & Co., 1865.

latter be monomeric (as in *Hybocodon* and *Corymorpha* producing free medusæ), or polymeric (as in *Coryne* with free medusæ).

3. The possibility of a third category of individuality had not arisen in the minds of philosophic naturalists until the question of the bilaterality of the two lower grand divisions of the animal kingdom had been discussed so vigorously, and elevated to such a prominence among the theories of the day as to extend its influence even to the determination of the oneness or duality of the members of the highest of all grand divisions, and indeed the highest of all animals, man himself. Here, at this point, we find breaking in upon us the Teratological essays of St. Hilaire, and the more recent decisions of Wyman upon the same subject, with the strange confirmations of Lereboullet, by his discoveries of the fission of the piscine egg, and the evolution of two heads or two tails from one centre of development—the *dualistic* tendency of the highest vertebrate emphasized by the presentation of the living tangible reality.¹

4. Such possibilities among the Vertebrata staring us in the face could not but send the thoughts flashing back among the inferior, less determined, less differentiated organizations; and the mind's eye needed not to dwell long among the many-headed Vorticellæ, Polypi, Hydromedusæ, Bryozoa, Ascididæ, Pyrosomidæ, Salpæ, etc., before discovering a multitude of more than shadowy tendencies; it became fixed upon numerous sharply and clearly established, unmistakable dualities and pluralities; all arising from one common centre, the *ovum*. Had we not the problem of plural individuality solved here—a *polycephalism*—? the diffuse vitality of the animal-egg of the lowest ranks of life outspoken in the indetermined number and localization of the subdivisions of the Polyp or Hydromedusa corporation; and even the organization itself undecided² as to whether it should exemplify its oneness in a simple unit of form, as in the *pseudoindividuum* of Bryozoa, Ascidiadæ, or resolve its offices and configuration into the repetitive, multiplied sameness of the sexless and sexual *proles* of Salpæ, Tæniæ, Annelidæ, and Hydromedusæ, or the excessive repetitions of the genitalia of Polypi.

5. The old type of monomerism, the vertebrate individual *par excellence*, has then become the modern, more than transcendental *duality*. The originals of multitudes of figures in St. Hilaire's "Teratologie," of the memoir of Lereboullet, and of the condensed aphoristic sketches of Wyman stand forth the real, material embodiments of the idea upon which all sentient life is founded. *Bilaterality* does not express the thought, it embraces too little; it is to be classed with antero-posteriority and dorso-ventrality, to signify the *subdominant* features of the animal architecture; features which evolve themselves as the concomitant resultants of the development of the primitive dominant which originally gave shape to the *bipolar ovum*. The embryologist, and to his thoughts the subject is most germane, reflecting upon the physical aspect of the forming egg, would naturally arrange its features in two antagonistic fields; and thereupon attempting to define their position in regard to the contour of the concrete sphere, almost inevitably would

¹ See remarks of the author on this subject in "Mind in Nature," ut sup., p. 1.

² See paragraphs 22 and 23.

give utterance to the word *polarity*. This is the dominant, main idea of sentient life.

6. It is *polarity* which is evinced when the self-dispersing, self-repellant potentiality of the animal-egg lays down the right and left of the germ on opposing sides of a line; when the cephalic and caudal areas grow in opposite directions from a common point of emanation; or when the animal and vegetative foundations project themselves into diametrically diverse, dorsal and ventral spaces. Each and all of these phenomena have a common point to rest upon; and they proclaim, by their mode of operation, the controlling influence of a power which, fixing itself upon that point, as it were, radiates itself through the whole organism, and disposes its several features in such a way that they all display, either in mode of evolution or by a direct connection, a polar tendency; a growing out of one pole and a dispersion toward the opposite one; features most developed and decided in configuration next the point of departure, and least developed and most diffuse and indeterminate in the opposite area; the latter always through life standing in the same relation to the former as supply does to demand, as nutrition does to the power which regulates the absorption of the nutriment.

7. But *bilaterality* carries with it something more than the mere dextral and sinistral opposition of the lateral halves of the body; it is not merely the bipartition of a *unit* of form; for the distal as well as the proximal edges of these halves—the free borders and the margins of contact—are mutually interchangeable; the former may take the place of the latter, and yet leave the apparent bipartite unit undisturbed in internal relations.

8. *Antero-posteriority* exhibits the same interchangeability as bilaterality, but, although plainly enough, not so conspicuously in a comparative, homological sense as in the physiological interplay of the functions, such as we see in the relations of the allantois to respiration in the embryo, or in the ratio of excretion of the renal organs dependent upon the degree of activity of the respiratory and perspiratory functions; or in the relation of the reproductive organs to the vocal and respiratory, when the former are in an abnormal condition, or when they change from one period of life to another, from youth to adolescence; and in many other interdependent relations familiar to the morphologist of the present day.

9. Bilaterality, antero-posteriority, and dorso-ventrality, the three principal *sub-dominants of polarity*, have a very methodical disposition, and are quite pronounced and sharply defined among the higher groups of animals—the more seemingly *units* of organization—but if we go to the opposite extreme of grade we shall find among the lower classes of life, that the polaric element (like the differentiation of organization, and that of function) is in an almost elementary condition, expressing itself vaguely in the scattered heads of a branch of *Coryne*, or *Tubularia*, or *Clavellina*; or a little more determinately in the distichous arrangement of the hydra heads of *Dynamena* and *Sertularia*, or in the singularly stellate disposition of the zooids of *Botryllus*, with their common cloacal orifice.

10. When, however, polymerism, in its usually accepted sense, fails, as it does step by step in the gradually rising degrees of rank, polarity gains the ascendancy in point of regularity and the closer intimacy and symmetrical arrangement of the

components of the organization which it holds sway over. Thus it is that two, or more, scattered, consimilar parts, or complete organizations may combine to form a seeming *one*, an apparent, bipartite or multipartite *unit*. The multiple repetition of heads among the lower polymeric kinds is here reduced to a dual repetition, and the parts condensed into one form an approximative unit, a zoological *individuum*, as the highest expression of unity attainable by the vertebrate *zoön*.

11. The duality, nay the plurality of the subdivision of the vertebrate axis, as illustrated by the embryo fishes of Lereboullet, is recalled in the diffusiveness of the many hydræ of the dendritic Campanulariæ, and is disguised under the interminable heteromorphism of the Siphonophoræ; it is polymeric but dimorphous in Salpa, or polymeric but monomorphous in the fresh-water Polyzoa; temporarily a polymeric, monomorphic *individuum* in the fissigemminating Hydra, it eventually resolves itself into disconnected *pseudo-individa*; for a time polymeric, but dimorphic, in the annelidan Myrianida of Milne-Edwards, it finally assumes the appearance of a true, self-contained *individuum* in each one of the separate, independently moving *sexual segments*, and in the original budding-stock (the direct legitimate offspring of the egg) from which they shot forth.

§ 2. *The hydroid and medusoid Cephalisms.*

12. Under the term *cephalism* we include two forms, or *morphs*, viz., (1) the *cephalid*, or such subdivisions of a body as have a complete organization, whether united in common (as in Spongida¹, some Vorticellidæ, Corals, Bryozoa, some Ascididæ, and Pyrosomidæ), or separating singly from the main stock (as in Hydra and Actiniæ); and (2) the *cephaloid*, or those divisions of a fissigemminating body which do not contain a complete organization, and may be either mostly *sexual* (as the so-called medusæ of Hydromedusæ, or the posterior divisions of Myrianida and other worms, or the joints of Tænia, or the Cercaria-brood of Distoma, or the chain of Salpa), or mostly vegetative and *sexless* (as the hydræ of Hydromedusæ, the Myrianida stock, the head of Tænia, the single, budding stock of Salpa, or the budding Cercaria-nurses of Distoma).

13. The thorough historian of the multifarious, so-called alternate generations of the Acalephæ will see nothing but a generative organ in the spermatie and ovarian sacs of Hydra; and detect nothing more in the grape-like clusters about the base of the head of Clava, or in the grouped moniliform projections behind the corona of tentacles of Eudendrium. The polymerism of these organs of Eudendrium is nothing more than a repetition of the simple sac of Clava; the diversity in form is only apparent. But one step higher in complexity and the observer will find in the tentaculiferous terminations of the reproductive sacs of Thamnocnidia and Parypha a premonition of a forthcoming *cephalic* independence, such as is already fully exemplified in the many hydras of the polymeric, dendritic mass. A similar progression toward cephalic freedom will

¹ See the author's memoir on "Spongiæ Ciliatæ as Infusoria Flagellata;" Memoirs Boston Soc. Nat. Hist., Vol. I. 1867.

also be seen in the simplest generative sacs of *Laomedea amphora*, *L. flexuosa*, etc., and, in other forms, rising through successive degrees of complexity to those of *Gonothyrea* (*Laomedea*) *Lovenii* *All.*, which are not only tipped with tentacular processes, as in *Parypha* and *Thamnoenidia*, but have within them a series of longitudinal tubes, like those in the homologous organ of *Tubularia indivisa*.

14. Gradually and methodically the progressive steps of complication lead on, with a more and more marked separation of the genitalia from a direct relation to the general mass, or even to the hydræ in particular, whilst a consentaneous development gathers around them and brings them into immediate alliance with an envelope whose *morph* is only a slightly varied repetition of that of the hydra, but whose greater degree of complexity gives it a better claim to be ranked as the highest among the *cephalic subdivisions* of the body. But the full aim of the train of development is not divulged here; its results only exemplify a part of it in the predominance of the reproductive function and a differentiation of the nutritive cavity into distinct channels of circulation, and the subordination of a definite region of its periphery to a tentacular, prehensile office. Step by step, however, all the elements of a complete organism are successively absorbed out of the primitive hydra-mass, and remodelled into the fashion of a medusoid; the reproductive character has become a less obtrusive feature; motion attracts attention above all others; prehension has full sway in the highly developed tentacles; and the latter point, like fingers, to the self-sustaining power of the aculephan *morph* in the complete organization of the longitudinal and circular chymiferous channels, opening into the receptive cavity of a highly flexible, probosciform *manubrium*. The preliminary processes of fission are complete; the primary genesis of the *ovum*, in its integrity, is finished; the primitive stock has become differentiated into two widely diverse varieties of one *morph*, the *hydroid cephaloid* and the *medusoid cephaloid*. Such is the condition at which the hydromedusaria of *Corymorpha*, *Hybocodon*, *Ectopleura* (*Tubularia*) *Dumortierii*, *Pennaria*, *Coryne mirabilis*, *Margelis*, *Bougainvillia*, and many *Campanulariæ* have arrived previous to the disintegration of their mass into the free *pseudo-individual medusoids*, and their less independent contemporary homologues, the persistent *hydroid cephalisms*.

15. The budding of the *medusoid* of *Podocoryne*, *Lizzia*, *Hybocodon*, and others shows that the polyccephalic individual retains not only its homological identity, but also its tendency to subdivide, in both of the parts which are separated from each other. In *Clava* we have a *hydra cephaloid* budding both medusoid cephaloids and hydra cephaloids, and the two are persistent and form a *dimorphous* body: whereas in *Hybocodon* there is a *hydra cephaloid* budding only medusoid cephaloids; but these latter bud other medusoid *morphs*, just as the hydra of *Clava* buds hydroid *morphs*. We would remark here, in passing, that it cannot be said justly, that a *medusoid* differs from a *hydroid* essentially, because the first has reproductive organs and is the parent (direct) of the eggs; for the simple globular sacs of *Clava*, *Hydractinia* and others are just as much the genital organs of the hydroid form, as the pendent sacs along the chymiferous tubes of the medusoid of *Tiaropsis*, *Eucope*, *Melicertum*, etc., are the genitals of the latter. Since, now, *Lizzia* was found by Claparède to have no intermediate hydra-state, the whole

morph, direct from the egg, is a medusoid cephaloid; the hydra-morph is left undeveloped to the lowest degree, in fact totally fails to appear, while the medusoid differentiates to the highest degree. This is just the reverse of what we observe in Clava, Hydraetina, Hydra, etc. Between these two extremes are found all possible intermediate grades in the reciprocally proportionate development of the hydroid to the medusoid; and singularly enough they are exhibited in Siphonophoræ in an almost infinite variety of morphs, so undecided in form as to leave it sometimes absolutely indeterminable whether a certain morph shall be called a hydroid or a medusoid.

15a. No one holding the present prevailing views in regard to individuality would find a difficulty in seeing that the members of a chain of Salpæ are so-called *individuals*, notwithstanding they are attached obliquely end to end, and *organically* connected. Now, although in the self-dividing worm, Myrianida for example, the so-called *asexual* stock may become, by actual separation, two individuals, apparently, viz., *sexless* and *sexual*, yet once they were more closely connected organically than the Salpæ which do not separate. Is now the closer connection of the yet unseparated asexual and sexual parts of the worm to make them less distinct individuals than those of the Salpa? It would seem so, according to the advocates of individualism; and therefore the Myrianida, with its posterior string of six or seven consecutive sexual *buds*, is a *monocephalic* individual. But in the sexless Salpa-form, budding the sexual chain, we have a closer parallelism with the worm than in the chain alone, in fact an identity of relation; and yet, for all that, we would not think of calling the stock (sexless) and the chain (sexual) together one individual, with *one* head, but rather *many* headed, or in other words a *polymeric unit or individual*, of sexual and sexless *cephalisms*. Therefore, by a parity of reasoning, we ought to denominate the Myrianida and its buds as a succession or series of *cephalisms*. The fact that the worm components are more in one line than in the Salpa only makes an *apparently* more individualistic body. Among tapeworms the several heads (*cephaloids*) of the *scolex* (Cœnurus) of Tænia Cœnurus are not arranged in a line, end to end, but all are free anteriorly, and connected with each other posteriorly by a common body. The closer connection of the subdivisions of the annelid is only one of degree; and as to having more organs in common than the Salpa, it is rather like the community of interest which the coral cephalisms have in the main trunk.

15b. Since the sexual and sexless are necessary to make up a complete organism, *i. e.*, vegetative and reproductive, the one a complement of the other, neither *alone* can represent the *individual* unit, or whole cycle of life: and CEPHALISM is, therefore, a better term to indicate the potentiality of these subdivisions to live apart (although this does not always occur, as in corals, Bryozoa, some Campanulariæ and Tubulariæ), but when living apart (as in other Tubulariæ [T. Dumortierii], Laomedæ [Eucope diaphana, etc.], and Salpæ, Myrianida, etc.), meaning more or less *incomplete* individuals (pseudo-individuals) which are either mainly vegetative or mainly reproductive, as the case may be. We look upon cephalism, then, on one hand as having a controlling influence of a low degree of independence when shared in common by the multiple heads of a coral polypidom,

and, on the other hand, as attaining to the highest independence as a controlling power, when the multiple parts of a so-called compound individual separate from each other, and are singly under the influence of this power. The latter obtains when a Hydra or Actinia separates its buds from itself; or when the sexual part of the annelid worm subdivides from the asexual one. Cephalism of a low degree is more readily recognized in the aggregated cephaloids of Salpa than in the undivided worm; but, unlike the latter, the former remain connected cephaloids (in the chain) when separated from the budding stock.

15c. By thus dividing the body of a Hydromedusa into two parts, which shall contain, severally, the vegetative dominant (*i. e.*, *vegetative cephaloid*) and the sexual dominant (*i. e.*, *sexual cephaloid*), we avoid the absurdity of assigning individuality to the *egg-sac* of Hydra and others of its allies which have evidently a mere genital organ. Although we might be inclined to admit that some *cephalisms* may gradually become complete individuals, as when the buds of Actinia or Hydra separate from the parent body; on the other hand, we must insist that an *individual* cannot retain the same significance when reduced to a mere *genital organ*, as when, in Coryne, a free medusoid (Sarsia) later in the season becomes an egg-sac; or when the free medusa of Tubularia (Ectopleura) Dumortierii is represented in Tubularia (Thamnocnidia) spectabilis and Parypha crocea by a plain sac; or where, as in Siphonophoræ, a subdivision may be either a sexual medusoid, or a sexless swimming-bell, or a mere "scale."

15d. Farther than this we need not go in order to illustrate our views in regard to the relations of the so-called polymorphic individuals. Why we would rather look upon them either as so many diverse forms of cephalic extremities—whether hydroid or medusoid, or doubtfully one or the other, as may happen among the Siphonophoræ—or purely as organs under various disguises, may be found set forth, *in extenso*, in the chapter on the individuality of Hydromedusæ and upon the comparative individuality of Acalephæ.

CHAPTER II.

THE TYPE OF FORM IS NOT RADIATE.

§ 3. *The dorso-ventrally repetitive type.*

16. YET one word more is needed to secure to the reader a full understanding of the point of view from which we are about to consider our subject. The commonly received theory, that the so-called *Radiata* are founded upon the idea of radiation, was combated by the author some five years ago,¹ and the reasons for

¹ Mind in Nature, ut sup., p. 128.

offering a new view of the typical relations of the organism were then given in a brief sketch; too brief in fact to suffice for our present purposes. In this place, however, we shall only state our position in regard to the matter, and refer to those chapters (Part XV) which are especially set apart for the discussion of the question.

17. We assume that, as in all the other four grand divisions of animals, the mouth is at the cephalic or anterior extremity of the body, and that all the rest of the organism is virtually, if not really, topographically behind it, and that whatever extends from the oral end of the body *does not radiate* from that end in two three, four, or five, or more directions, but trends posteriorly in so many lines parallel-wise to a longitudinal axis, and to a vertical sectant plane which divides the body into a bilateral figure. To give the idea a reality, we have but to point to the mouth of an Actinia as the cephalic end of our bilateral figure, and looking inwardly we shall see the flat stomach forming the sectant plane, which, extended in imagination, in two opposite directions, would strike the periphery of the body along two dorsal and ventral lines one hundred and eighty degrees from each other, and then, projected still further away from the mouth, would terminate finally in the posterior, adherent, discoid end. Parallel-wise with this plane all of the partitions of the digestive cavity trend, like a series of superposed shelves or galleries, in direct lines from the region lying right and left of the mouth, and of the flattened parallel sides of the stomach, backward along the inner face of the cylindrical periphery, so as to subdivide the included space into as many longitudinal corridors. It is these partitions which, by their multiplied sameness, constitute, among others, the elements that embody the *dorso-ventrally repetitive type*; the true ideal, as we fully believe, upon which this grand division is founded.

18. We think we shall be understood now, when we say that the multitudinous chymiferous canals of the disciform *Æquorea* and the quadruple channels of the cylindrical bell of *Sarsia* are two widely separated extremes of dorso-ventrally repetitive sameness; or that the numerous ambulacra of *Solaster* and the five of *Asterius* represent two extremes of dorso-ventral repetition, thrown forward, "into rank," to the same line with the mouth; whilst the retreating rows of *Echinus*, and the more differentiated ones of *Spatangus* and *Schizaster*, and the like, present the idea in a less disguised form, to be finally exemplified, in its fullest expression and clearness, in the elongated, vermiform *Holothuricæ*.

19. The reader, probably, will not fail to comprehend us then when we state that the proboscis of a Lucernarian lies at the anterior end of the body; that the region of the main cavity, the umbelliform part of this creature, is a great deal wider than it is long, *i. e.*, it is extremely foreshortened (no more difficult to conceive, we take it, than that the short, globose body of an Octopus or a Cirrhoten this is a foreshortening of the same typical elements that exist in the extremely elongated, slender body of a Loliopsis); and that the so-called *peduncle* forms a thick, cylindrical, caudal termination at that end of the longitudinal axis which lies most distant from the one where the mouth opens. Finally, we will add, that the lateral halves of the body lie right and left of a plane which passes through

two diagonally opposite, dorsal and ventral corners of the four-sided proboscis, so that two other corners and two pair of reproductive organs, as well as two partitions, stand respectively on the right and on the left.¹

CHAPTER III.

ANTERO-POSTERIOR (CEPHALO-CAUDAL) REPETITION.

§ 4. *The Scyphostoma and Ephyra, varieties of the same morph.*

20. IT would seem to be incumbent on us now to proceed at once to define more precisely the morphological and individualistic character of the Lucernariæ; but before we do that it seems desirable, in fact necessary, to prepare the way more clearly by a specific statement of our views in regard to the organization of the *strobiloid* Acalephæ, and particularly in reference to their morphology. If all the members of this order originated and developed in the same way as a certain Pelagia was observed to do by Krohn,² there would be neither such a thing as a strobiloid Acaleph, nor any dispute as to the strict individuality of the medusiform Acaleph; but reproduction by that method is not the only one, in fact it is an extreme between which and the more commonly known process there are no graduated means, such as exist so notably among the Hydromedusæ. In this Pelagia the scyphostoma and the ephyra are merged into one; or perhaps rather—and we only suggest the thought—the whole scyphostoma is developed from an early period directly into the ephyra, instead of first taking on a certain and quite advanced degree of complexity, and then metamorphosing itself, by self-division in part, into another variety of the same morph. It is in the latter case, *i. e. strobilism*, that we meet with a form of repetitive partition almost unknown among the Hydromedusæ; indeed we believe only to be found in the moniliform group of medusoids of Eudendrium, strung end to end.

21. In all probability the cephalic members of most of the Hydromedusæ are derived from the *bilateral* element of polarity, but in the strobiloid Acalephæ it would seem to be quite clear that *antero-posteriority* exhibits its peculiarity by an indeterminate number of *cephalo-caudal* repetitions along the longitudinal axis. We do not propose to enter here into any detailed argument to prove this, but will simply refer to the chapter (Part XI) on individuality for the minutiae, and merely state the facts which lead us to this conclusion, without further comment.

¹ See the section on the "Criterion of Symmetry," in Part XV, for proofs of the correctness of the above view in regard to the position of the dividing plane.

² See Krohn, "Ueber die frühesten Entwickl. der Pelagia noctiluca," Müll. Archiv, 1855, p. 491, Taf. XIX.

22. It most frequently happens at the beginning of the fissigemmatum period, just after the scyphostoma has developed to the proper condition, that, excepting the original one bearing the anterior corona of tentacles, all of the successive segments across the longitudinal axis are medusoid in character, and immediately after these, and while they are far from being fully prepared for an independent existence, a scyphostoma-like corona of tentacles develops into an exact repetition of the foremost one; but after this first crop of ephyræ has disappeared, it is a common occurrence to meet, in the succeeding crops, with a heterogeneous mixture of ephyræ, ephyroid, doubtfully ephyroid, or doubtfully scyphostomoid, scyphostomoid, and scyphostoma forms. Sometimes two or three scyphostoma coronæ succeed each other (see Agassiz, *Contributions to the Natural History of U. S.*, Vol. III, Pl. XI), or two or more lie behind the ephyræ (Ag., *Contrib.*, Pl. XI, fig. 16). Again a scyphostoma corona, following a series of ephyræ, has eye-spots at the bases of the tentacles (Ag., *Contrib.*, Pl. XI, fig. 5), or the edge of a segment is made up of alternate broad and narrow lobes, the first terminating in single, and the latter in three scyphostomoid tentacles (Ag., *Contrib.*, Pl. XI, fig. 19), thus imitating the ocular lobes of the ephyræ in relative position, and their composition in an exaggerated form, leaving it altogether uncertain whether the segment belongs to the scyphostomic or the ephyra morph; or again a number of ephyroid segments have their ocular lobes either tipped with scyphostomic tentacles (Ag., *Contrib.*, Pl. XI, figs. 15 and 22), or the latter are superadded close to the base of the ocular peduncle (Ag., *Contrib.*, Pl. XI, figs. 8, 14, and 16).

23. This is enough for the present to warrant us in assigning the ephyra and the scyphostoma to the same *morph*, thereby intimating that neither the elaboration of the one nor of the other necessarily has any reference to the formation of a particular kind of organ, but simply indicates that this is the method by which the different *varieties* of the cephalic morph are developed and repeated antero-posteriorly along the longitudinal axis of the *individuum*.

§ 5. *The individuality of Pelagia and Lucernariæ.*

24. The Pelagia which we have mentioned (20) retains its individuality in almost the strictest sense of which we have any example, in fact only the less so than in the highest vertebrates, because its dorso-ventrally repetitive element is less differentiated and more multiplied in its results.

25. The case of the Pelagia of Krohn brings us now directly to the consideration of the individuality of Lucernariæ. These cœnotypic forms of Acalephæ are only less individualized than Pelagia, because two varieties of one morph, viz., the hydroid and the medusoid, inseparably interfused, are patent to our senses in the same unit of form; memorizing, as it were, the separate condition of the hydroid and medusoid cephalisms among the lower, most indeterminately repetitive Hydro-medusæ.

26. A Lucernarian might be compared with a scyphostoma which, instead of developing the anterior segment into the most usual form, with its numerous, long, slender tentacles, has evolved from itself another variety of the same morph, a

medusoid, in fact a *Charybdean*, which remains a permanent part of the body, whilst the region posterior to that has become differentiated to the highest degree of which the scyphostomic morph is capable. The medusoid cephalism is persistent, it remains to perform, in addition to its usual functions, a part which is most commonly assigned to the hydroid; thereby illustrating, by a whole order of beings, the theory that not only the hydroid cephalism, but the *most highly developed medusoid cephalism*, normally, may remain a constant part of what is commonly called a polypidom.

27. Seen in this light, the *Pelagia* already mentioned was a free polypidom with a single cephalic *medusoid* member, and the *Lizzia*, which Claparède¹ saw develop directly from the egg, was also a free medusoid polypidom; but probably not a single cephalic member, because the same species, we believe, has been seen to bud medusoids like itself from the sides of the *manubrium*. If this be true, then the *Lizzia* in question was a free, polycephalic *medusoid* polypidom for a certain period, in the same sense that *Hydra* is periodically a free, polycephalic, but dimorphous, Hydromedusoid polypidom. A polypidom, so-called, may therefore consist either altogether of a single variety of a morph, for instance, of all medusoids (*Lizzia*), or of two varieties, *i. e.*, of medusoid and hydroid, indiscriminately mixed (*Hydra*, *Coryne*, etc.), or systematically disposed in their relations (*Sertulariæ*, *Tubulariæ*), or the two varieties, the hydroid and the medusoid, may be merged into one, and that one may be represented by a single cephalism, a *unit*, as in *Lucernariæ*.

28. Why a *Charybdean* is selected above, for comparison, rather than an *Aurelia* or *Cyanea* may be learned in detail in the chapter (Part XI) upon the morphology of *Charybdeidæ*; suffice it to say, here, that they cannot be specially homologized, neither with the strobiloid *Acalephæ* nor with the *Hydromedusæ*, and that they can be so compared with the *Lucernariæ*.

¹ Claparède, "Ueber geschlecht. Zeug. von Quallen durch Quallen," *Zeitsch. für Wiss. Zoöl.* 1860, vol. x, p. 401, Taf. xxxi, figs. 1, 2, 3.

PART II.

ANATOMY AND PHYSIOLOGY OF HALICLYSTUS AURICULA.

CHAPTER IV.

GENERAL FORM AND STRUCTURE.

§ 6. *Habitat, Habits, Form, and Size.*

29. *Form and Proportions* (Pl. I *figs.* 1-17).—In some of the attitudes (*fig.* 1) of this species, the form of the body, as a whole, might be compared to a lady's parasol heavily tasselled at eight about equally distant points around the edge. The handle, then, would correspond to the thick, short peduncle at the caudal end of the body, and the ferrule-bearing tip would represent the proboscis. Imagine the parasol turned inside out so that the usually concave under side becomes convex, and it would then have the shape which our Lucernarian most frequently assumes (*figs.* 4-7). It might, then, also be sometimes compared (*fig.* 5) to a broad, shallow, eight-sided fruit dish supported by a pedicel.

30. *Size*.—Keeping up the simile to the parasol, or umbrella, we proceed to indicate the size and proportions of this umbelliform mass. Full-grown specimens measure one inch (*figs.* 2, 3) across the umbel, or sometimes a little more, especially those collected at the latter end of the breeding season in our more northern, colder seasons. Including the tasselled tentacles the whole is equal to one and a half inches from side to side. The peduncular, caudal portion is at least one-half an inch long, and about one-twelfth of an inch thick, on the average, but, expanding rather abruptly at the extreme posterior end, into a truncate, discoidal, adherent termination, it is there a little more than one-eighth of an inch. The proboscis is the least conspicuous subdivision of the body, on account of its position and transparency; and, as it is extremely sensitive to the touch and highly contractile and extensible, its proportions can be made out only approximately, and therefore we can but say, in general terms, that it is about one-eighth, or from one-eighth to one-sixth of an inch long, or from one-fourth to one-third the length of the peduncle, and about as broad, in the average, as long. From these measurements, one would judge that the animal before us is, on the whole, rather stout and heavy in its proportions; certainly it is not slender, nor even approximately so, although it has a pretty wide range of general extensibility, and in some of its attitudes appears to be considerably elongated (*fig.* 7), but in the latter case this is more seeming than real.

31. *The interior configuration* (Pl. III. *fig.* 37) corresponds, in a general sense, with that of the exterior. The proboscis (ρ) forms the boundary of a similarly shaped space, and thence the passage is direct into a very wide quadripartite area (ω^1) which is coextensive with the depth and width of the umbella. The umbellar area (ω^1) narrows posteriorly into a broadly conical outline (ω^6), and then opens into four circumaxial, elongate, tunnel-like passages (τ^3), which extend to the posterior end of the caudal region. Essentially, therefore, the whole internal cavity constitutes one common chamber, which is subdivided in accordance with the configuration of the three principal regions of the body.

32. *Habitat*.—Although a free, single, independent body, *Halicystus auricula* is eminently sedentary in its habits, and even is partially encased in a very short *sheath* at its posterior attachment, so that it has the appearance of being a permanently adherent hydroid, like *Corymorpha*, *Hybocodon*, etc., and in fact it is very rare to find it disengaged from its caudal mooring, when in its natural habitat. When, however, it is transported, with the eel-grass to which it is most commonly attached, it very often loosens its hold, slips out of its sheath, and moves about from place to place in its temporary abode. As it is very difficult to keep it in a healthy condition, requiring a large amount of water, frequently to be renewed moreover, its habits, attitudes, configuration, and even general structure need to be observed as soon as possible after it is removed from its natural resting place, and if practicable, as we have often found it, even before this is done. The numerous figures (*figs.* 1–16) which we have placed on the plate (Pl. I) were drawn from life while the subjects were under the most favorable conditions, and are, therefore, fair samples of the natural attitudes and habits of this species.

33. As we have said above, it is most frequently found attached by its caudal extremity either to eel-grass (*Zostera*), or to the common *Fucus vesiculosus*, and very rarely to the solid rock. It would seem to prefer for its base of operations some object which is kept in constant motion by the action of the water, something which will assist it in coming in contact with the greatest possible amount of respiratory material. Hence we may account for the difficulty of keeping the animal in a healthy state in confinement. It will appear, to the inexperienced eye, to be perfectly well and fully expanded for three, four, or five days after capture, but during all this time it is quietly exfoliating its epidermis, both externally and internally, and finally indicates its illness, in its extreme, by falling from its attachment, and lying inactive at the bottom of the aquarium, contracted and rolled up into an almost shapeless mass. Such has been our experience whenever we ceased from making the utmost efforts to keep the animal supplied with an abundance of perfectly fresh and cool water. We have seen statements that it thrives well in an aquarium; but we are fully persuaded that it was only apparently so, and that, after the first forty-eight hours of confinement, it was unfit for anatomical investigation, certainly of a histological character.

34. *Attitudes*.—The principal attitudes of the body may be reduced to two in number; the one most common is when the umbelliform portion is more or less concave anteriorly (*fig.* 5), so that the proboscis is, as it were, surrounded by a very

broad excavation; and the other is when the umbel is thrown backward in such a way that its posterior face is concave (*fig. 1*) and the proboscis projects conspicuously from its convex anterior face. At times the umbel is arched so strongly forward that the body has the form of a wide-mouthed trumpet (*fig. 4*), or still more projected and narrowed it simulates the outline of a deep funnel (*fig. 7*). Yet near these two extremes of concavity and convexity of the front face there are all possible means, as may be seen by consulting the several figures which adorn the plate, representing this species at various ages. The highest degree of contractility of which it is capable is exhibited by inrolling the edge of the umbel so as to conceal the bunches of tentacles (*fig. 15*) and compacting itself into a globose mass, but without retracting the caudal cylindrical portion more than enough to give it a very broad columnar proportion (*fig. 14*), and never so much as to merge it into the general mass.

35. *Locomotion*.—The flexibility as well as the muscularity of the body is most vividly presented when the animal is roving from place to place. It has been said by continental observers that it swims like a pelagic medusoid, by alternately contracting and expanding its umbel; but although we have waded time and again for hours among the eel-grass where they were so numerous as to almost swarm, we have never once witnessed anything that could be compared to the pulsating movement of the umbella of a genuine oceanic Acaleph. It is true that we have seen these creatures detach themselves from their point of support, but they exhibited no systematically concerted motions which would drive them in any particular direction, and the whole process consisted in rapidly flexing or jerking the body from one side to another, with an occasional rapid folding together and unfolding of the opposite halves of the umbel. It is possible that the swimming faculty belongs to the *H. octoradiata* (*L. octoradiata*, Sars, *non* Lamarek), which has been so often and so long confounded with the species now under consideration. The usual mode of locomotion is by a process of creeping or stalking over bodies, after the manner of a Hydra, using as prehensile, or rather adherent, organs, the discoid caudal termination and the eight oval, kidney-like bodies (anchors, colletocystophores, § 104) which spring from the edge of the umbel, one by one, in the intervals between the clumps of tentacles. Rarely does this Lucernarian appear to use the tentacles as instruments of reptation, nor do they contain the adhesive bodies which make up so largely the mass of the kidney-like organs and the disciform truncation of the caudal end of the body. As the animal passes from point to point, it swings itself backward and forward, at one moment barely adherent by the edge of the caudal disk, and at the next, with an abrupt jerk, it throws the margin of the umbel against some object and tilts over, using one or two marginal bodies as *anchors* whilst it detaches the former base of support (*fig. 13*). In the latter condition it shows at times a high muscular power, by swimming abruptly from side to side, or with violent jerks and a sort of gyrating motion it throws itself into rapidly succeeding and varied positions, the heavy caudal region meanwhile whirling about in the watery space like a club in the hand of a gymnast.

36. *Color*.—The divers tints of the body range very widely, from a dark purple to an almost glassy green, and, even in the brownish colors, are always lighted up by a sort of opalescent play of varied intensity. Locality does not seem to have any influence here, for totally different hues are represented, side by side, in the same tide pool, and even upon the same blade of eel-grass. In any case the body is uniformly of one color, either all blue, or green, or olive, or yellow, or orange, very rarely red, but occasionally pink or violet, and from that it ranges in different individuals to a dark purple, or purplish brown. In very rare instances the color varies in different parts of the body.

§ 7. *The Proboscis*. (Pl. I, *figs.* 1, 2, 3; Pl. II, *fig.* 22; Pl. III, *fig.* 37; Pl. IV, *fig.* 50.)

37. The proboscis is not only typically, but actually, topographically, the anterior division, the foremost of the cephalic members of the body. In neither sense, though, is it distinctly separable from the umbellar region; the latter and the former insensibly shade off into each other, and, as it were, mutually overlap at alternate points. Generally speaking, the proboscis is quadrilateral from two different points of view (*figs.* 1, 2, 3, and 37 ρ), and so nearly alike in length and breadth that it has the contour of a cube, or of a very short quadrangular prism, the corners of which lie, respectively, two in the vertical axial plane of the body, and two, at ninety degrees from these, in the horizontal axial plane. The four sides of this organ, therefore, face obliquely at forty-five degrees from either of these planes. Viewed from the front (*figs.* 2, 3, 22), as the animal rests in the conventionally homological position for comparison, the proboscis presents a cruciate appearance, the angles forming the four extremities of the cross, thus +, the perpendicular arms of the cross corresponding to the vertical axial plane, and the horizontal limbs to the horizontal axial plane. Such are the outlines of this organ, in the main, but we must now particularize the several features, one by one, in order to complete the details of our topographical sketch.

38. The mouth is bordered by the four terminal smooth edges of the right and left sides of the proboscis (*fig.* 22 ρ); it is, therefore, quadrilateral also, but is modified more or less by the longitudinal plications and inarchings of these edges, so that, with varying degrees, it presents, from time to time, all of the intervening outlines between a rectilinear quadrilateral and a spherical quadrilateral. It is, moreover, altered in shape by the replication or rolling outward of the edges (*fig.* 1), or by their mutual approximation. There is no demarcation between the buccal orifice and the buccal cavity which is included between the four flanks of the proboscis; nor is the latter space separated by any intervening object from the post-buccal (ψ^6) or central umbellar chamber, which lies immediately behind it; the two latter insensibly run into each other, in the same way that the external contours of the proboscis and the umbel mutually blend.

39. *The basal region of the proboscis* is by far the most remarkable part of that organ, and is so singularly constructed that it would be impossible to describe it apart from the anterior umbellar floor, with which it forms a direct continuation.

It will on this account be more readily understood if we indicate, with a few light touches, the configuration of the anterior face of the umbel. This face is subdivided into eight alternately sunken and elevated regions, so placed that the sunken areas (*figs.* 22, 37, ζ^2) abut against the four sides of the proboscis, and the elevated fields are continuous with the corners (ζ^1) of the latter. The sides of the proboscis, it will be seen now, extend much further backward than the buttress-like corners; the former trending parallelwise with the axis of the body until they reach the uttermost depths of the umbellar concavity (at ρ^3 , *fig.* 37), gradually narrow as they approach the bottom of the U-shaped sunken areas, and meanwhile insensibly shade off, laterally, into the gradually and consentaneously widening proboscicial buttresses (ζ^1); while the latter rapidly rise from the adjacent hollows, and shade off with a very gentle slant into the corresponding elevated regions of the umbel. The latter regions, therefore, lie, respectively, two in the horizontal axial plane, and two in the vertical plane, while the sunken areas trend each at an angle of forty-five degrees to these planes.

40. The flat sides of the proboscis do not by any means always stretch with a straight, smooth surface in a direct line away from the mouth, but rather, and most frequently, they are transversely wrinkled, and often deeply folded in the same direction; and to such an extent, sometimes, do these folds reach that they cover over a considerable portion of the deeper, proximal ends of the sunken areas, and form thereby a sort of *marsupium* or pouch (*fig.* 22, ζ^2). These folds evidently possess a high degree of contractility and expansibility, as they may either be extended so as to reach at least half way to the margin of the umbel, or they may be so retracted that the sides of the proboscis are perfectly smooth, as may be seen on its upper right side in *fig.* 22. The extensibility as well as the strength of the proboscis may be observed also when it seizes and swallows a shrimp of comparatively large size. The marginal adherent organs (α) are on such occasions of eminent service, while the tentacles are occupied in thrusting the victim into the widely spread mouth, whence it passes through the proboscis, which fulfils merely the office of a throat, to the general cavity.

§ 8. *The Umbella.* (Pl. I, *figs.* 2, 3, 17; Pl. II, *fig.* 22; Pl. III, *fig.* 37; Pl. IV, *fig.* 47; Pl. VI, *figs.* 61, 62, 66.)

41. *The Umbella.*—We shall next consider the form, proportion, appendages, contents, and general and special morphological relations of the middle division of the body. The umbella presents an outline which varies to a considerable extent with the shifting moods and attitudes of the animal. In profile it is concave in front and convex behind (*figs.* 17, 37), the concavity holding the proboscis in the middle, and the convexity abruptly narrowing off at its axis, into the peduncular, caudal termination (τ). Viewed from the front (*figs.* 2, 3, 22), it presents an octolateral outline, with eight strongly projecting corners. Of these eight sides four alternate ones are usually shorter than the others, and they are those which lie directly opposite the four flanks of the proboscis (*figs.* 2, 22, 37). Frequently, however, the proportions are reversed and the longer four become the shorter ones

(*fig. 3*), or they are all alike. The first case, though, is the one which is most generally met with, and sometimes the shorter sides are so strongly contracted and narrowed that the umbel has rather the appearance of a quadrilateral with four double corners (*fig. 22*), or the corners project so far as to have rather the appearance of arms (*fig. 17*). These sides are always more or less inarched, and with such a uniform curvature that the middle of each broad sinus is the point nearest to the proboscis, and consequently the borders of the same are most distant, and combine to form the corners of the octolateral.

42. *Umbellar Appendages*.—A very strong emphasis is put upon these alternating corners and sinuses by the appendages which project from their edges. The corners are rendered apparently more prominent by the implanting thereon of a thick group of cylindrical, globe-tipped tentacles (*figs. 1-17, 22, 37, φ*), whilst the comparatively inconspicuous edge of each interval is intensified by the addition of a dark, oval, kidney-shaped adherent organ (*α*). The manner of attachment of these bodies will be described under their respective headings, as we do not wish here to complicate the subject any more than is necessary to render the relation of the various parts of the umbel sufficiently clear for a perfect understanding of topography and morphology. The adherent organs (anchors) from their position in the sinuses, form a marked feature in the subdivision of the octagon, inasmuch as they lie severally, either opposite the flat sides of the proboscis or exactly confronting its four corners, and, therefore, have a closer and more direct relation to the planes of bilaterality and dorso-ventrality than the tentacles possess, which, as it were, stand obliquely to these, at regularly alternating points.

43. *The longitudinal diameter of the umbella, i. e.*, the distance from the anterior to the posterior face, is quite diverse at different points, but not without system. We have already anticipated this by inference, in the description of the basal prolongations of the proboscis (39). Conjoined with the four proboscidal buttresses (*ζ*), the four equidistant regions which lie opposite the angles of the proboscis have a far greater antero-posterior extension from the front to the back face than any other portion of the umbel, whilst the middle of the four subdivisions, which abut against the flat sides of the proboscis, measures the least in this respect. The reason for this will be apparent enough without going into details, upon stating that the middle of each of the four sunken areas (39) corresponds to the line along which the walls of the anterior and posterior faces of the umbel are united. These lines of junction—internal partitions (ψ^2), as will be learned hereafter (47)—may be recognized from without as four narrow, light bands trending, severally, from each of the four sides of the proboscis almost to the margin of the umbel.¹ Consequent upon this it is plain that the antero-posterior faces are further apart at one intervening point than at the partitions,

¹ One of the most elegant and characteristic figures of this species thus far published (see A. Agassiz's Illustrated Catalogue of the Museum of Comparative Zoölogy, No. II., North American Acalephæ, Cambridge, Mass., 1865, p. 63, *fig. 88*) is unfortunately marred by a serious morphological mistake in the drawing, by which the *angles* of the proboscis are made to appear as if lying opposite the partitions of the umbella and consequently facing toward the four double reproductive organs, instead of toward four points intermediate between these.

and most distant opposite the corners of the proboscis, since the areas continuous with the buttresses are the least depressed (39). From the latter points the faces in question approximate each other along two diverse lines, one trending in the direction of the partitions, where they are conjoined, and the other running to the margin of the umbel, at which place they combine to form a common border.

44. *The physiognomy* of the anterior face of the umbel is still further affected by the location of the subdivisions of the muscular system. This system is much more intensified and conspicuous in the regions adjacent to the partitions (ψ^2) than in the intervening areas, but in both localities it may be recognized by numerous ribbon-like bands (m) which extend parallelwise from about the base of the proboscis to the periphery of the umbel. The subdivisions are divided into two sets, of which there are four more prominent subdivisions opposite the flanks of the proboscis, and four others regularly alternating with these and running directly from the buttresses (ζ^1) of the same organ. These eight subdivisions are not apparently in contact with each other, but seem to be separated by the intervention of eight other subdivisions of another system of organs. The latter, the *genitalia*, are dark, triangular, flat masses (\cdot), which present the appearance of a pavement-work as seen through the walls, and extend, one by one, from the sides of the buttresses to the tentaculiferous corners (ψ^4) of the octagon. The absence of the muscular system over these triangular areas is only apparent, and is obscured by the darkness of the underlying mass. Finally there is a narrow ribbon (m^1) of muscle which borders the front face of the umbella, but does not extend as a distinct band over the corners where the tentacles are situated. By the action of the muscles the front face of the umbel is largely modified at times, either by the contraction of the fainter, weaker set, in such a way that the whole area opposite each of the buttresses, with the latter included, is thrown forward into a strong narrow ridge, and the adjacent triangular masses of pavement-work are approximated so as to touch, or even overlap each other (*fig. 3*), or at other times the stronger muscles narrow the sunken areas in which they lie, until they become quite restricted in extent and deeper as a whole in an antero-posterior direction, and simultaneously the intertentacular margin is shortened and rendered more deeply sinuous (*fig. 22*). On the whole it may be said that the entire floor of this face is quite thin and highly expansible and contractile.

45. *The posterior face* (*figs. 17 and 66*) of the umbella is quite simple in configuration. Being coincident at its margin with that of the front face, it is bordered by the same appendages, *i. e.*, tentacles and adherent organs, and by its semi-transparency allows a tolerably clear view of the partitions (ψ^2) and the dark triangular bodies (λ). Its thickness is very marked in contrast with that of the anterior face, nor does it ever appear to become wrinkled or folded to any distinctly appreciable extent. This may be readily accounted for, since we know that the bulk of it consists of a highly resilient, gelatiniform substance, continuous with that in the peduncle (58). Contrasted, then, with the other face, it might well be described as rigid. Opposite the four partitions, however, it is more or less slightly impressed with a shallow, broad, longitudinal furrow, which scarcely attracts attention unless looked for. That it is capable of being compressed or bent is

evident by seeing its margin follow all the various shapes which are assumed by that of the front face, but unless so affected it does not appear ever to change its contour. As we shall see hereafter, in detail, it has no muscular component, but is simply resilient when bent or compressed. In this respect its junction with the front face is very abrupt, but in point of configuration is comparatively gradual, forming with the other a smooth rounded edge (*figs.* 61, 62).

46. Since the three main subdivisions of the body have a close relation to the disposition of the various members of the organization, one would be justified, upon these premises, in looking for something marked at the point of transition from the umbella to the peduncular, caudal regions (τ). This presumption, however, is not warranted so far as the exterior surface is concerned, for we find there a very gradual transition in point of external features, but a rather abrupt change of general form. We must look within for more evident diversities between these two regions. There is no visible, structural dividing line which separates them, as there is between the front and the posterior faces of the umbella, and therefore it is not possible to say where the one begins and the other ends; the most that we can state is that the bulk of the posterior umbellar face is convex, but that behind this it rapidly curves off into a more or less broad, conical form, and then insensibly makes a transition into the peduncle.

47. *The interior of the umbella* next demands our attention. In regard to its general configuration it might with propriety be described as the mould of that of the exterior. We have already (43) indicated its subdivision into four compartments, when referring to the four partitions which unite the anterior and posterior faces of this region, but we have further details to add here, and shall therefore begin with the partitions as the foundation for the principal modifications of the general cavity of this part of the body. The anterior (*figs.* 22, 37, 66, ζ) and posterior (β) parietes of the umbella are united by their interior faces at four equidistant points, or rather lines (ψ^2), which from without have the deceptive appearance of tubes, on account of their comparative transparency. These extremely elongate areas of attachment, or of mutual fusion, extend from each of the bases of the four flat sides of the proboscis to within a short distance of the margin of the umbella, and then abruptly terminate. Consequently at each of these four points of termination there is left a passage-way (ψ^7) from one compartment to the other, and therefore the subdivisions of the general cavity intercommunicate at their distal ends, as well as at the proximal apertures behind the base of the proboscis.

48. *These partitions* can scarcely be called division walls, as they have barely an appreciable depth, but are rather to be compared to low ridges on two opposing surfaces which have inosculated along their crests. By making a transverse section (*fig.* 61) across two approximated arm-like angles of the octagon, the slight depth of the partitions (ψ^2) can be very clearly demonstrated. We should not fail here to state their exact topographical relations, since they constitute an important element in the morphological construction of the body, both as regards its ordinal characters, and in the consideration of its embodiment of the typical idea of the grand division to which it belongs. The vertical and horizontal axial planes being understood to lie in continuation of the four diagonally opposite corners of the

proboscis, it will be seen that the partitions must be inclined at an angle of forty-five degrees to these planes, since they trend perpendicularly from the middle of each flank of this proboscis toward the umbellar sinus which lies nearest to and opposite said flank; and, moreover, it follows that the midline of each of the four compartments of the general cavity is coincident with either the one or the other of these planes. The lateral extent of these compartments is limited only by the narrow partitions, but that is enough to define exactly their relation to the angles of the proboscis, the buttresses (ζ^1) of the latter projecting in strong ridges over the middle of the compartments, and in fact forming, in part, the front wall of their proximal ends. Thus it is evident that the general cavity (ψ^1) cannot be separated by any demarcation from the post-buccal chambers (ψ^6). The peripheral extent of this chamber is limited only by the conjunction of the anterior and posterior parietes of the umbella, and it even is prolonged into the tentacles and adherent organs, both the latter and the former being hollow to their tips.

49. *The organs* which are included in these compartments belong to but one system—the *reproductive*. They have already been mentioned (44) as dark, triangular pavement-like bodies; but their exact relation to the walls of the umbella has not been stated, and therefore one of the most important morphological features of the whole animal remains to be delineated. That they are totally within the cavity embraced by the front and back faces of the umbella, and that they have no communication with the exterior except through that cavity, might be sufficient to affirm before the time of certain recent discoveries in regard to the relative position of the reproductive organs, or of the region of the reproductive process, but at present it is absolutely indispensable that one should enter into the utmost topographical *minutiae*. We shall not here, however, proceed to the ultimate details of these organs, but merely place them in the proper light as far as their *site* is concerned, and leave the rest to be worked out in the chapter (V) on the anatomy of the various organs with which the body is diversified.

50. *The reproductive organs* (λ - λ^5) would appear, without much consideration, to be as many as there are corners to the octagon which incloses them; but we are assured, for reasons which shall not be entered into here, but may be found in the chapters on their anatomy (V) and on ordinal characters (XIII), that there are only four subdivisions of this system, but that each part is two-fold. The whole system is adherent to the inner surface of the anterior wall, circumoral area, (ζ) of the umbella, and, from its proximo-distal extent, lies in almost the closest possible contiguity to the proboscis. Each half of the four subdivisions corresponds to one of the dark, triangular, pavement-like bodies already referred to (44). The triangle (*figs.* 22, 37, $\lambda^1, \lambda^2, \lambda^3$) is broadly obtuse, and its longest, basal side (λ^3) stretches in a slightly curved line, and at a very sharp angle to the neighboring partition, from a point close to the bases of the tentacles, two-thirds, or even three-quarters, of the distance (λ^4 to λ^5) to the axis of the body. Of the two other sides, one is shorter (λ^2) than the other (λ^1), and lies nearer the proboscis. They are both more or less outwardly arched, and by their conjunction sometimes appear to form parts of a continuous curve rather than a very obtuse angle. Each partition (ψ^2) lies midway between the two triangular

halves of an organ, and consequently, it seems plain enough that the halves of adjoining genitalia occupy the same umbellar compartment; or, from another point of view, the halves of the same genitalia are to be found in two different, but juxtaposed compartments of the general cavity. The longest side (λ^3) of each triangle faces its mate, and the two have a partition stretching between them equally distant from either.

51. In a former paper¹ upon this animal we have already drawn attention to the high specialization of these organs when contrasted with those of all the other Acalephæ, and we wish here to emphasize still more strongly the idea which was there set forth for the first time. It has been noticed that these triangular halves are compounded of irregularly rounded bodies so closely set together as to appear like a pavement-work (44). These are nothing less than spherical sacs (*figs.* 37, 61, 62, *s*), attached one by one, and by a short neck, to the inner face of the floor; and within these only are to be found the eggs or spermatoc material, according as the animal is male or female. It will be noticed, also, that the largest sacs are in the region of the obtuse angle of each triangle, and that they gradually diminish in size as they approach the basal side (λ^3) and the distal (λ^4) and proximal (λ^5) acute angles. Here, again, are two other eminent features of differentiation, and of a degree such as is not equalled in the whole class of Acalephæ; in fact it would seem as if we ought to consider each globular sac as a separate organ, and regard the triangular bodies as merely the expressions of the mode of grouping of the organs. At any rate, the suggestion will serve to heighten the sharpness of the features of differentiation so remarkably worked out here, and may perform the same office in estimating the quality of the same process in other creatures of this class. Nevertheless, we shall at least insist that every organ is composed of two of the triangular groups of spherules, and in this assumption we are supported by other evidence than that already adduced.

52. *The digitiform bodies* (χ), which appear in such large numbers near the base of the proboscis, are arranged with special reference to the divisions of each reproductive organ, and form the connective which gives unity of configuration to the genital halves. They are disposed quite regularly in three or four rows, which lie close together and extend from the proximal end of a partition in a direct line to each of the halves, and then border the shortest side (*fig.* 22, λ^2) of these triangles for about one-third of their length. We have, then, four groups of digitiform bodies, so appended to the genitalia that they appear not only to hem in the two parts of each organ, but also to stand as a barrier against communication between any two halves which lie in the same umbellar compartment. We do not pretend to say that they are functionally connected with the genitalia, but merely describe them thus from a topographical point of view. These are extremely flexible, plastic, and muscular bodies, and vary in shape from broad lanceolate, when they are contracted, to linear lanceolate, when extended to their full length. They are very active, constantly in motion, and no doubt serve

¹ Lucernaria the Cenotype of Acalephæ. Proc. Boston Soc. Nat. Hist., March 19, 1862, and American Journ. Science, May, 1863.

both as organs of prehension and adhesion, since they are covered on one of the opposite flattened sides with urticating organs and vibratile cilia, and on the other with adherent vesicles (see § 15). With such an array of grappling apparatus, crowded about the post-buccal cavity, and with the fact in view that these bodies are seen to project out of the mouth at times, there cannot be much doubt that they are eminently efficient in capturing and drawing the prey within the folds of the body, and into the general cavity.

53. *The posterior division* (ψ^6) of the main cavity lies altogether behind the entrance to the four lateral compartments, and is embraced within the broad conical termination of the umbella. Its outlines correspond almost exactly with the exterior configuration of the wall which contains it. Anteriorly it is directly continuous with the buccal cavity, and diverges in four different directions, right and left, and with very wide passages, into the four umbellar compartments (*fig.* 37, ψ^1). Posteriorly it is rounded off, and opens (*figs.* 37, 50, τ^4) directly and abruptly into the four, circumaxial, longitudinal channels (τ^3) of the peduncle. At four equidistant points in its lateral periphery there are as many longitudinal low ridges, which trend in a direct line from each of the partitions of the umbella backward, and gradually thin out and disappear a short distance in front of the apertures of the canals of the pedicel. They are composed, in the main, of fibres (r^2), which may be traced, anteriorly, into the flabelliform muscles which constitute a part of, and lie on each side of, the partitions, and posteriorly they plunge into the solid mass of the peduncle and run (r) to its extreme posterior end, keeping strictly in the middle of the spaces which intervene between the longitudinal canals (τ^3).

§ 9. *The Peduncle.* (Pl. I, *fig.* 17; Pl. II, *figs.* 18, 19; Pl. III, *fig.* 37; Pl. IV, *figs.* 47^a, 50, 51; Pl. V, *fig.* 52; Pl. VI, *fig.* 66 τ - τ^6 .)

54. *The peduncle* is unquestionably the preëminent feature of interest in considering the morphological relationships of this peculiar order. It is that which, added to the umbellar division of the body, caps the climax of the process which is at work reducing the diffuse medusoid and hydroid cephalisms of the lower groups to more intimate alliances in the higher families, and finally combining them in a single unit of form, the *hydra-medusa individuum*, Lucernaria. The complicated organization of the peduncle—the hydra element of our cœnotype—surpasses that of any hydra (scyphostoma included) thus far met with. The mode of junction with the umbella has already (46) been described in reference to the latter. The precise point is not observable on the outside, but the transparency of the wall allows the interior to be seen with full clearness, and in fact the organs there are so conspicuous as to blend in the vision of the exterior. By this we learn that the apertures (τ^4) of the peduncular canals (τ^3) are on a line with the spot where the posterior, conical termination of the umbella fades into the cylindrical shaft of the peduncle. From this point the caudal subdivision of the body retains its circular form in general outline, but is subdivided lengthwise by four furrows (*figs.* 52, 66 τ^6), which extend to the posterior truncate termination, and even over the

adherent face of the latter, and meet exactly in the axial line of the body (*fig.* 18 γ^1). The shaft, then, is slightly four-lobed in a transverse section (*fig.* 52), the dividing furrows (τ^6) running as if in continuation of the four slight, broad furrows which overlie the partitions in the umbella (45), and therefore standing in the same relation to the vertical and horizontal planes of the longitudinal axis. In the peduncle the furrows overlie the four muscular cords (r) which intervene between the longitudinal canals (τ^3). The sides of this shaft run nearly parallel to the axis, diverging but slightly, when the animal is fully expanded, except at the posterior terminus, where they spread abruptly to form a disk-like, truncate expansion (*figs.* 17, 37, 66 γ). This disk is four-lobed by the indentation of the longitudinal furrows, and its posterior face is not only divided into four equal areas by these furrows (*fig.* 18 γ), but is traversed in every direction by minor furrows, which form a sort of network. The obvious office of the disk is that of an adherent organ, and to that its minuter structure corresponds, since we find in its broad, transverse face a multitude of adherent vesicles (see §§ 14 and 28), identical with those which are imbedded in the surface of the marginal bodies (§§ 13 and 27) of the umbella. The general surface of the peduncle is slightly undulating when fully extended, but upon contraction it becomes quite strongly corrugated, and principally in a transverse direction. Under all conditions, whether of extension, expansion, or contraction, its disciform posterior termination retains its peculiar physiognomy, not only in regard to form but in reference to its singularly areolated surface. The flexibility of the peduncle has been noticed in an earlier paragraph (35) on the mode of locomotion of this creature.

55. *The sheath*, which we have formerly mentioned (32), is so short and transparent, and so closely set to the surface of the pedicel, that it is scarcely noticeable. It covers but a short space, reaching from the edge of the adherent disk hardly more than an eighth of an inch forward. It has sufficient consistency to retain its shape in a great measure after the pedicel has been withdrawn, and, although it is nothing more than a filmy excretion, its presence adds largely to the stock of characters which stamp upon this region of the body the impress of the hydroid morph.

56. *The caudal interior* is much more expressive of the hydra-morph than the exterior, for here we may find special parallelisms in organization with that of the scyphostoma-form of the strobiloids, as described by us in subsequent pages (Part XI). The exterior, by its form and the adherence of its base-like terminus, lends greatly to its similitude to a hydra; but it is the interior which, by its evidently special, organized fitness to perform the functions of the hydra-morph, gives the strongest testimony in this case. We discover, in the first place, not a single open space in this region, but no less than four interior compartments (*fig.* 52), and they are what appear from the exterior, to the superficial observer, to be so many dark longitudinal cords (*figs.* 17, 66, τ^3), and which obscure, by their semiopacity, the true muscular cords (r) that lie intermediate to them.

57. These *caudal compartments* (τ^3), or longitudinal canals of the peduncle are nothing more than four diverticuli from the main cavity; but yet they stand in such peculiar, definite relations to the other main compartments, and with like

precise relations to the several members of the organization, that they are by no means to be touched upon slightly in this general sketch. They lie exactly in the same relation to the vertical and horizontal axial planes as do the four anterior umbellar compartments (*fig.* 37, ψ^1), and, as mentioned above (53), alternating with the four muscles (r) of the pedicel, which run continuously backward from, and in the same trend with, the partitions of the umbella (see *figs.* 37 and 50, ψ^2 to r^2). They are narrowest at their entrances (τ^1), and do not increase in diameter for a short distance, but soon they broaden rather abruptly, and then gradually widen as we follow them backwards until they reach the transverse wall of the disk-like, adherent organ (*figs.* 37, 51, γ), where they again broaden rapidly, and become continuous (τ^5) with one another through lateral channels, and occupy nearly the whole thickness of the peduncle. In a longitudinal section (*figs.* 37, 50, 51) their outlines appear quite ragged, and this irregularity seems to increase toward the posterior end, and finally the indentations become so deep as to meet (τ^5) each other between adjoining canals, and form thereby very tortuous intercommunications in the solid gelatiniform mass. Upon making a transverse section (*fig.* 52) of the peduncle, the outline of these canals has an ovate figure (τ^3), with the narrower ends nearest the axis of the body, and the broader next the periphery. The vertical and horizontal axial planes correspond, therefore, to the larger axis of these ovate figures. Their broader ends, that is the distal sides of the tubes, lie about as far from the surface of the pedicel as their narrower ends are from the axis, leaving about the latter a solid mass, which is between one-fourth and one-third the diameter of the whole caudal region. Between every two tubes there is a little more than twice as much space, filled by solid matter, as each one of them occupies. The dark color of these tubes is owing to the large opaque muscles of the cells of the lining wall.

58. *The solid gelatiniform mass* of the pedicel, which is mentioned above (57), is directly continuous with an identical substance (*fig.* 50, e^1 to e) which constitutes the bulk of the wall of the posterior face τ of the umbella, and gives to it that resilient consistency so characteristic of it when contrasted with the anterior face. It is easily recognized by its transversely striated appearance, and is about equally thick in the umbella and in the peduncle, where it abuts against the compartments of these two subdivisions of the body. At alternating points to these it is a solid mass over the entire diameter of the shaft, but is broken in continuity by the muscular cords (*fig.* 52, r), which are embedded in it. At the posterior end of the peduncle it is perforated (*fig.* 51, e^3) and much reduced in quantity by the anastomosing channels (τ^5), and is considerably thinner than in front at the transverse face of the adherent disk, and is, moreover, deeply pitted there by very irregular indentations which give the inner surface the appearance of a network (*fig.* 19, τ^3).

59. *The muscular cords* are the last objects which will occupy our attention here. From their peculiarities and high degree of development and differentiation, they present the most urgent claim for our consideration. They are by far the most eminently specialized muscular organs to be found in the whole class of Acalephæ. Their structure will not be entered into here, as it belongs to the

sections on organography (Ch. V), and we shall, therefore, confine ourselves to laying down their topographical status and their relations to the sites of the other organs. This we have in part anticipated when describing the caudal compartments, but considering the importance of their morphological features, we need not hesitate to repeat what we have said concerning the muscles, especially as the subject matter will be viewed from another stand-point. In the paragraph (53) upon the posterior division of the main cavity, four low longitudinal ridges were described as trending along its inner face and finally disappearing near its junction with the caudal channels. These ridges (*figs.* 37, 50, r^2) are the muscular cords, which, in this region, come to the surface as they pass forward from the pedicel into the umbella. In a transverse section of the peduncle it will be observed that they appear as triangular bodies (*fig.* 52, r) which lie nearer to the surface than to the axis, and exactly half-way between the canals. At the extreme posterior end of the peduncle they expand rather abruptly into a sort of truncate brush (*fig.* 37, r^1), and bending there, at a right angle, extend along the inner face of the adherent disk to the axial line, still buried, however, in the gelatiniform layer (*fig.* 19, r^1). Passing forward, each one keeps its place midway between the canals, and pretty near the exterior at first, but, at the anterior third of the peduncle, swerves from this course, and gradually approximates the axial line, and finally strikes the surface of the posterior division of the main cavity a short distance in front of the entrances to the peduncular channels. Here it is that they begin to rise above the level of the parietes of the cavity, and extend, with rapidly decreasing diameter, in the form of low ridges (*figs.* 37, 47^a, 50, r^2) (¶ 53), to the proximal ends of the partitions. At these four points each one enters a partition (ψ^2) and passes forward very obliquely (*fig.* 47^a, r^2 to ψ^5) toward the outer surface of the anterior or *circumoral* face of the umbella, and there expands into a thin stratum (m^1) just beneath the superficial layer of cells. These then are the only points where the muscular layer of the umbella (¶ 44) is united with that part of the system which is in the peduncle. It is at these points, also, that the muscular layer of the proboscis (*fig.* 47^a, m^6) is connected with the cords.

CHAPTER V.

ORGANOGRAPHY.

§ 10. *The Walls.*

60. *The nomenclature* of the various regions of an Acaleph is as yet in its infancy, and particularly so in regard to the strata of cells or of substances of other forms which constitute the solid parts of the body. Huxley and Allman¹ were the earliest

¹ See Huxley in *Phil. Trans. Roy. Soc.*, 1849, and "*Oceanic Hydrozoa*," in *Roy. Soc. Pub.*, 1859. Also Allman, *Anat. Cordylophora*, *Phil. Trans.*, 1853, and *Report Brit. Assoc.* for 1863.

advocates of a distinctive nomenclature for the Acalephæ. The former designated the walls of the body as the "*foundation membranes*," and the latter applied to the same, the distinctive names: *ectoderm* for the outer wall and *endoderm* for the inner wall of Hydroïda. Later Allman added several other names to what he considered to be subdivisions of the ectoderm; but, as his views in regard to the relation and mode of development of the walls of a medusoid are so widely at variance with our own that we are wholly at a loss in the attempt to homologize the several parts of what we believe to be the typical medusa with those of Allman's type, we shall merely refer the reader to the section (PART XI) where these things are set forth in full detail, and proceed to describe the matter in hand with such terms as we may find most convenient and best adapted to our theory. These terms have been already, in part, promulgated in a note to an article¹ on the *non parthenogenesis* of Tubularia, and we shall add here a few more as the necessities of the case may demand. It will be understood at a glance that, since we apply this nomenclature to all of the Acalephæ—the Ctenophoræ being excluded, as we believe them to belong to a distinct class—we hold to the identity of the general conformation of the organs of every order included in this group. The minor details which serve to characterize each order and distinguish it from every other, may be, in part at least, indicated by the mode of using the nomenclature or by the introduction of such combinations of terms as will suit the ever-shifting exigencies of descriptive anatomy. For the sake of the convenience of reference, and a ready understanding of these terms, we have so constructed an *index* that it may be used as such, and at the same time for a *glossary*, by referring to the numbered paragraphs in the body of the memoir.

61. *The Opsophragma.* (Pl. III, *fig.* 33; Pl. IV, *figs.* 44, 47, 47^a; Pl. V, *figs.* 53, 54, 60; Pl. VI, *figs.* 61, 62, 63, 64; Pl. VII, *figs.* 74, 77; Pl. VIII, *figs.* 85, 88, 90, 91, 93; *n* to *n*².)—What one would very naturally call the outer wall of the body (without any reference to its mode of formation, but simply because it covers the organization from its extreme anterior end to its posterior terminus), in reality embodies two distinct subdivisions; yet both of them lie upon the surface. One of these divisions extends from the mouth to the edge of the umbrella, and the other from the latter point to the posterior end of the peduncle. The first of these corresponds to what we have, on a former occasion, designated as the *endophragma* of the medusa-form of the Hydroïda, on account of its internal position, within the campanule, during the process of fission. Under present circumstances, however, we have deemed it best to introduce another term, of equally distinctive meaning, but having particular reference to our views in regard to the antero-posterior axis of the body—*opsophragma*, meaning the *face-wall*. It is confined strictly to the anterior division, or *front face*, of the umbrella, and embraces within its folds the tentacles and the marginal adhesive corpuscles (*anchors*). It varies in thickness to a considerable degree, and passes from the *minimum* to the *maximum*

¹ "*Tubularia not Parthenogenous*," Am. Journ. Science, Jan. 1864, p. 65. "On the walls of the most highly developed medusoid."

in this respect, with no little abruptness, at some points on the periphery; but, notwithstanding this, it never presents more than a *single stratum of cells* (*figs.* 85-92) between its outer and inner surfaces. Consequently the varying thickness is due to a diversity in the depth of the cells, and not to a greater or lesser amount of these, superposed one upon another.

62. If we commence at the mouth (*fig.* 53, ρ^1) and trace this layer over the various subdivisions of the hydra-medusa, we shall meet with the following characteristics. At the edge of the lip (ρ^1) it (n^3) is continuous with the inner wall (\bar{v}), and is very thin and epithelioid at all times, but varies with the amount of contraction or expansion of the proboscis (*manubrium*, Allman). From this point passing backward over the manubrium, and along its buttresses to the umbella (n) and thence to the margin of the latter, we do not notice any marked change in the thickness of the wall until we approach the region of the tentacles and the anchors, but observe that it is here and there wrinkled, or compressed into tubercular or ridge-like thickenings by the action of the underlying muscular layer (m). At the margin intervening between the prehensile organs it passes directly into the wall (*figs.* 61, 62, f) (*ectophragma*) of the posterior face without any marked change, but at its transit to the tentacles and in particular to the anchors it becomes more massive. On the tentacles which lie most distally it scarcely thickens throughout their length, but where it becomes a part of their globose terminal expansions it increases in depth very abruptly (*figs.* 33, 54, ϕ^2), so as to form full two-thirds of the radial diameter of the spheroids. On the youngest tentacles (*fig.* 54, Λ , ϕ^2) it thickens quite rapidly until it reaches its maximum at their gradually expanding tips. Its passage over the anchors is signalized by quite variable changes in thickness. In the median furrow (*fig.* 47, n^2) it becomes only moderately thick, but almost abruptly so, while at the sides of these organs it rapidly deepens to four, five, and even six times its thickness on the face of the umbella, and finally thins out suddenly, on the distal side of the anchor, just as it makes a junction with the *ectophragma* (*fig.* 47, f).

63. *The ectophragma* (Pl. II, *fig.* 19; Pl. IV, *figs.* 46, 47, 47^a, 51; Pl. V, *figs.* 52, 54, 60; Pl. VI, *figs.* 61, 62, 63, 64, f to f^2) is the true outer wall of the body, in a homological sense; although it seems here, upon casual observation, as we have limited it, to be only a part of the external envelope. Its homological limits, though, are bordered by the peripheral margin of the *opsophragma* on the front face of the umbella, and it is, therefore, restricted to the posterior face and its caudal prolongation, the so-called peduncle. Throughout this wide extent of length and breadth it is quite smooth and does not vary in thickness, and but little exceeds that of the *opsophragma*, until it enters the region which we have designated as the adherent disk (*figs.* 19, 46, 51, f^2) of the peduncle. There it rapidly attains to double or treble its previous depth, and becomes, at times, quite strongly corrugated as it follows the abrupt, sharp angles of the network of furrows; but still, like the *opsophragma*, it consists of only one stratum of cells.

64. *The opsomyoplax* (Pl. IV, *figs.* 47, 47^a, 48; Pl. V, *figs.* 53, 60; Pl. VI, *figs.* 61-64; Pl. VII, *figs.* 74, 77, 82, 83; Pl. VIII, *figs.* 85, 90, 91, 93, m to m^b) is the stratum of muscular substance which immediately subtends the *opsophragma* (¶ 61),

or, in other words defining the meaning of the term, it is the *face muscular layer*; and to it are due all the numerous changes of physiognomy and attitude which the umbrella of this creature exhibits from time to time. It has the same extent both anteriorly and posteriorly, and over the tentacles and anchors, as the wall which it underlies, but, unlike the latter, its borders terminate abruptly, without connection with any other stratum. Its continuation with the peduncular cords has already been described in a previous paragraph (59). The peripheral margin (*figs.* 61, 62, *h*¹) is not exactly coincident with that of the opsophragma, as it terminates at this place in a peculiar manner, which will be described hereafter in the section (§ 11) on the muscular system. As it is one of the layers which add to the bulk of the body and serve as partitions between other strata, it is desirable to mention certain features here which distinguish it from those on each side of it, or which serve to assist in defining the boundaries of adjacent strata. In general terms it may be said to be even thinner than the opsophragma, at its least depth, but, unlike that, it does not vary in thickness over considerable areas, and yet there are regions, quite limited it is true, within which it appears to attain a great thickness. But these are rather to be considered as deep folds (*figs.* 61, 62, *m*¹, *m*²), and correspond in position to those places where the muscular system seems to be composed of parallel bands or cords (see ¶ 44). After what has been said above, it will hardly seem necessary to remark that it totally fails in the region of the *ectophragma* (¶ 63); but we must not omit to add that another part of the same system, in another form—the peduncular cords (¶ 59)—appears in that portion of the body, but, in this genus, does not form a distinct layer.

65. *The chondromyoplax* (Pl. III, *fig.* 33; Pl. IV, *figs.* 44, 47, 47^a, 48; Pl. V, *figs.* 53, 54, 60; Pl. VI, *figs.* 61-64; Pl. VII, *figs.* 74, 77, 82, 83; Pl. VIII, *figs.* 90, 91; Pl. IX, *figs.* 98, 100, *b* to *b*⁵), or the *musculo-gelatiniform layer* as we have called it in another paper,¹ and the *chondrophys*, or the *gelatiniform layer*, constitute, together, by far the greater bulk of the solid material of the body. They are the jelly-like substance which renders the umbrella of the medusiform Acaleph so massive. Among the Hydroida it is the *chondrophys* which forms the distinctive feature of the medusa-cephaloid, and the only thing which the hydrocephaloid variety of this morph has not, the *chondromyoplax* being altogether absent in neither (Part XI). Among the Strobiloida, the medusa-cephaloid possesses both of these layers, while its hydra-cephaloid—the *Scyphostoma*—has only the *chondromyoplax* (Part XI, *Aurelia*). The latter will here receive our first attention. The most notable feature, besides the thickness of the chondromyoplax and its excessive extensibility, flexibility, and compressibility, is the striation which traverses it from surface to surface; yet we do not pretend to say that by this the layer may be distinguished from all others, for a similar striation prevails in the chondrophys (¶ 69), but we claim that it alone, among the walls of the front parietes of the umbrella, possesses this characteristic, and by means of it may be traced to its utmost limits with a comparatively low magnifying power. This layer underlies and is coextensive with the opsomyoplax (64), and in fact we cannot well persuade ourselves that it is altogether a separate *stratum* from the

¹ "Lucernaria the Cœnotype," etc., *ut sup.*

latter, the one seeming to bear the same relation to the other that the cells of some tissues do to the *cytoblastema* in which they are imbedded. We shall speak of this again in the section (§ 25) on histology, and consider it here as a distinct layer, on account of its large share in making up the bulk of this subdivision of the umbrella.

66. At the edge of the lips of the *manubrium* (*fig. 53, p*¹) the chondromyoplax takes its rise with a sharp border (*b*⁷), but rapidly thickens until a section of its diameter measures six or eight times that of the neighboring opsophragma (61). At the base of the proboscis it thins considerably (*b*), but with varying degrees, according to the direction in which we trace it. If we follow it along the proboscicial buttresses (*i. e.*, from the angles of the manubrium) passing between adjacent genitalia, directly to the border of the umbrella, but a little to one side of the marginal corpuscle, we shall find that it preserves a tolerably uniform thickness until within a short distance of its periphery, and then it thickens again at a rapid rate and continues to do so (*figs. 61, 62, b*) until it terminates abruptly with a concavo-truncate edge, only separated from the equally abrupt terminal border of the chondrophys (*c*) by a thin fold (*k*¹) of the opsomyoplax (§ 54). It is this fold, then, which is the peripheral terminus of the muscular layer of the umbrella, and at the same time the intervening partition which prevents the chondromyoplax (*b*) from abutting directly against the convex edge of the chondrophys (*c*). Here is the dividing line between the two antero-posterior subdivisions of the umbrella, and such, we shall learn, is the characteristic feature of it at all points of the periphery. If we trace the chondromyoplax from the buttresses directly to the anchors, it will be seen that it does not thicken so rapidly as before near the latter, and that it passes directly into them (*fig. 47, b*²), as it cannot otherwise do, since these organs are nothing but saccular protrusions of the marginal portion of the anterior face of the umbrella. The mode of termination at the distal side of the base of the anchors is the same as at all other points in the periphery. Within this saccule the chondromyoplax thickens rapidly as it enters, and attains to a greater depth by the time it reaches the muscular partition (*k*¹) which divides it from the chondrophys, and there ends abruptly (against *k*¹). Again, if we make a section of this layer along one of the genital halves from the proboscis to, and inclusive of, one of the bunches of tentacles (*fig. 37*), it does not appear to differ in point of thickness from the last section, but its course is varied by diverging at the digitiform bodies (*fig. 98, b*⁴) and every genital saccule (*figs. 74, 77, b*³), and penetrating them to form one of their strata; and finally, without any change, it passes onward and into the tentacles and becomes a component of no small proportions in those organs (*figs. 90, 91, b*¹). After traversing the intervals between the tentacles, diverging into the latter on the one side (*figs. 54, 60, b*¹), and into the intertentacular internal lobules (*b*²) on the other, it terminates at the distal side of the tentacles (against *k*¹) in the same way as described in the other sections, but with a thickness less by one-half.

67. There are four places in the umbrella at which the chondromyoplax comes into direct contact with the chondrophys, and these correspond to the four lines along which the anterior and posterior internal faces are united to form the parti-

tions (47, 48). The peculiar relations of this stratum are best displayed by two sections made at right angles to each other, the one (*figs.* 47, 47^a, *b*) passing from the proboscis lengthwise along a partition, so as to split it, and the anchor which lies opposite to it, and the other cut traversing it crosswise (*figs.* 61, 63, *b*, *b*^s) so as to show its breadth between the two adjoining umbellar camerae. In the longitudinal section (*figs.* 47, 47^a, *b*) it exhibits a pretty uniform thickness from the proximal to the distal end of the partitions; but is not so thin by one-half as at intermediate points, as the crosswise section (*figs.* 61, 63, *b*^s) shows very conclusively; and it evidently constitutes almost all—a thickening (*m*⁴) of the opsomyoplax along this line occupying the rest—of the depth and breadth of the partition, the chondrophys (*c*⁴) which meets it, scarcely projecting beyond the level of the posterior inner surface of the adjacent camerae. Just before it reaches the distal end of the partitions it begins to thicken, and finally that part which fills these partitions terminates abruptly (*fig.* 47, *b*) at the passage-ways (ψ^7) between the compartments of the main cavity, while its more anterior portion stretches onward into the anchors (*b*²), and is there disposed and terminated in the same way as indicated when speaking of this layer in the four alternate anchors. At the proximal ends (*fig.* 47^a, ψ^5) of the partitions it runs backward behind the base (ρ^3) of the proboscis a short distance, and forms a part of the four low ridges, which were described in a former paragraph (53) upon the posterior division of the main umbellar cavity, and thins out to nothing just at the point where the peduncular muscle (*r*²), in passing forward to the anterior parietes of the umbella, strikes the lining wall (*i*) of this cavity. Here too the chondromyoplax is perforated, or rather, since it is scarcely wider than the muscular cord, is cut in two by it, as the latter penetrates to the front and joins the anterior subdivision of the muscular system—the *opsomyoplax* (*m*⁴).

68. One of the most convenient methods of getting a general view of the varying thickness and irregularities of the chondromyoplax, is by taking advantage of the sometimes unusual elongation of the corners of the umbella, and making sections across them singly or across a pair of them, as we have done (*figs.* 61, 62). In the one across a single corner (*fig.* 62) we see that where the layer in question comes to the edge of the umbella it has a very abrupt, truncate-concave termination (*b*), fitting, with the intervening opsomyoplax (*k*¹), against the convex abrupt edge of the chondrophys (*c*), like a ball-and-socket joint. We notice, too, that near these edges it is deeply indented by folds (*m*¹) of the marginal muscle, and that the same phenomenon occurs over a narrow space close to the genital saccules, where the muscular bands (*m*³) are strongest and heaviest as they trend parallelwise to the partitions, in their course toward the periphery of the umbella. Its relation to the genital saccules, we have already (¶ 66) pointed out, and we will, therefore, proceed to consider the other section (*fig.* 61), which in this case includes one of the partitions (ψ^2). The marginal termination, and the relation of the chondromyoplax to the genital saccules is the same as in the previous sectional view, but between the saccules and the partition it differs in that the whole breadth of it is strongly indented by thick folds (*m*) of the opsomyoplax, and immediately opposite the partition this muscular layer (*m*¹) is so thick as to reach almost to the base level of the

partition, and is so strongly convoluted as to appear like the end of a bundle of threads cut across.

69. *The chondrophys* or chondrin-like layer (Pl. II, *fig.* 19; Pl. III, *fig.* 37; Pl. IV, *figs.* 46, 47, 47^a, 50, 51; Pl. V, *figs.* 52, 54, 58, 60; Pl. VI, *figs.* 61-64; Pl. VII, *figs.* 82, 83; Pl. X, *figs.* 127, 128; *b* to *b*^s) is restricted to the posterior parietes (*fig.* 37, β) of the umbella, and to the peduncle. Compared with the chondromyoplax (65-68) it is much more rigid, dense, and inflexible, quite resilient and elastic, and of a tough, jelly-like consistency. That it is dilatible and compressible is plain enough when the corners of the octagonal umbella are prolonged into conical arm-like projections, or when the peduncle shortens from half an inch to one-eighth of an inch in length, and then regains its first proportions. Like the chondromyoplax, it is nearly colorless, only slightly tinged with yellow or amber-color, and very transparent. It is faced on the front by the lining wall (*gastrophragma*, ¶ 75) of the main cavity, except at the partitions, where it meets the chondromyoplax, as was stated in a previous paragraph (67), and is covered on the opposite side by the outermost wall (*ectophragma*, ¶ 63) of the posterior parietes of the umbella. The massiveness and weight of this layer are unapproached by those of the chondromyoplax, and the only point at which the latter equals the former in thickness is at the margin of the umbella, but yet even there we do not find the mean depth of the chondrophys. In a rough estimate the latter might be set down at about three times the average thickness of the chondromyoplax. The general uniformity in the depth of the chondrophys makes it much easier to measure than the other layer, but still it has some variations in thickness which are not to be passed by, for more than one reason. In the first place they are variations in form as well as diameter, and secondly they are connected with structural peculiarities. These points will be developed as we proceed in our delineations of the outlines of the different subdivisions of the layer.

70. To begin with, we would state that the chondrophys is to all appearances a double layer; that is to say, it is differentiated into two well-marked strata (*c*, *c'*), which, however, do not seem to be separable, like other adjoining layers. Still they have such an amount of diversity in character as to warrant us in taking particular notice of each by itself. In the first place, we will speak of them as if they were one, under the term, *the chondrophys*, inasmuch as they are inseparable; the one being found wherever the other is to be met with. At all points of the periphery of the umbella, except at the distal side of the bunches of tentacles (*fig.* 54, *c*), the chondrophys has an abruptly terminating, rounded-truncate edge (*figs.* 61, 62, etc., *c*) fitting into the concave-truncate border of the chondromyoplax (¶ 65-68); whereas at the points excepted (*figs.* 54, 58, 60, *c*), which are eight in number, the edge of the layer is bevelled off, so as to meet the chondromyoplax (*b'*) at an oblique angle, the two overlapping each other as it were, the margin of the former lying exterior to that of the latter. The manner in which a thin layer of the opsomyoplax intervenes to prevent the actual contact of the borders of the chondrophys and chondromyoplax is described in a previous paragraph (66). In a longitudinal section of the body, in two different planes which meet at the axis, namely, one running through an anchor and along a partition, and one of the

muscular cords of the peduncle (*figs.* 37, 47, 47^a), and the other (*fig.* 37) through a bunch of tentacles and one of the genital halves, and just within the periphery of a longitudinal camera (τ^3) of the peduncle, a very good idea of the nearly uniform thickness of the chondrophys may be obtained.

71. From the anchor—which lies a little beyond the distal end of the partition—to the base of the proboscis where the partition terminates (ψ^5), there is a very slight but distinct and gradual increase in depth, and from the latter place to the entrances (*fig.* 50, τ^4) of the peduncular cameræ, there is no change; but, passing beyond that, the gelatinous mass abruptly expands and stretches to the very axis of the peduncle (e^1) and fills up all the space between the four chambers (τ^3). The relation of the several parts here mentioned is exhibited best in a comprehensive manner by making a transverse section of the peduncle (*fig.* 52), which at the same time displays the disposition of those portions that are concerned in the other longitudinal section (*fig.* 37). Taking the second course indicated, we find the chondrophys considerably thinner than the average at the margin skirting the distal side of the tentacular group (*fig.* 37, ϕ), and commencing with a sharp edge; but passing backward it rapidly thickens to the average measure and then stretches with unbroken uniformity to the apertures of the chambers (τ^3) of the peduncle, and thence to the very posterior end of the body with the same general thickness, but frequently indented somewhat deeply (*fig.* 51, e^1) in such a way as to render its free surface, which abuts on the camera, very ragged. That portion of it which forms the interior transverse lining of the truncate terminations of the cameræ is still more jagged than along the sides of the peduncle, and it is also much thinner (*fig.* 51, e^3). These indentations are frequently so deep as to completely pierce the chondrophys, and then they extend to the exterior wall (*ectophragma*) of the adherent disk. In a face view of them (*fig.* 19, τ^3) it becomes evident that they are so numerous and so disposed as to form a sort of network by running into each other.

72. By reverting to some previous paragraphs (57, 58) a partial description of this peculiarity will be found, and in addition something about the lateral connections of the posterior ends of the cameræ through irregular passage-ways (τ^5) in the gelatinous mass. To render our description here complete we will refer to those paragraphs for details concerning the adjoining organs, and fill up what is wanting by adding further minutiae. These passage-ways are very easily displayed for observation by sections which divide diagonally opposite cameræ lengthwise (*fig.* 51, τ^3), and by a transverse cut across the peduncle just in front of the inner face of the adhesive disk (*fig.* 19). In the former may be seen the extremely irregular and even branching longitudinal projections (τ^3) of the passage-ways into the axial solid mass (e^1) of the chondrophys; and in the latter (*fig.* 19, at e^3) is the direct proof of how little of the chondrophys is left—a few columns—between adjacent cameræ by these extensive burrowings. The muscular cords (*fig.* 19, r) are scarcely exempt from these encroachments; at least their periphery is uncovered by this substance, and would be laid bare in some places were it not for the lining wall (*endophragma*) of the cameræ, which follows all these sinuosities to their minutest ramifications; and their posterior truncate ends are undermined by an occasional *diverticulum* (*fig.* 46, τ^5) from the main burrows. Sections (*figs.* 61, 62)

across the angles of the umbella disclose a rigid uniformity in the thickness of the chondrophys, and at the same time expose the abrupt, marginal juncture of the latter with the chondromyoplax, as explained in a former paragraph (66).

73. The *double layer* (70) which we have comprised under the name chondrophys, possesses certain dissimilar characteristics in each of its subdivisions, which lead us to describe them as if separate, although we do not believe that they are originally of diverse origin. We shall defer giving the details regarding these (¶ 197) until we come to the histological anatomy of this animal, and content ourselves with merely indicating the appearances which first catch the eye upon a cursory survey of the mass. In any of the sections mentioned above, it will be noticed that the chondrophys is composed of a comparatively thin layer (e^1), which forms the inner division, and of a very thick stratum (e), which is at least four to six times as thick as the other. It is a peculiarity of the thinner one that it terminates with a sharp edge (*figs.* 60, 61, 62, e^1) at this point of junction of the anterior and posterior parietes of the umbella, and therefore bears no part in forming the abrupt margin of the chondrophys. Again, the striations which traverse the thickness of this layer are much finer and closer together than those in the thicker stratum, and moreover they always, even in the peduncle, trend in one direction, *i. e.*, in parallel lines from face to face; whereas those of the greater mass are comparatively heavy, and are remarkable for the regular and systematic manner in which they cross each other about the axis of the peduncle (*fig.* 52, e^1), there being no less than five distinct sets of decussating fibres at this point. (See ¶ 198 for details.)

74. The *gastromyoplax* (Pl. VII, *figs.* 74, 77, *o*; Pl. IX, *figs.* 98, 99, 103, *h*).—For the purposes of homology this term is better suited than another (*oömyoplax*, ovarian muscular layer) which would signify the restricted limits of this layer in the region of the reproductive organs of *Lucernariæ*. It is essentially an oömyoplax because it is developed only in and about the genitalia, and cannot be traced beyond the outskirts of the saccules (¶ 51) and the digitiform bodies (¶ 52). In regard to the latter, the presence of this layer in them as well as in the saccules tends to confirm their association as a part of the reproductive organs. But the oömyoplax is homologically identical with the gastromyoplax of the Strobiloid medusa-cephaloid, whose true oömyoplax is incorporated with another layer—the *opsomyoplax*. The term oömyoplax, then, can be used only as indicative of function and not of structural relation. We shall scarcely do more here than mention this layer, because it forms a part, though small, of the body-wall, and refer for all the necessary details to the paragraphs (135–137) on the reproductive organs, to which it strictly belongs in *Lucernariæ*. As the muscular cords emerge from the chondrophys of the peduncle and cut their way through the chondromyoplax (see ¶ 59 and 67) to enter the proximal ends of the partitions, a thin film of muscle is given off, just behind the base of the proboscis (*fig.* 47^a, ρ^3), and extends into the nearest digitiform bodies (γ). There it forms a layer (*fig.* 98, *h*) just beneath their outer wall, and then passes on in the same way to the others, and finally, without leaving its position on the under side of the *gastrophragma* (*figs.* 74, 77, *i*), it pushes its way along the saccules of the genital organs and, diverging there, runs as a distinct layer (*o*) beneath the exterior wall (i^1 , *oöphragma*) of each capsule.

75. *The gastrophragma* (Pl. III, *fig.* 33; Pl. IV, *figs.* 44, 47, 48; Pl. V, *figs.* 53, 54, 58, 60; Pl. VI, *figs.* 61, 62; Pl. VII, *figs.* 74, 77, 82, 83; Pl. VIII, *figs.* 90, 91; Pl. IX, *figs.* 98, 99; Pl. X, *figs.* 127, 128, *i* to *i'*).—Excepting in the area over which the oömyoplax (*gastromyoplax*, 74) is spread, the lining wall of the general cavity of the body is applied directly to the inner face of the chondromyoplax (§ 65) and the chondrophys (69), and follows them through all their divergences into the tentacles, anchors, genital saccules, and over the digitiform bodies; and faces every indentation, no matter how deep or narrow, nor how extensively ramified; not even excepting the jagged, tortuous passage-ways between the cameræ, at the posterior end of the peduncle (72). Since the nutritive fluid circulates within the immediate embraces of this layer, we have given it the appellation which heads this paragraph; but lest this might mislead the reader into a misapprehension of our views of its homological relations, it is necessary for us to state here that it is the same as what we have termed the *mesophragma* in the medusa-cephalid of Hydroida. It does not, however, bear the same special relations to the walls on each side of it that obtains in the Hydroida and Strobiloida, and it is this difference which constitutes one of the most essential grounds of argument in favor of separating the Lucernariæ from the other two orders. In the Strobiloida the gastrophragma is a *double* layer throughout the area over which the chymiferous fluids circulate; the chymiferous tubes, so-called, being merely spaces left where the juxtaposed faces of the anterior and posterior walls separate from each other. In the Hydroida the gastrophragma is a *single* wall within whose solid mass are hollowed a set of longitudinal and circular channels—the chymiferous tubes. In the Lucernariæ neither one nor the other of these modes is prevalent, nor is the gastrophragma uniformly continuous, since it is interrupted at the partitions where the chondromyoplax and chondrophys are brought into actual contact (67). It is always present as a lining wall—composed of a single stratum of cells—where there is a cavity, but in no case does it lie, a solid mass, between these strata. It always has one free surface throughout its length and breadth, which cannot be said of the corresponding layer, neither in the Strobiloida nor in the Hydroida.

76. This layer varies in thickness to a great extent, and is considerably diversified in the functional subdivisions to which it is apportioned. At the edge of the mouth the passage from the opsophragma (§ 61, *fig.* 53, *w*³) into this layer (*i'*) is rather abrupt, as the latter suddenly thickens so as to exceed the former by about one-third in this respect, and retains this depth to the base of the proboscis. There it begins to thin off (*i*) and gradually diminishes to the dimension of the opsophragma; and, excepting in that part of it which covers the digitiform bodies (*figs.* 47^a, 98, *i'*), it retains this measurement throughout the broader, open chambers of the umbrella and the peduncle. Whenever it becomes a part of some organ it changes its character and, usually, its thickness to a greater or less extent. On the genital saccules (*figs.* 74, 77, *i'*) it is about as thick as in the broad areas about them, but it rapidly increases in depth by one-third as it extends over the digitiform bodies, and even by one-half at the ends (*fig.* 98, *C*) of the latter. At the tips of the intertentacular lobules (*figs.* 54, 60, *i'*) it is as thin as anywhere, but from these points until it fairly enters the cavity of the tentacles it thickens very rapidly and

to an enormous depth (i^2), amounting to at least twelve to fifteen times its measurement in the umbellar cameræ. In this case the tentacles are supposed to be extended to a moderate degree; yet when they are stretched to their utmost capabilities these proportions are not very much diminished. In the anchors the difference is still higher, but there is considerable irregularity owing to frequent indentations in the chondromyoplax, as a longitudinal section (*fig. 47, i'*) of one of these organs shows; yet it amounts, here and there, to even twenty times as much as the thickness in the more open spaces. In a general way it may be set down as a rule that, at the newly forming part of an organ, or where new subdivisions of an organ are developing, this wall is thicker than in the older portions (*figs. 58, 82, 83*). In this layer is situated by far the larger part of the pigment-like matter which gives color to the body; and we may add, without unnecessarily anticipating what properly belongs to the histological portion of this memoir, that the nuclei of the cells are the principal elements in giving depth of hue, while the more widely spread, and scattered interstitial granules produce a general diffuseness and uniformity of tint.

77. *The vibratile cilia* (Pl. VII, *fig. 74*; Pl. IX, *figs. 98, 99, 100, ω*; Pl. X, *fig. 109, ω*) are truly the next deeply-seated parts of this organization, and although they cannot be included strictly under the head of walls, they at least form appendages to these layers, and, therefore, properly deserve mention here, with a statement in regard to the extent of surface over which they are spread. They occur in all parts of the interior, but are particularly abundant upon the genital saccules and upon one of the flattened sides of the digitiform bodies, but fail entirely on the others, and we believe also in the tentacles. Their structure and especial relations to the cells of the wall upon which they are situated will be found set forth, with full details, in the chapter on histology (Ch. VII, 201).

§ 11. *The Muscular System.*

78. *General distribution*—A few of the subdivisions of this system have already been mentioned, or in part described, in preceding paragraphs (44, 53, 57, 59, 64), and, therefore, we shall not here enter so fully into all the details necessary to an understanding of their topography and general form as we might otherwise do; but still, not to leave the sequences of our subject disconnected, we shall refer, from time to time, to such of those paragraphs as may be found desirable to complete the description. If we except the posterior parietes of the umbella it can be said without exaggeration that every subdivision of every organ of the body is supplied with some branch of the muscular system, and even the excepted region is affected almost directly by one of these subdivisions, for instance, that part of the *opsomyoplax* which, in the form of a thick rib, trends along the partitions where the chondromyoplax and chondrophys have their only lines of contact (48, 67, 68); or in that part—the doubtful umbello-peduncular region—where the muscular cords emerge from the peduncle and pass obliquely forward into the proximal ends of the partitions (§ 59). In point of relative position the distribution of the various parts of this system is widely diversified; at one place it is either upon, or imbedded

in the *chondromyoplax*, or in another locality it is on the opposite face of the latter or it is buried in the solid mass of the *chondrophys*. If we trace it now through all its windings and variations of form we shall meet with the following subdivisions.

79. In the *proboscis* (*figs.* 47^a, 53, *m*^o) it is a very thin, uniform layer which, on the one hand, lies against the posterior face of the opsophragma (*n*¹), and on the other, overlies the chondromyoplax (*b*¹). It commences abruptly at the edge (ρ^1) of the mouth, in the angle just at the line of junction between the opsophragma (*n*³) and the gastrophragma (*l*¹), and follows all the curves, undulations, and wrinkles of the manubrium, marking its way by numerous, delicate, longitudinal striations. It requires a magnifying power of at least two hundred diameters to determine that these striations are *fibrillæ*, and that they are not to be confounded with the heavier striæ and ribbon-like elements of the umbella proper, which can be seen with a very low amplification. Their nearest homologues are to be found in the tentacles and anchors, but the relations of the two are not altogether identical, since the fibrillæ of the latter do not form a continuous stratum like that in the proboscis. It is but just to say that a similar striation is discernible in all parts of this system; but we must observe that in the manubrium it is the only marked feature of organization, whereas in the umbella and the peduncle it is the arrangement of these features in folds, columns, etc., which, in the most conspicuous manner, indicate to the eye the *site* of the muscular subdivisions of the body.

80. *Muscles in the umbella*.—Beyond the limits of the proboscis the system is differentiated in such a decided, methodical manner as to form a prominent guide, among a few others, in localizing the surrounding organs and the specially endowed regions. It continues from the proboscis to the margin of the umbella without changing its position relatively to the opsophragma, but although still lying in front of the chondromyoplax, it is somewhat altered in conformation and in its connections with the latter layer. It will be observed in our figures (*figs.* 22, 37, 50, *m*) that a coarse kind of striæ pervades the anterior parietes of the umbella, but that it is not uniform in quality, and seems to be divided into two sets of four subdivisions each, alternating with one another. In the four areas which overlie the middle of the four umbellar camerae the striation is simple, and extends from the proboscidal buttresses (ζ^1) with a wide flabelliform divergence, and merges gradually into a moderately broad, marginal band (*m*¹) of strong parallel striæ. Immediately over the eight genital halves (λ) this quality of striation is absent, and is replaced by the finer kind, only discernible, as in the proboscis, with a comparatively high power.

81. In the space included between the halves of each genital, and lying collateral to the partitions (ψ^2), we find the most evident expressions of strength and solidity to be met with in any part or organ of the body, excepting the peduncle. The striation here possesses more of the character, in appearance, of a banded surface, owing to the regular distances apart at which the striæ are disposed. They have a pennate rather than a flabelliform arrangement, but so situated, that, although they diverge from each side of the partitions along the whole length of the latter, they all tend obliquely to the margin (ψ^3) of the umbella, and there run gradually into those groups of deeply marked striæ which run, like a band (*m*¹) along the

periphery. The apparently jointed structure of the pennate bands does not belong to them, but is the result of the contraction of the muscular layer, along these lines, which wrinkles the opsophragma, at stated points, transversely to the trend of the bands. A few experiments with the point of a needle will soon convince one that the irritability of the animal may be exhibited by contractions at single points, or along certain lines, as well as by a general shrinking of the body. One of these bands may thus be impelled to contract so strongly as to produce heavy folds in the opsophragma along that line, while it remains quite smooth on each side of it. Before we enter into a more intimate research upon the structure of this part of the muscular system, we should make this superficial reconnoissance complete by taking special notice of the marginal terminus of the opsomyoplax, although it has already been characterized in a general way. This terminus has the form of a finely plaited border (m^1), the plaits running parallel to its sides, and fading out near the groups of tentacles. Except at the last place mentioned, it is well marked in character at all points of the periphery, but particularly pronounced (*fig. 25, m^1*) at the bases of the anchors; the latter category standing in strong contrast with its smoothness in the neighborhood of the tentacles, the homologues of the anchors.

82. We will proceed now to revise, from another point of view, the several areas which we have just passed over, commencing with those which are most directly continuous with the parietes of the proboscis. These we shall find between the corners of the buttresses (ζ^1) and the umbellar margin. By bringing the muscular layer here into profile view, by means of a transverse section (*fig. 62, m*), we disclose the fundamental element which lies at the bottom of the striation, noticed above. This turns out to be a more or less extended thickening of the stratum along stated lines, which run in the direction indicated by the striæ. These thickenings appear in the form of narrow ridges of varying height in other areas, but here they are quite low, and do not rise at very sharp angles from the general mass, yet they are of sufficient altitude to produce, by their comparative opacity, a distinct contrast with the transparency of the thinner intervals; and hence arise the lighter and darker lines, which have been spoken of as striæ. Approaching the margin of the umbrella the striæ grow stronger, and the ridges become correspondingly higher, at first no greater in altitude than in breadth; but finally, as the marginal, plaited band is entered, they abruptly increase to the proportions of very lofty narrow and thin crests (m^1), with intervals of breadth equal to them, between their bases. At the less elevated points the ridges do not encroach upon the chondromyoplax (b) very sensibly, but as they become more prominent they plunge deeper into its anterior face, and within the marginal, plaited band they cut nearly through it, and, in fact, occupy as much, if not more, of the anterior parietes of the umbrella along its border, than the layer in which they are imbedded, and have partially displaced. At last the muscular stratum meets the abrupt, convex margin of the chondrophys (c), close to the under surface of the opsophragma. This is not its termination, however; that is to be found along the line at which the inner layer (c^1) of the chondrophys thins out to a sharp edge; and in order to reach this place the muscle makes a final plunge between the abrupt convex margin

of the chondrophys (*c*) and the equally abrupt concave borders of the chondromyoplax (*b*), forming an intervening partition (*k*¹) there, and terminates, as just indicated, a few lines above. In such a precise, peculiar manner the umbellar division of this system intervenes between the juxtaposed margins of the two gelatiniform strata at all points in the periphery; not only along the sinuses of the octagon, but even at the distal side of the bases of the groups of tentacles and the anchors. The modes of approach to this terminus, though, are quite diverse in the several regions mentioned, and are, therefore, to be described separately.

83. We turn now to the ribbon-like pennations which diverge from the partitions. Their internal conformation is best exposed by a section across two of the corners of the octagonal umbella, with an intervening partition (*fig.* 61). By this we learn that the bands in question are the expressions of the thinner portions of the muscle which lie between less transparent ridge-like thickenings (*m*). The disposition of the ridges is peculiar to this region, and differs from that described in the last paragraph, inasmuch as the intervals in the present case are two or three times broader than the ridges. The latter are heavier and plunge deeper into the chondromyoplax than the ridges of the buttresses and the adjoining face of the umbella; in fact they reach half way or more through the thickness of this gelatiniform layer. We ought to qualify this, however, by stating that, as the muscle approaches the margin of the umbella, it loses its folds for a short distance, and is as thin and smooth as that portion of it which lies in front of the genitalia, but soon it becomes ridged again, and then joins the marginal band (*m*¹). One more peculiarity is to be mentioned, and that is to be found along the line of the partitions. Here the muscle attains to its greatest thickness and massiveness, assuming the form of a broad rib (*m*¹), which is about half as thick as it is wide, and occupies the whole depth of the chondromyoplax, excepting that part of it (*b*²) which constitutes the mass of the partition. It is not homogeneous, by any means, but on the contrary, as a transverse section shows, it appears to be deeply folded lengthwise; the folds, where cut across, resembling the ends of so many divided threads. Surveying it in a longitudinal section (*fig.* 64, *m*¹), the folds evidently run parallel with each other, but not continuously, some fading out while others begin, and all trending in one general direction. At the proximal ends (*fig.* 47^a, ψ ⁵) of the partitions, the folds run into the larger conduplications of the muscular cord (*r*²) just as it comes forward from the peduncle and enters the umbella.

84. *The marginal band* of muscle is so strongly marked by its ridges that it appears, at first sight, as if it were a distinct strip, a deeply plaited hem; but we have already seen (§ 82) that it is continuous with the neighboring opsomyoplax, and that its conduplicated physiognomy is due to the ridges which project from the general mass into the chondromyoplax. When, therefore, we speak of it as the marginal muscle, or band, it must be understood in this light. In the neighborhood of the tentacles its ridges disappear, and it then ceases to be recognized as anything more than a thin, uniform stratum (100), indistinguishable from the rest of the muscular layer; while opposite the anchors (*fig.* 25) it retains a considerable proportion of its ridges (*m*¹); yet these are variable in number and strength. The true opsomyoplax is strictly confined to the parietes of the umbella, and

wherever it passes beyond that, although not dissolving its continuity, it becomes another subdivision of the system, for instance, that of the tentacles, or of the anchors. At the anchors its junction with them is indicated by the prolongation of the ridges of the marginal band (m^1) into the stem of these organs (at m^1), and may be readily traced by a surface examination; but since all the ridges fail in the region of the tentacles, the relation of this layer to its continuation in the latter organs can only be determined by an actual section of the parietes thereabout, thus displaying a profile of its thickness, and the course it takes in making the connection.

85. The *gastromyoplax*, or *oömyoplax* has already received all the attention that is necessary to define its position and connections in reference to its general surroundings, and, as we have said in a preceding paragraph (74), since it is wholly devoted to the reproductive organs and their appendages, we shall defer a special description of it until those organs come under particular examination; but, inasmuch as it is a branch of the great subdivision which converges at the proximal ends of the partitions, and concentrates in the peduncular cords, it is eminently proper to repeat here what has been said in reference to its mode of junction with the latter, and perhaps to add some other matters of interest. Contrasted with the *opsomyoplax* it is very thin, and might readily escape the eye of the observer, unless his attention were drawn to it by the activity and evident muscularity of the digitiform bodies. Between the necks of the genital saccules it is thickest; it thins very sensibly as it passes into the latter and into their appendages, and is a mere film where it folds over the proximal ends of the partitions and joins the great cords of the peduncle. (See ¶ 76.)

86. In the *tentacles* the muscular system (*figs.* 43, 54, 90, 91) ceases to be a continuous layer, but still it retains the same relations to the *opsophragma* and the *chondromyoplax* that it had in the umbrella. The difference consists in this: instead of being a distinct stratum, it is, as it were, split into a large number of threads which are grouped in bundles (*fig.* 90, m^2) of two, three, or four, more or less mutually overlying; the bundles being separated from each other by varying intervals, and trending lengthwise of the tentacles. This accounts for the longitudinally ribbed appearance (*figs.* 43, 54) of these prehensile organs when viewed with a low power.

87. The *anchors* (*colletocystophores*, § 13) possess a modification of the muscular layer identical with that in the tentacles, which may be as conveniently traced in their youngest stages of development, before their tentacular nature is disguised; but, in consequence of the great changes which take place, by the thickening of the outer wall and the development in it of the adhesive vesicles (*colletocysts*, § 27), the full-grown organs present great difficulties in the way of tracing the course of the bundles of muscular threads. We have succeeded in doing so, notwithstanding, and shall describe the results in detail in the special paragraphs (§ 13) on these organs, since the relations of the fibres in question cannot be properly understood without a knowledge of the peculiar conformation of the several strata which constitute the anchors. This reason will apply with equal force to the tentacles.

88. The *muscular cords* (*figs.* 19, 46, 47^a, 50, 52, 113, 117, r to r^3) of the peduncle necessarily demand our notice here, as a part of a general system, although

their peculiarities have already been nearly exhausted in a former paragraph (59); in fact there is nothing left to be said in regard to their relative position in the peduncle, nor in reference to their mode of connection with the other subdivisions of the system, but their structure yet remains to be described. In that is embodied the most singular of all their qualities. They are in reality, what they appear to be upon superficial examination, cords whose mass is so deeply furrowed lengthwise that they could almost be said to be groups of four bands united by one of their edges. The nature of this mode of subdivision of the cords becomes quite clear when they are cut across (*figs.* 52, 117, *r*). Here we see the general outline of the periphery, as well as the minor details of the surface in all their fullness. Each cord, it appears, has a sectional outline resembling an obtuse-angled triangle, two of whose sides face away from the axis of the body, and the third and longer one is convex and faces toward the axis. It might well be compared to a triangular prism. Its mass is split nearly through to the apex of the triangle, so as to be parted into two divisions of equal size; and each moiety (*fig.* 117) is again penetrated by a fissure, which does not extend more than about half way through it, but trends, like the first one, toward the obtuse angle. All of these subdivisions, in fact the whole surface of the cord, is still farther indented by deep flutings which give it the appearance of being finely ribbed (*fig.* 113). A highly magnified view of a transverse section of one of these fluted divisions (*fig.* 117) presents the aspect of a deeply lobed triangular mass. Thus it is that the prismatic cord imitates, in a more concentrated form, the deeply ridged muscular layer of the umbella; the idea is the same in both, but here it is carried out to the extreme, apparently serving to increase the surface of contact between it, the moving agent, and the gelatiniform mass (*c'*) about it. At the posterior truncate end the furrows terminate, for the most part, abruptly; but a few follow it beyond that, along the course of the gradually narrowing muscle, as it bends at a right angle (*fig.* 46), and comes to a point in the middle of the adherent disk (*figs.* 19, 46, *r-r'*). And so it is at the anterior end of the cord, where it gradually decreases in diameter (*fig.* 47^a, *r*²) until it penetrates the chondromyoplax, and then rapidly expands, in the umbella, into a flat mass, the opsomyoplax (*m'*). There we find the transition from the deeply fluted condition of the prismatic mass of the cord into that of the heavily ridged and grooved stratum which pervades the area on each side of the partitions. The greater diameter of the cords is about equal to the shorter diameter of the pedicellar cameræ, and from one-third to one-half the breadth of the space between the latter. We have already stated that they are completely imbedded in the chondrophys, but the precise relation which they hold to the decussating fibres of that mass is yet to be illustrated; and, since that would involve a description of the minutest structure of the gelatiniform column, we must postpone the subject to the chapter on histology (198, § 25).

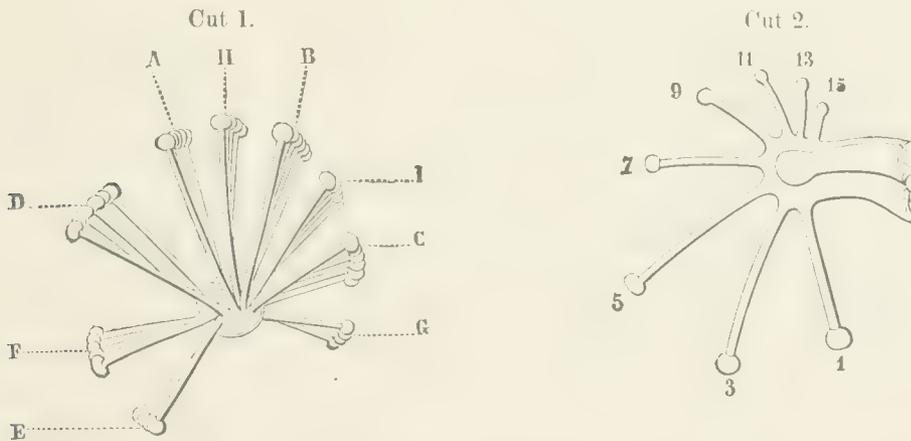
§ 12. *The Tentacles.*

89. *Basis of Attachment.*—The tentacles (*figs.* 17, 22, 54, ϕ to ϕ^3) are nothing more nor less than hollow cylindrical protrusions of the anterior parietes of the

umbrella, as if its constituent layers had been pushed outward, at stated points, into finger-like projections, and had become fixed there. Such we may see they are, essentially, if we follow their course of development—their budding—as any one can do, either with young specimens or old ones in hand. The groups into which they are gathered number eight in all, and are situated singly on each corner (ψ^4) of the octagonal umbrella, close to the marginal junction of its circumoral and aboral parietes, the bases of the older, most distal tentacles (*fig. 54, D*) actually abutting against the margin of the latter. They are, however, distinctly separate from that, not only by virtue of their position, but also in the quality of their walls; and prove to be, in their minuter details, identical in kind with the layers of the circumoral parietes from which they arise and are directly prolonged. From a taxonomical point of view they are very peculiarly situated, no single bunch being complete in regard to symmetry, neither in reference to the relative position of the tentacles among themselves, nor in their relative ages and sizes. In as few words as possible we express their arrangement by saying that they are one-sided, asymmetrical bunches. Yet their very asymmetry is symmetrical; for if, of two groups adjoining a partition (ψ^2), one group preponderates on the side nearest that partition, the other also leans toward it, and thus they present a symmetrical relation to each other similar to what we find in the anisoscelean triangular halves (λ) of the genitals. If we combine, now, the functional relations of the regions comprising the genitalia with the apparent taxonomical mutual reference of the tentacular groups which lie opposite those regions, it becomes evident that the umbrella is subdivided into four symmetrical portions, each separated from the other by the areas which extend from the corners (ζ^1) of the proboscis to the margin. Such a prominent relationship would seem to demand that these subdivisions should stand in the principal planes dividing the body into right and left, and into dorsal and ventral segments; yet, not only would the animal be just as symmetrical if divided along the planes intermediate to these, *i. e.*, planes prolonged from the corners (ζ^1) of the proboscis, but there is every reason to believe that the latter way would be the right one. Why this is so cannot be entered into here, but our reasons for so believing may be found, expressed in full, in the section (Part XV) on the “criterion of symmetry.”

90. *Taxonomy.*—The asymmetry of the groups of tentacles referred to in the last paragraph may be most conveniently illustrated in the mode and succession of development of these organs in the young, before they become so numerous and crowded as to render their relations to each other more multiplied and complicated. A special section or paragraph (149, 150, 155) has been devoted to this in a subsequent chapter (VI), and for the sake of clearness we would ask the reader's perusal of that part of the subject before proceeding with what we have now to present. The guide to the disposition of the members of each group is a single tentacle, situated on the distal side, and, as near as the eye can judge, about opposite the middle of the bunch (*figs. 17, 22*). We should state, before proceeding farther, that the usual number of tentacles in the adults is about one hundred; but not infrequently very large specimens are met with which possess as many as one hundred and twenty in each bunch. Now, for certain purposes, such multitudes,

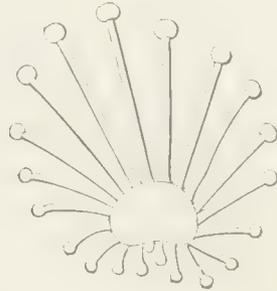
so far from hindering the investigation of their taxonomy, are of eminent assistance, especially in guiding the eye through their singularly well-disposed ranks. Although they do not actually map out their arrangement on their foundation, they nevertheless force themselves upon the attention of the observer, and lead him to infer, at a glance, that they are by no means scattered indiscriminately over the area which they occupy. When they are quiet, and extended in full vigor, the eye is struck with their apparently ranked arrangement, as if they stood in file. Frequently the files seem to cross each other in systematic order, like the decussating lines on the milled back of a watch; but the ranks are particularly noticeable when the body is viewed directly from in front, looking along its axis, as it were (*fig. 22*, and cut no. 1). Then one may count as many as eight or ten rows, trending from the proximal to the distal side of the group; and usually it is clear that one of these rows is more prominent than the others on either side; that the tentacles composing it are, on the whole, larger than in the neighboring rows. If now this file be followed to its distal end, it will be noted that it runs through the middle of the group, or thereabouts—certainly nearer to that line than any other file—and that it terminates in the largest tentacle on that side. That is the tentacle which we have spoken of, a few lines back, as the “guide;” it is the primary, single, *oldest* tentacle. There is no mistaking it, nor its position, in very young animals (*figs. 121, 125*, no. 1) where the members of a bunch are few.



91. Keeping the main file in view while taking a general survey of a group, the preponderance of the multitude on one side of that row is quite marked; the oval outline of the bunch appears gibbous; and if we plunge to the bases of the tentacles we shall find that the area from which they arise is excentric to the oval which circumscribes their tips (cut 3). We naturally infer, therefore, that the general physiognomy is expressive of the arrangement of those details which combine to make up the whole; and this is true in one sense; but, as we shall discover presently, the outlying portions are not capable of being reduced to that rigid test which would prove what their real relations are. Their numbers, and, above all, their mobility are serious, insuperable obstacles in the way of such a determination. What at times appears to be a single file is, in reality, formed by the combination

of two rows, or perhaps three; the true rows lie so close together that the slightest possible swerving of the tips of the tentacles to one side brings those of neighboring ranks so nearly into line that the eye fails to detect the want of perfect continuity in it. It must be kept in mind here, though, that the globose tips of these organs stand at a considerable distance apart, and that their range is over a long line which is arched in the direction of the plane in which the file trends (cut 2). The eye,

Cut 3.

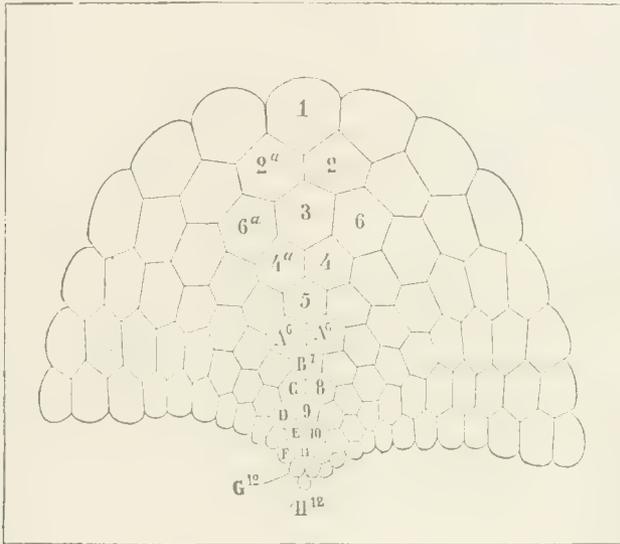


therefore, cannot take in the whole file of tips at once, but must pass from point to point, and in so doing the slight divergence from the plane is not noticed. Still it is possible to determine to a certainty whether a file is single, or double, or triple, or more; but we must confess that it was not until after we had become familiar with these bodies and their various attitudes, by long and painstaking observation, that we could come to any definite conclusion, even as to their general arrangement, much less in regard to their special taxis.

92. The clue to the one-sidedness of a group was not detected until the process of development had been traced in young animals. It is true that by following any one tentacle of a file down to its base, where it was in contact with others all around it, we could determine whether it originated from the same line as the others next to it in the apparently single row above; but the large number of the group taken together, and the crowded state of the numerous younger tentacles was a great hindrance to a true appreciation of their relations. The clue once discovered, though, in the young animal, it was no difficult matter to see the trend of the development of these organs, and a reason for the asymmetry of a bunch in the adult; but still, such were the obstacles arising from numbers, approximate identity in size, the convex surface over which they were spread, and in particular the mobility and unstable condition of this surface in the region where the younger tentacles were budding and growing, that it was impossible to determine the exact status of each one, either in regard to dimensions or relative position. This has been accomplished with the fullest satisfaction in the young (§ 149, 150, 155); showing, incontestably, that the older tentacles preponderate on that side of a group which lies next a partition, but the investigation was not carried on far enough to form a groundwork for the deduction of a mathematical formula of taxis, although it seemed quite probable that it was a rather high figure. Our diagram of the taxis (cut 4) of a group of an adult animal, must be taken, therefore, only as approximate and general. The value of the diagrams of development in the

young is positive so far as the relative age and position of the tentacles are concerned, and the reader will not do amiss to consult the paragraph devoted to their elucidation, while following out the description of the adult forms.

Cut 4.



93. The resemblance of the accompanying diagram (cut 4) to a segment of a honey-comb is obvious at a glance, not only in the relative position of the tentacles, but also in the shape of the outline of their bases. The proportions in size, however, are altogether different. Except on the periphery of a group, every tentacle is surrounded by six or, perhaps, sometimes five others, and, as they are all in contact, they naturally compress their bases into the polygonal forms which we have exhibited in the diagram. Those on the periphery are rounded on the free side, and consequently seem to prove that the many-sidedness of the others is due to a mutual restriction of their limits. The asymmetry of the group may be well expressed by comparing its outline to an anisosceles spherical triangle, projected on a plane in such a way that its longest side is convex and the two others concave. The longest side will then correspond to the distal border of the group, and the next longer will trend along that border which faces towards a partition. Generally speaking, the oldest tentacles lie nearest the convex or distal side of the figure, or rather, we might say, are embraced in the angle formed by the two longest sides; and the site of new developments is near the shortest side, or verges in that direction. When, now, the tentacles appear to be in files one may observe that they all diverge from about one point, and that that point is at the junction of the two shortest sides of the triangle. Of course it will be seen that those in one row alternate with those in the next on either side, and that, inasmuch as those on each side of any one file fit into the intervals, and actually meet at their bases between the succeeding tentacles of that file, a very slight divergence of two lateral rows may bring the globose tips so nearly into exact line with those of the middle one as to make them appear to form a perfect continuity.

It is a very noticeable fact that the tentacles on the distal side of a group are not the longest, nor, on the whole, the largest; and it is all the more remarkable and unexpected because some of them are the oldest, and usually appear to be the stoutest. This difference is most observable when a file is brought into profile (cut 2, p. 43); then the second, third, and fourth appear to be longer than the outermost one, and sometimes the third the longest of all.

94. *The form* (*figs.* 42, 54) of the tentacles in *Halicystus*, and we have good reason to believe in all Lucernariæ, is unique among Acalephæ. They do not taper. In the young this seems not to be so, strictly speaking, but that is when they are in a formative state; and even then we do not recognize the distinct taper which is so marked in the globe-tipped tentacles of *Coryne*, *Pennaria*, etc. When fully extended a tentacle arises from its base abruptly, with the proportions and form of a very slender cylinder (*fig.* 42), from twenty-four to twenty-eight times longer than thick, and terminates in a depressed globose mass (ϕ^2), the diameter of which is from two to two and a half times greater than that of the shaft (ϕ^1).

In very old specimens the globe (*fig.* 41) very commonly has three times the diameter of the cylinder, but from this downward, among the younger members of the group, the difference gradually diminishes (*fig.* 34) until it disappears, and the end of the shaft is merely rounded (*fig.* 54, A). A group usually presents more or less of a bristling look, as if the tentacles were rigid and inflexible. This is owing to the manner in which they comport themselves with reference to each other; always free from entanglements, notwithstanding their large number, and rising, with an abrupt, clear stretch, perpendicular from their arched foundation. Frequently the rigidity of a group is relieved by a graceful curving of the shafts all in one direction, as if by common consent, and again, without any apparent cause, they assume an angular port, the shaft being bent more or less abruptly, at one or two points, into a zigzag form. Occasionally we may see a tentacle undulated (*fig.* 36) from tip to base by numerous closely succeeding curves, which alternate on opposite sides with such regularity that they have the appearance of being the turns of a helix. The longitudinally ribbed surface is not real, but arises from the conspicuity of the bundles of muscular fibres which lie just beneath the outer wall. There is evidently such a limit to the extensibility of a tentacle that it can never assume the proportion of a mere thread, such as we see in *Hydra*, and the scyphostoma of the *Strobiloida*; and we are indeed inclined to believe that it is more restricted in this sense than in most Acalephæ. The form never passes beyond the proportions of a very slender cylinder, not even approximating a filament in the relations of its length to its breadth. By designating it as a slender shaft we express its relative dimensions in the best general terms obtainable. Its positive length is from one-sixth to one-fifth of an inch when the umbella measures one inch across. The contractility of these organs is also subjected to certain recognizable limits. When disturbed they usually retract so as to be quite thick in proportion to their length; and if the irritation is persisted in they may become still farther shortened, until the length is to the diameter as four or five is to one. The spheroidal tips do not seem to partake in the general contraction to any appreciable extent. The instinct of self-preservation appears to be exhibited by the consentaneous contraction and

inrolling of the tentacles, and a subsequent folding together of the sides of the umbrella (*figs.* 14, 15); whilst the activity demonstrates itself by a wide expansion of the body, a reversion of the periphery of the umbrella, and an extreme elongation of the tentacles (*fig.* 1). Any one of the latter is movable singly, or a number of them follow each other in one file, with a succession of quick, abrupt flexions of the tip toward the base, or, again, the whole bunch is carried toward the mouth by the arm-like corner of the umbrella; especially if the tentacles have come in contact with an object fit for food. The prehensile apparatus in this operation is to be found in the urticating organs (*cnidæ*, or *nematocysts*). Their structure and mode of action are fully described in the chapter on Histology (Chapter VII). Normally a tentacle is single, but now and then one encounters a double specimen; it may be forked from near the base, or at the ends, only the globose tips being double, sometimes one spheroid supports another on its side (*fig.* 38), or at some point of its periphery. Our figure (*fig.* 54, C) represents a tentacle which is double for about half its length. The prongs of the fork are scarcely smaller than the main shaft, and do not differ from it or the corresponding region of the other tentacles in any respect.

95. The *globose tip* (*figs.* 41, 42, 54, ϕ^2) is always broader than long, and is set, like a cap, on the end of the shaft, in such a way that the axis of the one coincides with that of the other. The form of the spheroid varies to some extent, but always, it would seem, at the end, where, at one time, it projects from the convex surface like a very low cone (*fig.* 42), or, at another time, it is considerably depressed (*fig.* 41) below the general level. The latter is particularly noticeable in the oldest tentacles, the depression being carried to such a degree that the spheroid has rather the appearance of a very thick disk with rounded edges. The thinness of the walls in such cases, and their consequent semi-transparency, has given rise to the assertion, put forth by some naturalists, that the tip of the tentacle is perforate. But that this is a mistake may be proved, not only by careful inspection, especially of the younger specimens, but also by the fact that the depression is frequently at the side (*fig.* 39), and, moreover, two and even three (*fig.* 40) occur at one time at diverse points on the periphery. They are formed at will, and are evidently due to the action of the muscle which immediately underlies the outer wall. The opacity of the spheroid of the largest tentacles is so great as to render it completely impervious to the powers of the microscope, unless it be compressed into an unnatural condition. Younger tentacles, however, are more transparent and allow a thorough investigation of this part without subjecting them to any artificial preparation. Its prickly and dotted appearance (*figs.* 43, 44) is produced by numerous nettling organs (*nematocysts*) which are embedded just beneath the surface, and the color and opacity are owing principally to the intercellular pigment masses which lie at the inner face of the exterior wall. This accounts for the fact that they are darker near the centre than at the periphery.

96. *The walls of the tentacles* are identical in number with those of the foundation from which these cylindrical shafts arise; but they differ considerably in certain qualities, such as proportionate thickness, and some minor details of organization. We have, then, in them direct prolongations from the opsophragma (¶ 61),

the opsomyoplax (64), the chondromyoplax (65), and the gastrophragma (75). Although the differences between the same walls in the tentacles and in the umbella are in certain points very great, the change from the one to the other is by no means abrupt, as may be seen while we enumerate and describe them, each in its turn passing from without inward. It would be well to bear in mind, during this description, that the tentacles are fully extended.

97. *The opsophragma* is the foundation of the outer wall (*figs.* 54, 90, 91, n^1) of the tentacles, and so far as the latter is confined to the shaft it has about the same thickness, excepting at its distal end, where it is slightly incrassated and forms the neck-like junction with the spheroidal tip. To complete its course, though, it enters the globose mass (*fig.* 54, ϕ^2), in fact it almost becomes the mass itself, since it forms so great a proportion of it; and yet it consists of but a single stratum of cells. This is effected by a very abrupt and enormous thickening of the layer, so great, indeed, as to equal fully one-third of the diameter of the spheroid. This leaves, then, only a central third to be occupied by the other walls and the cavity of the organ (see also *fig.* 48, ϕ^2 , n^1). The thickening (*fig.* 35, α^3) of the wall at certain points on the shaft, which is to be met with now and then, although quite rarely, is not of the same character as in the globose tip, but is a tendency to carry out what is so fully expressed in a normal way in the anchors (§ 166, etc.). But more of this when we come to the description of the latter. There are no adhesive vesicles in the tentacles. We have already spoken of the apparently furrowed and ribbed appearance of the shaft (§ 94), and referred it to the lumen of the underlying bundles of muscular fibres. At times the phenomenon is really on the surface of the outer wall, or within its thickness, and is produced by the peculiar action of these fibres, or at least it seems to be so, for along their course the cells of the wall in question are arranged in lines, and, moreover, they are elongated in that direction. It can scarcely be denied that the muscles are at the bottom of this singular feature, and also that they cause the wrinklins in lines running in the same course (see § 202, A).

98. *The tentacular muscles* are not only the most important element of the prehensile organs, but also the most conspicuous. As we have seen above, they lend largely to the physiognomical character of the shaft. We speak of this motor apparatus as muscles, and not as a layer, and we do this advisedly, for the fibres do not form a continuous stratum, but the latter is, as it were, split into strips or threads (see § 86), and these are grouped into bundles (*figs.* 90, 91, m^2) of two, three, or four. And again we notice that these fibrillæ do not lie in one horizon but are more or less superposed, and even mutually intertwined, thus warranting us in using the term fibres for their combined forces. Still there are here and there traces of a tendency to form a continuous layer, judging from the manner in which a fibrilla wanders now and then across the interval from one fibre to another. On the whole, the fibrous bundles run from the base to the tip of the shaft in parallel lines, and are so evident to the senses that they can be counted very readily. By a careful handling of these irritable creatures, taking the precaution not to disturb them by any sudden movement, but always slowly and steadily, and with no little patience, turning them from side to side, or even over and over, we have succeeded

in counting the number of fibres which lie in the circumference of the shaft of a tentacle. According to our notes there are, at least, as many as fifty in the oldest shafts.

99. In this connection it will not be out of place to say a word in regard to our method of avoiding the main obstacle in the way of preserving the natural proportions of the various parts of the organization. In the beginning of our investigations the constant and extensive contraction of the body was a source of annoyance whenever it became necessary to lay open any region with the knife. Finally we discovered that under persistent handling the body lost its irritability, and afterward it struck us that if we could but avoid or lessen the shock of contact the results would be not so violent. Upon this we always placed our instruments in the neighborhood of the body with caution, and sometimes took the pains to let the animal bring itself in contact with them, as if training it to the presence of a foreign object. Brass seemed to be particularly objectionable, even though it did not actually touch the body; probably tainting the water by decomposition, or perhaps by inducing electric currents in it. On the whole, well polished steel needles served our purpose best, taking care to renew them as soon as rust appeared on their surface. With these carefully ground down to lancet point and edge, many of our sections were made with scarcely a sign of impatience on the part of the animal. The slowness of the process was certainly trying, not only to the patience, but also to the endurance, for the utmost steadiness of hand was indispensable to success. Nor did we find that cutting with a very sharp instrument was as irritating as pressure with a dull one; the sharper the blade the less the resistance, and consequently a diminution in weight, and in the diffusion of it. We were simply applying a well-known physiological phenomenon, viz., the confused sense of the contact of two closely approximated points upon the surface of the sensitive membranes. After using the precaution to observe the exact condition of the region to be operated upon, and allowing the parts to recover from whatever little contraction they had been excited into, through the division of their substance by the scalpel, we could proceed with the confidence that whatever distortion might appear did not amount to more than the body could be supposed to assume in many of its most normal attitudes. Even the high muscularity of the tentacles did not prevent us from obtaining a fully expanded transverse section of the shaft, and applying a very high power to it. The crushing blades of scissors were always avoided if possible, although even these seemed not to disturb some parts of the body—the region of the chondrophys in particular.

100. The *chondromyoplax of the tentacles* (figs. 54, 90, 91, *b'*) is coextensive with the muscular system of these organs, and forms the next to the innermost layer, lying intermediate to the gastrophragma (¶ 75) on the proximal side and the opsomyoplax (¶ 98) on the distal face. It preserves all the characteristics of the foundation (¶ 65-68) from which it is prolonged, and we need not therefore repeat them here. In a fully extended tentacle it is not much thicker than the outer wall. Its depth is pretty uniform from the base to the end of the shaft, but diminishes slightly as it enters the globose tip. There it terminates in a rounded closed extremity, and contributes to swell the mass of concentric layers, all, like itself, per-

manently imperforate. At the bases of the tentacles this layer is uninterruptedly continuous from one shaft to another, but in the passage it varies largely in thickness (*figs.* 54, 60, *b*^v), since its proximal side is drawn out into heavy irregular ridges and bosses (π), which constitute the main bulk of the large solid, *intertentacular lobules* (§ 103). We should not forget to mention, also, that, as the distal tentacles of a group border close upon the line of junction between the circumoral and aboral parietes of the umbella, the chondromyoplax of the shafts comes to an abrupt terminus at that line; and, moreover, we would add, that the muscular fibres of these organs project from their basal ends and form a continuous stratum there, lying, like a partition (*fig.* 60, *k*¹), between the umbellar chondrophys (*c*) and the chondromyoplax (*b*¹). Laterally, as we have already pointed out (§ 84), it is continuous with the marginal muscular band of the umbella, but is, strictly speaking, homologous only with that part of its border which lies between the termini of the two gelatiniform layers just mentioned.

101. The *gastrophragma* or lining wall (*figs.* 54, 60, 90, 91, *i*²) of the tentacles is their thickest layer. Excepting a slight diminution at the apex of the shaft, we find this stratum has a uniform thickness throughout its length until we come to within a short distance of its base. Here a marked change takes place, and what was once an enormously deep wall, although composed of a single layer of cells, measuring from one-fifth to one-fourth the diameter of the tentacle, rapidly thins out (*fig.* 60, *i*, *i*¹) backward to the slender dimensions of the lining wall of the umbella soon after it passes beyond the entrance to the main cavity, in fact before it reaches the ends of the intertentacular lobules, where it is virtually the umbellar gastrophragma (§ 75). The proximal face of the lining wall of the tentacles is particularly well marked; not so much, though, by any inherent characters as by the dark, irregular pigment granules (*fig.* 90, *e*²) which crowd into the interstices and across the inner ends of its prismatic cells, lying so thickly as to almost tempt one into considering them bodily as a distinct stratum. They also serve to light up, by contrast, the boundary of the cavity which they cover, and they are eminently useful in assisting the eye to follow the continuity of this cavity into the umbellar chamber.

102. The *hollowness of the tentacles* is unquestionable, and more than that, they openly communicate (*fig.* 60, ϕ ³) with the main cavity of the body. It has been asserted by some naturalists that they communicate only with the lobules at their bases, which have also been described as hollow, and compared to the ampullaceous sacs at the basal ends of the ambulacra of Starfishes.¹ This is altogether untrue, the lobules being perfectly solid and, moreover, interbasal, instead of being direct prolongations from the tentacles. In the largest, full-grown specimens it is an easy matter to introduce the head of a fine cambric needle between these lobules and far into the cavity of the tentacles. It is true that the passage is not broad after the entrance has been fairly made, but it is quite distinct in the young, where the lobules are not developed until some time after the first tentacles appear, and the entrance to the tentacular cavity is quite broadly open; and the same may be observed among the budding tentacles of old individuals.

¹ Milne-Edwards and Haime, *Hist. Corall.*

103. *Intertentacular lobules* (*figs.* 54, 56, 60, π). The reader, no doubt, has learned by this time that these bodies are internal prolongations of that part of the parietes of the umbella from which the tentacles take their origin. Their relative position in regard to the latter might well lead a hasty observer to infer their similarity to the ampullaceous sacs of Echinodermata; but no very prolonged investigation is needed to determine that they have not the form of sacs, and that they are irregular, thick ridges which here and there anastomose into a sort of network (*fig.* 56), and send out, from scattered points, more or less flattened, irregularly oval lobular processes. The general trend of the plane of the greater diameter of the latter is parallel with the anterior and posterior parietes of the umbella. The depressions between the ridges of the network are the vestibules of the entrances (ϕ^3) to the tentacles; and the lobules, with their ready flexibility, suggest a valvular function which they might perform about these apertures. They consist of only two layers (*fig.* 60), the gastrophragma (i^3) and the chondromyoplax (b^i), and neither of these is strictly muscular, although we have elsewhere (§ 65, 196) suggested that the chondromyoplax is only one undeveloped portion of the muscular layer (opsomyoplax). That would seem to be true here, if we may judge from the irritability and activity of these bodies; or it is possible that the gastrophragma is underlaid by an excessively thin muscular stratum which has escaped our eyes. The surface wall, or *gastrophragma* (i^3), has the same dimensions as in the more open areas of the general cavity, but is particularly characterized here by the dense deposit of pigment matter over its surface. This accounts for the dark patch of color so noticeable at the proximal bases of the tentacular groups, and which remind one of eye-spots, as the body is viewed from in front. The *chondromyoplax* (b^i) is an actual thickening of the mass with which it is continuous, and not a lateral projection from it; so that the length of a lobule is the measure of the depth of this layer. This is proved by the course of the fibrillæ, which pass in direct lines from the distal surface—lying between the bases of the tentacles—to the innermost free ends of the lobules.

§ 13. *The marginal adhesive bodies (Colletocystophora)*, *figs.* 17, 22, 23, 24, 25, 37, 45, 47; α to α^8 .

104. *Form and Position.*—The most attentive examination of an anchor in its extreme old age would not lead one to suspect that it was once a mere tentacle in form, proportions, and general structure. The proofs that this is so may be found in abundance in the section on Embryology (Chapter VI). We only wish, here, to draw the parallelism for the sake of their homological relations to the regions of the umbella when compared with the tentacles. There are eight of these bodies attached singly (*figs.* 17, 22, 37, α) to the eight intertentaculiferous margins of the umbella, exactly half way between the angles (ψ^4) of the octagon. Those four which lie opposite the partitions of the umbella are slightly longer than the other four, and the average length is about equal to the diameter of the peduncle. They consist of a short, thick stem (*figs.* 23, 24, α^1), or neck, supporting a heavy, flattened, ovate mass (α^3). The neck is attached to one of the flattened sides, and

near the broader end, at an acute angle to the longer axis of the oval. A profile (*fig.* 23) of the anchor reminds one of the spheroidal tip of a tentacle, asymmetrical in outline, and attached obliquely to a shaft which is broader than it is long. Defining the contour of the ovate mass more closely we should say that it is convex on the distal or posterior face, and hollowed by a broad furrow (*fig.* 24, α^6) which trends along its mid-line, on the proximal or anterior face; it is, on the whole, comparable to a date-stone, leaving out the greater proportionate length of the latter, since the ovate mass of the anchor is scarcely more than half again longer than broad. In their usual attitude the anchors are reflexed posteriorly over the margin of the umbella to a greater or less degree, and sometimes so strongly that from one-half to two-thirds of the ovate mass is hidden from sight when the body is viewed from in front (*fig.* 22). The anchor proper is altogether an offspring of the anterior parietes of the umbella, but a part of what appears to form the stem is a projection or ledge (*fig.* 25, β^1) stretching out from the border (β) of the posterior parietes. The line of junction between the ledge and the true stem is clearly marked by the margin of the muscular layer.

105. The stem of the anchor contains all the elements of the shaft of a tentacle, and these were originally disposed in like manner; but at the present age they are considerably altered, principally in their direction. This applies in particular to the muscular fibres, which are so conspicuous as to demand attention among the general features of these organs, and, indeed, were it not for them the singularly oblique attachment of the stem to the margin of the umbella would readily escape casual observation. They produce the effect of a striation (*figs.* 23, 25) on the surface in the same way that the ridges of the opsoomyoplax appear like striæ in the umbella (§ 81). By following these striations in their course from the marginal band (*fig.* 25, m^1) outwardly it will be noticed that they converge considerably, so as to form a sort of isthmus (m^5) directly opposite an anchor. Here the striæ are parallel for a short distance and then diverge as they run out toward the ledge (β^1) above mentioned (§ 104). The divergence grows stronger as they proceed, and gradually those along the borders of the isthmus pass obliquely around the neck (*fig.* 23, α^1) in two opposite directions, following the edge of the ledge, until they meet on the distal side, and then, like those nearer the middle of the isthmus, pass on directly to the ovate mass (α^3). Between these two extremes there are, of course, all possible grades of obliquity, and consequently the neck or stem appears as if it were twisted, when seen in profile (*fig.* 23). This portion of the anchor is very short, not more than one-half or two-thirds as long as it is broad. It is apparently longer, but that is because the ledge from the chondrophys sets it out from the umbellar margin, and, moreover, under a moderate magnifying power, it seems to form a part of it.

106. The ovate mass (α^3) is also the homologue of the shaft of a tentacle, but it is so disguised as to deceive and mislead the observer who is not familiar with its successive stages of development, and very naturally might induce one, in that case, to see more than a mere resemblance to the spheroidal tip of a tentacle, and set it down as a homologue with the latter. That would indeed be far from correct, as we shall now show by pointing out the remnants of what was once a distinct,

spherical, nematocystigerous tip to an equally well-proportioned shaft. If the broad median furrow (*fig.* 24, α^6) of the anterior face of the ovate mass, be followed outwardly toward the distal end, it will be noted that it gradually becomes less opaque than the area adjoining, and finally assumes a semi-transparent appearance for a short distance before it terminates. In the middle of this semi-transparent area (*fig.* 25, α^5) there is a dark spot, which some observers in their haste have mistaken for an opening, supposing the darkness to be the pigment mass lining the interior of the cavity of this body. So far, though, from being thus, the dark spot is not only the surface of a solid, but that solid is slightly elevated above the area in which it is set, as one may see by glancing along the furrow, when it will appear as a spheroidal mass (α^2) imbedded on the top of a low boss, or truncate cone. Here again we meet with the striæ noticed on the neck, but not so strongly marked, yet sufficiently distinct to be traced along the semi-transparent area and upon the boss to the margin of the spheroidal mass. We hardly need say that the latter is the homologue of the globose tips of the tentacles. In extremely old animals the boss, even, is obliterated, and the spheroid is sunken into the face of the semi-transparent area, but is still distinctly recognizable by the numerous nematocysts which are embedded in its substance (*fig.* 47, α^2). It is not then the globose tip of the tentacles that we find here metamorphosed into an immense ovate, swollen mass, but a part of the shaft lying intermediate between the base and the end of it.

107. Keeping in mind, now, that the stem is attached obliquely to the broader end of the ovate mass on its posterior side, and that the spheroidal tip has been found at its narrower, distal end, and on the *anterior* face, we are prepared to understand that this mass trends obliquely to the longer axis of the whole, *i. e.*, the shaft, and completely encircles it in the form of a thick, broad, ovate, pad-like ring. The breadth and depth of this mass is not altogether due to the thickness of the ovate ring, but is in part accounted for by the very considerable extent of the cavity (*fig.* 47, α^4) of this organ, occupying not less than one-third of its diameter. Like the tentacles, the anchors are capable of expansion and contraction, but not to as great a degree. In the common run of adult specimens they are slightly knobbed or have an undulating outline, but in the very old ones they are deeply puckered, as if shrivelled, reminding one of a dried prune or raisin. Their color and opacity are the result of the combination of two distinct sets of pigment matter; the one lying near the surface, constituting the large, dark nuclei of the cells of the outer wall, and the other seeming to form a layer on the interior face, but in reality embedded in the lining wall, occupying in it the place of nuclei of the cells. The adhesive vesicles (¶ 208, A) which are buried just beneath the exterior surface add a little to the opacity; but being colorless, they are not conspicuous, notwithstanding their large numbers.

108. It is no difficult matter to expose the entrance (*fig.* 45, α^5) to the cavity of the anchor and at the same time prove that it has, like the tentacles, an open communication with the wide chambers of the umbrella. There are no intertentacular, internal lobules here to obscure the view, and if one wishes to verify, by the tactile method, what has been ascertained with the eye alone, it can be readily done by cutting and raising a flap of the anterior parietes of the umbrella, so as to

expose the internal base of the organ in question. Then one may either look directly into the passage way, or, if there be any suspicion that it is closed by a transparent membrane, the head of a fine needle can be thrust into it. We have fully satisfied ourselves, by all of these methods, that there is here a direct, smooth, and widely open passage leading into the cavity, and that the latter is not subdivided in any way, but is tolerably uniform in its length and breadth. In the stem the passage has rather the character of a channel, and expands quite rapidly into a tolerably wide chamber (*fig. 47, α^4*) soon after it enters the ovate mass. The chamber occupies the middle third of the shorter diameter of the mass, and lies at about an equal distance from the external surface both at its sides and at its distal end, yet approximates rather more closely to the anterior face.

109. *The walls of the anchors (fig. 47)* are remarkable for their great thickness at nearly all points; and if there is any exception to this it is to be found in the region which is homologous to the thickest part of the tentacles. The process of development is just the reverse in the two organs; in the tentacles the whole tendency is to give the nematocystigerous tip a preponderance in point of size and in the thickness of its walls; whereas, in the anchors, the greater weight is thrown into the midregion of the shaft, both in reference to its general amplitude and the incrassation of the walls, whilst the nematocystigerous tip (α^2) is gradually reduced to comparative insignificance, a mere reminiscence of its type. It is remarkable that we should have in these organs a repetition of that singular irregularity in the thickness of the walls which is so prominent in and about the adhesive disk at the caudal end of the body. Here, as there, the peculiarity is confined to the two innermost layers.

110. *The outer wall (fig. 47, n^2)* is a direct continuation of the opsophragma of the umbella, but is much deeper than the latter over the greater part of the stem and ovate mass. On the anterior face of the stem there is very little, if any, difference, but upon passing around toward the posterior face, and outward also into the ovate mass, the wall thickens rapidly to triple, quadruple, and even sextuple the measure in the first place mentioned. There is considerable variation in thickness at diverse points, but it is quite systematic in this respect. Along the broad median furrow it is thinner than anywhere else on the ovate mass, not being more than two and a half to three times the depth on the stem, and even this proportion is lessened greatly in the semi-transparent area at its distal end, until it actually falls below what obtains on the umbella. In the remnant of the nematocystigerous tip (α^2) of the tentacle the wall rapidly thickens again to equal the greatest measurement along the proximal end of the furrow. Passing laterally, from the midline, around the mass, the depth increases gradually until it reaches the maximum, sextuple measurement mentioned above. Where the anterior and posterior parietes of the umbella meet, at the distal side of the base of the anchor, the outer wall thins abruptly just as it joins the ectophragma (*fig. 63*). The adhesive vesicles (*colletocysts*) which form the main characteristic of the functions of the anchor, notwithstanding their multitude, have nothing to do with increasing the thickness of the wall; they are merely superficial adjuncts to its mass, while the

long prismatic cells which extend through its whole depth are the prime, and only elements concerned.

111. *Anchor muscles* (*fig. 47, m³*). The peculiar arrangement of the fibres of the muscles has already been indirectly described when tracing the course of the oblique striæ on the stem, and in the semi-transparent area (§ 105). After stating that they are identical in character with those of the tentacles, we have very little more to add, and that is principally in regard to the thickness of the layer, if it may be so called. The fibres are not so widely separate as in the tentacles, and consequently approach, in their combination, more nearly to a continuous stratum. They certainly are much heavier, and wherever a section runs along a band, the muscle appears much thicker. The mode of its termination and intrusion (at *k¹*) between the approximated margins of the chondromyoplax (*b²*) and chondrophys (*c*), at the distal side of the base of the anchor, is the same as that of the tentacles, in a general sense, but differs somewhat in the trend, since it does not lie so obliquely, but traverses the intervening space much more nearly at a right angle to the surfaces of these layers. Not alone, though, do we find this intervening muscular partition at the distal side; it is also to be traced all along the border of the ledge (*fig. 25, β¹*) of chondrophys which supports the stem, and thence inwardly, skirting the "isthmus" (§ 105) of muscle which joins the marginal plicate band, and becomes continuous with the similar curtain which that band protrudes (§ 82) between these gelatiniform layers, at all points of the periphery of the umbella.

112. *The chondromyoplax* (*fig. 47, b²*) of the anchors exists in a far more bulky proportion than in any other region of the body, unless we consider that in the proboscis as its equal in this respect. It lies in exactly the same relation to the other walls as in the tentacles, but, unlike it, has but one regular face, the outer one, whilst the inner contour is constantly changing its direction, at one point running deeply into the gelatiniform mass, sometimes plunging almost through its thickness, and then retreating at an acute angle back to its former level. The acute angled sinuses, that are so prevalent in the section which we have illustrated, are the expressions of as many conical pits and lateral diverticuli. They are abundant in all parts of the colletocystigerous mass, but fail in its stem. Along the anterior side of the latter the chondromyoplax is only a little thicker than in the thinnest parts on the umbella. From this region it thickens rapidly, going in two directions, one around the stem, and the other directly out into the ovate mass. Within the latter its general depth, leaving out the points occupied by the conical pits, varies but little, and is about two-thirds that of the chondrophys (*c*), just behind this organ. At the distal side of the stem it is fully as thick as the edge of the chondrophys which lies next to it; or nearly three times its own measure at the anterior side of the stem. The mode of termination at this point is the same as along the umbellar margin (§ 66), but it is not penetrated by ridges of the muscular layer as in the latter.

113. The *gastrophragma* (*fig. 47, v¹*) of the anchors is remarkable for its extreme thickness, and the singular character of the prismatic cells which compose it (see § 211). Within the limits of the stem it is only a little thicker than in the broad camera of the umbella, but just as it enters the cavity of the ovate mass it rapidly

increases to its maximum depth, which is, on the average, fully, if not more than, one-half that of the chondromyoplax (*b*). It is rather irregular and undulating on its inner free surface; and on its other face it varies exceedingly, according to the irregularities of the chondromyoplax; filling every conical pit and diverticulum of the latter as if it had been moulded upon it. The chief peculiarity of this layer rests in the histological elements, and to that section of the subject the reader must therefore turn for further information in regard to the more intimate structure of the organ.

§ 14. *The Caudal Adherent Disk* (*figs.* 17, 18, 19, 37, 46, 51, γ).

114. The place which this part of the body holds among the organs is not so much due to its being a distinct anatomical form, as to the fact that it is the basis of certain functions which it performs in common with the anchors. Still its construction is such that it is evidently something more than a mere caudal terminus. Whether we look at it as a means constructed and adapted to a certain end, or as a means which has found itself best fitted for the purpose to which it is now put, it matters not; creative ingenuity would appear just as potential in the one case as in the other. The simplicity and slight differentiation which the organ—if we may so call it—presents, renders it none the less capable of doing what it, ostensibly, is intended to do than if it were the most highly complicated of all the systems of the body. Differentiation does not necessarily tend to the better performance of any one duty, but to the separation of two or more functions which may have been confided to the care of some organically simple organ. Every physiologist knows that, although the nutritive system of the highly complicated vertebrate animal is subdivided into an intestinal tract, to break down the food, etc. etc., and a set of bloodvessels to carry the absorbed nourishment to the tissues, these tissues are no more faithfully and thoroughly supplied with nourishment than those of the simple Polyp whose general cavity is both a digestive system to prepare the food for absorption and a circulatory system to bring the assimilable matter into contact with the tissues.

115. A very slight modification of the form of the caudal shaft suffices to give it the appearance of an official character, although we can readily conceive that it could perform its present duty without its discal expansion. The comparative extent of adherent surface would be the only element concerned. A change from a truncate terminus to a rounded or pointed one would make a great deal of difference as to the nature of the substance adhered to, whether flat or irregular. This species always elings to flat surfaces; and, as it lives where the currents and wave action are very strong, its expanded disciform tail seems to be eminently adapted to increase its power of resisting the tractive force of the moving water. The principal modifications of the layers of the shaft in the formation of the adherent disk consist, in the first place, in a rather abrupt expansion of the whole, followed immediately by a sudden changing of the course of the outline to a direction at right angles to its previous trend; virtually truncating the caudal terminus. The corresponding internal changes are noticeable chiefly in the ectophragma (*fig.* 19, *f*²)

and the muscular cords (*fig.* 46, *r*). In the former it consists in a thickening of its mass to double its measurement on the shaft, and the embedding of adhesive vesicles (colletocysts, *a*) just beneath its outer, free surface. These cysts are very numerous and tolerably well crowded all over the flat face of the disk, but do not extend forward beyond its edge. The sucker-like shape of this organ is not, therefore, indicative of a sucker-like function on its part, and the power of adhering to bodies by its mere edge confirms the most warrantable inference, that the cysts are the true organs of adhesion. Some minor modifications are yet to be mentioned; but as they are already described in previous paragraphs (54, 63) on the form of the peduncle they need not be repeated here. The same may be said in regard to the muscular cord, which is described in paragraphs 59 and 88, but we will draw attention to the position of the two main furrows which cross each other at right angles (*fig.* 18, γ^1) on the face of the disk, as corresponding to the line along which the muscular cords (*fig.* 19, *r*¹) run. These furrows are but continuations of the four which trend at equal distances apart (ninety degrees) along the shaft, opposite the muscles, toward the umbella, and become there slight depressions, opposite the partitions, extending to the periphery. The most obvious relation of the furrows to the muscles is one of cause and effect. The muscles must have a *point d'appui*, and the furrows are simply indicative of the line of traction, which is nearest to the point where the contractile force is least expanded. From these lines it diffuses systematically all over the body. The minor furrows (*fig.* 18) on the disk, anastomosing into a network, probably correspond to the greatly varying irregular thickness of the chondrophys (see ¶ 57, 58, 72), which tends to become bent and folded in the direction of the lines of the least rigidity when the muscles, which are embedded in it, are contracted. The same feature is observable in the highly muscular anchors, in which we have also described a great inequality and want of regularity in the depth of the chondromyoplax.

§ 15. *The Digitiform Bodies (Digituli).*

116. *Form* (*figs.* 47^a, 65, 80, 98, 99, 100, 101). Notwithstanding the apparent relation of the *digitiform bodies* to the reproductive organs they are preëminently allies of the exterior prehensile organs, and, therefore, are most fittingly described here, no matter in what connection or for what purpose they perform their duties. The position and form of these bodies have already (¶ 52) been described in a general way, but the peculiar features for which they are so eminently remarkable remain to be illustrated here. Their elongate lanceolate outline is only observable when the flattened sides (*figs.* 47^a, 65) are turned toward the observer. Seen thus they appear narrow at the base and gradually expand to about their midlength and then as gently taper to a rounded point. Viewed at right angles to this (*fig.* 98) they taper, from a slightly constricted neck, uniformly to the tip. The thickness, at the broadest part, is to the breadth as one is to four or five. Usually they are single, but occasionally two or even three have a common stem for a short distance (*fig.* 65), and these pass on separately with the same form as the single ones. They are capable of a great range and variety in form and proportions. At one time they

are very slender and extend far out of the mouth of the proboscis, and at another, they are shortened down to broad, ovate bodies with blunt tips, and more than usually convex sides, approximating to fusiform. As to flexibility they seem to be unlimited, and so in regard to plasticity; now coiling like a mass of suckers, in an apparently indissoluble tangle, or spreading laterally, and folding at the sides, assuming a deeply concavo-convex shape, as if a sac with a wide lateral aperture. In the latter condition they have a wonderful resemblance to the laterally opening genital sacs. We have illustrated the two, side by side, at the time when the *digituli* were in the sacciform attitude (*fig. 80, n, s*¹). It would be difficult to state precisely what their size is, still there is probably a limit to it. When they elongate they also become more slender, and when they shorten they also widen, at a corresponding rate. An average length is about equal to the greatest breadth of a triangular genital half, or half as long as a fully extended tentacle.

117. *Function*.—The flattened lanceolate form of these bodies is by no means independent of other characteristics, of which there are two principal ones. In the first place the broad faces are turned respectively toward and away from the proboscis, and in the second place, *that face which looks toward the proboscis is covered, except near the tip, with a dense layer of colletocysts (fig. 98, A), while the opposite face and the excepted part of the other side, are beset with nematocysts, and heavily clothed with vibratile cilia (B, C)*. Between these two sets of organs there is a sharp line of demarcation, and evidently, from the nature of their constituents, devoted to quite diverse functions. The proximity of these bodies to the proboscis and their occasional protrusion from the mouth, conjoined with the presence of colletocysts and nematocysts, all tend to indicate their use as prehensile organs, either in the transfer of food inwardly, or in the removal of material, fecal matter, or perhaps eggs, from within outward. Their adhesive powers are great, and their urticating organs are numerous, and no doubt serve more efficiently than the tentacles to reduce the struggles of prey, shrimps and other animals, and bring them into manageable condition for being thrust into the lateral camerae of the umbella.

118. *The Gastrophragma*.—The walls of the *digituli* are direct prolongations from the three innermost strata of the anterior umbellar parietes. The *gastrophragma* is doubled in thickness as it becomes the peripheral layers (*figs. 98, 99, 100, i*⁶) of these bodies. Its inner as well as exterior outline is sharply defined, particularly on the side (A) facing toward the proboscis, because it is there composed almost entirely of colletocysts (*a*), with their dense, semi-opaque, granular contents. Toward the tip (C) its inner surface is rather irregular and somewhat thicker than elsewhere.

119. *The muscular layer (h)* is the only division of the *gastromyoplax* (or *oömyoplax*) which is not exclusively devoted to the genital saccules. It is very thin, almost filmy, scarcely measuring one-sixth the depth of the gastrophragma, and then only where it is thickened into ridges. The latter appear, with a low power, to be coarse longitudinal striæ, but a closer examination, with a higher amplification, proves them to be interrupted ridges (*fig. 99, h*), trending parallel-wise to the longitudinal axis of the *digitulus*, along the exterior surface of the

stratum. Their average distance apart is, as we may judge from the drawing, about equal to the measure of the thickness of the gastrophragma.

120. *The Chondromyoplax* (b^1 , see also 196).—We have every reason to believe that the fibrous prolongations which traverse this mass are direct emanations from the muscular layer (h^1), and that the amorphous portions of the chondromyoplax constitute the interstitial cytoblastema. There can be no doubt that fibres do pervade this mass, and, from analogy—with facts which we have observed in regard to the development of the chondrophys in the young Lucernariæ, and other Acalephæ—we do not hesitate to judge that they are part and parcel with the muscular layer which lies on the surface. The *chondromyoplax* (b^1) and the *gastromyoplax* (h) are here but two subdivisions of one layer. In passing we would add that in the *digituli* of young Aurelia-medusids the subdivision is much less marked than here, in fact leaving no room to evade the conclusion which we have come to in the present case. If this be true here, it would seem, of necessity, to be so throughout the anterior parietes of the umbrella, but the subdivision is more nearly complete than in the *digituli*, and there is a higher specialization of the muscular layer, as evinced by the systematically arranged ridges, which tends to indicate a separate function for each, the one contractile and the other simply *resilient*. In the Lucernariæ these functions incline to blend, as far as their areas of action are concerned, and in the medusoid of Aurelia they are completely intermingled in that respect. Although the *digituli* are, like the internal intertentacular lobules (§ 103), prolonged from the circumoral parietes of the umbrella, their internal arrangements are quite diverse from those of the latter; since in the former the fibrillæ run across the longer axis of the gelatiniform mass, and consequently at right angles to the trend of their homologues in the circumoral chondromyoplax. At the base of these organs the transition of the trend of their fibrillæ into that of the umbellar chondromyoplax is gradual, just as it is in the genital saccules, and likewise in the same manner. It should be noted, in particular, that not only do they traverse the gelatiniform mass at right angles to its longitudinal axis but that their trend is from one broad face of the *digituli* to the other (fig. 100, b^4).

121. *Résumé*.—The amount and diversity of differentiation in these bodies doubtless surpasses, by far, anything of the kind in the whole class of Acalephæ; at least it would seem so since some of the highest forms which we have examined fall short in this respect. This tendency to outstrip its allies in special points, while failing to equal them in other respects, is everywhere characteristic of the comprehensive types. Among the Selachians we find the sharks imitating the placentation of the Mammalia, in this respect, therefore, rising above Reptilia and Aves. They doubtless surpass the Teliosts in every respect, except in the skeleton, and they fall short there only in the lack of hardness of the bone, but rise far above them in the conformation and differentiation of that system. In the Annelida a complete sanguineous circulation, but without distinct walls, is the premonition of a more fully developed system in the Arachnida; but this is almost lost in the perisplanchnic diffuseness of the hexapod Insecta. But, if Blanchard be right, the peritracheal circulation reproduces what is lost, in another, and

perhaps higher form, the blood going to the respiratory surfaces in distinct tubes, after the manner of the Vertebrata. Again, and finally, there are the Cystideans, prototypes of the Holothuria Apoda, and, if we mistake not, the genuine progenitors of Holothuria, exhibiting, like the highest of the latter, the clearest bilaterality and a strong reduction or suppression of the dorso-ventral repetition of parts. Their sedentary condition and a certain want of regularity and definiteness in the arrangement of their plates, are indicative of their inferiority, at least in the latter respects, to those Crinoids which have been disposed in systematic order. In our Lucernarian there is very little left, in point of inferiority, that debars it from taking the highest rank among Acalephæ. On a former occasion¹ we have placed the Lucernariæ—in a tabular view of their systematic position—as if intermediate in rank between the *Steganophthalmata* and the *Gymnophthalmata*. We think now that it would be doing better justice to arrange them almost on a level with the *Steganophthalmata*, overlapping their lower ranks, as it were, but failing to come up to the horizon of the topmost grades. But we are anticipating what we shall present in regard to this matter in another chapter (Part X), and we have yet in reserve more matter of equal interest to those who are curious to know what the status of our Acalephan subject may be. We have allowed ourselves to be diverted into this digression merely for the sake of laying heavier stress upon the quality and value of the singular diversities of differentiation in the *digituli*, while the mind is fresh from the work of investigation. Let us, therefore, recapitulate their prominent features in brief terms, and then proceed to the subject of the next section. In the first place they are lanceolate and *flat*. That leads to a survey of their position, in which we find their broad sides systematically facing toward and away from the proboscis. Again, these broad sides are diverse in character, the diversity of one kind always on the corresponding side: for instance, the one bearing the colletocysts facing toward the proboscis, and the other, covered by vibratile cilia and bearing nematocysts, facing in the opposite direction. Then there is the muscular layer more pointedly separated from the chondromyoplax than in the *digituli* of Aurelia, and doubtless others of the same order. And, finally, not only do the fibrillæ which traverse the chondromyoplax trend at right angles to those in the circumoral parietes, but they stand in very exact relations to the form of the *digituli*, trending directly from one broad face to the other, as if linking the layers of colletocysts and nematocysts to each other.

§ 16. *The Digestive System.*

122. *Forceal Homologues.*—We have scarcely anything to do here in the way of a description of the digestive system, since nearly all that is concerned in it has been so thoroughly delineated from another, or several points of view as to render further illustration entirely superfluous. It will suffice, therefore, if we do no more than enumerate the several regions of the body which take part in the

¹ Lucernaria the Cœnotype, etc., ut sup., p. 22.

function in question; and this is absolutely necessary to a proper understanding of the limits of this system. That an Acaleph is possessed of a stomach or chymiferous cavity distinct from a general chyliferous chamber can only be asserted, even in part, by admitting, as we certainly do not, the Ctenophoræ into this class. That the Ctenophoræ have these two cavities is enough to rule them out of the circle within which the Strobiloida, Lucernariæ, and Hydroida are included. The peculiarity of Ctenophoræ approximates them, in this respect, *i. e.*, functionally, to the Polypi; and some naturalists have even gone so far as to assert that they belong there. We must confess that we do not see the faintest glimmer of a reason for so doing. Those who are accustomed to making forced homologues, by supposing this a little changed, and that a little something else, and the other not quite so much so, and everything else a tithe otherwise than what it really is, can easily twist the ideal Ctenophore completely out of its type, even, without knowing it, and with a logical (illogical) jump land in the midst of a totally different category of relations, and yet suppose that they have been standing still all the while.

123. *The Digestive Cavity Monomerous.*—The Lucernariæ also have been classed among the Polypi by all early observers, and even at this late day a place is claimed for them there by some naturalists. The character of their digestive system alone is enough to debar them from such an alliance. They challenge the closest homological comparison with the Acalephæ, as we have limited the class above, and no one who is at all familiar with their structure can fail to see their intimate relationship with them. The food does not digest in the proboscis (*fig. 37, ρ*), but is transferred to the post-buccal or central cavity (ψ^6), and even to the lateral camerae (ψ^1) of the umbella. We have often noticed, in the latter place in particular, quite large shrimps undergoing the process of breaking down. There is, therefore, no subdivision of the digestive system into two parts, as in Polypi and Ctenophoræ. The food enters the mouth and glides through the proboscis (*fig. 37, ρ*) as if the latter were a mere conduit. It can scarcely be called anything else; assuredly it does not present the appearance of a digestive organ, for of all parts of the digestive system it is the least endowed with anything in the form of interstitial pigment or brown glandular-looking matter; and so far from being narrowed at its posterior end, it opens widely there, and passes insensibly into the general central cavity (ψ^6). We might even say that the digestive surface of the system is more diffuse than in the other two orders of Acalephæ; for in them the heavy, large masses of food cannot gain access to the lateral passages of the umbella, the so-called chymiferous tubes. There is, then, in the latter a closer approximation to that subdivision which obtains in Polypi than exists in the digestive system of Lucernariæ. Neither is there any dividing line, structurally speaking, that separates the four camerae (τ^3) of the peduncle from the general cavity. There is a slight constriction of the breadth of space at their entrance (τ^4) and for a short distance posterior to that, but nothing that approaches to a valvular apparatus, nor anything of the sort. In *Calvadosia*, *Lucernaria*, and *Manania* the caudal chamber is single, and passes with widely spreading walls insensibly into the general umbellar cavity. There is also very little or no restriction to the entrance of the umbellar fluid into the tentacles and anchors of *Halicystus*. If we look for accessory organs to the main digestive cavity, we meet with no glands, nor anything that approaches such a

structure; unless we hold the pigmental interstitial matter in that category, and even that is most abundant in the regions farthest removed from the centre of action, where it is supposed to be in greatest demand.

124. *Rank.*—In regard to the rank of the Lucernariæ, as affected by the conformation of the digestive system, the first thought would be to consider it as indicative of a low grade, because of its apparent diffuseness and want of subdivision into the central cavity and chymiferous tubes, as in the majority of the members of the other orders. There may be some truth in this, but it probably does not affect their status to such an extent as might be supposed. We have spoken of this diffuseness as *apparent*, and so we would seem to be warranted in doing if we assume certain features in the other orders as *criteria*; for instance the digestive system of the highest of the Strobiloida, viz., *Rhizostoma*, *Cyanea*, and their immediate allies. We do not think that the Lucernariæ should be compared with the incipient *ephyra-stage* of the Strobiloida, because the latter happens to have broad pouch-like camerae. There is a similarity but not a homology in their forms; but the latter becomes a reality, as far as their different ordinal relations will allow, when the circular tube is developed in the *ephyra*. But when that takes place the young creature is then on the way to a higher status, and that very process of going upward is one in which the digestive chambers are becoming more diffuse, less circumscribed, and tending to run all into one broad-spread cavity. This is the condition of things in the *Rhizostomidæ*, and *Cyaneæ*, while in the confessedly lower ranks of *Aureliæ* and *Pelagiæ* the diffuseness is least.

125. *Retrograde Metamorphosis.*—Perhaps all this may be explained on the score of a partial, digestive retrograde metamorphosis; and if so, it must be a tendency to a reversion to the simplicity of the *Scyphostoma*. But we are not willing to admit the verity of that commonly received phenomenon. So far from being a *retrograde* metamorphosis, we doubt very much if any case of the kind that ever came to hand was either more or less than a mere *mimetism*. This is our theory of the so-called retrograde metamorphosis. In every case which we have examined we found that the organization, instead of retracing its steps, actually took long strides forward. The nervous system of *Cirripectia* is a notable instance. The nervous system also of the *Acaridean Linguatula* is in advance of the same in its normally shaped colleagues; its vermiform outlines do not bear out the idea of the correspondence of form to internal structure. The so-called retrograde metamorphosis of the feet of the Loggerhead, and other marine turtles, from their embryonic, short, stumped, terrestrial form to the elongate, fin-like flapper, with completely inclosed digits, is a mere disguise; and curiously enough a *mimetism* of the limb of a higher type, a *Cetacean*, while it actually surpasses it in point of structural development; in fact retaining the principal elements of the limbs of its terrestrial congeners, the apparent retrocession being simply an external feature resulting from a mere elongation of the bones, and their adaptation by conjoined, consentaneous action to another kind of locomotion. And so we might go on with innumerable instances, but we have ventured to digress only far enough to illustrate our views in regard to the apparent inferiority of the digestive system of *Lucernariæ*, and do not wish to make an entire treatise upon the subject. If there is anything

meant by this apparent diffuseness it is a mere *mimetism*, while its simplicity is in all probability a form of unity and concentration. There is certainly a far less prevalent repetition of consimilar parts than in any of the *Strobiloida*. Were it not, indeed, for the strong indications of a special nervous system, as evinced by the highly developed optical apparatus in that order, there would be hardly anything left to rank it above the *Lucernarie*.

126. Neither a *circulatory* nor a *respiratory system* can be said to exist, *per se*, in the *Lucernarie*. The effect of these functions is produced, no doubt, at the same time that digestion takes place. The three are mere subdivisions of the process of nutrition and waste, according to modern theories of the physiology of the higher animals. Our *Lucernarian* stands in the same rank in regard to these subdivisions that the embryo vertebrate does, at the time when its nervous system is just dawning into existence, and the embryonic disk is nourished directly by the metamorphosis of the vitelline, subsidiary strata; when there are no vessels to carry material to the newly forming tissue, and no allantois to spread out these vessels over its surface, in closest proximity to the air.

§ 17. *Nervous System.*

127. *The Eye-spots* (*figs.* 26, 27, 32, 83, 9).—We are cognizant of the existence of a nervous system, or rather, we should say, of a nervous sense, by inference rather than by an actual view of anything tangible. Our deductions are drawn from two sources; the one comprises the action of the animal for a determinate end, and its irritability, and the other is represented by the *eye-spots*. The latter is the only legitimate basis upon which to found a nervous specialization, and that, even, is excessively meagre. We speak of these eye-spots because they occupy a position at the proximal side of the base of the anchors homologous with that in which a more highly developed and even well defined optical apparatus is to be found in other *Acalephæ*. In our *Lucernarian* it amounts to a mere accumulation of pigment, in unusual quantity, in a small circle, among the interstices of the prismatic cells of a specially thickened wall (*fig.* 83, *opsophragma*). The boss-like protuberance of the wall at these spots, conjoined with the conspicuous coloring matter imbedded in it down to half its depth, give it strong claims to some special functional status, or to a typical representation of what finds its full development in other *Acalephs*. The accumulation of pigment matter at any point concentrates light there rather than any other force capable of being taken note of by a nervous centre. Neither odor nor sound would be affected by it, nor does it seem possible that taste could be seated at a point so distant from the digestive system. That it is after all a mere foreshadowing, or a *mimetism*, of a more efficient organ of vision becomes strongly probable when we learn that these spots lose their distinctness, or disappear altogether, by the time the animal measures one-half an inch across the umbrella. When the latter is about one-fifth of an inch across (*figs.* 26, 27, 28, 83) the spots have attained to their greatest definiteness, and from that period onward they gradually become obliterated; not so much, though, by fading out as by the increase of pigment all around them, until they lose their distinctness for want of contrast.

128. *Nervous System Formless.*—Beyond this indication of the eye-spots we have not discovered the least trace of anything that could be assigned to the nervous system. The remarkable regularity with which the cells of each wall of the body are disposed renders every step in a survey a positive advance in the knowledge of their histological relations; and we feel assured that no combination of strata and no assemblage of cells was ever more thoroughly studied, and we doubt if, but rarely, they ever received so much attention. If, then, there is a nervous system with a *form*, it must constitute a part of what we have described as the *muscular* system. This is a mere suggestion, and has no real basis, except that the muscles have a fibrous structure, and, as a bare possibility, might include among themselves nervous threads of a similar form. We know that it is no uncommon difficulty to determine, in some animals, what is nervous and what is tendinous or unstriped muscular fibre, but seldom do these barriers arise from their intermingling in one common *stratum*, or trending in parallel lines with each other. Much less do they originate from an impossibility to distinguish the one from the other, when they can be subjected to the highest powers of the microscope. This is our ground for assuring ourselves that there is no nervous system, having a *form*, intermingled with the muscular mass. That it has a potential existence, there can be no doubt, and that it can transfer sensations from the remotest points of the periphery of the body to its centre no one will deny upon seeing the tips of the tentacles convey some miniature victim to the mouth. Along what lines these sensations and volitions are propagated it is not possible to determine, but it seems to us more likely that interstitial *cytoblastema* should be the medium than that cells which are already appointed to the formation of a wall or a tissue should perform a double duty.

129. *Cytoblastema.*—In the lowest ranks of life, it is the amorphous cytoblastematous substance that prevails, that even constitutes the whole body, as every student of the lower Protozoa is well aware. The Amœba, Difflugia, in fact all Rhizopoda, are moving, sentient masses of *cytoblastema*. The velocity of retraction of a *pseudopodium* of a Rhizopod cannot be surpassed by the most highly developed muscle of a Vertebrate. The consciousness with which a Difflugia builds up its *test*, bearing each grain of sand to its place in the domicile with well-defined intent, is none the less an exhibition of the coursing of a nervous current through its homomorphous, cell-less mass, than is that of the Phryganean larva, with abundant striated muscles and sharply segregated nervous cord and fibres, building up its caddice-case, with all the ingenuity of a human basket maker. The cells which form the elements of a system, whether nervous or muscular, are not so much the necessary concomitants of the *function* which is to operate along certain lines, as the indicators of the outlines of the *differentiation* process—the guide posts, one might say, to prevent the nervous couriers from losing their way, and straying off, diffusing themselves in unknown regions of cytoblastema. The comparative diffuseness of the nervous centres in the middle ranks of Invertebrata prepares us for a still greater indefiniteness in the lowest grades; and we should not be surprised to hear of any one coming to the conclusion that in the latter there are no main centres of dispersion and reception of nervous power and sensation, but that they are as well displayed at one point in the body as at another, and from thence propagate

what they receive to other regions, with no more special adaptation for doing so than at any chance place.

130. *Nervous Centres*.—We are not willing, however, to accept this conclusion in its fullest sense, for we are too well aware of, and have said not a little in regard to, the relation of the nervous mass to the polar regions of the typical animal. Whatever the apparent diffuseness of the nervous centres may be, there can be no misapprehension as to their tendencies toward concentration in a certain region of the body. Any motion having a determinate end must be under the control of an influence which emanates from a well-defined *site*, to which all others, however diffuse, must stand in the relation of accessories, outlying posts, or frontier sentinels. The fact that all eggs, not excepting those of the lowest animals, exhibit a *polarity*, conjoined with the equally important fact that, at least in the middle and highest classes, these poles correspond respectively to the nervous and nutritive regions of the body, giving one the highest warrant for the assumption that even in the most inferior ranks there is a slight preponderance of the nervous elements, a tendency to centralize, in some one region rather than in another. The line of separation may be no more trenchant than that between the albuminous and oleaginous poles of the egg, and yet it will be enough to indicate an oppositeness of condition. And so we conclude, then, that, although the Lucernariæ have no visible nervous system, there is at least one or more regions of centralized power, from which nervous currents emanate and in which sensation leaves its impress.

131. *Homological Position*.—We cannot dismiss this subject without drawing particular attention to the homological position of the eye-spots, and thence to their significance as indicators of a specialization of the nervous system in reference to their function. They stand respectively, four opposite the flanks of the proboscis, and four opposite the angles of that organ. They are also subterminal, *i. e.*, not at the distal end of the tentacle (anchor), but at its base, or, more properly, where the base joins the umbella. By their swollen, boss-like character they remind one of incipient tentacles, springing up close to the next older that preceded them. They are then probably to be set down as rudimentary oculiferous tentacles situated within the line along which the anchors are disposed. Now in all Acalephæ the eye, so called, stands in close proximity to the margin of the umbella, and always in connection with its circumoral parietes. The Charybdeidæ are not even an exception to this, nor the Æginidæ; notwithstanding the ocular peduncle projects from the aboral side, its base is attached to the circumoral face. Rarely it lies on the distal side of the base of the tentacles, as in the medusoid of Coryne, but most frequently on the proximal side, as in Bougainvillia, Eucopidæ, etc. In the highest of the Hydroida (Tiaropsis, and the like), it is totally disjoined from the tentacles, but still is within, and not on, the line along which the latter are arranged. In the Strobiloida—whose optical apparatus is far more highly developed than in Tiaropsis and others of the superior ranks of Hydroida—the eye is borne on the end of a cylindrical, tentacle-like peduncle, and yet it is never marginal, but submarginal. It lies in a different line from the tentacles, whether the latter be strictly marginal, as in Aurelia, or submarginal, as in Cyanea. All of these correspondences form the thread which guides one from the lower depths of ocular

development, among the pigment spots of the Corynidaë, up to the unmistakably refracting, and, we doubt not, image-forming, plano-convex lenses of Aurelia.¹ Now although we have never been able, after the most diligent search, to discover a trace of a nervous fibre in Aurelia, yet its optical apparatus is so undeniably an organ of vision that a special nervous localization seems inevitable. Unfortunately for our wishes, Aurelia does not stand so high among the members of its grand division as to be subjected to that kind of differentiation which segregates the nervous matter from the surrounding mass and puts the cell-mark upon it. If then Aurelia fails in this respect, what can we expect to find in Lucernariæ, with their ill-defined eye-spots, but a far less developed nervous system, and still more diffused and undefined areas of nervous power?

§ 18. *The Reproductive System.*

132. *Differentiation.*—Of the two main points of difference between the Lucernariæ and the Strobiloida, the character of the reproductive system is scarcely second in importance. It is, beyond all question, unparalleled in concentration and differentiation, and is *unique* in design. But, as if these were not enough, there is added to one form of specialization another none the less marked, and certainly more conspicuous, in a total separation of the reproductive *stroma* from the mass of the umbellar parietes. The strata which inclose the eggs or spermatozoa have no part in forming the bulk of the umbella; they are *mere appendages* moulded into the form of globular sacs, and attached in the same way as the *digituli* to the circumoral face.

133. In the Strobiloida the reproductive material is imbedded in the general mass which forms the parietes of the umbella. The region of their genital organs, it is true, is specialized after a certain model, but it does not make it any the less a part and parcel of the boundary-wall of the general cavity of the body. We wish it to be clearly understood here that, when speaking of the Strobiloida, we do not include the Charybdeidæ in that order. Where the latter belong, in our opinion, may be found in the chapter (Part XI) on their morphology and in the one devoted to ordinal characters (Chapter XIII).

134. *The sexes* of the Lucernariæ are separate, but the structure of the saccules of both is identical. In description of the topographical position and the homological relations of the various organs to each other and to certain parts of the body, we have given all the general information that is necessary to a perfect understanding of the site of the reproductive system (§ 50), its general outlines, appendages (§ 52), arrangement, and relative age of the saccules (§ 51). The structure, shape, and peculiar position of these organs remain yet to be given in detail.

135. *Structure of Saccules.*—In a previous paragraph (116) of the section on the *digituli*, we have described a singular attitude which these bodies sometimes assume, simulating the form of a sac with a broad spread mouth opening at the side

¹ See our description and illustration of this apparatus in the Contributions, Nat. Hist. N. Am. of L. Agassiz, Vol. III, Pl. XI, and Vol. IV, p. 41.

instead of at the end, by drawing the edges and ends of the digitulus together toward one side, so as to inclose a hollow space. The genital saccules (*figs.* 54, 61, 62, 74–77, 98, s , s^1 , s^6) are permanent embodiments of this configuration, but carried to a much higher degree of development. They are, in the strictest sense, *hollow* spheroidal saccules, and not mere solid globular masses of tissue and reproductive material, and are attached by a short, thick neck to the inner face of the circumoral parietes (*fig.* 54, ζ). They are totally disconnected from each other, but usually are so crowded that their peripheries come in contact and mutually mould themselves into polygonal shapes. On this account their appearance, from the exterior (*fig.* 37), is like a mosaic pavement. The oldest are considerably larger than the globular tips of the tentacles. • In a full grown saccule the middle third of the diameter is a spherical chamber (s^1), which has its exit through an aperture (s^6) in the side of the neck. This aperture is as singularly marked in its position as the saccule is in general conformation, for it invariably faces away from the nearest umbellar partition in the direction of the older side of a genital half, and obliquely towards the proboscis. We are reminded here of the singular position of the flattened sides of the *digituli* (*fig.* 98, A, B), which we have taken note of in a former paragraph (117), seeming to show a relationship something more real than that of mere proximity. The component elements of the walls are also disposed very much after the manner of those of *digituli*. There is one-half, the exterior (*fig.* 74, v^1), of a saccule covered by vibratile cilia, but there are no nematocysts, and the other or inner side, instead of colletocysts (208, A), bears a bed of eggs (*fig.* 74, g), or spermatozoa (*figs.* 75, 76), sunken in pouches (s^1) formed by folds of the lining wall. Between these two walls the fibrillæ of the *chondromyoplax* (b^3) trend perpendicularly to its surfaces, but terminate against an underlying muscular stratum. There is from one hundred and thirty to one hundred and fifty saccules in each triangular genital half.

136. *The Walls and Layers* have very little to distinguish them in their cellular constituents, or other histological elements, from those of the circumoral parietes, to which the saccules are attached; but they differ widely in their conformation, and in the substances which they inclose. The outer wall (*oöphragma*, v^1) is a direct continuation of the *gastrophragma* (i), and has the same general characters, cellular composition, and covering of vibratile cilia as the latter, and is spread over the surface of the saccule quite uniformly and smoothly. At the mouth (s^6) of the saccule a rapid change takes place in the *oöphragma*, not only in its disposition but also in its cellular structure. Regarding the latter feature first, we will state that the cells (*fig.* 78, i) of the interior wall lose the prismatic shape of those of the exterior, and become more or less irregularly oval and flattened, but still retain their relative position in a single layer, although overlapping each other more or less.

137. *The Egg-Follicles of the Saccules*.—As for the lining wall (*figs.* 74, 77, v) in its totality, it is so disposed about the central chambers (s^1) as to render it one of the most conspicuous and important elements among the several peculiar differentiations which distinguish the Lucernariæ from all other orders of Acalephæ. It is *par excellence* the egg-bearing layer, *oöphragma*, since it immediately incloses the reproductive material in special *pouches* (s^2) which are formed by an inversion of

the wall upon itself. Each pouch or follicle contains either a certain amount of spermatogenous material (*figs.* 75, 76), or one, two, or three eggs (*fig.* 74, *g*), according to whether the individual is male or female. The follicles crowd closely upon each other, and all open into the central chamber. At the appointed time, when the eggs or spermatozoa are ripe, they are discharged from the mouths of the pouches into the general chamber (*s*¹) of the saccule, and thence pass outward, through the lateral aperture (*s*²) in the neck, into the broad cameræ of the umbella. A full description of the eggs and spermatozoa may be found in the chapter on Embryology. As well as we can make out, there are from one hundred to one hundred and twenty-five pouches in a fully developed saccule. Their mouths are closed until near the time for the extrusion of their contents, and then, especially in the males, they are rather wide open. The space between the central chamber and the outer wall is almost entirely filled by the follicles and their contents, but what is left is occupied by the muscular layer (*öomyoplax*) and the *chondromyoplax* (*b*³). The *öomyoplax* envelops the pouches like a *stroma*, and it might not inaptly be compared to that, and the *ööphragma* to a *tunica granulosa*. The fibrillæ of the *chondromyoplax* are arranged with tolerable regularity in the region of the neck, stretching directly from the outer to the inner fold of the wall of the saccule; but where they mingle with the pouches they form a sort of irregular mesh or network, and are not to be distinguished positively from the fibres of the muscular layer. This only serves to confirm us in the belief that all those fibrillæ which traverse the *chondromyoplax* in any part of the body are prolongations from the muscular layer, although we would not claim that they are identical with the muscular fibrillæ, but rather a prolongation of connective tissue. After the discharge of their contents the saccules collapse and shrivel to two-thirds or even one-half their former size, and the follicles gape widely and assume irregular shapes (*fig.* 77), while the fibrillæ of the *chondromyoplax* appear to be torn or more irregular than ever. An empty follicle (*fig.* 79) seems to be dotted all over its outer surface, but if examined by a profile view these dots turn out to be the broken and retracted fibrillæ of the *chondromyoplax*.

138. *Genitalia of Strobiloida*.—This investigation reveals to us here the fact that there is a double differentiation in the reproductive organs, which, when contrasted with the condition of the homologous organs in the Strobiloida, assumes the highest morphological importance. We do not intend to discuss the matter at this point, but will merely state the significant facts, that not only, as mentioned above (§ 132, 133), do the genitalia of the Strobiloida form a continuous part of the umbellar parietes, but the eggs are simply immersed in the *chondromyoplax*, close to, and partly imbedded in, the *opsomyoplax*, *i. e.*, just beneath the exterior wall of the circumoral area. In the males the spermatogenous material lies in hollows in the same layer as do the eggs in the female, but a sort of follicle is formed about them by a superabundant gathering of fibrillæ which are prolonged principally from the *opsomyoplax*. This is their nearest approach to a true follicle that we have met with. The walls, strictly speaking, have nothing to do with it. We shall dwell at length on this point in the chapter (Part XI) assigned to the anatomy and morphology of Aurelia, and need not, therefore, proceed to further

details in this place. Frequently, if not always, the spermatozoa escape *through the opsophragma* directly into the outer world,¹ a thing impossible in Lucernariæ, since the genitalia have no connection with the two outer layers.

139. The *digitiform bodies* (*digituli*, ¶ 116) demand notice in this connection, not so much from any functional relation which they possess, as from their homological position when contrasted with the site of similar organs in the Strobiloida. It may fairly be questioned whether their *proximity* to the genitalia has any reference to their functions in connection with those organs, or whether they are there merely as the result of carrying out a certain architectural design. In some of the Charybdeidæ, as we learn through a letter² from Fritz Muller, "The digitiform bodies . . . in *Tamoya* are completely separated from the genitalia, and are to be found within the common *atrium* of the digestive chambers." This, we observe, is particularly noticeable in *Tamoya quadrumana*,³ where the *digituli* lie in semicircles directly opposite the partitions of the umbella, but completely within the main central chamber. Their proximity to the genitalia is lessened considerably when compared with the closer connection of those in the true Strobiloida, but their relative position, as regards the prime vertical and horizontal planes of the body, and in reference to the genital organs and to the sides of the proboscis is not altered in the least, the architectural plan remaining the same. Notwithstanding, therefore, their apparent functional connection with the reproductive organs in almost all those Acalephæ which possess them, their true relations are evidently with the prehensile organs of the exterior, and we have, consequently, described them in that light, in a previous section (§ 15, p. 57). This does not affect their topographical homologies in the least, but, if anything, serves to disconnect them from that false estimate which gives more weight to anatomical structure and functional identities, than to morphological and homological relations, in determining the classificatory alliances of Acalephæ. To describe the *digituli* in connection with the *genitalia*, solely because of their proximity to them, would be about as reasonable as to include the hind legs of Marsupialia in the category of reproductive organs, because they happen to be the nearest appendages, and, in part, help to support the *marsupium*.

¹ See Lucernaria the Cœnotype, etc., ut sup.

² Dated "January 1, 1865, Desterro, Brazil."

³ Since Milne Edwards has corrected (see *Leçons Physiol.*, vol. iii, p. 56) his mistake in regard to the chymiferous canals of Charybdea, and has shown that what he formerly considered as such are the partitions of the umbella, and what once seemed to be solid intervening masses are broad tubes, or *cameræ*, alternating with the partitions, it becomes clear that the *Tamoya haplonema* of F. Muller is a *Charybdea*, and the *T. quadrumana*, F. Muller, remains the true representative type of the genus *Tamoya*, while the *Chiropsalmus*, Agassiz, founded on this species, becomes a synonym.

CHAPTER VI.

EMBRYOLOGY.

§ 19. *The Egg and the Spermatozoa.*

140. *The Egg.* (Pl. IX, fig. 108).—If it be taken for granted that all the illustrations of the eggs of diverse animals are full and faithful representations of their structure, then the one which we now offer for the consideration of naturalists is fully as complicated as any that exists. This, however, we are not at all willing to believe, for we have had such glimpses of what may be learned by the use of the microscope of the present day, as lead us to avow emphatically, and without fear of disproof hereafter, that the structure of the egg, as described and illustrated in various works, is useless, except in the most general way. What we want is an exhaustive comparative study of the development and anatomy of the *ovum* from its inception in the *cytoblastemon* of the ovary, through all its phases, up to the period when it is fecundated and passes on to its second stage. Such a series, for even any one species, does not exist in all our works and papers upon embryology. The labor is too hard to tempt any one of ordinary strength and patience. The single figure on our plate represents a fully developed egg of *Haliclystus auricula*, as seen in profile. It was difficult to persuade ourselves, at first, that the egg of so lowly an animal could be so highly organized; we suspected some mistake; yet repeated observations only led to the same result; and we therefore present it here as an isolated fact, but with the remark that, as far as it goes, *i. e.*, as a representation of the consummation of one stage in the life of the animal, it is as full in detail and physiognomy as the best lenses of the time enabled us to make out. The albuminous and oleaginous poles are segregated with remarkable distinctness. The former or *germinal vesicle* (*gv*) occupies a pretty large proportion of the space embraced by the vitelline membrane, and lies close to the inner surface of the latter. The rest of the mass consists of the oleaginous material or *vitellus* (*vi*).

141. *The Vitellus.*—The form of the egg is an irregular oval, and its mass is more or less flattened by mutual pressure arising from the crowded state of these bodies in the saccule. It measures about $\frac{1}{750}$ of an inch in length. As many as three have been found in one of the pouches of a saccule. The *vitelline sac* (*vs*) is very thin, but is easily distinguished from the surface of the yolk on account of the peculiar structure of the latter, and presents sharp smooth exterior and interior surfaces. Its thickness is about $\frac{1}{25000}$ of an inch, and it appears to be homogeneous in texture throughout—a perfectly structureless, colorless membrane. *The yolk* (*vi*) has all the appearance of passing through the process of segmentation, but the presence of the sharply defined germinal vesicle and macula warns us against

accepting that view of it. Its whole mass is made up of colorless, minute granular matter shaped into spherical conglomerations which are packed so closely together as to leave no apparent space between them. This is all so transparent as to readily escape casual observation with direct illumination, and one might be led to refer the spheres to the *lumen* of granules out of the focus of the lens. A careful appliance of the light and the proper adjustments will bring out these features as strongly as we have represented them. There being no smooth, uniform surface to the yolk, but a series of irregular, rounded projections, there is no universal, continuous line of contact between it and the vitelline membrane, and consequently the inner surface of the latter stands out sharply and clearly. The diameter of the spherical conglomeration is from one-fourth to one-third that of the germinal vesicle. We are so surprised at this strange structure that we naturally seek to explain it by supposing the spherules to be the granular contents of cells, but that idea we are obliged to resign, for after the most careful search we have failed to detect the faintest trace of a wall about the globules.

142. *The germinative vesicle (gv)* is not much less than one-half the shorter diameter of the egg. In shape it varies from spherical to broadly oval or spheroidal, perhaps owing to the mutual pressure of the eggs. It is perfectly clear, and free from granules, and contains a large *macula* or *vesicula Wagneri (wv)*. The contents of the latter are even less refractive than that of the germinal vesicle, and both are so in a very low degree. The wall of the germinal vesicle is excessively thin, appearing like a mere film under a magnifying power of five hundred diameters, and consequently its contents seem to be in a hollow space excavated in the side of the yolk.

143. *The Egg is an organized being.*—There is here, in the singular relations and form of the constituents of the yolk, in its stability and evidently organized condition, the very reverse of an unstable, simply fluid state. We have for a number of years argued that the yolk of the egg of all animals is not a homogeneous, homomorphous, mere fluid contents of a sac, stored as if in a reservoir for future elaboration, but, on the contrary, is an organized aggregation of matter under the influence of certain forces of a vital nature, which direct the laying down of its parts in definite places and in certain forms, always retaining them there from the very beginning of the development of the egg. Embryologists have frequently noted the precision and systematic order with which the contents of an egg are disposed, but they have invariably failed to recognize the organized character of the different regions and their distinct relations to each other, and to the changes which are to take place in the future. We need but refer to the eggs of birds to prove that the *ovum* is so far organized as to be inherently self-sustaining, existing in a low state of vitality for a comparatively indefinite length of time, waiting for the coming of such circumstances—either belonging to the parent or arising from purely physical sources—as shall cause it to develop to a higher phase.

We are well aware of the fact that some embryologists claim that the embryo always develops in the region where the germinal vesicle lies, and that the yolk is drawn into the body as if it were a mere supply of crude nourishment, but we do not know that any one but ourselves has promulgated the idea that the germinal

vesicle and the yolk form an organized whole, the *animal-egg*, representing, in its lowest condition, the *animal* and the *vegetative* compound which we call a *zoön*.

144. The fact that in some animals, *e. g.*, the Vermes, Nematoda, and Trematoda, the germinal vesicle originates in a separate division of the ovary from that in which the yolk is developed, does not invalidate our theory, but, on the contrary, tends to sustain it. The ovarian *cytoblastemon* furnishes the material to start with, in any case; the albuminous substance on the one hand and the oleaginous on the other, and it is only a question of degree whether these two elements are brought together particle by particle and then each develops its peculiarities by consentaneous action in time and place, or each masses its atoms in a separate division of the ovary and elaborates its characteristic qualities there, and then are united into one mass. In either of these two extreme cases, the moment the particles of albumen and oleaginous matter come together they assume certain relations which we have indicated by the term *polarity*, and that is the beginning of the *animal egg*. The direct connection of the polarity of the so-called egg with the polarity of the later stages of the animal offers unmistakable evidence that the first stage, *i. e.*, the *egg-stage*, is not to be separated from the second any more than the second should be from the third. *All* are parts of what are necessary to make up the life of the *animal*. Each stage has its functions, the egg-stage has its, and so has old age; and the first should no more be separated from the second or third stage, because its functions are not identical with theirs, than the last, or old age should be, because it fails in some of the offices of the one previous to it.

145. *The Spermatozoa* (Pl. XI, *figs.* 130, 131, 132).—The general outline of the body is that of a cone which is twice as high as it is broad at its base. The interior is perfectly homogeneous and colorless. It is not a fixed, rigid attitude that we observe here, but one that varies considerably, especially about the apex of the cone. At the latter point we find the body continued into two excessively delicate filaments which are six or seven times longer than itself. These filaments are very severe tests of the powers of a microscope. They are much more slender than the so-called tail of the spermatozoon, and do not taper, but preserve the same diameter to their tips, where they terminate abruptly. Upon seeing these lash-like bodies coiling and twisting or swinging from side to side with every movement of the highly flexible, conical apex, we are reminded of certain flagellate infusoria. The broader end of the cone is indented where the tail is inserted. The tail is of enormous length, measuring at least twenty times that of the body. It does not taper, except for a short distance from its attachment.

§ 20. *A Young Haliclystus auricula, nearly $\frac{1}{16}$ th of an inch in diameter* (Pl. X, *figs.* 121, 122 A. to D., 123).

146. Our records and illustrations of intermediate stages between the egg and the adult are intended not so much to furnish the details of changes which take place between youth and old age, as to explain the *morphogenic* phases through which the organs and certain regions of the body pass in order to reach their perfection. Their value, therefore, will be more appreciated upon contrasting them

with the organization of other Acalephæ, than when considered separately. Instead, however, of taking up the history of the development of each organ, and following it through all its stages, as is the more common method in embryology, we think the interests of morphology will be subserved better if the morphogenic phases of all the various organs, at any one period, are exhibited in their fullest interdependence. We regret that we have failed to raise the young from the egg. There is an almost insuperable obstacle to doing so, because the parent does not thrive in confinement, and, again, the young are not pelagic, but follow the habits of the adult, and creep over the eel-grass from a very early period. The chances of finding them in the latter condition, therefore, are few, because they are so small. We have not succeeded in obtaining specimens but a little less than one-sixteenth of an inch in diameter across the umbella.

147. *General Features*.—The minutest individuals that we have met with, had already four or five tentacles in each group, and measured not quite *one-sixteenth* of an inch across the umbella. At this time not a trace of the reproductive organs is to be seen (*fig.* 121); but they appear soon after, as will be shown in the next set of phases that come under our notice. The specimens upon which our investigations were made were found about the middle of September, although we have discovered young of the same size two or three weeks earlier. The form of the umbella is so nearly circular that its slightly octangular contour scarcely attracts notice. The great prominence of the thickened, colletocystigerous portions of the anchors (α) renders them so conspicuous that they seem to be the true angles of the umbella. In profile, the body is much less cyathiform than in the adult, the umbella being so strongly flattened as to approximate quite closely to a T-form. The peduncle is proportionately very thick, so that, as a whole, the body is far less slender than the adult. As to colors, they vary as much as at any other time of life, but they are by no means so intense as at the latest periods.

148. *The proboscis* stands exactly in the same relative position, and is as distinctly four-sided as that of the adult, but is proportionally much thicker. Its buttresses, however, are not so prominent. The main peculiarity of the interior of the umbella proper is the great thickness of the *partitions* (ψ^2), and the very considerable breadth of the passages, between the four chambers, across the distal ends of the partitions. The *peduncular camerae* are singular for their total separation from each other at their posterior ends, and they do not extend so far forward as in later periods. This, then, leaves the peduncle partially monocamerous, and leads one to suspect that, at a much earlier period, it is altogether so. This feature, no doubt, will serve among others as an embryonic *criterion* to determine the relative rank of the members of this order. The monocamerous genera *Lucernaria* and *Calvaulosia*, from this point of view, rank lower than *Halicylistus*, and we would add that in other respects they confirm this testimony.

149. *The Tentacles* (*figs.* 121, 122, Nos. 1, 1^a etc. to 4^a).—At this period of development the prehensile organs are in such a condition as enables us, better than at any other time, to ascertain their *taxis* and mode of succession, as they increase in numbers. As may be judged from their relative position, there is every probability that at an earlier time but *one tentacle* terminated each corner of the

umbrella; and since the anchors were then, doubtless, merely tentacles in form, there must have been sixteen tentacles standing isolatedly and equidistantly, forming a single row on the margin of the umbrella. In other genera, like *Calvadosia* and *Lucernaria*, which have no anchors, there probably were, at a period corresponding to this, eight single tentacles at as many equidistant points. When describing these bodies in their adult state (§ 89, 90), we pointed out the singular relation which each bunch bears to every other one in regard to its taxis and its general conformation. We find the same peculiarity here, and, moreover, an explanation of it is also presented to us by the mode of development of the tentacles. In the specimen under present consideration, there are only four tentacles in some of the bunches (*figs.* 121, A, A'). Their relative position is made out at a glance, as it were; they evidently belong to no less than three parallel, concentric rows, the oldest standing on the distal side, and the youngest nearest to the proboscis. The following diagram, at the head of the next paragraph, and the figures (*figs.* 121, A, A', 122, A), in the plate, will serve to illustrate their taxis, as well as their succession in development.



150. The figure 1 represents the primary tentacle, standing in the most distal row. That it is alone in the group is shown by the position of the two nearest (2 and 2^a), as they not only lie nearer the axis of the body, but actually unite at their bases across the proximal side of number 1, and form the second row; and number 3, the smallest, stands still further in toward the proboscis, but opposite to 1, and alternating with 2 and 2^a, and is the first of the third row.¹ Why we have numbered those of the second row 2 and 2^a, instead of both alike,

¹ In *N. Am. Acalephæ*, *Illust. Cat. Mus. Comp. Zool.*, by Alexander Agassiz, p. 63, fig. 90, there is an illustration of what purports to be a young *Halichlystus auricula*, "about one-tenth of an inch in height." It is slightly larger than the one which we are just now describing, and should, therefore, exhibit in the arrangement of its tentacles more of the characters of the adult. On the contrary, however, the author says, "the arrangement of the tentacles is totally different from that of the adult. They are as yet not arranged in clusters, but placed at regular intervals in one line on the edge of the disk." There is here such a marked discrepancy between the figure and the ostensible description that we are driven to suspect that the latter was intended for a totally different animal. So far from being in one line, the figure shows the single oldest tentacle overlapping the two of the next inner row, as it should be, when seen from the distal side of the group. Now, tentacles cannot well be "in one line," when of a number near together, as in the figure of the youngest group which is here described, two unite at their bases in front of the primary one, and separate it from the single one of the third inner row. Assuredly these are in a cluster. Again, we find another discrepancy between the figure and the description of our author in regard to the anchors, when he says, "No difference can at present be detected between the anchors and the tentacles of the disk," whereas the figure plainly shows the swollen colletocystigerous mass just below the tip of each organ, giving it a strongly humped appearance. The figure is in perfect accordance with our observations, but the description might apply to a *Carduella*; and singularly enough the author says, "The young *Lucernaria* is in this state a close representative of the genus *Carduella* which may possibly prove to be only the young of some European species." Now this looks very much as if the description was taken from a genuine *Carduella*, and, if so, we congratulate the discoverer, while by some inadvertence the wrong figure was supplied to illustrate it, representing the young of a genus belonging to a *different family*; but the figure is in the right place among the *Eleutherocarpidæ*, and the description, perhaps, should be among the *Cleistocarpidæ*.

will become evident upon consulting the figure (*fig.* 122, B), which we shall use to illustrate the next step; we will merely state here that 2 begins to develop before 2^a, although in the same row. The + on the right of the diagram indicates where the next tentacle is to appear in the fourth row, and serves to set out the one-sidedness of the group, and its thread of development, in a stronger light.

150 (A). In other groups (*figs.* 121, B, B¹, B², B³, 122, B) on the same indi-



vidual, there are five tentacles in four rows, the youngest of which is numbered 4, and the four others as in the previous group (A). It will be noticed, perhaps, that the succession of numbers is not alike, in point of position, in each bunch, for instance, in one group the numbers 1, 2, 4 lie on the left, as the observer faces the anterior end of the body, and in another bunch, 1, 2, 4 are on the right. Now, if the vertical plane of the body be assumed as a dividing line, we shall have these numbers in the two uppermost groups standing as if in antagonism to each other, the line of development in one trending in the opposite direction from that in the other; and so it is in the two lower groups; and likewise on the two sides of the horizontal plane. Or, if we look at them from another point of view, making the partitions (ψ^2) the dividing lines between the two groups nearest to them, we shall find the same antagonism, but with a reversal of the trend, so that 1, 2, 4 in each bunch lie next the partition. This gives us the clue to the one-sidedness of the groups, the preponderance, as we have noticed in the early part (§ 12) of this memoir, being on the side next the partition; for after the first tentacle was assigned its place, the second appeared on the side nearest the partition, and thenceforth threw the balance of age and size in that direction.

150 (B). Before any member of the fifth row begins to develop, another tentacle of the fourth row appears on the side most distant from the partition. It is numbered 4^a (*figs.* 121, C, C¹, 122, C). Thus far we have been dealing with the tentacles of one individual, and have found some slight variation in the number of these organs in different groups, but yet always preserving, in the order of their succession, a perfect symmetry relative to the partition. Their further development will be illustrated in the next section (§ 21).

151. The *size* of the largest tentacles in these young groups is much greater, in proportion to the magnitude of the body, than at maturity, as they measure in length from one-sixth to one-fourth the diameter of the umbella, *i. e.*, an average of one-fifth, but are very thick and stout, the diameter being at least one-fifth as great as the length. In the adult the proportion is as one is to twenty-five. As for the globose tip, it is quite distinct, but not remarkably prominent, and is about

one-third greater in diameter than that of the shaft, whereas in the adult it is three times that of the shaft. We shall not stop here to describe the mode of development of the nascent tentacle, as that will be done in a future paragraph, but it will not be amiss here to state simply that these organs originate as rounded papillæ, elongate into broad cylindrical shafts, and finally expand at the end into globose tips. The breadth of a group is so great as to leave only a very narrow interval between it and the anchors, so that we should say that, altogether, they occupy about two-fifths of the circumference of the umbella. If now we add the tentacle-like anchors, which cover another third of the circumference, we shall see that so little marginal space is left, and that, too, divided into no less than sixteen parts, that the umbella appears to be fringed by an almost continuous corona of tentacles.

152. *The Anchors* (*fig.* 121, α ; 122, D; 123).—The distinctive characteristic of these organs is not so far advanced in development as to obscure the tentacular nature, and this is particularly noticeable on the proximal side, where scarcely a trace of the colletocystigerous mass is to be seen; and the walls are identical in their general features with those of the true tentacles. In point of size these bodies, exclusive of the colletocystigerous mass (α^3), are about equal, in length and breadth, to the tentacles. They have a similar thick shaft (α^7), and a well-defined globular tip (α^2). As regards their attitude, they are more rigid, and remain nearly fixed in a slightly bent form, inclined forward. The already large development of the outer wall, into a colletocystigerous cushion (α^3), gives the anchor a still more strongly bent figure, on the distal side, and in fact makes it appear as if it were humped. The greater portion of the colletocystigerous mass lies on the distal side of the organ, and extends a little more than two-thirds of the way to the globose tip. At the sides (*fig.* 121) it is nearly as thick as on the distal face, and thins out all around as it stretches toward the base and the proximal side of the shaft. Since, now, the tentacle-like portion has a tapering form, and expands at the base, passing gradually, as far as outline is concerned, into the umbellar margin, and the colletocystigerous layer thins out in the same direction, the tendencies of the two are mutually counteracted, and the combined parts present the appearance in front (*fig.* 121) of a broad projection with parallel sides, supporting a very short, globe-tipped tentacle in a sinus at its end.

152^a. *The Chondrophys* (*fig.* 123, *c*).—Of the gelatiniform layers we have but a word or two to say, and that only in reference to the chondrophys. The formation of this layer, in all probability, begins long before the time at which we have found it, as at this period it is already very thick in the umbella, at least five or six times thicker than the outer wall.

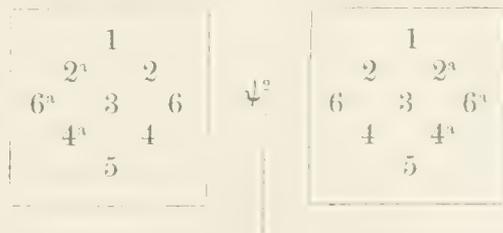
§ 21. *A Specimen* $\frac{3}{8}$ *of an inch across the Umbella* (Pl. II, *figs.* 20, 21; Pl. X, *figs.* 124 to 129).

153. At this age the chief point of interest centres in the incipient reproductive organs (*fig.* 20, λ). The stage previous to this might well be designated as the *proximo-ovuline stage*, and the one in which the reproductive organs originate, develop, and perform their functions might be denominated the *adult stage*. At

first thought it would seem advisable to recognize an intermediate phase between the latter and the former, to indicate the period when the reproductive organs are developing up to the fertilizable condition; but there is an insuperable objection to this mode of subdivision of ages, namely, there is no time, not even when the animal has reached extreme old age, in which some of the genital saccules are not originating and developing. If any one will turn to the description and figures of the adult organs (§ 51), he will there learn that on one border of a genital-half the oldest saccules are invariably found, and that from that point onward toward the opposite side these saccules become gradually less in size and lower in the degree of development, until at the extreme border they are no further advanced than in the young individual now before us.

154. Specimens of the size mentioned above were found in the last week of September. The umbrella (*fig.* 20) at last has a distinct octagonal outline, and the margin (ψ^3) between the groups of tentacles, is slightly retreating. In profile the body appears more strongly cyathiform than in the *proximo-ovuline* phase (§ 20), and the pedicle is more slender. Added to these we mention the increased length and greater slenderness of the tentacles as tending largely to give the body a more graceful appearance. At the same time their increased numbers render them more conspicuous, while the anchors are only a secondary feature in point of prominence. The peduncle, also, is more slender than in the last stage, and its adherent disk is a strongly marked expansion. There is nothing peculiar in the proboscis (ρ) to distinguish this phase; but we would call attention to the drawing for the sake of explaining away the apparently minute size of this organ. It happens to be represented when it was strongly contracted at its anterior end, and the mouth nearly closed. The object in presenting it in that state was to expose the proximal ends of the four umbellar partitions (ψ^2), and of the reproductive organs (λ). The muscular system of the umbrella is sufficiently developed to be recognized readily, but is too faint to affect the general physiognomy of this region.

155. *The Tentacles.*—At this age we observe for the first time traces of the peculiar ranked arrangement, so characteristic of the full-grown forms. This is the result of the taxial relation under which the tentacles originate, and theoretically prevails in the group from its initiation; but it does not strike the attention of the observer until increased numbers add to the length of the ranks. In the last, or proximo-ovuline phase, we have noted as many as six tentacles in a group. In the specimen now under our eyes, there are no less than nine tentacles (*figs.* 20, 125,



126) in some bunches, and one or two more in the others (*fig.* 21). Next to 4^v of the last phase (§ 20) 5 succeeds and lies in line with 1 and 3, so that the members

of the middle rank would be designated by the numbers 1, 3, 5. The eighth tentacle is numbered 6, and is so placed as to alternate with 2 and 4, and presses against their bases. The ninth is numbered 6^a, and holds the same relation to 2^a and 4^a that 6 does to 2 and 4. As the numbers increase, the tendency is to widen the group, by the development of new tentacles in the neighborhood of the oldest. This is seen in the appearance of 6 and 6^a, so far away from 5, and so near to 2 and 2^a. We cannot say positively where the next that are to increase the lateral extension will appear, but we have good reason to think that they will arise alternate with 1 and 2 on one side, and 1 and 2^a on the other (see cut 4, p. 45). An inspection of the diagram (see cut No. 4) of the taxis of a full-grown group will assist us in this matter. It is plain enough here that the tentacles lying on each side of 1 must have originated where they stand, and, according to the method exhibited in the diagrams of young groups, after 2 and 2^a, and consequently on the distal side of the latter.

156. The relative age of the tentacles on each side of 1 is not to be seen in their proportional size; but if we follow the curved rank along the distal side of the group (see cut No. 2, p. 43), we shall find that, as we recede from 1, they decrease in magnitude regularly, until they attain a *minimum*, at the proximal side, in the last one at each side of the row. This would seem to show quite conclusively that there are two lines of progress in the development of the tentacles; the one trending centripetally, as indicated by the numbers 1, 3, 5, etc., and the other trending laterally on each side of 1, and following the margin of the umbrella. That those in either of these *trends* succeed each other in one, two, three order is far from true; but that those in one trend alternate with those of the other trend in the time of their origin and rate of development, is probably indisputable, judging from the diagrams of the taxial succession of the young groups. What *formula* expresses the taxis in the present case we do not pretend to have discovered, and we must leave it to the determination of more profound taxonomists than ourselves. The diagram of the youngest group (¶ 150) which we have met with would indicate the three ranked arrangement if applied to a plant, the formula of which is $\frac{1}{3}$. In the diagram of nine tentacles (¶ 155), this taxis seems to be carried out as far as the seventh (No. 5) tentacle; but the introduction of 6 and 6^a alternate with 2 and 4, and 2^a and 4^a destroys the continuity, and evidently introduces the element of another formula.

156a. From the manner in which the tentacles in the diagram (cut No. 4) of an adult group succeed each other, it is plain that the transverse rows should be numbered thus, row 1 = No. 1; row 2 = Nos. 2^a, 2; row 3 = Nos. 6^a, 3, 6; row 4 = Nos. 4^a, 4; row 5 = No. 5; row 6 = A⁶, A⁶; row 7 = B⁷; row 8 = C⁸, C⁸, etc., to H¹², because, starting with No. 1, we saw in the young (§ 20) that 2^a, 2, developing next, united across the proximal side of 1, and formed row 2; and since 2^a, 2 separate 3 from 1, No. 3 must be in row 3. Then, again, since 4, 4 stand in the same relation to 3 that 2^a, 2 do to 1, it follows that 4^a, 4 belong to the next row within 3, *i. e.*, to row 4; and so 5 succeeds in the next, or fifth row. Thus going inward toward the proximal side of the group, A⁶, A⁶ are in row 6, and B⁷ in row 7, etc., etc., to H¹²

Except in the case of 6^a, 6 we do not know how the above enumerated rows are extended on each side. It is plain that 6^a, 6 extend row 3 on each side, since they do not introduce a new row. Hence we infer that row 1 is extended by the development of the tentacles on each side of No. 1; and so with row 2^a, 2, and 3, etc. etc. In *Carduella* it appears that row 1 is extended so as to have at least half a dozen tentacles before row 2 begins, and that row 2 also extends considerably before row 3 commences. In *Halimocyathus*, the development is more rapid in the formation of new rows, contrasted with the lateral extension of the oldest rows in *Halicyllus*, as we have shown in our Prodrômus (Journ. Boston Soc. Nat. Hist. 1863, p. 534).

157. The proportions of length and thickness of the oldest tentacles have changed considerably since the last phase, and they are much more slender in the present case, but yet quite heavy when contrasted with those of the full-grown animal. The prominence of the groups is due not alone to the length of the tentacles, but is increased considerably by the strong projection of the angles of the umbella. Taking this into account, and also the fact that the marginal interval between the groups and the anchors is much greater than in the last phase, we can readily understand why these two sets of prehensile organs do not seem to form a continuous row along the umbellar border.

158. *The anchors* (fig. 20, α). The tentacular origin of these bodies is still strongly hinted at, notwithstanding the greatly increased development of the colletocystigerous mass. The latter, when seen from in front, forms a Y-shaped figure about as long as wide, and bears the tentacle-like portion in the deep terminal sinus. Altogether about one-half of what was originally a tentacle still retains that form, while the basal half is disguised by the development of the colletocystigerous mass. One-third only, or a little less, of the intertentacular umbellar margin is occupied by the basal attachment of the anchor, leaving unoccupied, therefore, two-thirds of it as a pure border, unmodified by the lateral extension of the neighboring organs. This is, in a marked degree, a contrast with the corresponding space in the preovuline stage (§ 20), when the transition from the bases of the tentacles to those of the anchors was almost uninterrupted by a margin.

159. *The general cavity* is but slightly modified since the last stage, and that only in the umbella, where the incipient genitalia (λ) form slightly raised, elongate-oblong plateaus. Of course it will be understood that these plateaus are built up, as it were, by the closely juxtaposed, nascent genital saccules, eventually constituting a sort of pavement-work, as in the full-grown animal. The partitions (ψ^2) are as yet quite thick, and very conspicuous from without. They seem to have the full proximo-distal extent of those of the oldest individuals. Their diameter is increased, no doubt, largely by the great depth of the *gastrophragma* (§ 75, 76), which is nearly or altogether as thick in the peduncle and umbella as at the bases of the tentacles or within them. The actual thickness of the *gastrophragma* is much greater in the umbella and peduncle than at the same points in full-grown bodies. The four *cameræ* (fig. 127, τ^3) of the peduncle, as yet, remain totally distinct from each other posteriorly. They lie much nearer the axis (fig. 128), and occupy a larger portion of the peduncle than in their maturity, by one-

third, at least, in lateral extent; but no more between the axis and the periphery. At the posterior end (*fig.* 127) they are still more expanded, indeed almost to double their diameter in front. In a transverse section (*fig.* 128) they present a broadly ovate outline, with the narrower end next the axis; or in the posterior region (*fig.* 127) they are approximately triangular.

160. *The Muscular System* (*figs.* 20, μ , 127, 128, r).—We have once before spoken of the muscles of the umbrella (*fig.* 20, μ), and yet revert to them here in order to add that their presence is proved not only by their histological elements, but by the already well pronounced ridge-like incassations which extend like the rods of a fan from the proboscis to the margin of the umbrella. The marginal muscle is still inconspicuous, as far as external appearances would indicate its presence. The chief point of interest is in the *peduncular cords*. Viewed from without they might very naturally be mistaken for a second set of canals alternating with the true cameræ. They have, in reality, the form of a hollow cylinder, which is slit open along its whole length on the side facing the axis. In a transverse section (*fig.* 128, r) they appear like crescents, with the horns nearly in contact, imbedded in the chondrophys (c^1). At the posterior end the cylinder expands (*fig.* 127, r) a little and terminates abruptly, without sending off a process toward the axis, as is done in the later periods of life. The mass seems to be composed of minor cords placed side by side, so as to inclose, in a rough way, a space, which opens on one side, as mentioned above. This gives the muscle a longitudinally furrowed appearance, both without and within the cylinder. The deeper and more conspicuous furrows are evidently the spaces between the minor cords, and the smaller furrows are mere longitudinal depressions in the solid mass. If, now, we contrast these cylinders with the cords of a full grown individual (*fig.* 52, r), we shall find that the younger ones are proportionally a great deal larger, as any one may see at a glance, upon inspecting the transverse section of the peduncle of the animals at these two extreme ages, and comparing the cords with the cameræ (τ^3). Observe also the space which the former occupy between the latter, or between the axis and the periphery of the peduncle. Finally, we would draw attention to the peculiar relation of the interior of these muscular cylinders to the chondrophys. It would seem to be a law in the organization of these parts that the *chondrophys* shall form a surface of contact to every exposed part of the muscle, and, therefore, here in the young, even the interior face of the contractile cylinders abuts against the fibres of the chondrophys (c^1), the latter entering the cavity of the former through its longitudinal slit. These fibres have essentially the same arrangement throughout the peduncle as in the full grown body (¶ 198), but they are much fewer, and are less delicate.

160a. *The Chondrophys* (*figs.* 127, 128, c^1).—The great thickness of this layer in the peduncle at this period leads us to the conclusion that it was not much less in the previous phase, since in that it was very deep in the umbrella. Its relation to the muscular cords has already been indicated with sufficient precision when describing these bodies, except so far as regards its histological, fibrous elements, and these will be treated in due time, in the chapters on the structure and development of the tissues (Chapter VII).

§ 22. *A Young Specimen $\frac{1}{8}$ of an inch across. Special Development of a Tentacle, a Colletocystophore, and a Genital Sac.* (Pl. III, figs. 29-33; Pl. V, figs. 58, 59; Pl. VII, figs. 67-73.)

161. This specimen exceeds the last more in size than in the degree of development of its organs, and we might, therefore, almost say that the following description is but a continuation of the previous one. Although only one-eighth of an inch across, the umbella seems broader because the tentacles are so conspicuous, and are longer and more slender than in the last stage. This will appear plain enough if we reflect that as the longest tentacles (fig. 33) are one-fortieth of an inch long, they extend the limits of the body one-twentieth ($\frac{2}{40}$); and as the umbella is one-eighth ($\frac{5}{40}$) of an inch across, the proportion of the latter to the augmentation by the tentacles will be as $\frac{5}{40}$ to $\frac{2}{40}$, or 5 to 2. In the full grown animal the proportion is as 4 to 2.

162. *The Tentacles.*—We have recorded, above, the relative length of the oldest tentacles of this specimen; and now propose to trace the development of these organs from their initial stage up to their full stature. The foundation of this investigation lies in the specimen before us, but the older stages are to be sought for in advanced animals, where the multiplicity of tentacles furnishes a more complete series than where there are only ten or a dozen of these organs in a group. In the first place we will recall the fact, already stated (¶ 93), that the youngest tentacles are always found on the proximal side of a group, and that the oldest lie next the boundary line between the circumoral and aboral faces of the umbella. The earliest trace of an incipient tentacle is exhibited by the appearance of numerous *nematocysts* (fig. 58, ϕ^2), collected in a closely crowded group very near the bases of the other tentacles. It is, therefore, evident that the globular, nematocystigerous tip, the prehensile region, *par excellence*, is the first to develop, and, as we shall see hereafter, to perform the duties assigned to the organ of which it forms a part. The shaft is merely the basis, the handle as it were, by which the instrument is moved from place to place. After this a rounded protuberance (fig. 59, ϕ^2) rises gradually above the circumjacent area, bearing on its summit the group of nematocysts just mentioned. A profile view of this bud discloses its relation to the walls of the body, and we find that from the beginning the whole depth of the circumoral face (ζ) is enlisted in the process, even to the innermost wall, the *gastrophragma* (*i*); for as the bud rises on the outer surface the inner wall also pushes outward with the others, and thus a hollow hernia is formed by the combined action of all. The elements concerned in this process are as follows, taking them in their order from without inward: first, the *opsophragma* (*n*), in which the nematocysts are imbedded; second, the *opsomyoplax* (*m*); third, a faint trace of the *chondromyoplax* (*b*); and fourth, the *gastrophragma* (*i*). The first, at the outset, is considerably thicker than in the adjacent parts. The second offers nothing remarkable. The third, from its peculiar relation to the second (see ¶ 65), is not to be separated from it by any trenchant line. The fourth is thicker than its homologue (*i*) in the umbella, but thinner than in the older tentacles next to it. From

the very beginning to the latest period of life there is always the same, unvarying, *single stratum* of cells in the *opsophragma* and the *gastrophragma*, no matter how great the changes they undergo in other respects.

163. The bud soon becomes a prominent feature by rising quite abruptly from its foundation. It does not, however, present any marked change in its constituent walls, nor in its proportion, except that it becomes distinctly cylindrical, until it is longer than it is broad, and then (*fig.* 54, A) it begins to expand more rapidly at the base and becomes pyriform. At no time does its interior (ϕ^3) cease to communicate openly with the general cavity of the body; nor is the passage-way into it flanked by intertentacular processes until it has advanced considerably beyond the mere bud-like stage. At the beginning of the *pyriform stage* (*fig.* 54, A) the outermost and innermost walls are a great deal thicker near the tip (ϕ^2) than at the base (ϕ^1) of the tentacle. The outer wall gradually thickens along the shaft until it becomes twice as deep in the region of the nematocysts as below. In the innermost wall the difference is not so great by one-half, nor is the transition so gradual, the thickening proceeding very rapidly where the opposite faces converge at the tip. The circumscription of the nematocystigerous area is not yet distinct, as we find the nematocysts extending down the shaft, in diminishing numbers. The myoplax and the chondromyoplax begin to be distinguishable as separate layers, but the latter is very thin, a mere film. It will be judged from these facts that the development of a tentacle is not a mere mechanical protrusion of the walls, stretching outward into finger-like processes and there fixing themselves. If it were so the already well developed chondromyoplax of the circumjacent area would be fully represented, and not obscurely merged into the myoplax. There is, however, one remarkable feature to be noted here, and that is, the bud is very nearly as broad as the bases of the oldest tentacles. This is not because the walls are as thick, but the cavity is much broader in proportion. On this account it is not an easy matter to determine the relative ages of those which stand intermediate between the pyriform stage and that in which the globose tip is distinctly marked out.

164. From this time onward the principal changes consist in the elongation of the shaft, and an increasing slenderness (*fig.* 34), while its innermost wall (*fig.* 48, v'') and the chondromyoplax (b^1) thicken gradually, and diminish the diameter of the cavity. At the same time the nematocystigerous region (ϕ^2) increases very rapidly in depth, and its boundaries become insensibly more circumscribed, until by the time the tentacle has attained a length which is from ten to twelve times greater than the diameter of the shaft, it finally assumes a decidedly globular form, and is separated from the shaft by a sharply defined line. The latter is particularly noticeable in the largest tentacles (*figs.* 54, 55) of full grown individuals, where it may be recognized as a narrow, light band, in reality a sharp constriction, at the line of junction between the shaft (ϕ^1) and the spheroid (ϕ^2). It is also observable in quite young tentacles (*fig.* 33, ϕ^4), but is far less conspicuous than in the oldest of these organs. The last noticeable change occurs after the tentacle is very nearly full grown, and then the spherical tip becomes depressed at the distal end and assumes a more or less oblate spheroidal figure (*figs.* 41, 42).

165. *The interior intertentacular processes* demand a little attention in this connection, since they are something more than mere intermediate areas between the tentacles. What their precise office is we do not even pretend to suggest, from the knowledge of any established facts; nor is it necessary that they should have any functional importance, notwithstanding their very marked features. They appear initially as simple, low, conical protrusions (*fig.* 58, π) from the areas between the adjacent bases of the tentacles. They are perfectly solid, and include only the gastrophragma and the chondromyoplax (b') within their limits; not differing, therefore, in this respect, from their full-grown condition (*fig.* 55, π). Their innermost wall, at this period, is very thick, fully equal to that of the tentacles. Eventually they become more prominent, and, at the same time, connect laterally with each other, forming a network of ridges. This occurs as early as when the umbella is no more than one-eighth of an inch in diameter, and the processes have a slightly pyriform shape. Finally they thicken largely toward the free end, by the enormous development of the chondromyoplax, and become as we have described them (§ 103) in their full grown condition. During the gradual expansion of the chondromyoplax, the gastrophragma proceeds in the inverse way, and finally becomes excessively thin by the time the animal reaches maturity.

166. *The Anchors*.—By means of an arrest, or rather retardation, of development in one specimen, evidently arising from an injury to one side of the umbella, we are enabled to trace the process of the formation of the colletocystigerous layer, and to prove, beyond all demands for testimony, that the anchor originally has the proportions and structure of a tentacle. The character of the anchors in a normal condition is illustrated in a figure (*fig.* 32) which we shall describe presently; but we must go back now to a younger stage of these bodies, as exhibited by an anchor which has developed less rapidly than the others, belonging to the same individual. This example (*figs.* 30, 31) has all the appearances of a tentacle far advanced in development; the globose tip (α^2) abounds in nematocysts, and is sharply restricted from the shaft; the latter is four or five times longer than thick, and its muscles are so strongly developed as to appear like heavy ridges (α^1, α^7), as in a full grown, genuine tentacle. The only difference between the tentacle and the anchor is to be found in a slight thickening (α^3) of the outer wall of the latter over the middle third of the shaft, along the distal and lateral portions. This has an oval form, and is studded with *colletocysts*, scattered in an irregular manner, just beneath the surface. It is thickest on the distal side, and thins out at its edges, to the depth of the wall immediately about it. Its distinctness is due largely to the great development of pigment matter within the nuclei of the cells of the outer wall. There is nothing of the kind as yet on the proximal side, the wall retaining, up to this time, a purely tentacular character (α^4) from one end of the shaft to the other.

167. The next earliest stage after the one just described is to be found in the anchor of the youngest Lucernaria that has come under our notice, and described in a previous section (§ 20). In addition to what is there recorded we will make some further statements, principally in the way of comparison with the previous stage. The main point of difference lies in the relative thickness and extent of the colletocystic mass, which in the present instance (*fig.* 123, α^3) is considerably

greater in both respects, since it almost encircles the proximal as well as the distal and lateral faces, and also has such a strong development of its depth as to present a prominent hump on the distal side. We ought to mention, also, that the chondromyoplax (b^2) is a strongly marked layer in the colletocystic mass.

168. Returning, now, to the specimen from which we obtained the youngest anchors, we find, in a normal condition, (*fig. 32*) a phase slightly advanced beyond the last; differing principally in the increased relative shortness of the shaft, tending, as we shall see hereafter, to sink the globose tip into the colletocystic pad (α^3). There is no diminution, however, in the intensity of the tentacle characteristic; in fact, we might justly say that it is rather increased in some respects, for instance, by the greater sharpness of the line of demarcation between the shaft and the spheroidal tip, and particularly by the appearance of the narrow, elastic band at that point, so eminently conspicuous in tentacles far advanced in development. The physiognomy of the colletocystic mass does not vary from the youngest example, as regards its histological elements, but, as for its proportions as a whole, there is a sufficiently marked change to render a comparison of it with a fully-developed anchor facile enough to satisfy the most exacting criterion. Already the terminal portion of the shaft and the globose tip have the appearance of being appendages of the colletocystic pad, rather than the reverse. The dominant feature of the anchor is rapidly approaching the condition when it is the only one to be seen without a special search. We think this will be clear enough to any one who will take the trouble to glance over the following figures (*figs. 81, 82, 83, 26, 27, 25*), which are yet to be used to illustrate our subject. We have yet to mention one other feature of progress in the case before us, and that is, the strong bulge (*fig. 32, α^6*) of the proximal face of the shaft, opposite the area covered by the pad. It is not yet encroached upon by the colletocystic mass, but yet it may be forced out into a prominence by the gradual enlargement of the lateral extent and depth of that mass, rather than by any inherent property. The cavity of this organ, however, would seem to militate in favor of the latter view, for we learn, upon close scrutiny, that the lining wall—*gastrophragma*—bulges and thickens a little also, in the same region, so as to trend parallel with the outer wall. This could hardly be produced by any influence that the colletocystic mass might bring to bear, especially as it is the initiatory step in the formation of the larger freed chamber of the full grown organ. The chondromyoplax plays a much more conspicuous part here than in the oldest tentacles of this individual, occupying at least three-fifths of the depth of all the combined layers.

169. In order to make the developmental process of the anchors as clear as possible, it seems advisable to describe it in a continued succession of sketches, and we shall, therefore, draw into the limits of this section all the phases that we possess, in the form of illustrations. The next one that we shall take up for consideration (*figs. 81, 82, 83*) has lost a large part of the shaft of the tentacular form, and the globose tip (α^2) stands out like a high knob on the oblique face of the colletocystic pad (α^3). It belongs to a specimen which measures slightly less than one-fifth of an inch across the umbrella (*fig. 84*). The pad (α^3) itself extends, on the distal side, downward to the base of the original shaft, as in the

full grown organ, but, although it converges right and left much nearer to the median line of the proximal side than in the last phase, it does not form a complete circle about the shaft. It is much the thickest on the distal side nearest to the nematocystic knob (α^2), and thins out gradually backwards, and passes insensibly into the ectophragma (f') of the aboral side of the umbrella. Its true termination is indicated by the disappearance of the colletocysts, and by the edge (k^1) of the muscular layer. It thins out at the same rate at the sides (*fig. 82*), but rapidly loses in depth as it approaches the proximal side, and finally ceases to exhibit its characteristic features, the colletocysts, before it completely embraces the shaft. Its near approximation to the entire encirclement of the shaft is indicated by the great thickening of the opsophragma (n^2) along the median line of the proximal side.

170. All of the elements of a complete anchor are here well exemplified, both in point of distinctness and thickness. The opsophragma of the colletocystic portion (α^3) is nearly at its full grown *maximum* thickness on the distal side, near the knob, and equals in this respect the combined depth of the subjacent layers. Curiously enough, though, this proportion is reversed at the base of the organ, for as the opsophragma (n^2) decreases in thickness, the *gastrophragma* (i^3) increases in like degree, so as to be nearly as deep as the greatest measurement of the former. At no point, though, is the outer wall as thin as on the umbrella proper; not even where it joins its homologue on the aboral side of the umbrella, since there it does not suddenly cease its diminution in depth, but continues to do so for a short distance backward, until it attains a certain measure, and then spreads with a uniform thickness over the aboral area thereabout. The *myoplax* (m^3) is quite thick and sharply defined throughout the anchor, not excepting the tentacular portion. The *chondromyoplax* (b^2) is also equally well marked with the myoplax, and as thick, on the average, as the gastrophragma, but, unlike the latter, is nearly of uniform thickness throughout its length and breadth; only exhibiting a slight thinning at the sides of the anchor, and at the base of the nematocystic knob. The *gastrophragma* (i^3), except along the distal side of the anchor, is generally a little thinner than the chondromyoplax, but, like the latter, thins a little at the sides and at the base of the knob. In accordance with the preponderating weight of the colletocystic mass on the distal side, the internal cavity (α^4) of the latter projects in the same direction, much more than it does in any other, forming on that side a broad *diverticulum*. The average diameter of the cavity of the anchor in a proximo-distal direction is not more than one-third the measure at right angles to that. Within the base of the globose tip, however, it abruptly thins out to a narrow tube, but at its proximal end it gradually widens (*fig. 82*) into the general cavity of the umbrella.

171. The *nematocystigerous*, globose tip (α^2) of the original tentacular shaft of this organ is quite densely crowded with the larger and smaller kinds of nematocysts. Up to this period, at least, there seems to have been an increased development of these cysts, both as regards their numbers and the perfection of their structure. In order that their present condition may be well understood, we refer to the figure (*fig. 48*) and description of the globose tip of a very young tentacle

belonging to the same individual as the anchor. After this time there seems to be a retrograde metamorphosis taking place in the nematocystigerous sphere, corresponding to the advancement of the colletocystigerous mass; but we are pretty well assured that this is rather an arrest of development, and a scattering of the cysts over a wider area, consequent upon the growth and expansion of the walls in which they are imbedded. The decrease in the number of the nematocysts does not necessarily imply a retrograde metamorphosis, for their disappearance may be accounted for in the habitual falling away of similar bodies in the tentacles, at all ages. Such a phenomenon in the tentacles assuredly does not indicate a retrograde metamorphosis; and the failure to reappear in the anchors means no more than an arrest of development. In the course of time, therefore, the characteristic feature which enables the observer to identify the tentacles with the anchors disappears in the latter, and a totally new one is implanted in its stead. This is but another proof added to the list which sustains us in the belief that the so-called retrograde metamorphosis is nothing more than *mimetism*, and a preponderating development of one or more parts of an organism, subservient to a particular end. (See ¶ 125.)

172. In the next phase (*figs.* 26, 27) of the anchor, which we shall illustrate, the colletocystigerous mass (α^2) has united across the median line of the proximal face of the shaft (α^7), and thus formed a complete circle about it. The animal bearing this organ measured a trifle more than one-fifth, say six twenty-fifths of an inch across the umbella (*fig.* 28). The specimen argues a certain amount of irregularity in the rate of growth and development of the anchors of this species, as one may judge for himself by comparing the figure of the phase now under consideration with that of the one preceding it, when he will observe that, notwithstanding the colletocystic mass of the older stage is more advanced than that of the younger, the terminal part of the shaft (*fig.* 83, α^7) of the latter is the shorter of the two, and evidently has ceased to grow at an earlier period. The main progress which the oldest phase has made is exhibited by the very heavy preponderance of the colletocystic mass (*figs.* 26, 27) on the distal side of the anchor, extending obliquely outward and posteriorly, so as to almost equal the reach of the globose, nematocystigerous tip (α^2). The latter, in consequence, arises from the oblique proximal face of the pad, and has rather the appearance of a lateral appendage than of a real terminus of the anchor. Still it preserves the tentacle-like physiognomy strongly enough to suggest its original form, and the colletocystic mass looks like a huge circular bolster set about its neck. The cavity (α^1) of this organ, like the pad, preponderates so strongly on the distal side that at least four-fifths of it lies exterior to the longitudinal axis of the original shaft. Therefore, all of the tendencies of development toward a determinate end are here fully marked out, and nothing is wanted to complete the organ but changes in the proportions of the several parts.

173. These changes, however, are by no means small, although no new elements are introduced in the process. In the phase just described, the nematocystophore (α^2) arises midway between the two extremes of the colletocystophore (α^3) on its oblique proximal face, whereas in the full developed organ (*fig.* 47) the former

lies near the distal extremity of the latter, the first being indicated by a slight protuberance (α^2), dotted with a few nematocysts, and the last presenting itself under the guise of a huge, broad, oval mass (α^3), furrowed along one side, and simulating a coffee-bean in proportion and physiognomy. As an intermediate stage between these two last, we offer for inspection a figure of the anchor (*fig. 25*) of an individual which was two-thirds grown, or about three-fifths of an inch across the umbella. This view is designed principally to show the proportionate size of the nematocystophore (α^2), and its relation to the longitudinal furrow of the colletocystophore (α^3), and the latter is, therefore, foreshortened from its proximal face. The nematocystophore (α^2) still projects above the level of the main mass which surrounds it, the meagre remnant of a once vigorous organ. It will be seen, from these three views, that the change which transports the nematocystophore in the youngest stage to the extreme distal end of the colletocystophore in the fully grown animal, consists in the development of a very large proportion of the colletocystic mass on the proximal side of the clear space (α^5) from which the tentacular knob arises, and consequently throwing the latter into the extreme opposite direction. Accompanying this process there is also a gradual broadening of the mass until it becomes so much wider than the peduncular portion that the latter appears slender when contrasted with its former relative proportions in the penultimate and antepenultimate stages. We return now to the general description of the organs of the phase with which this section was opened.

174. *The Muscular System.*—The inconspicuous marginal muscle of the last phase has become in this a sharply defined, ribbed band (*fig. 58, m'*), running along the same line as in the full grown animal. We have endeavored to display its internal face in our illustration by cutting open the circumoral parietes and throwing it back so as to expose its interior surface. From this point of view, the band may be seen thinning out, and finally disappearing as it reaches the base of the tentacular group. Concerning the rest of the muscular system we have nothing to say, except that the ridges of the opso-myoplax, in the umbella, are so well developed that the circumoral face presents as great a diversity of physiognomy, as far as these ridges affect it, as in the full grown animal, although not so strongly marked and conspicuous.

175. *Reproductive Organs (figs. 67-73).*—A clear understanding of the mode of development of the reproductive organs of *Lucernarie* is of paramount importance, for more reasons than one. In the first place, they lie at the foundation of the *type idea* of this order, and, therefore, their exact relations to the walls of the umbella, and to its exterior and interior faces should be made manifest from all points of view. Their initiatory stages will, therefore, present them in their simplest form and connections, before they have become so complicated and extended as to obscure, more or less, the membranes from which they arise. This is, moreover, quite essential, because they can at that period be compared most readily with the reproductive organs in the other orders of *Acalephæ*. In the second place, we shall not find it so difficult to comprehend the situation of the inverted wall of the fully developed genital sac, with all its convolutions, if we trace it, step by step, from its simplest condition up to its most complicated form; and, again, the two cate-

gories of proof, as to its structure, insensibly merge into each other, and mutually sustain their position. It will become evident at the outset that the internal surface of the genital sacs was originally the free face of the general cavity of the umbella. In the description (§ 135) of the full grown sacs we have pointed to the fact that the eggs are "sunken in pouches formed by folds of the lining wall;" that is, they do not lie beneath this wall, but against its free surface; the same surface that is continuous with the free face of the lining wall, *gastrophragma*, of the general cavity of the umbella. In all other orders of Acalephæ the eggs, or the spermatie mass, are actually covered by the gastrophragma; and some even by the gastromyoplax and chondromyoplax, and imbedded by the opso-myoplax. We have already noted the advent of the elements of the reproductive organs in the previous section, but special observations were not made until the present phase came to hand, and we possess, therefore, a wider range of development, in a single individual, than we could have obtained previously.

176. *The initiatory process* in the formation of a saccule consists in an abrupt rising of a thick, ridge-like fold, in the form of a semicircle (*figs.* 67, 68). The convex side (i') of the semicircle faces toward the periphery of the umbella, and the concave side (i) opens (at s^6) toward the proboscis. Thus in the very beginning one of the prime features, which render this order so singular, is established, as if it were an inevitable necessity to the completion of the type. The ridge is not an actual thickening of the oöphragma, but a clear duplication of this layer as it grows and rises above the general surface. The elevation increases but a little while, and then another phase of procedure is introduced (*figs.* 69, 70) which complicates matters to a slight degree. The concave side (i) ceases to grow as fast as the convex side (i'), and the latter in consequence leans over towards the former, very much in the same manner that the crest of an incoming wave arches over its base just as it breaks on the shore. This goes on rapidly, especially midway between the two ends of the ridge, until a distinct hood is formed. This is the condition in which our figure represents the saccule, as seen from two points of view. The wall of the fold (i' , i), it will be observed, is no thicker than its basal continuity (i). At this time the cavity of the new organ is quite deep from its broad aperture (s^6) to its innermost parietes (i), but it is very shallow.

177. Soon after this the aperture begins to narrow under the influence of the onward growth and contraction of the edge of the hood, and at the same time the cavity enlarges and becomes more nearly alike in breadth and depth. The first results is the formation of a narrow, rounded entrance (*figs.* 71, 72, s'), on a level with the circumjacent area, and the second is accompanied by conduplicatures of the inner wall, at a considerable number of closely approximated points, resulting in the formation of little, shallow, wide-mouthed pouches or concavities (s^2) opening into the general chamber (s^1) of the genital. The latter is, at this period, about as broad in one direction as in the other, and not so deep, but rather preserves the proportions of a hemisphere attached by its equatorial face. Between the outer wall of the sac and the follicles there is scarcely any space except at the intervals about the latter. A short distance from the entrance, the wall is contracted on all sides, so closely as to fill up the passage way (s^6) to the interior com-

pletely, but immediately beyond, however, it expands laterally and diverges into the main fold. By plunging through the circumoral floor, and focussing up and down upon the saccules, we learn that the follicles do not develop at an equal rate throughout the cavity into which they open, but on the contrary originate progressively and grow at a corresponding rate. This is clear enough if we compare those which lie on a level with the aperture of the saccule with those which are placed at more distant points; the former appearing as scarcely more than shallow depressions (*fig. 71*) in the inverted wall, while the latter are to be recognized as unequivocal pouches (*fig. 72, s²*) with a rounded contour and a narrow aperture. That all of the follicles do not originate at once is proved by a glance at the next figure (*fig. 73*) which we shall use to illustrate the series.

178. We now present the last phase of development of the saccules that we are in possession of; and we think that it is far enough advanced to connect the earlier stage of the organ with its full grown condition. There is really nothing new in point of character in the specimen (*fig. 73*), and it differs from the previous one merely in the greater size and more abundant follicles (*s'*) opening into the general cavity of the saccule. Up to this period no trace of eggs nor of spermiatic particles has been met with, neither, unfortunately, are we able to furnish any information in regard to the mode of origin of the reproductive material. The size of the saccule before us measures from one-fourth to one-third the diameter of full grown ones; and the follicles are as yet far less in number, amounting at most to only forty or fifty. The latter are a little larger than those of the last stage (*figs. 71, 72*), and press closely against the outer wall of the saccule.

179. *The Chondromyoplax*.—We return now to the more legitimate objects of this section, and take up in turn the successive layers of which the body is composed, as far as we have the material to work with. We find at this stage of growth the first tolerably clear differentiation of the *chondromyoplax* from the muscular layer. This is seen best in the oldest tentacles (*fig. 59, b, m²*), and with rather more difficulty in the circumoral region. In either case it is not more than two-thirds as thick as the outer and inner walls in the same place, and from two to three times thicker than the muscular layer. In the anchors (*fig. 32*) it has a much greater depth, amounting to from three to four times that of the outer wall. As yet it appears to be perfectly homomorphous, a mere structureless, chondroid *stratum*. This is all we have to say, here, of the *chondromyoplax*. The description of its origin and mode of development belongs more properly to the histology of the layer.

180. *The Chondrophys*.—This layer is at least twice as deep in the umbella as the diameter of the oldest tentacles of the individual now in hand. $\frac{1}{2}$ Its histological elements are much more delicate than in the last phase, as far as it may be estimated from that part of it in the peduncle of the latter; and it is differentiated into two distinct *strata* (*fig. 58, c, c'*). The outer *stratum* (*c'*) is comparatively thin, not more than half the thickness of the outer, aboral wall immediately overlying it. Moreover, it, conjointly with the muscular layer, forms the partition which lies between the great mass of the *chondrophys* (*c*) and that part of the *chondromyoplax* which is in the tentacles. The inner *stratum* constitutes nine-

teen-twentieths of the whole chondrophys. The innermost of the three subdivisions of the chondrophys, so conspicuous in the full grown individual, is not to be seen as yet, although it is quite strongly marked in the next, and not much older phase (*figs.* 82, 83, *c*¹).

181. *The Nematocysts* constitute a marked and very conspicuous feature in the surface of the body, especially in the aboral face; forming numerous, thickly scattered, wart-like processes, by developing in closely set groups (*figs.* 30, 31, 32, *l*). On this account the outer wall appears much thicker than is really the case; although its true depth is considerably greater than on the tentacles. In the full grown animal these cnidigerous warts are so widely scattered that they scarcely attract attention. In *Calvadosia campanulata* they are, on the other hand, a singularly prominent part of the physiognomy.

182. *The Eye-spots* (*fig.* 32, *θ*).—In the paragraph (§ 127, § 17) on the nervous system of the full grown animal we have enlarged considerably upon the relation of the so-called eye-spots to the visual function, and have spoken of them there as interstitial deposits of pigment matter. The present stage of development is the earliest one in which we have observed such accumulations. Here they form low bosses, extending over about one-quarter the breadth of the oral face of the base of the right anchors. The true nature of these bosses will be better illustrated in the next phase (§ 23), showing that there are certain concomitant features in the cellular mass of the wall in which they are situated.

§ 23. *Young, $\frac{1}{5}$ of an Inch Across.* (Pl. IV, *fig.* 48; Pl. V, *fig.* 53; Pl. VIII, *figs.* 81-84; Pl. IX, *figs.* 106, 107.)

183. By the time the umbrella has reached the diameter mentioned at the head of this section the proportions of the body as a whole are very similar to those of a full grown individual, but are rather more slender. The transparency of the body renders it more light and airy in appearance than its elder companions, and in consequence seemingly less bulky and clumsy. The *tentacles*, however, still fall short of the proportions of the highest development; the shaft of the oldest members of a bunch being, as yet, relatively quite thick. The *anchors* (*figs.* 81, 82, 83), as has already been stated in a previous paragraph (§ 169), have “lost a large part of the shaft of the tentacular form, and the globose tip stands out like a high knob on the oblique face of the colletocystigerous pad.” Further details may be learned by reference to the paragraphs 169, 170, 171.

184. *The Muscular System.*—The *opsomyoplaxic* division of this system is clearly defined throughout the umbrella (*figs.* 53, 83, *m*, *m*¹, *m*²), and the tentacles (*fig.* 48, *m*²), and anchors (*figs.* 82, 83, *m*³), but the *oömyoplax* (*figs.* 53, 83, *m*, *m*¹, *m*²), (§ 74) is not visible. The former is distinctly fibrous, and of about equal thickness in the different members mentioned, although apparently less in the proboscis (*fig.* 53, *m*²), on account of its more regular outline on its proximal face. In the latter organ, at this age, its abrupt termination at the mouth (ρ^1) is very distinctly seen without the help of the dissecting knife.

185. *The chondromyoplax* is more or less strongly marked by transverse stria-

tions in all regions of the body in which it is destined to develop. In the tentacles (*fig.* 48, *b'*) it is on the average as thick as the outer or inner walls, and is very delicately striated. The same may be said in regard to the anchors (*figs.* 82, 83, *b'*). In the umbella it is variable in thickness; in the circumoral area (*fig.* 53, *b*) it is fully twice as thick as either the outer or inner wall, but scarcely more than half the depth that obtains in the proboscis (*b'*). Throughout, however, it is much more heavily striated than in the tentacles and anchors. In absolute thickness this layer has in the anchors from two to two and a half times more depth than in the tentacles and circumoral area.

186. *The Chondrophys* at the umbella exhibits a higher number of subdivisions than we have detected at subsequent periods. Of the three (*figs.* 82, 83, *c*, *c'*, *c''*) now visible, the innermost, thin substratum (*c'*) was not observed in the last phase. This is the one which is conspicuous throughout the remainder of the existence of the animal, while the outermost, and by far the thinnest one (*c''*), seems subsequently to lose its character as a separate subdivision. The latter in its earliest phase was very conspicuous, but in the present state it is quite faint, and nearly escaped our attention when the chondrophys was under the microscope. It is apparently quite homogeneous in substance, of a light yellow color, and about as thick as the outer, aboral wall. It is barely possible that it exists in mature individuals, but is so excessively faint as to require a special effort to find it. The main bulk, or middle portion (*c*) of the chondrophys, is enormously thick; equalling at least four times the diameter of the shaft of the oldest tentacles. Unlike the two thinner subdivisions, it is strongly striated in transverse section, and thickly penetrated by fibrous prolongations, which originate in the two outer subdivisions (see ¶ 197, A). Its marginal termination at the bases of the anchors has nothing of the abruptness of the mature form, but, rather, tapers off rapidly to a sharp edge where the muscular layer of the anchors intervenes (at *k'*) between it and the chondromyoplax (*b''*).

187. *The Opsophragma*, or circumoral (*fig.* 53, *n*) and proboscidal (*n''*) outer wall, differs but little, if any, in thickness from that of the mature individual. Its proportion on the anchors (*figs.* 82, 83, *n''*) has already been described (¶ 170), when the development of these organs was under consideration (§ 22). The *ectophragma* (*figs.* 82, 83, *f*), or outer wall of the aboral side, also closely approximates that of the full grown body in character and proportion.

188. *The Gastrophragma*, or innermost wall, at this age may be traced, with great facility, into its direct continuation with the opsophragma at the mouth (*fig.* 53, *i'*) of the proboscis. It is there very thick, and continues so to the base of the proboscis, where it rapidly thins out and loses nearly two-thirds its depth as it passes along the circumoral area (*i*) to the periphery of the umbellar chambers. Its rapid thickening as it approaches and enters the anchors (*figs.* 82, 83, *i'*) has already been touched upon (¶ 170) in the history of the development of the latter organs, and needs no further notice here, except to contrast it, at the present age, with its proportions and absolute thickness in the mature animal (*fig.* 47, *i'*). It will be seen, by comparing the illustrations of the first (*fig.* 83, *i'*) and of the last (*fig.* 47, *i'*), that, in order to attain to the proportions of the latter, this wall must

diminish the relative thickness fully one-half, within the anchors, and to a far greater extent in the region of the passage-way (*fig.* 83, ψ^7) between the umbellar *camera*.

189. *The Eye-spot*.—At two or three points (§ 127–130, 182) in the progress of this memoir we have enlarged more or less upon the functional nature of the so-called eye-spot. In addition to what has been already offered we would draw attention to the peculiar manner in which the pigment matter is disposed. We find it holding exactly the same relation to the prismatic cells (*fig.* 83, *b*), *i. e.*, forming a dark casing or envelope about them, as the pigment does to the facets of the eyes of *Articulata*. Adding to this the evidently special character of these cells, as exhibited by their extreme elongation, and by their close aggregation and prominence at a given point, we have all that can be brought forward in favor of their functional characters as elements of an optical apparatus. Although we are not eager to assert that they are capable of forming distinct images of surrounding objects, we are, on the contrary, far from denying that they may possibly be capable of acting as refractive agents; since every cell that possesses a convex contour is a fraction of a lens; and a combination of such cells as we have here may constitute a whole lens in effect. It may not be unadvisable to state here that we hold, with others, that, notwithstanding the so-called eye of an insect is a compound of many *single* eyes, it none the less is *functionally* an optical *unit* so far as its effects upon the optic nerve is concerned; producing, like the pair of human eyes, but a single image on the brain.

§ 24. *Young, $\frac{6}{5}$ of an Inch Across.* (Pl. III, *figs.* 26, 27, 28.)

190. *The Anchors and Eye-spots*.—There is but one feature of this phase that our illustrations are intended for, and that is the condition of the *collocystophores* or anchors. The prehensile portion (∞^3) of these bodies has been described in a previous section (§ 22) with considerable fulness, and therefore needs no further notice here, but the so-called *eye-spot* (*b*) remains yet to be considered, although it has also been touched upon in preceding paragraphs (§ 127, 189). We have nothing in the way of details to add to what was given in regard to the preceding phase (§ 189), but we may say a word or two more in reference to the latest condition in which this organ has been observed. It now attracts the attention of the observer by its distinctly marked outline, deep color, and particularly by its boss-like prominence (*fig.* 26, *θ*). It is remarkable for appearing to be possessed of a lens imbedded in its middle; but this is a fallacy arising from the more abundant accumulation of pigment granules in the periphery of the eye-spot than at the centre, and hence a comparatively clear area is left in its midst. After this period the eye-spot is gradually lost sight of; but still we cannot say positively that its functional character is obliterated, for we are not sure that it is possessed of such at any time; and it may possibly retain all its potential features, even when, in extreme old age, it is obscured, to the eye of the observer, by the abundance of diffused pigment spots all around it.

CHAPTER VII.

HISTOLOGY OF HALICLYSTUS AURICULA.

§ 25. *The Umbellar and Peduncular Walls.*

191. In some respects it would be better to connect the histology of the parts and organs of the body with their general structure, so that all their characteristics might be presented in one view; but there are other and weightier reasons why a separate chapter should be devoted to the intimate structure of the tissues. In the first place the subject and arrangement of the sections are rendered much less complicated and clearer for comparison; and again, it leaves more room for the discussion of collateral questions, such as the *cell-theory*, and the like, without involving the confusion of parenthetical sentences and explanatory notes. Yet we shall so arrange the sections that each may be read as a continuation of any previous one devoted to the general description of a corresponding organ or part. In accordance with this purpose we begin with the outermost wall of the anterior face of the umbella.

192. To those who accept the theory that the tissues of *Acalephæ*, and other groups of this grand division, are composed of true cells, wherever there is the *appearance* of such bodies, it will come with most force, when we state that in *Lucernariæ*, as in other orders of the class, there is but a *single stratum of cells* in each wall. If we except the family *Tabularidæ*, this may be announced as a *law* among all *Acalephæ*, both in the hydroid as well as in the medusoid morph. In most highly developed medusoid morphs these strata are so excessively thin, that is to say, the component cells are so shallow, that they have more of the character of a filmy epithelium than of a true wall; whereas in the hydroid morphs it frequently happens that some one of the layers is so thick as to constitute three-quarters or more of the whole bulk of the body. In *Lucernariæ* we find these two extremes indiscriminately intermixed.

193. *The opsophragma* (see ¶ 61, 62) of the umbella (*figs.* 74, 85, 86, $n-n^3$) is composed mainly of the single stratum of cells which are so conspicuous, even to a casual observer; but these cells are by no means all that give bulk to this layer, for they stand at more or less considerable distances apart from each other, and the large interspaces that intervene add greatly to the physiognomy. In fact the color of this region is almost altogether due to the large masses of pigment granules (e^2) which crowd these interspaces, and underlie the cells; and the latter are rendered all the more conspicuous by the dark ground-work in which they are imbedded. The *cells* are not arranged collaterally in any particular order, nor have they a uniform size, some being at least twice, and occasionally three times the diameter of others; on the average they are about one-quarter deeper than

broad. Their true, exterior boundary is irregularly polygonal, but rather inconspicuous on account of the abundance of the pigment masses thereabout; whereas the interior boundary, which is an irregular oval, or sometimes obscurely polygonal, is very sharply and distinctly marked, and moreover so conspicuous as to give the stratum, under a low magnifying power, the appearance of being a mass of dark, granular blastema, filled with clear vacuoles. It will be seen from this that the exterior and interior faces of the cell-membrane (d') are not parallel, in other words, that this membrane is of unequal thickness; and, from the nature of things, incrassated most at the angles. On the whole it is quite thick, but yet plastic to a considerable degree, both in reference to lateral pressure and to what ever tends to increase its depth at the expense of its breadth. The extensibility of this layer, however, is not altogether a property of the cells, for the interstitial substance is not to be overlooked, nor have we any reason to believe that it is less plastic or dilatable than the vesicles. Nor, on the other hand, do we admit that either the one or the other is capable of extending or retracting itself, unless we altogether ignore the muscular layer (*opsomyoplax*, *fig. 85, m*), which presses closely against the inner face of this wall. The contents of a cell are of two kinds, and very simple in quality so far as their mechanical, or rather physical, nature is concerned; the one is a perfectly homogeneous, fluid-like, colorless, slightly refracting mass (d''), filling the entire inclosed space, with the exception of that occupied by the nucleus, which is the other part of the contents. The *nucleus* (d^1) is the most noteworthy feature of the cell on account of its invariable lateral position. Without an exception we have always found it attached to the cell-membrane between the exterior and inner ends of the cell, *i. e.*, against the faces of mutual contact. Here we should naturally expect to find it, in a wall composed of a single *stratum* of cells, which grows by self-division of its components, the nucleus, as is well understood, lying in the line of separation. This uniformity of position is carried still further, for the nucleus seems to be fixed about midway between the two extremes of the cell, so that in a profile view (*fig. 85*) of the stratum they appear as if arranged in a row when observed collectively. We shall see presently that this arrangement is still more striking in the corresponding wall of the tentacles. The outline of the nucleus is tolerably well defined, but not sharp nor rigid, and the whole presents a uniform, quite conspicuous, colorless, semi-transparent, lenticular mass, attached by one of its broad sides to the cell-membrane. On an average its diameter is about one-fifth or one-sixth the depth of a cell. The *intercellular blastema* not only lies between the cells and beneath them, but completely covers their outer, free ends, and therefore it may be said, without exaggeration, that the cells are completely imbedded in the blastema. The pigment (e^2), which gives color to this formless mass, consists of irregular granules of great diversity in size, some equalling the nuclei of the cells, and others measuring less, and so on down to those which are, comparatively, mere specks. The larger granules usually alternate with the cells, filling the interspaces at the angles with a highly refracting, often brilliantly colored mass. The finer and speck-like granules crowd the blastema which overlies the ends of the cells, and lend considerable aid in imparting color to the wall, in fact giving uniformity to the tint, which otherwise would

run like a network in the interspaces. Frequently highly refracting, large, oval, or globular bodies (*l*) may be observed, mixed with the coarser pigment, at the junction of three or four cells. A close examination proves these to be urticating vesicles (*nematocysts*). Their refracting power renders them quite brilliant objects, and lights up the face of the wall with bright, salient points. The bristle-like projections, which are often observed on the free surface of the wall, are portions of the blastema which are apparently thrust outward by the partially extruded filaments of the nematocysts. More will be said of this hereafter, in the description of these offensive weapons (§ 30), and the true relation of the bristle-like bodies will be amply explained. (See also ¶ 203 (A)).

194. *The ectophragma* (¶ 63) of the umbrella and peduncle (*fig.* 87) consists of cellular elements which exhibit a close affinity with those of the *opsophragma* (¶ 193), still there is a decided and readily observable difference between the two. The cell-membrane, the exterior and interior configuration of the cells, their size and proportion, their mode of arrangement, the fluid-like contents, and, finally, the granular interstitial blastema, might all be described in the same words as used for the components of the opsophragma. The main diversity then is narrowed down to the character of the *nucleus* (*d*¹), and this we shall find is not inconsiderable. Strictly speaking, the nucleus is no longer visible, if it exists at all, and seems to be either covered up, or replaced by very dark, highly refracting, irregular, large granules, which are heaped together in twos, threes, or fours and fives at the side of the cell. Occasionally they are detached and lie in the midst of the homogeneous contents. These *pseudo-nuclei* are many times larger than the nuclei of the cells of the opsophragma, and such is their opacity and intensity of color, to say nothing of size, that they effect far more, in producing the tint of this stratum, than the interstitial, granular blastema (*e*). Hence it is that this face of the umbrella is darker than on its front. We should add, also, that the nematocysts (*l*) are more numerous than at any other part of the exterior of the umbrella, and frequently are collected in groups of from three or four to a dozen, glittering, from their strong refraction, like clusters of jewels.

195. *The opsomyoplax* (¶ 64) of the umbrella (*fig.* 85, *m*). In the general description of this layer we have stated that it uniformly spreads beneath the opsophragma, and that it is made up of fibrillæ which are placed side by side. We premise this much here in order that we may also recall the arrangement of similar fibrillæ in the tentacles, in which they are disposed, in a broken stratum, at regular distances apart, in groups or bundles. These are the main differences of the muscular system in the two regions in question, and therefore the description of the histological elements of the one may serve for that of the other. Inasmuch, however, as we have illustrated the microscopic structure of this layer in the tentacles with such fulness of detail, and under more advantageous circumstances than could be had elsewhere, we shall refer the reader to the description of the histology of those organs for whatever information may be desirable in regard to the composition of the fibrillæ. The cellulo-fibrous elements are alike in both. We refer also to paragraph 199 for a description of the still more highly developed muscles of the peduncle.

196. *The Chondromyoplax* (¶ 65-68) of the umbrella. We have, on more than one occasion, in various papers, urged the necessity of the closest and minutest, critical observation of the details of all parts of the body of an animal; leaving no point untouched as if it were of too slight importance to deserve more than a passing notice, or as if it had no direct relation with the rest of the organization. The piecemeal manner in which the anatomy of living beings is frequently worked out, a few notes made here, and a few there, with no particular reference to anything except to the novelty of the subject in the mind of the observer, has no doubt led on to the meagre, scattered, and unsatisfactory results which lie hidden in innumerable periodicals, journals, memoirs, and even the popular papers, weeklies and dailies. One cannot sometimes help fancying that a large part of the so-called *facts* of science are the result of the labors, or we might say the struggles, of innumerable incompetents, who, like some of the inmates of an insane asylum, delight in secreting valuables in out of the way places. The lower we descend among the inferior ranks of animals the more directly do the histological elements appear to be connected with the plan of their organization. No doubt this is owing in a large measure to the want of diversity in the form of the organs and their slight degree of differentiation for physiological or other purposes. In fact we might venture to say that a differentiation of histological elements precedes that of organs and regions. That this is most notably so, in some cases at least, no one who is familiar with the muscular system of *Ctenophoræ*, and especially with that of *Pleurobrachia* or *Cydippe*, need doubt. In these creatures the bulk of the body is made up of a gelatiniform mass, which at first sight appears to be homogeneous throughout. Closer scrutiny reveals the fact that it is not so, but composed of two elements; *the one* a clear, transparent, homogeneous, all-pervading, jelly-like substance, and *the other* dispersed throughout the latter in the form of innumerable, hyaline fibres. These fibres, however, are not scattered irregularly here and there, but disposed in a most orderly and methodical manner; yet still do not attain to the main essentiality of true differentiation, viz., segregation and concentration into a well defined organ; but, on the contrary, the fibres of one group thoroughly intermix with those of another, and cross and recross each other without confusion. Thus, then, we see that a differentiation into contractile and non-contractile tissue is decided, whilst a differentiation into distinct organs is but half carried out—merely foreshadowed. The plan of the arrangement of the *fibres* is inseparable from the plan of the arrangement of the *groups* which they compose, and the first plan precedes the second. Such and similar considerations have led us to give more than a passing glance at the disposition of the histological elements of the gelatine-like mass of the body of *Lucernariæ*. Not only do we find in *Haliclystus* a muscular system developed to the highest degree among *Acalephæ*, but also the elements of the *chondrophys* and *chondromyoplax* arranged with a greater preciseness and method than can be observed in any other order. It is not a little remarkable, too, and as if confirmatory of the high rank which we claim for *Lucernariæ*, that the arrangement of the fibrillæ in the *chondrophys* of the peduncle recalls the disposition of those in the *Ctenophoræ*, in spite of their clearly diverse function. Looking at the *chondromyoplax* from a physiological point of

view we have hesitated slightly as to whether this stratum is altogether separate from the *opsomyoplax* and the *oömyoplax*. The forms of the histological elements are different enough, as we shall show presently, and have homological relations distinct from each other; but we believe that the *chondromyoplax* must be looked upon in the light of an *elastic connective tissue* of the muscular layer, and intermediate between it and the adjoining layers, the *opsophragma* on one side and the *gastrophragma* on the other. The fibrillæ of the tissue (*figs.* 53, 74, 77, *b, b'*) are highly elastic; but in no other respect do they exhibit any affinity with the muscular fibrillæ. They are purely homogeneous throughout, with not a trace of anything like a nucleus; in fact, they have more of the appearance of aciniform streaks in a homogeneous, jelly-like mass than aught else we can compare them with. They seem to be direct prolongations of the fibrillæ of the muscular layer (*m*), but that they are not such is proved by their well-marked histological differences. There can be no doubt that the muscular fibrillæ confine themselves strictly within the horizon of the *opsomyoplax*, as we have illustrated most fully in the tentacles, and that the fibrillæ of the *chondromyoplax* alone stretch at right angles to the surface of the layer, directly across its thickness. Consequently, in a section of the depth of this layer, it appears to be transversely striated. The fibres do not, however, always trend through the layer very strictly at right angles, but more or less obliquely to the surface; nor are they of equal breadth throughout, but taper gradually from a base of considerable width to an infinitesimal point, often extending two-thirds or three-fourths through the layer. As they are based on the opposite faces of this layer, their tapering points meet and cross each other at the middle of the thickness of the stratum intervening, as it were, just as the bristles of two brushes do when forced together face to face.¹

¹ (A) The question here very naturally arises as to what is the mode of origin of these fibrillæ. In most connective tissue, as is well known, we may find nuclear bodies scattered here and there among the fibrillæ, but in that which we have now in hand there is nothing of the kind. Have we not here then an independent fibrillization of a cytoblastema? If Virchow and Beale and their numerous adherents admit that a cell need not have a cell-membrane, and requires only the presence of some one concentrated material as the centre of centripeto-centrifugal changes and developments in order to be a *cell*, or "*elementary part*," what must we call these self-originating fibrillæ of the *chondromyoplax*? The same question applies with equal, if not greater, force to the muscular fibrillæ of Ctenophoræ, and our inferences are the same. We cannot see that they lie within the boundaries of a "*cell-territory*" of Virchow; nor at any time or age have we detected "*germinal matter*" of Beale among them. Why should they not be classed as the original "*elementary parts*"? They seem to have originated spontaneously, and we feel compelled, therefore, to admit that they have all the value of cells in the most modern acceptance of the term. We are the more easily led to adopt this view after having convinced ourselves that *cells* so-called (no matter whether constituted according to the older histologists, or according to the most recent theory) are, after all, of secondary importance, and that the *cytoblastema* (which we do not distinguish from intercellular substance) is the main and *essential element*, the potential progenitor of all tissues, and that it projects itself into the utmost future of the living body by a process of self-proliferation. Through this, and this only, can a true *law of continuous development* be illustrated; whilst the various forms of cell-tissue, and fibre-tissue, and bone-tissue, etc. etc., are but the disjointed, collateral developments, each one irrespective of the other, from the continuous, onward stream of cytoblastema. Among the Protozoa, particularly the Amæboids and their Rhizopodic congeners, the cytoblastemic condition of the *ovum* is continued unchanged, as to form, in the adult stage; and so, as we have said in a previous para-

197. *The Chondrophys* (§ 69) of the *umbrella* (figs. 82, 83, c, c², c⁴, c⁵, 106, 107, 109). In the same way that the chondromyoplax stands as an elastic connective

graph (§ 129), all Rhizopods are "moving, sentient masses of *Cytoblastema*," and that alone. Here, then, one cannot doubt that cytoblastema is self-proliferous when an *Amœba* grows. It is most generally adopted as a theory that the cells, of which a wall or tissue is composed, are of *primary* importance, not only in the adult age, but *ab initio*; that it is to the cells that the wall or tissue owes its existence *primarily*. This seems to be the opinion of most histologists, from Schwam down to Virchow and Beale. Schwam (*Mikroskop. Untersuch.*, 1838) claims that cells crystallize out, as it were, from an amorphous cytoblastema. The *nucleolus*, when present, originating first, and condensing around it material for *nucleus*, and the latter carrying on the operation begun by the nucleolus; that they have a *metabolic* power of drawing from the cytoblastema material for development and producing chemical changes in it, while the cytoblastema itself remains *passive*, merely furnishing the nutriment for these purposes. In order to account for the *initial impetus* he is obliged to assume that the cytoblastema is heterogeneous, that it is studded with numerous points of greater density than the general mass, and that at these points a tendency is exerted which draws surrounding material toward them, very much in the same way, he argues,—although he does not positively insist on an identity,—that crystals are induced to form around or in certain areas of condensation. This amounts, after all, and however much he may wish to make it appear otherwise, to an admission that the cytoblastema has within itself the *originating* power of cell-formation. And, moreover, this admission is enhanced by his asserting that the cytoblastema is self-generating, *i. e.*, *proliferous*, and that often the nucleus is an undefined mass for a long time after the peripheric portions of the cell have begun to develop; thus divulging the fact, although unwittingly, that the area of condensation is not precisely about, and in reference to the power of one body, but that this body, or *nucleus*, is merely the guide-post which assists the congregating particles of matter in arranging themselves in symmetrical order in reference to some one lateral point in the cell. Schwam interprets it differently, however, and claims to have proved that the nucleolus, nucleus, and cell-membrane each attracts to itself, and by its own inherent power, material which differs from that entering into the composition of the others. We must quote him, therefore, for what he claims, and not for what he proves, strictly speaking. All animal tissues, in the opinion of this author, are originally cellular, but a part of them cease to be so by a transformation of the cells into tubes, or fibres and fibrillæ. He does not, though, go so far as his successors, and claim that a cell necessarily has a membrane about it; on the contrary, he says that "many cells, however, do not exhibit any appearance of the formation of a cell-membrane, but they seem to be solid, and all that can be remarked is that the external portion of the layer is somewhat more compact." In this respect he anticipates the theory of Beale, and also of Virchow, of late.

(B) Virchow originally, like others, demanded that a body must have a distinct wall about it in order to be a cell, and denied that cells developed by free cell formation, *i. e.*, without the intervention of previously existing cells; his motto was *omnis cellula e cellula*. He agreed with Schwam that cells have a self-asserting power, and went beyond him in attempting to prove that they exercise a control over the interstitial substance, insisting that "the intercellular substance is dependent in a certain definite manner upon the cells, and that it is necessary to draw boundaries in it also, so that certain districts belong to one cell, and certain others to another." (See Virchow, "Cellular Pathology," translated by Chance.) But he also takes considerable pains to impress upon his hearers that interstitial substance is *not* cytoblastema, and that the latter formative fluid does not exist in nature; thus taking away the very foundation of free cell formation. If, however, we are to believe information which comes to us at second hand (see "Edinburgh Med. Journ.," February, 1865) Virchow "now did not regard a cell wall as an essential part of the cell, as given in cellular pathology, but that a nucleus surrounded by a molecular blastema was sufficient to constitute a cell." This certainly looks like going back to Schwam again, and, as he makes the presence or absence of a cell-membrane of no account, the *cell* is left in more open communication with the interstitial substance; the "*cell territory*" is scarcely to be distinguished from the *cell* proper, whose influence radiates into its furthest boundaries. While Schwam asserts that the interstitial substance (*cytoblastema*,

tissue in the oral face of the umbella, so the chondrophys is to the walls and organs of the aboral region. But we are inclined to class the latter with inelastic, fibrous connective tissue, like Kölliker's *reticulative connective tissue*, or something between that and *fibro-cartilage*. If the fibre-like bodies (*c'*) in the chondrophys are, as we hope to demonstrate, of the nature of cells or "elementary parts," we think we should be not far from correct if we set this stratum down in the category of *cartilage*, the fibre-cells taking the place of cartilage-cells, so called. In the earliest stages of growth the true, cellular walls, the gastrophragma (*i*) and the ectophragma (*f*), of the aboral side of the umbella and of the pedicel, lie closely apposed to each other; but in course of time they begin to separate and the intervening space is at the same time filled by an amorphous hyaline substance in which are imbedded irregular bands (*fig.* 129, *c*²) of less transparent matter, sparsely dotted by granules. These bands at first are continued from wall to wall, but as development proceeds they become clearer, less granular, more elongate and straightened, and thinned out at the middle, so that they resemble a very slender hour-glass (*figs.* 82, 83, *c*). In the last condition they have, in a general way, the appearance of structureless fibrillæ traversing the thickness of the amorphous hyaline substance. The latter and the former constitute the *chondrophys*. In their earliest or granular condition they evidently are amorphous bodies, differentiated out of the "hyaline substance;" and, notwithstanding their form, may well be identified with the nucleus of an "elementary particle." Their subsequent development has all the appearance of the strongest proof of the truth of this view, for they are finally invested by a distinct membrane (*figs.* 106, 107), which can be nothing else than the homologue of a cell-membrane. These fibrillæ then are extremely elongate cells in a low state of development, in which the periphery has become differentiated into a distinct *wall*, while the contents (*d*²) have remained

Schwam) remains passive and unchanged, except in growth by direct *proliferation*, and that the nucleus draws from it nutriment which it changes chemically into cell-material; Virchow attributes to the nucleus, or rather to the cell, the faculty of producing changes in the intercellular substance itself; each cell having a well-defined "*cell-territory*" over which it presides, at one time causing a fibrillation of the blastema (*fibrous tissue*), or an increase in bulk of the same without any perceptible change, as at the ends of the bones where *cartilage* prevails, or another form, among the membranous supports of the body, *connective tissue*. Beale (various works, and particularly "How to Work with the Microscope" 4th ed., 1868) admits the existence of a cytoblastema (his "nutrient inanimate matter," lifeless pabulum), yet does not identify it, like Schwam, with intercellular substance, but says that "*oval bodies*" (nuclei, or more or less developed *cells*) originate spontaneously, *i. e.*, by *free cell development*, and then by a process of absorption and exfoliation convert the surrounding blastema into various forms of interstitial substance, such as the ordinary intercellular material, or cartilage, or fibrous tendon, etc. etc.

(C) Putting it more concisely, now, we may say that while Virchow asserts that cells never spontaneously originate themselves, but continue their kind by *proliferation*, by "an external law of *continuous development*," and also cause the interstitial substance to *grow*, and to change into fibrillæ, etc. etc., as a mere outskirting appendage of the cells, inseparable from them, Schwam, on the other hand, attributes to cells the power of self-originators by *free cell development* out of a cytoblastema, and that it is the latter, the *cytoblastema*, which is independent, self-generative, *i. e.*, *proliferous, ab initio ad finem*; and finally, Beale differs mainly from Virchow, and agrees with Schwam, by insisting upon free-cell-development, but not in a genuine cytoblastema.

undifferentiated from the nucleus. Their distal ends lie in close contact and thereby have become polygonal, and present the appearance of an irregular network when this stratum is seen from either of its faces (*fig.* 106). We must not omit to mention, also, that the cell-membrane is ribbed lengthwise (*fig.* 107) with the cell.

197 (A). Another peculiarity in the disposition of these cell-fibrillæ explains the apparent subdivision of the chondrophys into three layers (*figs.* 82, 83, *c*, *c*¹, *c*²). Where their ends are crowded together their membranes become partially fused into each other, and seem to lose their refractive power, and become more transparent; so that their outlines are exceedingly faint. Now if we observe carefully, we may see that they are applied against each other to a certain length, forming thus a sort of pavement-work, of a definite depth, and then they all together, along one horizon, abruptly separate from each other and taper off toward their mid-length. The pavement-work, then, at each end of the fibrillæ, corresponds to the two pale subdivisions (*c*¹, *c*²) of the chondrophys (see ¶ 186), next the gastrophragma and the ectophragma, and the middle subdivision, to the region in which the fibrillæ are tapered down to a slender waist. The finer and parallel striation in the two pale subdivisions is due to the longitudinal ribs of the fibre-cells. The outermost subdivision is at most not more than one-third as thick as the inner one, and becomes obliterated in the advanced stages of growth, by the retraction of the parietes of the fibre-cells until they cease to touch each other, except at their extreme termini, where they abut against the cells of the ectophragma. That these fibre-cells are not fibre-like hollows, or plications of the amorphous hyaline substances, is proved by an inspection of a cut surface of the chondrophys, made by a section through its thickness, when the fibrillæ will be found more or less curled or bent, and projecting loosely (*fig.* 83, *c*²) from the matrix in which they were developed.

197 (B). The size of the fibre-cells varies considerably, but within certain limits. They are never so small as to cover less than three or four of the cells of the walls upon which they rest, and sometimes they extend over half a dozen of them. In this case, then, they cannot have been developed within any of Virchow's "cell-territories," to say nothing of other reasons, given above, why they could not have originated thus. As a general thing they extend directly through the thickness of the chondrophys from the gastrophragma to the ectophragma; but there are some modifications of this at certain points. We have shown in a previous section (¶ 67) that, at the partitions of the umbella, the chondromyoplax and the chondrophys lie in immediate contact; the gastrophragma failing here. Consequently the proximal ends of the fibre-cells of the chondrophys (*fig.* 83, *c*¹) abut against the inner ends of the fibrillæ (fibre-cells!) of the chondromyoplax (*b*¹). At the edge of the umbella, along the intertentacular margin and at the base of the tentacles, the *distal* ends of these fibres abut against the muscular partition (*figs.* 60, 61, 62, *k*¹), which separates the border of the chondromyoplax from that of the chondrophys. At the anchors (colletocystophores) it appears that the *proximal* ends of these fibres abut against the muscular partition (*fig.* 83, *k*¹). If now there were any derivative connection between these fibres and the adjacent walls, they

ought, it would seem, in order to be consistent, to diverge in the partitions of the umbella toward the proximate points in the gastrophragma, instead of trending directly to the chondromyoplax (*fig. 61, b*). In the peduncle (§ 198) we shall see that they exhibit still less relationship with the gastrophragma.

198. *The Chondrophys of the Peduncle* (§ 71).—The fibre-cells (*fig. 52, c¹, c⁴*) of this layer in the peduncle have the same form, properties, and no doubt the same origin as those in the umbella, but they are so singularly arranged as to make them worthy of special consideration. Those lying next the periphery trend in direct parallel lines from the ectophragma (*f¹*) to the lining wall (gastrophragma) of the four cameræ (τ^3), except where they are interrupted in their course by the four muscular cords, and in that case their proximal ends abut against the latter (*r*). Beside the peripheral set there are no less than seven others; and these do not reach to the ectophragma, but are restricted to an area within the circle of the four cameræ and the four muscular cords. Five of these sets lie between every two adjoining cameræ, crossing each other at either very acute or very obtuse angles. The sixth and seventh cross each other at right angles through the axis of the peduncle. In all cases they curve outwardly to a greater or less extent toward the axis. For the sake of convenience we will give each set a number, supposing the observer to be on the outside of the peduncle, and one of the muscular bands (*r*) nearest him. In what we may call set number *one* the fibres extend from the proximal face of the three-sided muscle to the camera on the *right*, diverging in such a way that those arising on the extreme right of the muscle seek the nearest point of the camera, striking at about half way between its distal and proximal sides, while those arising on the extreme left of the muscle run to the proximal side of the camera, and those starting from intermediate points on the muscle strike intermediate points on the camera. Set number *two* start from the same face of the muscle as number one, but trend to the left, and abut against corresponding points in the camera on that side. Consequently the fibres of sets numbers one and two cross each other at right angles. The fibres of set number *three* arise from a limited area half way between the proximal and distal side of the camera on the right end, converging slightly, trend to the left and strike the camera on that side at its proximal border. Set number *four* are arranged exactly as in number three, but originate on the left and terminate on the right, the fibres of the two crossing each other and also those of set number one and two at an obtuse angle. The fibres of set number *five* pass in the most direct way between two adjoining cameræ, arising at all intermediate points between the proximal side of the cameræ and a point half way to the distal side. They therefore cross the sets, number one, two, three, and four, at a variety of angles, which gives them, when taken together, a very complicated appearance. So far the sets between any two adjoining cameræ are unmixed with those of any other two; but we come now to two sets, number six and seven, which partially bind them to each other. Set number *six*, instead of joining two neighboring cameræ, connect two which are diagonally opposite; for instance, the nearest on the right and the most distant on the left. The fibres then cross the axis of the peduncle, and abut against the proximal side of the cameræ, and for a short distance toward the distal side. In doing this they cross,

at various angles, a part of those of sets numbers one to five. Set number *seven* has the same relation to the other two camerae as that which number six has to the first two mentioned, and crosses the latter at right angles in and about the axis. These two latter sets are the only ones which occupy the axis, the others forming an intricate inclosure about it, the fibres of number four approaching nearest to the centre, and forming a quadrangle between the proximate sides of the four camerae. In point of complexity and regularity of arrangement, combined, there is nothing in the whole class of Acalephæ that can approach what we have here described, and it is to be matched only in a higher class, the Ctenophoræ. In the youngest specimen, about one-eighth of an inch across the umbrella, the fibres of these sets (*fig.* 128, *c*) are much less numerous than in the full grown animal; in fact those of numbers three and four are not made out. It is remarkable, too, that fibres of numbers one and two penetrate the hollow of the cylindrical muscles. At the extreme posterior end of the peduncle (*fig.* 127, *c'*), where the chondrophys forms a part of the floor of the transverse "adherent disk," the fibres pursue a different course, gradually verging around from their position in front until they assume a trend which is at right angles to that, and consequently parallelwise with the longitudinal axis. In this region their arrangement seems to be reduced to the utmost simplicity, all trending uniformly in the same direction.

198 (A). As to the mode of origin of these fibre-cells very little can be added to what has been said of those in the umbrella proper, except to confirm the view there expressed by referring to their multiple decussation in the peduncle. It is plain that the cells of the gastrophragma have nothing in their arrangement upon which so many varied positions of the fibres could be based, all at the same time, and there are certainly no other cellular collections near at hand, but in the muscular cords. The all-pervading, hyaline substance, then, is our only resort, from which to derive the fibres that are imbedded in it. Just as the crystal lays down its faces and angles in definite relation to its several axes, so may the less inanimate, more highly endowed hyaline substance of the chondrophys apportion to each fibre-cell its place and attitude in reference to its fellows, and that, too, without going beyond its own boundaries, or self-evident area of activity.

199. *Histology of the Peduncular Muscles* (¶ 59, 88) (*fig.* 116).—The fibrous appearance, which these muscles present under a moderate magnifying power, is deceptive, and is due to the longitudinal folds and not to the visibility of the fibrillæ. The latter, on the contrary, are so excessively transparent and fine as to require a high power and a very clear definition to even so much as detect them. In addition to this there are very serious obstacles in the way of isolating the fibrillæ (*fig.* 116, *r*³); and these are nothing less than numberless globules or spheroidal cells (*l*¹), which pervade and crowd the tissue. Indeed these cells, varying considerably in size, constitute one-half, at least, of the bulk of the muscle; and by reason of their conspicuity seem to form a purely cellular tissue (*fig.* 114) with large intercellular spaces. More careful research revealed the fact that these apparent interspaces are occupied by a close network of anastomosing fibrillæ (*fig.* 116, *r*¹). The latter, no doubt, are the true motor agents of the muscle, while the globose cells form the framework for support and attachment.

The fibrillæ vary somewhat in their proportions; some being very slender and thread-like, and others more or less fusiform and irregularly nucleated, or granulated. They all run out into exceedingly thin infinitesimal points, or at least two opposite sides, and some have three or even four such prolongations (1 r^3). Their anastomoses do not seem to be formed by actual organic fusion, so as to obliterate their lines of contact, but are mere approximations resulting in a mechanical adhesion of contiguous surfaces. The general trend of the fibrillæ is parallelwise with the axis of the muscle, but it is slightly modified by the lateral anastomoses.

199 (A). That the spheroidal cells are intimately connected with the fibrillæ would seem to be incontestable after an inspection of our illustration; and even more than that, for so closely wrapped are they, frequently (2 r^3) by the anastomosis of neighboring fibril-cells, that they have almost led us into the belief that they are the nucleolated, gigantic nuclei of the latter. The common occurrence of fibril-cells without such encumbrances (r^3), and the high improbability of the existence of nuclei of such large proportions and complicated structure, prevented us from entertaining the idea after serious consideration. We may add, also, that in other parts, *e. g.*, in the tentacles, where the fibrillæ have been made subjects of a special investigation, there is not a trace of such cells (¶ 204). Not only are the spheroidal cells themselves very conspicuous, but also the single nucleus (d') of each. The latter is, moreover, very large, and frequently fills more than one-third of the diameter of the cell. Its outline is as distinct as that of the latter, and less transparency renders it a rather more prominent object.

200. *The gastrophragma* of the umbella and peduncle (¶ 75). In the digestive chamber proper the cells of this layer differ very little in character from those of the ectophragma, and that is not so much in themselves as in the intercellular blastema, which is nearly barren of pigment granules. There is, however, a much wider range in size and proportion among those of the gastrophragma, though they remain, as everywhere else, in a single *stratum*. Only the greater part of the interior the cells (*figs.* 74, 77, *i*) are like those of the ectophragma in breadth and depth, but at certain points they depart greatly from this, *viz.*, at the entrance to the cavity of the anchors they rapidly thin down to mere scales, like epithelium (*fig.* 94, C), and their large, dark, irregular nucleus (*fig.* 95, d') dwindles in size and intensity of color. In the *peduncle* (*fig.* 105) we find the reverse, usually, and especially where irregular passage-ways are being formed by the resorption of the chondrophys (e') between the four cameræ, and the development of the gastrophragma (B, C) as a lining. Here the cells have a depth more than double their breadth, and the nucleus (*fig.* 105, d') appears again very large from a great accumulation of pigment matter about it. We find here, also, as in the ectophragma and opsophragma, that the nucleus adheres to the side of the cell, but near its attached rather than its free end. The cells, moreover, have an exceeding brilliancy, an illumined look; no doubt owing, in part, to their freedom from intercellular pigment, and in a measure to the strong contrast produced by the intense, dark, highly refracting nucleus, in the homogeneous contents, of a singular vitreous transparency. On the genitalia they are, sometimes at least, several times deeper than broad (*fig.* 109, d''), and the nucleus (d') is small and transparent. They

assume this proportion, also, frequently near the partitions, in the region of greater muscular activity (*fig. 104, i*).

201. *Vibratile Cilia* (§ 77).—In describing these bodies here the principal interest to the histologist concerns their mode of relation to the cells upon which they seem to be based. It is commonly received as a dogma that vibratile cilia are direct prolongations of cells, forming an integral part of them. The most recent investigations and teachings of our acknowledged leaders in histology have reduced the typical idea of a cell to that of a mere concrete mass of "forming" and "formed material" (see note, p. 97 et seq.), but have not divulged anything new in regard to the vibrating *cilium*. It is now some five years since we ventured to announce our opinion that "*all vibratile cilia originate in the amorphous intercellular substance.*"¹ This has particular reference to those cilia that cover cells which are fully developed, and have a distinct cell-membrane. It would be true, as a matter of course, in the opinion of those who hold that Infusoria are composed of *sarcodæ*, but apparently untenable if we admit with Kölliker, which we do not, that they are unicellular. While we deny that these cilia are direct prolongations of the cells which they seem to be so closely related to, we do not assert that they are always disconnected with some form of cell in the modern acceptance of the ideal cell. We do, however, believe that they are never the filiform proliferations of a distinct cell-membrane, however much they may appear to be so, but that in such cases they arise from the cytoblastema which overlies the cells.

201 (A). We have now to offer new proof, supposing our observations to be correct, that the opinion announced in 1863 is a true expression of the relation of the vibratile cilia to the cells of the wall which they cover. Taking advantage of the profile aspect offered by the oöphragma (*figs. 109, 110*), as it curves over the rounded contour of the genitalia, we were enabled to view the bodies in question without any artificial preparation, such was the great range of adjustability of the objective used in this investigation. We wish particularly to observe here that the extent and thickness of the cytoblastemic intercellular substance in the oöphragma are rendered quite conspicuous by the abundance of granular matter (e^2 e^3) which is imbedded in it. By means of these granules we would, as it were, locate, relatively, the position of the swollen, knob-like bases of the cilia. These knobs vary in size and proportion to a considerable extent; some of them are scarcely wider than the cilium, while others are many times broader, with a proportionate length (*fig. 112, E to K*). They are usually longer than broad, and often elongate, oval, or fusiform (E K). In the latter case their points project to no inconsiderable distance downward between the cells. As far as we can make out, the larger proportion of the cilia arise at points alternate with the cells, but still, here and there, some overlie them. When the cilia become separated, as they readily do, from their attachments, the knobs may be traced to their direct transition into the filamentary part without any doubt as to their relationship. We have figured (*fig. 112, E to K*) several cilia in such a condition, not only from the oöphragma, but also from the gastrophragma, at a point near the edge of the

¹ See Proc. Boston Soc. Nat. Hist., Sept., 1863, p. 283; and Ann. Mag. Nat. Hist., Dec., 1864.

umbrella. By fits and starts these were very active, moving rapidly by means of the *cilium*.

201 (B). We do not believe that it has been observed to what extent vibratile cilia are individualistic in their movements, at times, just as an arm or a leg is individualized. Cilia are commonly treated of like masses of men in an army, all moving to one determined end; as if the recorder of their movements did not think that the animal possessing them had the discriminating power of controlling the actions of any one separately. As well might one claim that the numerous legs of a Centipede are not capable of individual control. In contravention of such a mistaken assumption, we have been at some pains to illustrate the varying attitudes of the cilia (*fig.* 109, *w*) of the generative organ at a time when they were in a less active state than usual. Some of them project in rigid, straight lines from their bases; some again are straight at the base and undulating rapidly near the tip; others are in long curves from end to end, while here and there one vibrates in short, sharp curves throughout its length. These motions may be, by some persons, attributed to irritability, such as is often observed in recently killed animals; but the animal is fully alive in this case. We are well aware of the fact that we, ourselves, are unconscious of the movements of the vibratile cilia in our own body, but, on the other hand, no one, who is well versed in the habits of the Protozoa, will deny that the cilia and flagella of those creatures are to them what the arms and legs are to man. We claim, therefore, here, that the phenomena observed in Lucernariæ furnish just reason for assuming that the vibratile cilia are, at least in a measure, individually controllable.

It will be observed that our figures represent the cilia as having an equal thickness from base to tip. This we believe to be the fact in many other animals, but it is not generally so represented, because the tips of the cilia are usually so much more active than toward the base as to mislead one into inferring that they are thinnest there, since that part is not so easily detected.

201 (C). The *genital saccules* differ so little from the circumoral parietes in the histological elements of the walls, that all that is necessary to characterize them has been incorporated in the section (§ 18) where their general structure is described.

§ 26. *Histology of the Tentacles (figs. 88, 89, 90, 91, 92, 93).*

202. *The Ectophragma of the Tentacles (¶ 96).*—Notwithstanding the very extensive modifications to which this layer is subjected, in the different regions of the body, whether as the *ectophragma* proper on the posterior face of the umbrella, or in the thickened peduncular disk, or as the thin *opsophragma* in front, or its prolongation on the shafts of the tentacles, or its great thickening mass on the globose tips of the tentacles, everywhere it retains its simple character as a *single stratum of cells*. No amount of differentiation, whether in reference to form or function, obliterates, or even disguises, that one unvarying, dominant character. These diversities are brought about by the least possible means; no repetitions, no circumambient or collateral appliances are connected with the pro-

cess. The means, as it were, become the end. In the globose tip of the tentacles each individual cell (*fig.* 88) constitutes the enormous depth of the layer at that point where it lies, and the expansion of the peripheral end of the same cell is the measure of the superficial extent of the spheroid at that point. We have already adverted (§ 192) to an almost universal law among the *Acalephæ*, viz., that each cellular wall is composed of a single *stratum* of cells, but did not point out the inevitable result of such an arrangement, which is, as explained above, that organs are formed, not so much by peculiar modes of aggregating multiplied cells, as by varied modifications of comparatively few cells. This law becomes most prominent to the observer when studying the inherent characters of the cells themselves; and we then find that their essential qualities, such as they all have in common, are more or less inseparable from their modifications. One instance will suffice to illustrate this. The nucleus of the cells of the *opsophragma* occupies a corresponding position in all of them, so that in a profile view (*figs.* 88, 90, 91, 93) of the thickness of this wall the nuclei appear arranged in a single line, about halfway between the two ends of the cells; but where these latter are so modified, in the globose tip of the tentacles, that their depth is several times greater than their breadth, the row of nuclei (*fig.* 88, *d'*) lies conspicuously near the peripheric end of the cells. Here the proportions of the form are not alone modified, but also the relative position of the contents of the cells.

202 (A). When we consider the extreme mobility of the tentacles, as exhibited in their powers of great elongation and high contractility, we cannot avoid inferring that their component cells are adjustable in a commensurate degree between the limits of these changes. This observation proves to be true; but we could hardly foresee that, besides varying in form, they would, at times, arrange themselves, or rather perhaps allow themselves to be arranged, in definite lines, or rows, corresponding to the trend of the muscular fibrillæ which underlie them. In a word, we find that when a tentacle is contracted, the cells of the *ectophragma* not only are broader in the direction of the contraction, so that their major diameters trend parallelwise with each other, and consequently with the axis of the tentacle, but they are also arranged in lines (*fig.* 92, *d*) more or less regular, parallel with the muscular fibrillæ (*m*²) (§ 98), and usually alternate with them, the latter being slightly imbedded between the ends of the former. Now it would seem as if the contraction of the whole mass would tend to compress the ectophragmal cells, so that their major diameters would trend transverse to the axis of the tentacle, but as it is not so we must infer that the lateral pressure is greater than the longitudinal, yet we have to account for the linear arrangement of these cells, and their evident connection, in this respect, with the muscular fibrillæ. It would seem plain enough that when these fibrillæ contract they must of necessity decrease the diameter of the adjoining cells, in the same direction as the contraction, and throwing them sideways against each other, mingle them promiscuously; but we should not overlook the fact that as a muscle contracts it broadens, and hence it will exert a lateral pressure, and in doing so it will force the neighboring cells to arrange themselves in lines on each side of it.

We must also take into account the fact that the force of contraction operates

upon the cells, not exactly parallel with the axis of the tentacle, but obliquely to it, *centrifugally*, and hence, as a proof of it, we find the same cells, which were not quite twice so deep as broad when the tentacle was extended (*fig. 90, n'*), are here (*figs. 92, 93*) at least five times deeper than broad, that is, they are very narrow, and moreover, from mutual pressure, prismatic in appearance, when viewed in a body.

202 (B). It is well worth while to observe that, when these cells deepen, the change appears to be confined mostly to that region which lies between the nucleus (*d'*) and the end next the muscular fibrillæ (*m''*), while the modification at the other end consists of little else than a narrowing in one direction, and a broadening at right angles to that. Why the nucleus marks these limits we cannot conjecture; and although it may be readily understood why the cells should deepen more at the proximal end, that being nearer in the line of the pressure induced by contraction, there is no apparent reason why there should be such a sudden change on the distal side of the nucleus, where the depth increases very little. When the tentacle is fully extended the nucleus (*figs. 90, 91, d'*) of the ectophragmal cells is a little nearer to the distal than to the proximal end. Between this condition and that of extreme contraction of the tentacles there are to be observed all possible grades within a short space of time; there is no absolute standard of proportion in any part of the shaft of these organs. In their spheroidal tips, however, the cells of this layer (*figs. 88, 89*) seem to have been crystallized, as it were; fixed within extremely narrow limits of change, and varying but slightly in depth, which is to their average breadth as five or six is to one. But of this we shall speak hereafter more in detail.

202 (C). *Contents.*—The ectophragmal cells of the shaft (*figs. 90–93, n'*) are very transparent, not only as regards their contents (*d''*), which are perfectly homogeneous, but as to their walls (*d*). The latter are moderately thick, evidently; although it is quite difficult to detect the line of mutual apposition of adjacent walls, which is still more uncertain at those places where interstitial granules (*e''*) are crowded between them, or overlie their peripheric or proximal ends. Beside this very abundant and more or less highly colored, interstitial, granular substance, there are scattered here and there, quite rarely, isolated *nematocysts* (*l*). The nucleus (*d'*) lends little or nothing to the color, as it is of a grayish transparency; but still, it is readily detected, on account of its peculiar, soft, semi-opacity. It is rather oval than circular in profile, and might be compared to a slightly flattened disk, attached by one of its faces to the cell-wall. Its greatest breadth is fully three times the thickness of that wall.

203. *The ectophragma of the spheroidal tip* (nematocystophore) of the tentacles presents some peculiar modifications not to be found on the shaft. This is the part which is formed first (*figs. 58, 59, φ''*) in a young tentacle, and may be recognized, even before the organ amounts to more than a mere papilla, by an accumulation of numerous nematocysts imbedded in the interstices of the cells, and also by an extraordinary deepening of these cells, so as to give an abrupt increase to the thickness of the layer. Even at this early period the cells are three or four times deeper than broad, and they continue to develop in this respect until the tentacle is full

grown, when they may be found measuring in depth several times the breadth (*figs.* 88, 89). As to form, the main peculiarity of these cells in an adult tentacle lies in their gradually widening calibre, which is narrowest at the proximal, and broadest at the distal end. On the whole, then, each cell has the form of a very elongated, prismatic conoid, inverted on its apex; but it is so modified by the lateral pressure of the interstitially imbedded nematocysts (*l, l'*) as to be more or less irregular in shape. They differ also from the cells of the shaft in having a very narrow range of mobility; in fact they are comparatively fixed, and not subject to wide changes in form as the tentacle expands or contracts. They differ, again, in the position of the *nucleus* (*d'*), as that is attached much nearer the distal end. They are, besides, more considerably modified in form by the greater amount of granular interstitial matter (*e²*), especially between their proximal basal ends. This is so abundant in very old tentacles as to render their tips nearly opaque; and, as it varies in color, like the pigment masses in other regions, it gives varied hues to the globose mass.

203 (A). *The interstitial cytoblastema* merits particular attention here, on account of its specialized condition. We have just spoken of the mass of pigment granules in its proximal side, about the bases of the cells; but here we wish to draw attention to its exclusive devotion, at the distal side, to the formation and development of *nematocysts*. Not only do these cysts (*l, l'*) originate in it, and remain imbedded there, sometimes considerably below the general surface of the layer, thus giving to the *cytoblastema* a specialized character in this region, but they also involve it, indirectly at least, in the apparatus of prehension. We refer here to the bristling points (*fig.* 88, *e¹*), which are so numerous on the surface, standing singly in the intervals between the cells. From many points of view they project as if in direct prolongation of the axis of a nematocyst; and frequently, when the shaft of the latter is partially everted, it seems to be the cause of the bristling, appearing to push the plastic blastema before it until it is forced out into a fine point. But that this is not so is shown by the fact that these bristles still continue to project, while the nematocyst is completely closed (*fig.* 88, A). They may have been formed originally under the influence of the nematocysts, and then retained the form imposed upon them; but that partakes too much of the mechanical in its method, and makes them appear as if the mere accidents of contiguity. Moreover, if they were so formed, they ought to stand directly in the way of the shaft of the nematocyst when it protrudes; but they do not, and so far from it that each bristle stands more or less to one side of the shaft when that is out, and sometimes, even, at a greater distance when the same is retracted. These facts may be more easily elucidated in common fresh-water *Hydræ* than in *Lucernariæ*. We are, therefore, rather disposed to think that they were developed, just as the parts of the thread of the nematocysts were, in place. Their connection with the prehensile organs, functionally considered, it is true, is inferred mainly from their occurrence only where these organs exist, but we think that that is enough to show at least their architectural relations. Their one-sided, asymmetrical form, added to their lateral position, suggests strongly that they possibly may perform the office of valves or lids; but on the whole we believe them to be *tactile bodies*, standing sentinel at

the doors of the nematocysts, to give warning of the approach of any foreign body.

204. *Muscular Fibrillæ* (§ 98) (*figs.* 91, 92, 1 m^2 , 2 m^2 , 3 m^2).—Notwithstanding that these fibrillæ exhibit a quite marked tendency to arrange themselves in fascicles, as if to form a distinct organ, like that in the peduncle (§ 59, 88, 199), we meet with no trace of intermixture of such cells as are so abundant in the latter. The fibrillæ of the tentacles are remarkably distinct from all surrounding tissue, both as a whole and as regards their component elements, the elongated, fusiform cells. Their only connection with the ectophragma (n^1), on the one hand, and the chondromyoplax (b^1) on the other, is that of mechanical contact. They are buried mostly in the peripheral surface of the chondromyoplax (*fig.* 91, b^1), and very slightly impress themselves on the inner face of the ectophragma. The cellular elements of a fibril are not so clearly apparent from that point of view which regards them face-wise, *i. e.*, looking in a line perpendicular to the layers of the tentacles, as they then seem organically united with each other, end to end, and do not allow their lines of junction to be seen. Taken together, then, they form an undulating thread, which is slightly swollen from point to point, with a faint elongated nucleus occupying a large part of the length of each swelling. That these swellings correspond to individual cells, each containing a single nucleus, may be proved by obtaining a view at right angles to this, that is, observing them in profile (at 1 m^2); when they will have all the appearance of a linear series of separate, fusiform bodies, overlapping each other at their pointed ends. From this point of view, and in a transverse section (*fig.* 91, m^2) also, we can determine most satisfactorily that the fibril cells have no organic connection with the chondromyoplax (b^1). The amorphous, rigid fibrillæ of the latter abut at their broader ends with a most decided line of separation between them and the fusiform cells of the muscles. The two have nothing in common, unless it be the intervening blastema which constitutes the mould in which all cells are cast. (See § 196.)

205. *The Chondromyoplax* (§ 196) (*figs.* 90, 91, b^1).—In immediate connection with what has just been said, incidentally, in regard to this layer, we have only to add a few words, particularly in reference to the function it possesses in the economy of the organ to which it belongs. When discussing its qualities as a layer (§ 65, 196) in the front of the umbella, we argued that it had rather the function of elastic connective tissue, without saying precisely how it operated. In that position it would more likely be subjected to traction than to compression, or at least to a much greater degree. There can be no hesitation in deciding that in the tentacles it acts as a resilient body, in counteracting the retractile force of the muscles, and repressing, to a certain degree, the expansive force of water injected into the tentacle from the main cavity of the body. Its prime value, however, is felt when, by its great resiliency, it extends the tentacles to their extreme length. There are no annular muscles in these organs, and their longitudinal fibres can only retract them, or flex them from side to side. The histological elements of this layer are the same as in the umbella, and, as they have been described (§ 196) pretty fully in that connection, we will not repeat the description here.

The position of the fibrillæ, however, needs special mention. They hold the same general relation to the adjoining layers as in the umbrella, but in the latter they all point or trend one way, *i. e.*, antero-posteriorly, while in the tentacles they vary, not in reference to the ectophragma and endophragma (gastrophragma), but following the curvatures of the latter as they form the hollow shaft, they always trend in the direction of the radii of these curves. As a consequence of this, then, their trends radiate from the axis of the shaft, except at the tip of the organ, where the layers converge and form a series of superposed hollow hemispheres, and there the trends of the fibrillæ radiate as if from the centre of a sphere. Their trend in the *intertentacular lobules* will be best comprehended in connection with the description of the morphology of these bodies, to be found in a previous paragraph (§ 103).

205 (A). Over a greater part of the regions in which the chondromyoplax prevails its fibrillæ abut at right angles against the adjoining layers, but at the bases of the tentacles their disposition is modified in a marked degree, in connection with the peculiar arrangements of the muscular layer. The latter, as described in a former paragraph (§ 82, 100) with considerable detail, passes obliquely from the periphery to the inner layer, or gastrophragma, forming a partition (*fig. 60, k'*) between the chondromyoplax (*b'*) and the edge of the chondrophys (*c*). The fibrillæ of both these layers abut against this oblique partition, at very acute angles, their proximal ends being based on the gastrophragma (*i, i''*). This we should say, also, takes place along the whole circuit of the edge of the umbrella, wherever the chondrophys and chondromyoplax adjoin a common area of termination.

206. *The Gastrophragma (endophragma)* (§ 101) of the tentacles (*figs. 90, 91, i'*). This single *stratum* of cells owes its great thickness only to the extreme depth of the latter. It varies considerably according as the tentacle is extended or contracted; in the former case the cells, lessening to their minimum depth, are still three or four times deeper than broad, and in the latter case they have a much greater measurement. They do not, therefore, exhibit that wide range of variation in proportion which the cells of the ectophragma (*n'*) of the shaft do, but have rather the approximate fixedness of those of the globular tip; and, as they are not so irregular in outline at the sides, they are more prismatic in appearance. In a profile view (*fig. 90*) of a tentacle these cells present parallel sides, but in a cross sectional view (*fig. 91, i'*) of this organ, they very naturally, from being arranged radiatingly about an imaginary axis, appear narrowest at their proximal ends, and gradually expand, wedge-like, to their distal terminations. They are not, though, four-sided, as these two views might, perhaps, lead us to suppose, but irregularly polyhedral, varying from three to six sides, as may be learned by looking at them endwise (*fig. 90, 1 i'*). Their walls are about as thick as those of the ectophragma (*n'*), and, like those, very sharply defined within, but rather obscurely without, either because they are overlaid by the intervening pigment granules (*e''*) about their proximal halves, or from being more or less organically united along their lines of contact, at their distal halves. The rigidity of a prismatic conformation is negatived by a long undulating contour, which rather enhances, than lessens, the brilliancy, by the ever-varying surface which the walls

present to the eye. By contrast, also, these cells are apparently endowed with a superabundance of light. Their contents (d^2) are perfectly homogeneous and transparent, and therefore the deeply-colored nucleus (d^1) is rendered highly prominent, both from its isolateness as well as from its marked difference in refraction. We are reminded, in this respect, of the intensely brilliant cells of the gastrophragma in the peduncle (§ 200).

206 (A). The *nucleus* (d^1) is not in itself so deeply colored, but is irregularly coated by an accumulation of dark, fine, granular matter; and that, at the same time, gives it a jagged appearance. This is a peculiarity, though not so strong, which it has in common with the nuclei in other parts of the body, as in the endophragma of the peduncle and the anchors, and in the ectophragma of the aboral side of the umbella. Its true form and aspect are identical with those (§ 205) of the ectophragma of the tentacular shaft. The position of the nucleus is the same as in the ectophragmal cells (*fig.* 88, d^1) of the spheroidal tip, *i. e.*, it lies nearer the distal than the proximal end, or about half-way between the end and the middle of the cell; and thus all the nuclei, taken together at one view, appear to stand in an irregular row, parallel with the surface of the layer which they compose. It differs, though, in one respect, in that it is nearer the attached than the free end of the cell, which is the same as in the gastrophragma of the peduncle (§ 200). We have stated in another place (§ 36) that the pigment is uniform in color throughout the body, and therefore the color of the nucleus, or rather its granular envelope, corresponds to the prevailing tint.

206 (B). The *intercellular pigment* (e^2) of the gastrophragma merits pointed attention here, not so much because we have any positive function to assign to it, as for its peculiar constitution. It has been customary among physiologists to attribute a biliary function to any highly colored, especially brownish, masses of irregular cells or cell-like bodies, if they coat the inner face of the digestive cavity. Now if, instead of finding in the hollow of the tentacle such a dense coating of pigment-like, and even cell-like bodies, we met with it on the inner face of the general cavity of the body, it would be very natural to surmise that its components might possibly possess a glandular nature, perhaps biliary, or even urinigerous. Since, however, they are comparatively scant in the latter region, we guess nothing of the kind; and as such functions would appear out of place in a tentacle, we have no such teleological appliances to thrust in there, nor any other, inasmuch as these granules present no obvious use. It is true that some seem to possess a transparent envelope, which gives them a marked cell-like appearance; but in this respect, as in all others, they are, like those which embrace the proximal ends of the ectophragmal cells (*fig.* 88, e^2) of the spheroidal tips, buried deep in the thickness of the tissue.

§ 27. *Histology of the Colletocystophores (Anchors) (figs. 47, 82, 83, 94, 95, 96, 97).*

207. *General Features.*—Both in an histological as well as in an organical point of view the fully grown *colletocystophore* is divided into three distinct regions, *viz.*, the pedicle, the nematocystophore, and the colletocystophoric mass. In the young

(¶ 166-173), these areas are more sharply defined in external appearance, but they do not attain to a well-marked histological differentiation until a late period. It is true that the colletocysts appear as soon as a change commences on the tentaculoid shaft, but the corresponding changes in the interior walls are not completed until the animal is probably two-thirds developed in size.

208. The *Ectophragma* (*Opsophragma*) of the *colletocystophore*. In the earliest stages the cells of this layer are identical with those in the shaft of a tentacle, but they soon lose this character, and become gradually, yet rapidly, very deep and prismatic (*figs.* 82, 83, *a*³), like those in the globose nematocystophore (*a*²), and, at the same time, adherent vesicles (*a*), the *colletocysts*, originate and develop in their interspaces. This process goes on until, as described in the previous paragraphs (¶ 160-173) on embryology, the whole shaft is metamorphosed into a thick, pad-like mass of very deep, prismatic cells and imbedded colletocysts. These cells vary considerably in depth in different parts of the full-grown organ (*fig.* 47, *n*²), yet they are not subject to changes in length and breadth to any very appreciable extent, since the colletocystophore is relatively far less expansile and contractile than the tentacles. They are most closely allied in form and proportions to those of the globose tip (nematocystophore) of the tentacles, but they are not so tapering and conoid, since they are arranged in a layer which has a much broader curve, and consequently they approach more closely to a strictly prismatic form. They are conspicuous for their large and dark nucleus-like body (*fig.* 97, *d*¹), which is in reality a mass of pigment-granules enveloping a transparent, single nucleus. In this respect they resemble those of the gastrophragma (*figs.* 94, 95, *d*¹) of this organ, but the nuclear-body is not near as large in the former.

208 (A). The *intercellular colletocysts* (*figs.* 96, 97, *a*) modify the arrangement of the cells of the ectophragma more extensively than do the nematocysts in the tentacles. They lie not strictly in the intercellular spaces, as they are much larger than the cells, but, as it were, on the top of them, in a hollow or deep depression, sunken in the layer. These pits (*fig.* 96, *a*¹) contain from one to three colletocysts (*a*), and occupy more space than the areas between them. Still this does not appear so, because the ends of the surrounding cells curve inwardly so as to partially cover (*fig.* 97) the colletocysts, and thus form, collectively, a narrowed entrance to the pit. This arrangement leaves a part of each colletocyst naked, and ready to adhere to any substance that may come in contact with it. Whether the animal has the power of opening or closing the aperture of the pits, and thus varying the breadth of the adherent surface of the colletocysts, we cannot say; but if it be so, it must be done indirectly, because there is no contractility in the cells themselves. It is possible, however, that the underlying cells may be forced up by the action of the muscular layer beneath them, and that the colletocysts be protruded through the aperture of the pits. As the colletocysts are colorless, the granular intercellular bodies and the pigmented nucleus of the cells constitute the coloring matter of the layer. The structural details of the colletocysts are to be found in a separate section, or the prehensile organs (§ 30). Occasionally we have also met with nematocysts (*l*) intermingled with the colletocysts, but as they are rare, and usually

quite small, we judge that they are not of special importance in this region, but rather remnants of an embryonic condition.

208 (B). The colletocystophoric *nematocystophore* in its earlier days has all the proportions in shape and numbers of that of a true tentacle of the same age; and in fact the one could not be distinguished from the other if detached from the body so that their position might not be known. At that period they seem to be of equal value as prehensile organs, but in course of time, as the colletocysts progress in development the nematocysts decrease in number, and the layer in which they are imbedded grows less in thickness. Still as the change is not abrupt but gradual, we should judge from appearances that the nematocystophores retained their power largely until the body had grown to from one-quarter (*figs.* 82, 83, 84) to one-half its adult size. In the full-grown condition (*fig.* 47), at last, we find a mere remnant (a^2), and so faint as to readily escape notice. The nematocysts are relatively very few, and the layer of prismatic cells is a meagre representative of what it once was, a slight knob or undulation on the surface of the semi-transparent area, peculiar to that region of the colletocystophore.

209. The *opsomyoplax* (*fig.* 47, m^3) of the colletocystophores offers nothing peculiar, or different histologically from what may be observed in the tentacles, but as to the arrangement of the muscular fibrils there is a marked diversity; yet as that has been given with sufficient details in the general description (§ 105, 111) of the layers we will not repeat anything here.

210. The colletocystophoric *chondromyoplax* (*fig.* 47, b^2) does not seem to differ from that in the tentacles (*figs.* 90, 91, b'), as far as its *histological* elements are concerned; not even after it has been so irregularly disposed, as to thickness, as we find it in a fully developed anchor (see § 112). The more or less abruptly changing diversities in the depth of this layer are accompanied by as abrupt shortenings or lengthenings of the fibrils, but not by any other modifications that we could discover.

211. The *gastrophragma* (*figs.* 47, v^1 , 94, 95) of the anchors embodies the most remarkable modifications of cells, excepting the nematocysts and colletocysts, that we have met with in this animal. Yet, as will be seen presently, traces of what here amounts to a singularity are to be found in other parts of the body, both without and within; and serve to clear up what appears to be at first glance a strange anomaly. In the depths of the cavity of this organ the gastrophragmic cells are from three to four times deeper than broad; and on the whole may be set down as prismatic in contour; each prism occupying the whole depth of the layer (*fig.* 94, A, B). The wall (w) of each cell is quite thick, especially at the ends, and perfectly transparent and homogeneous in texture; but it varies in thickness in a most remarkable way, however. This consists in an internal annular thickening of the wall at two points so disposed as to divide the cell into three equal regions. The annular semipartitions are broad at the base, but rapidly run out to a sharp edge, which sometimes projects one-quarter the distance across the cell-cavity, but usually less than this amount. This reminds me of a cell undergoing self-division; and the disposition of the contents seems to bear out the analogy; but although rarely, here and there, one of these dark internal masses is

divided into three distinct portions (A), we have never been able to find a true, undoubted cell-multiplication. The peculiar disposition of the contents is as singular as the modifications of the wall; and it seems to be strictly in accordance with the latter. It would appear that the same influence which produced the annular semipartitions also affected the dark, innermost, pigment mass (d') in such a way as to constrict it exactly opposite these annuli; but yet not by the direct impression of the latter upon the former, for a considerable clear, transparent layer (d''), forming the periphery of the contents, intervenes. If, therefore, there is any impression transmitted it must be through the latter layer. Laying aside, now, this rather mechanical, physico-motor explanation, which we have used merely as a matter of convenience, and not to illustrate any real series of sequences, which might be supposed to arise the one from the other, we will state, in brief, our conviction that the cell-contents have, by an inherent property, assumed the subdivided form which is presented there, and that the *annuli* of the wall are rather formed last, and probably deposited from the surface of the contents.

211 (A). As we recede, now, toward the entrance to the cavity of the colletocystophore, we actually advance toward an explanation of the nature and origin of these singular contents. Gradually the layer grows less and less in thickness (A to D), and the component cells decrease at a corresponding rate in depth. But we particularly note that the annular semipartitions gradually lower their ridges, and the constrictions grow shallower until both disappear by the time we arrive at those cells which are about as deep as they are broad (D). The innermost dark pigment mass yet consists of very large, closely-packed, irregular granules, but rather smaller than in the thickest part of the layer. From this point, still receding, the dark mass grows proportionally less, and the clear contents correspondingly greater (*fig.* 95, d''), while the cell bodily shallows down to near the proportion of dermal epithelium (C). In the latter condition the dark pigment-mass appears, in a profile view, like a thin streak in the middle of the cell, but in an end view it has the appearance of an irregular nucleus (*fig.* 95, d''), being in reality nothing more nor less than a nucleus covered by a coating of pigment-granules, as we have described in the ectophragma (§|| 194) and other places. Now, if there be any part of the cell that influences internal changes more than another, it certainly is where the nucleus usually appears; and we consider the nucleus to be the expression of an intensified concentration of cell-power, and not an isolated body, as it is usually described. When, therefore, the dark pigment mass accumulates in all the intervening space between the nucleus and the extremities of the cell cavity, we do not suppose that it gradually thickens as a coating over the nucleus, by any condensing power of the latter; but that it develops in mass under the all-pervading cell-power which radiates, as it were, from one point of greatest intensification. In this way we may explain the final appearance of the constriction of the dark mass, and the annular semipartitions of the wall. These peculiarities could no more be produced by the operations of an isolated body at a distance, a self-contained nucleus, than could the analogous changes which eventuate in the appearance of the spiral coil of the nematocyst (*figs.* 135-145). It will be apparent enough, without further explanation, that

the great depth of color of the anchor is due largely to these enormous masses of intra-cellular pigment. The tint varies in different individuals, but is uniform, with varying intensity, in the same body, the latter being either altogether green, or orange, or purple, or blue, etc., and not a combination of any of these colors; but sometimes is apparently so, as, for instance, when a light purple or violet umbrella seems to have black anchors, the latter, though, when examined under a slight magnifying power, turning out to be of an intense, concentrated, dark purple. Notwithstanding the remarkably abrupt changes in depth which the gastro-phragma exhibits at irregular intervals throughout the colletocystophore, the component cells neither increase nor decrease in numbers, but always remain combined in a single *stratum*, simply varying in depth according to the greater or less abrupt thickenings or thinnings of the layer (see ¶ 113).

§ 28. *Histology of the Caudal Disk* (¶ 115) (*figs.* 118, 119, 120).

212. *The Ectophragma* (¶ 63, 194).—Since this is the only layer which is modified differently from those of the peduncle proper, which are described in a previous section (§ 25), we shall confine ourselves to it alone. As in the anchors, so here the cells are prismatic in form, but proportionately much broader and exceedingly small, when contrasted with those of the former. Their share, though, in the formation of the layer is considerably less, because they are obscured and overlaid almost entirely by the nearly close ranks of colletocysts and nematocysts; in fact, a profile view of a section of this layer (*fig.* 118, *f*¹) presents the appearance of being composed, at least for two-thirds of its depth, almost entirely of these two last-mentioned bodies (*a*, *l*). A face-view (*fig.* 119) is, therefore, a much better exemplification of the true state of relationships here. By that we learn that there are but very narrow areas, next the outer surface of the layer, which are occupied by the normal, prismatic components of the layer, and the rest is filled up by irregularly alternating colletocysts (*fig.* 118, *a*) and nematocysts (*l*). The inner third of the layer is purely cellular, and the outer or distal two-thirds is compounded as described above, yet still there is but one *stratum* of cells proper; those alternating with the imbedded bodies being the longest, and extending from the proximal to the distal surface, and those overlaid by the nematocysts and colletocysts abutting against the latter with their distal ends. The *colletocysts* (*a*) are not more than one-tenth or one-eighth the diameter of those of the anchors (*fig.* 97, *a*), excepting here and there a few of equal size, but they are far more closely packed together, and thus make up in point of numbers what they lack in size. They are treated of *in extenso* in the section on the prehensile organs (§ 30). The *nematocysts* (*l*), which serve to partly fill up the intervals between the colletocysts, are excessively small, and hardly recognizable as prehensile organs of that kind; but they are conspicuous simply because they are numerous, although looking more like granules than urticating organs under a magnifying power of several hundred diameters (*figs.* 118, 120, *l*).

§ 29. *Histology of the Digituli* (§ 52, 116-121) (*figs.* 98, 99, 100, 101, 102).

213. *Topography*.—In the general description of the walls (§ 116-121) of the digitiform bodies we have, unavoidably, entered so far into the consideration of their histological elements that there is but little to add here. The disposition of these elements, whether they be true cells or fibre-like in character, is so thoroughly intermingled with the topographical apportioning of the several layers and their subdivisions, that any attempt to describe the latter without including the former would utterly fail to present a picture of the nature of these organs, beyond a mere idea of their outlines. We will not, however, repeat here what has already been given so fully, but beg our readers to consider § 15 and the present section as one, for the time being. In regard to a single point in the paragraph (§ 117) which concerns the relative positions of the nematocysts and the colletocysts on the supposed flat sides of the *digituli*, we would add one more fact, without commenting upon its significance, if there be any. We refer to the corresponding position of the vibratile cilia (*figs.* 98, 100, *co*) with those on the genital organs, the areas of both facing in the same direction in a general way; whilst the area of the colletocysts (*a*) corresponds to that in the genitalia which bears the layer of reproductive bodies, either eggs or spermatozoa.

214. *Gastrophragma of the Digituli* (*v*).—Within the area which is covered by the colletocysts (*a*) the latter occupy about four-fifths of the space, and the true cells the rest, filling up the intervals; while, on the other side, the nematocysts (*l*) are set quite wide apart, and are a subordinate feature in the composition of the layer. In a profile, sectional view (*figs.* 99, 100, *a*) of the wall in which the colletocysts are imbedded, the latter appear to constitute the whole layer, so nearly obscured are the cells by these densely packed vesicles; yet, from a face-view (*fig.* 99, *1a*, *fig.* 101), we learn that the cells do actually form a continuous *stratum*, but so thoroughly intersected by the vesicles that it has the appearance of a network of a single, or more or less double, row of cells.

Whether on the side of the nematocysts, or where the colletocysts prevail, the cells of the gastrophragma (*fig.* 101, *v*) have the same structure and contents. They are by far the smallest of those that belong to this layer in any part of the body, but they have the same elements. There is the same clear homogeneous contents, and a like single nucleus, so encrusted by pigment-matter that the mass occupies from one-third to one-half the diameter of the cell. It is a notable fact that none of these cells underlie the colletocysts, as they do in the cetophragma of the colletocystophores (§ 208 (A)), and for this reason, that the colletocysts of the *digituli* extend through the whole depth of the gastrophragma, and abut immediately against the muscular layer; and in a measure adhere to it. In regard to the latter statement, we will say, in passing, that the colletocysts are the last to break away from the underlying tissue when the layer is disorganized by the application of fresh water (*fig.* 103, *a*); and they seem to be organically attached by a narrow, short stem or neck to the muscular layer (*a*). In point of size they are quite diminutive, not more than one-quarter the diameter of those in the colletocystophore (*fig.* 97, *a*), and yet about three times the diameter of those in the pedun-

cular disk (*figs.* 118, 120, *a*). The *nematocysts* (*fig.* 100, *l*) also occupy the whole thickness of the gastrophragma. As to the vibratile cilia (*fig.* 100, *co*) we have only to add that they are unusually long, and very thickly set together.

§ 30. *The Prehensile Cysts. (Nematocysts and Colletocysts.)*

215. *The Nematocysts* (Pl. XI, *figs.* 133 to 145).—These bodies have been so frequently described and so fully illustrated of late years that we do not expect, here, to add materially to the knowledge of them, as far as their general structure is concerned. We merely present some new forms, or at least new variations of the type, from a hitherto unknown source. In an article, which we published under the title of "*Lucernaria the Cœnotype of Acalephæ*," in the American Journal of Science and Arts for May, 1863, p. 346, there is a note appended, on p. 352, which is devoted to a concise description of the two kinds of nematocysts that are common to *Haliclystus auricula*. We propose to reproduce that note here, with some few additional remarks, and a number of illustrations. That nematocysts have an *inter-cellular* and not an *intra-cellular* position we think has been made sufficiently manifest when describing the cellular structure of the outer wall (opsophragma) of the globular tip (nematocystophore) of a tentacle (see ¶ 203, 203 (A)). We have recorded our opinion elsewhere (Proc. Boston Soc. Nat. Hist., Sept. 16, 1863, p. 283, in note) that they also have an *inter-cellular origin*, and do not develop within the cells which form the layer in which they are imbedded, but commence their career, *de novo*, by free cell formation in the cytoblastema. Their relation to the cytoblastema is curiously illustrated in another way; we refer to the supposed "tactile bristles," which have been described quite fully enough, probably, in a former paragraph (¶ 203 (A)). Their presence there, and nowhere else, seems to show a more intimate relationship than usual between the cytoblastema and the cells; and points argumentatively to the agency of the same cytoblastema in that shaping out of the nematocysts.

216. A *nematocyst* of the larger kind (*figs.* 133 to 141), belonging to the tentacles, consists of an oval, thick-walled vesicle (*fig.* 134, *cl*), about $\frac{1}{2000}$ of an inch long, or a little less, one end of which is introverted, and projects, in the form of a stout hollow shaft (*sl*), along the axis of the cell, about four-fifths of its length, and then, rather suddenly thinning into a slender thread (*tl*), which also is hollow, it bends upon itself, returns nearly to the aperture (*ml*) of the cell, and again receding and pressing closely against the inner face of the cell-wall, it forms there a close coil (*lc*), which terminates at the end opposite the mouth (*ml*) of the introversion. In a younger and smaller cyst (*fig.* 133) the shaft (*sl*) extends from the aperture almost to the opposite end, and then the thread proceeds to coil up as in the fully grown. The spiral ridges apparently on the shaft of young specimens are formed by rows of bristle-like bodies which are packed closely together, and overlap in the hollow of this introverted body. In an old cyst the separate bristles may be seen in place, while the cell is closed (*fig.* 134), but it requires very careful research.

When the coil of thread is ejected (*fig.* 139, *tl*), which is accomplished by

sliding through the hollow axial shaft (*figs.* 135, 136, 137), which in its turn retroverts also, just as the finger of a glove is turned inside out, the whole aspect of the apparatus is changed (*fig.* 139). The oval cell (*cl*) is considerably diminished in size, and from its aperture (*ml*) the more enormously enlarged hollow shaft (*bl*, *dl*) projects in a straight line; the part of the shaft next the cell is cylindrical (*bl*), and half as broad as the latter, with a slight expansion where it joins the mouth of the cell; the distal half abruptly expands into an oval form (*dl*), half again broader than the cylindrical portion, and rapidly tapers into a smooth, trihedral, twisted thread (*fig.* 141, *tl*). The oval part (*dl*) of the shaft is endowed with three equidistant spiral rows of setæ, which number about a dozen in each row. The setæ are comparatively large, and in length equal two-thirds the broadest diameter of that part of the shaft from which they project. Each row makes but one turn about the shaft, and terminates as if in continuation (*fig.* 141) of the angles of the trihedral thread. There is not the least trace of setæ or projections of any kind upon the trihedral thread, but it continues, with a very gradual taper, perfectly smooth, to a blunt termination. The angles (*fig.* 141) of the thread appear, at first glance, as if they might be spiral rows of setæ, but a most careful and prolonged examination, with one of Spencer's $\frac{1}{4}$ inch objectives, convinced us that they are truly the angles of a twisted trihedral filament. The extent of the thread is from twenty to twenty-four times the length of the cyst. That the thread and shaft are not ejected by a breaking open of the cyst, as some have asserted, we present proofs like those given by other authors, but particularly valuable on account of the distinctness of the several regions of the shaft and the thread during retroversion. In *fig.* 135 the proximal or basal half of the shaft (*bl*) only is everted, and stands out clearly from the distal portion (*dl*) which remains within it. In the latter the spiral rows of setæ are packed down one upon another so as to form ridges. The thread (*tl*), of course, is slightly drawn out of the cyst into the basal portion of the shaft. In figure 136 the whole shaft is everted, and has its characteristic form, but the thread still remains within, extending back, in a winding course, through the hollow of the shaft into the cyst, where it lies in looser coils than in a perfectly closed organ. The next figure (*fig.* 137) illustrates the expansibility of the thread itself (*tl*). In order that its distal or free portion (B) may slide through the bottom of the basal part (A), the latter must dilate until its calibre is at least equal to the diameter of the former. But it does even more than that, as the figure (*fig.* 138), of diagrammatic size, shows, for there the calibre of the everted portion (A) is large enough to allow the rest (B) to wind through it in a zigzag course. As is perfectly clear by the figure (*fig.* 137), but a small part is everted, and the remainder, after winding back through the shaft, is loosely coiled up in the cyst. It is a noteworthy fact that, after the thread is wholly everted (*fig.* 139), the cyst does not close its aperture. Whether this is due to a certain inherent resiliency in the region where the shaft is attached, or results from the contraction of the cyst upon the contained fluid, tending to force it outward, but restrained by the closed hollow of the thread, we hesitate to decide upon. Since we have frequently seen a cyst rapidly diminish in size upon the sudden ejection of the thread, although it lay free in the field of the micro-

scope, it is plain enough that it is self-contractile. As we are not in the habit of using that dangerous instrument, the *compressorium*, we have no allowance to make for mistakes in that direction. Whether a thread, after being once ejected, is ever retracted into the cyst again remains as yet undetermined by observation, but the circumstances of its eversion render it highly probable that it is not.

217. The *smaller nematocysts* (*figs.* 142, 143, 144, 145) are much more simple in structure than the larger forms, but remarkable in other respects. The introverted shaft (*fig.* 142, *sl*) is very slender, in fact no larger than the rest of the thread. It does not project into the axis of the cylindrico-oval cell, but presses close to its side, and extends four-fifths of the way to its opposite end, and then, bending abruptly upon itself, the thread passes with a long curved sweep nearly to the aperture of the cell, whence it again returns with another long sweep, which is repeated eight to ten times (*figs.* 143, 144), until the inner face of the cell-wall is lined by a close coil (*lc*), which winds lengthwise, instead of transversely, as it does in the larger nematocysts (*fig.* 134). When extended (*fig.* 145, *tl*) the thread is from twelve to fourteen times the length of the cell; and it offers not the least sign of appendages of any kind, but is simply a smooth, round filament, of uniform thickness throughout, except at the end, where it tapers slightly and terminates in a blunt tip. The cell itself, when everted, is sensibly diminished in size, and narrows rapidly into the prolonged filamentary portion. Both of these kinds of nematocysts, and these only, are found in other parts of the body besides upon the tentacles, but they vary a great deal in size, and in some cases are very small, as, for instance, in the adherent disk of the pedicle. Möbius has favored us with a copy of his memoir (*Ueber den Bau, etc. etc., der Nesselkapseln, etc.*; Abhandl. des Naturwiss. Vereins zu Hamburg; Erstes Heft, des fünften Bandes, 1866) upon these bodies, in which he claims that the shaft is closely invaginated upon itself, when the cyst is closed. We have not had an opportunity of looking at this point since the reception of the paper. If it be true, it seems to explain the sudden jerk with which the shaft of the nematocyst is often everted, as if with explosion. This is remarkable in the cysts of Hydra.

218. *The Colletocysts* (*figs.* 96, 97, 101, 102, *a*, *a'*).—The discovery of these bodies added a third kind of prehensile cyst to those so well known among the Acalephæ and Ctenophoræ. Ehrenberg recognized the office of the nematocyst (Abhandl. Berlin Akad., 1835 [1837]), but we owe to Doyère (Compte Rendu, Août, 1842) the original solution of its structure, as an invaginated, hollow thread within a cyst of which it is a direct prolongation. We, ourselves, were so fortunate as to discover the structure of the second, or *non-invaginated* type of nematocyst peculiar to the Ctenophoræ (see H. J. C., in Agassiz, Contrib. Nat. Hist. U. S., vol. iii, p. 237, *figs.*). The original sketch of the third kind of cyst, the *colletocyst*, was published by us several years ago in the paper on the "*Ceratomyx of Acalephæ*" (Proc. Boston Soc. Nat. Hist., March, 1862; and American Journal of Science, May, 1863).

In previous paragraphs (§ 110, 208 (A), 117, 115, 212) of this memoir we have described the position of these bodies among the cells with which they are associated, on the colletocystophores, digituli, and the adhesive "disk" of the

peduncle. Such is the simplicity of a colletocyst that we can scarcely add anything that will characterize it better than as a "peculiar, granuliferous vesicle," briefly mentioned in the original article above alluded to. Our figures, above enumerated, may assist considerably in forming a conception of its nature. It consists of two kinds of materials, of which one is a perfectly homogeneous, transparent, highly adhesive, and tractile semifluid mass (*figs.* 97, 102, *a*²), which prevails to the extreme limits of the cyst, and the other is a coarsely granular, colorless, semi-transparent substance (*a*), which occupies the same area as the first, with the exception of their *peripheral stratum* (*a*²). The latter, from its optical appearance, would seem to have the character of a cell-wall, but that is hardly consistent with its office as an adhesive body, nor with its faculty of being drawn out into considerable extensions (*fig.* 102, *a*²). It is possible, though, that it is adherent and plastic only on its exposed side; since we may occasionally see two or three colletocysts (*fig.* 96) lying in contact, side by side, and yet with a sharp line of demarcation between them. They vary considerable in size according to locality. Those in the colletocystophores (*figs.* 96, 97, *a*) have five or six times the diameter of those of the digituli (*fig.* 101, *a*), and the latter are at least three times the size of those most prevalent in the caudal adhesive disk (*figs.* 118, 120, *a*).

DESCRIPTION OF THE PLATES I.—XI.; GLOSSARY AND INDEX OF SUBJECTS.

General Lettering of Haliclystus auricula J. Clark.—Throughout the memoir and in the plates corresponding parts are lettered alike, excepting in a few cases where capitals are used to indicate particular regions or subdivisions. For organs and parts, or regions, of organs Greek letters are used, and for minute and microscopic portions, walls, cells, etc., italicized English letters have been adopted.

NUMBER	PARAGRAPH
1. Anchor (Colletocystophore), * ¹ α	13, 104
“ stem, α ¹	105
“ nematocystophore, α ²	106, 166, etc.
“ colletocystophoric pad, α ³	106, 166, etc.
“ cavity, α ⁴	108
“ clear space, α ⁵	106
“ median furrow, α ⁶	106
“ shaft of nematocystophore (α ²) α ⁷	106, 166
“ entrance to, α ⁸	108
2. Aboral face of body, β	45
“ projection at base of anchors, β ¹	104
3. Adherent (caudal) disk, γ	114
“ “ “ furrows, γ ¹	115
4. Caudal disk (see 3)	114
5. Circumoral area, ζ	43
“ buttresses, ζ ¹	39
“ pouches, or their covering, ζ ²	40
6. Colletocyst, α (χολλητήρ, one who glues; κυστίς, a bladder)	107, 208 (A), 218
“ pit of, α ¹	208 (A)
“ clear peripheral part, α ²	218
6 ³ . Colletocystophore (see anchor) (colletocyst, φορὰ, bearing)	13, 104
7. Chondromyoplax in umbel, β (χονδρος, cartilage; μυς, muscle; κλάξ, a layer)	65, 66, 196
“ “ tentacle, β ¹	100
“ “ anchor, β ²	112
“ “ genitalia, β ³	137
“ “ digituli, β ⁴	120
“ “ intertentacular lobes, β ⁵	103
“ fibrils of, β ⁶	196
“ in proboscis, β ⁷	66
“ “ partitions, β ⁸	67
8. Chondrophys in umbel, γ (χονδρος, cartilage; φυσίς, to be by nature)	69, 197
“ “ peduncle, γ ¹	58, 70, 198
“ fibrils, γ ²	197, 198
“ in adherent disk, γ ³	198
“ innermost layer, γ ⁴	197 (A)

NUMBER		PARAGRAPH
	Chondrophys outermost layer, <i>c</i> ⁵	197 (A)
9.	Cell-wall (or cell), <i>d</i>	193, etc.
	“ nucleus, <i>d</i> ¹	193
	“ contents, <i>d</i> ²	193
	“ pigment, <i>d</i> ³	193
10.	Cytoblastema, <i>e</i> (<i>κύτος</i> , a cell; <i>βλαστήμων</i> , producing)	129
	“ tactile bodies of, <i>e</i> ¹	203 (A)
	“ pigment matter in, <i>e</i> ² and <i>e</i> ³	206 (B), etc.
11.	Digituli, <i>η</i> (<i>digitulus</i> , a little finger)	52, 116
12.	Eye-spot, <i>θ</i>	127
13.	Ectophragma in umbel, <i>f</i> (<i>επτός</i> , outer; <i>φράγμα</i> , a wall)	63, 194
	“ “ peduncle, <i>f</i> ¹	63, 194
	“ “ adherent disk, <i>f</i> ²	63, 114, 212
14.	Egg, <i>g</i>	140
	“ yolk-sac, <i>vs</i>	141
	“ “ <i>vi</i>	141
	“ germinal vesicle, <i>gv</i>	142
	“ “ dot, <i>wv</i>	142
15.	Genitalia, <i>λ</i>	50
	“ <i>λ</i> ¹ next longest, <i>λ</i> ² shortest, <i>λ</i> ³ longest side of genital half	50
	“ distal end, <i>λ</i> ⁴	50
	“ proximal end, <i>λ</i> ⁵	50
15 ^a .	Genital sac, <i>s</i>	51, 135
	“ “ cavity, <i>s</i> ¹	135
	“ “ follicles or pouches, <i>s</i> ²	137
	“ “ mouth or entrance, <i>s</i> ⁶	135
16.	Gastromyoplax in digituli, <i>h</i> (<i>γαστήρ</i> , stomach; <i>μυς</i> , muscle; <i>πλάξ</i> , a layer)	74, 119
	“ “ genital sacs (see number 24)	74, 85, 137
17.	Gastrophragma in umbel, <i>i</i> (<i>γαστήρ</i> , stomach; <i>φράγμα</i> , a wall)	75
	“ “ genital sac (surface), <i>i</i> ¹	136
	“ within genital sac, <i>i</i> ³	136
	“ in tentacles, <i>i</i> ²	76, 101
	“ “ intertacular lobes, <i>i</i> ⁷	103
	“ “ anchors, <i>i</i> ⁴	76, 113
	“ “ peduncle, <i>i</i> ⁵	76
	“ “ digituli, <i>i</i> ⁶	118
	“ “ proboscis, <i>i</i> ⁷	76
18.	Intertentacular lobes, <i>π</i>	103
19.	Muscles, <i>k</i> ; circumoral (see number 22); peduncular (see number 30); of genital sac (see number 24)	103
	“ between edges of <i>b</i> and <i>c</i> , <i>k</i> ¹ , <i>k</i> ²	82
20.	Nematocystophore (see number 28 and 1) (<i>nematocyst</i> ; <i>φορέα</i> , bearing)	82
21.	Nematocyst, <i>l</i> (large) (<i>νημα</i> , a thread; <i>κύστις</i> , a cyst)	94, 203, 216
	“ <i>l</i> ¹ (small)	217
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	“ cell-mouth, <i>ml</i>	216
	“ shaft when in, <i>sl</i>	216
	“ “ out (basal half), <i>bl</i>	216
	“ “ “ (distal half), <i>dl</i>	216
	“ thread, <i>tl</i>	216
	“ thread coiled, <i>lc</i>	216
22.	Opsomyoplax in umbel, <i>m</i> (<i>ὄψις</i> , the face; <i>μυς</i> , muscle; <i>πλάξ</i> , layer)	64, 80
	“ at margin, <i>m</i> ¹	84

NUMBER		PARAGRAPH
	Opsomyoplax in tentacles, m^2	86, 98
	“ band in circumoral face, m^1	83
	“ in anchor, m^3	87, 111
	“ “ partitions, m^4	83
	“ “ peduncle of anchor, m^5	88
	“ “ in proboscis, m^6	79
23.	Opsophragma in umbel, u ($\sigma\psi\iota\varsigma$, the face; $\phi\rho\alpha\gamma\mu\alpha$, wall)	61
	“ “ tentacle, n^1	62, 97
	“ “ anchor, n^2	62, 110
	“ “ proboscis, n^3	62
24.	Oömyoplax ($\omega\delta\omicron\nu$, an egg; $\mu\nu\varsigma$, muscle; $\kappa\lambda\alpha\xi$, a layer)	74, 85, 137
25.	Proboscis, ρ	37
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	“ (buccal) cavity, ρ^2	38
	“ base, ρ^3	39
	“ buttresses (see circumoral buttresses)	39
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*¹ In fig. 25, a^3 should be a^5 ; in fig. 23, a^4 should be a^7 ; in fig. 27, a^3 should be a^2 .

*² In figs. 47a, 49, and 50, the engraver has erroneously used y and y^2 , instead of r and r^2 .

PLATE I. *Figures 1 to 17.*

Figures 1 to 16, Haliclystus auricula Jas. Clark; natural size and various attitudes and ages.

Fig. 1, profile view, the umbella turned backward. *Figs. 2 and 3*, anterior face, the arms in two attitudes. *Figs. 4 and 5*, two profile views with the umbella thrown forward. *Fig. 6*, the umbella folded across the middle, and two opposite halves brought near together, face to face. *Fig. 7*, the

umbrella thrown forward and so contracted at the periphery as to form a deep funnel. *Figs. 8 to 12*, half-grown individuals in various attitudes. *Fig. 13*, a specimen clinging by its anchors to a leaf of *Zostera*. *Figs. 14 and 15*, the umbrella strongly enrolled at the margin. *Fig. 16*, profile of a very young specimen.

Fig. 17. A magnified profile view of a nearly full-grown individual. To avoid confusion only the four nearest bunches of tentacles (ϕ) are represented. Only the aboral side (β) of the umbrella is exposed. The anchors (α) are thrown strongly back over the edge of the umbrella. The tentacles (ϕ) on the left are expanded to the fullest extent.

PLATE II. *Figures 18 to 24.*

Fig. 18. Posterior face of the caudal disk, magnified 15 diameters, to show the four main furrows (γ^1) and the network of minor furrows.

Fig. 19. Interior face of caudal disk, the peduncle being cut across just in front of it and removed. Principally to show the passage-ways between the four camerae (τ^3) and the convergence of the four muscles (r^1) to the axis.

Fig. 20. Oral face of a young specimen $\frac{3}{8}$ of an inch across the umbrella, magnified 24 diameters. The proboscis (ρ) being strongly contracted appears disproportionately small, but possesses the advantage of exposing the proximal ends of the partitions (ψ^2) of the umbrella, as well as of the genitalia (λ).

Fig. 21. Aboral view of a group of tentacles of *fig. 20*.

Fig. 22. Magnified (5 diam.) oral face of a full grown specimen. Only two bunches of tentacles (ρ) are represented. On the left, above, the proximal end (ψ^5) of the partition and the attachments of the digituli (γ) are exposed by the retraction of the side of the proboscis near them. At the other three quadrants the circumoral pouches are widely covered by the extended flanks (ζ) of the proboscis. The four double genitalia lie, both above and below, right and left of the vertical plane, a partition (ψ^2) lying in the middle of each pair. The three sides of a triangular genital-half are lettered respectively $\lambda^1, \lambda^2, \lambda^3$. The anchors (colletocystophores) (α) are in varied positions; mostly turned strongly backward over the umbellar margin (ψ^3), two partly reverted, and one projecting straight out so as to fully expose its anterior face with its median furrow. The tentacles (ϕ) are fully extended.

Fig. 23. Lateral view of an adult anchor (*colletocystophore*) with a part of the umbellar margin (magnified 15 diameters).

Fig. 24. Front of basal region of a *colletocystophore* principally to show depth of median furrow (α^6), and the proportions of the stem (α^1) and the colletocystophoric pad (α^3) (15 diam.).

PLATE III. *Figures 25 to 37.*

Fig. 25. Basal front view (magnified 60 diam.) of the anchor, and a part of the umbellar margin of a specimen about two-thirds grown. The anchor is here shown to be supported on its distal side by a prolongation (β^1) from the aboral side (β) of the umbrella. The colletocystophoric pad (α^3) is strongly dotted by colletocysts. The remnant of the tentacle-like stage is quite distinct (α^2, α^5) in the distance.

Fig. 26. Magnified (200 diam.) outline profile of a *colletocyst* (anchor) from a young specimen (*fig. 28*) only $\frac{6}{10}$ of an inch across the umbrella.

Fig. 27. Anterior face of *fig. 26*, the tentacular character still strongly marked ($\alpha^2, \alpha^5, \alpha^7$), and the eye-spot (θ) very distinct.

Fig. 28. Young specimen, natural size, from which *figs. 26, 27* were taken.

Fig. 29. Natural size of a young specimen ($\frac{1}{8}$ of an inch across the umbrella), from which *figs. 30, 31, 32, and 33* were taken.

Fig. 30. Posterior face of a *colletocystophore* (anchor) retarded in growth, probably by an injury on that side of the body. From *fig. 29*. As yet it is strongly tentacular in proportions and nature,

although the colletocystophoric pad (α^3) is considerably developed. At m^3 is the margin of the muscular layer, (magnified 175 diam.).

Fig. 31. Profile view of *fig. 30*, showing the front face (α^6) to be still purely tentacular.

Fig. 32. Normal development of an anchor, seen in profile, from *fig. 29* (mag. 175 diam.). The colletocystophoric pad (α^3) is considerably more advanced than in *figs. 30, 31*.

Fig. 33. One of the oldest tentacles of *fig. 29* (§ 22), fully expanded to show the proportionate thickness of the walls and the relative size of the globular tip (nematocystophore) (ϕ^2). The neck (ϕ^4) at the base of ϕ^2 is well marked (mag. 175 diam.).

Fig. 34. Young tentacle whose nematocystophore (ϕ^2) is not yet distinct from the shaft (ϕ^1), (mag. 175 diam.).

Fig. 35. Abnormal development of colletocysts (α^3) on a young tentacle (mag. 60 diam.).

Fig. 36. Part of the shaft of a tentacle while contracted into a zigzag (mag. 60 diam.).

Fig. 37. Magnified (5 diam.) longitudinal section of adult along two diverse lines, on nearly opposite sides. The section on the left passes through a group of tentacles (ϕ), a genital half (ζ), and through the proboscis (ρ) near one of its corners, and thence backward along the peduncle, just this side of a canal (τ^3) to its posterior end. The section on the right, passing through a colletocystophore (α), extends along the midline of a partition (ψ^2) and of a flat side of the proboscis (ρ), thence along a muscular cord (r^2) in the post-buccal region, and continues to follow it (r) into the peduncle to its expanded posterior end (r^1). The peduncular canal (τ^4) on this side is seen in the distance, beyond the muscular cord (r). The section on the left exposes the umbellar cavity (ψ^1) as well as the digituli (η) festooned about the post-buccal cavity (ψ^6).

PLATE IV. *Figures 38 to 51.*

Figs. 38, 39, 40. Abnormal conditions of the nematocystophore of tentacles (mag. 60 diam.).

Fig. 41. Normal condition of a fully developed tentacle, showing the depressed end of the nematocystophore (60 diam.).

Fig. 42. Fully extended tentacle of a two-thirds grown individual. It very commonly assumes the curved attitude here represented (60 diam.).

Fig. 43. End of a young, but fully formed tentacle, principally to display its ribbed appearance, and the bristling tactile bodies and the nematocysts which dot the globular tip (ϕ^2) (175 diam.).

Fig. 44. Different view of same as *fig. 43*, showing the end of the nematocystophore (ϕ^2), but the shaft curved around into profile, and drawn to exhibit the zigzag position of the innermost wall (τ^2), moving *apparently* free within the outer wall. The great plasticity and extensibility of the intervening layer (chondromyoplax) (b^1) allows these two walls to slide over each other to a great extent, and apparently, with a low power, as if without any intervening connective tissue (175 diam.).

Fig. 45. (20 diam.). Interior of the region about a colletocystophore to expose its entrance (α^8). The oral side (ζ) of the umbella is thrown upward. The margin of the pigment coloring of the aboral side (β) is well marked along the edge of the marginal muscle (m^1).

Fig. 46 (60 diam.). Profile of the posterior end of a peduncular muscle (r) and its extension (r^1) toward the middle of the adherent disk (γ).

Fig. 47 (60 diam.). Section of a colletocystophore and the adjoining umbellar margin, including a portion of the distal end of a partition next an intercameral passage-way (ψ^7), showing the relative thickness and position of the layers, and exposing the interior cavity.

Fig. 47^a (60 diam.). Continuation of the section above figured (*fig. 47*) into the region about the base (ρ^3) of the proboscis; principally to show the relation of the layers of the umbella and the proboscis and to expose the peduncular muscle (γ), where it passes forward into the proximal end (ψ^5) of the partition, and thence diverges into the proboscis (at m^6) and into the umbella (at m^4).

Fig. 48 (350 diam.). A young tentacle contracted; displaying, in a sectional view, the relative position, thickness, and the elementary structure of the layers, and the imbedded nematocysts (l).

Fig. 49 (60 diam.). Interior view of the peduncular muscle (γ) at the point where it plunges forward, narrows (γ^2) a little, and then expands into a flattened layer (m) in the circumoral area. (Compare this with *fig. 47^a*.)

Fig. 50 (60 diam.). Sectional view of the region about the base of the proboscis (ρ), including the post-buccal cavity (Ψ^b) and a part of the peduncle. The muscles (r), right and left, are exposed, and the canals (τ^3) lie in the distance, as well as one of the muscles (at r^2) in the post-buccal cavity. In the umbella, m is the expanded prolongation of r^2 each side of the partition (Ψ^2). Compare Ψ^3 with the same in *fig. 47^a*.

Fig. 51 (60 diam.). Longitudinal section through two diagonally opposite tubes (τ^3) at the posterior end of the peduncle, showing the irregular passage-ways (τ^5) in the region of the adherent disk.

PLATE V. *Figures 52 to 60.*

Fig. 52 (75 diam.). Transverse section of the peduncle to display the relative positions of the muscular cords (r) and the tubes (τ^3), as well as the arrangement of the fibrils of the chondrophys (c^1, c^4).

Fig. 52^a (75 diam.). One of the muscles of the peduncle cut across, and lettered in reference to the main subdivisions.

Fig. 53 (175 diam.). Longitudinal section of one side of the proboscis of a young specimen (*fig. 84*), with a portion of the circumoral area. At ρ^1 to ρ^3 is a face view of the innermost wall (i) in the distance.

Fig. 54 (100 diam.). Section, slightly varying in direction, through a group of tentacles, cutting some (A, D) lengthwise, and opening the base of others (B, C), as well as exposing the interior of some of the solid intertentacular lobes (π). The mouth (s^6) of the genital sac (s) is always turned toward the proboscis, as drawn here.

Fig. 55 (100 diam.). Outline view of the globular tip of a tentacle to show the terminal depression.

Fig. 56 (100 diam.). Interior face-view of the region occupied by the intertentacular lobes (π) and the entrances (ϕ^3) of the tentacular cavities.

Fig. 57 (470 diam.). The tissue and pigment granules about the entrance (ϕ^3) to the hollow of a tentacle.

Fig. 58 (175 diam.). Longitudinal section of the basal part of the tentacles, tentacular lobes, and a part of the umbella. The circumoral floor (ζ) thrown up slightly so as to expose the inner face, and the marginal muscle (m^1). From a very young animal (§ 22).

Fig. 59 (175 diam.). A budding tentacle (from *fig. 58*) with a part of the walls of a larger tentacle (ϕ).

Fig. 60 (300 diam.). Sectional view of the base of a tentacle, intertentacular lobe, and the adjoining aboral umbellar margin.

PLATE VI. *Figures 61 to 66.*

Fig. 61 (100 diam.). Section across two extended corners of the umbella and the partition (Ψ^2) lying between them. The section across one of the corners is partially omitted, as it is an exact duplicate of the other, reversed. The genital sacs (s) all open (s^6), in one direction, into the umbellar camera (Ψ^1). At b^3 the chondromyoplax meets the chondrophys (c^4) and breaks the continuity of the innermost wall (i) of the camera, and forms the bulk of the partition.

Fig. 62 (100 diam.). Section across one corner of the umbella nearer its margin than in the last, principally to show the considerable depth of the ridges (m^1, m^2) of the muscular layer, and the peculiar concavo-convex surface of contact of the circumoral (ζ) and aboral (β) floors of the umbella, against the intervening muscular layer (k^1).

Fig. 63 (200 diam.). Section across an umbellar partition (Ψ^2) and a part of the circumoral and aboral floors near it, at a point nearer the proboscis than in *figs. 61* and *62*, including one of the youngest genital sacs (s).

Fig. 64 (200 diam.). Longitudinal section at the same point as *fig. 63*, cutting the partition (m^1) lengthwise.

Fig. 65 (200 diam.). A group of digitiform bodies (digituli) pendent from the circumoral floor. One of them is remarkable for its triple forking.

Fig. 66 (5 diam.). The peduncle and a part of the umbella near a partition (ψ^2), including a marginal body (colletoecystophore) (α); chiefly to display the distinctness, from an exterior view, of the canals (τ^3), and the filmy caudal sheath (τ^1). The deep furrow (τ^6) lies over the muscular cord which extends forward into the partition (ψ^2 , ψ^5) of the umbella.

PLATE VII. *Figures 67 to 84.*

Figs. 67 to 73 (175 diam.). A progressive series of developments of the genital sac, seen from different points of view. *Fig. 67*. View from within the umbella. *Fig. 68*, same as *fig. 67*, but seen from the end opposite the entrance (s^6) of the sac, the outer wall (i) overlying the initiatory double folds (i^3) of the inner, or ovigerous layer. (Compare *fig. 74*, and adult sac.) *Figs. 69* and *70*, face and profile of the same sac seen from within the umbella. *Figs. 71* and *72* face and end views of the same sac, the third in the series, seen from the exterior, through the circumoral floor. *Fig. 73*, the fourth and last of the series, seen from without, as in the last.

Fig. 74 (350 diam.). One of the smaller genital sacs, of an adult female, sectional profile, pendent from the circumoral floor. The aperture (s^6), surrounded by large vibratile cilia, leads into a central chamber (s^1) surrounded by ovigerous follicles.

Fig. 75 (350 diam.). View from opposite the entrance (s^6) of a male genital sac. The follicles (s^2) converge toward and open into the central chamber (s^1).

Fig. 76 (350 diam.). The same as *fig. 75*, seen through the circumoral floor, from a different point of view.

Fig. 77 (350 diam.). Empty female genital sac, chiefly to show the manner in which the follicles (s^2) open into the central chamber (s^1).

Fig. 78 (350 diam.). An egg-follicle to illustrate the histological character of the ovigerous layer (i^3) (internal oöphragma), and the position of the eggs (vi).

Fig. 79 (350 diam.). An empty egg-follicle dotted all over with the torn fragments of the fibrils of the chondromyoplax (see *fig. 77*, b^3).

Fig. 80 (200 diam.). Singular attitude of a digitulus (η), its sides folded together to form a sac with a broad mouth (ηs), imitating a genital sac (s^1).

Fig. 81. An anchor (colletoecystophore) of a very young individual (*fig. 84* nat. size), and a portion of the umbellar margin. The edge of the muscular layer (opsomyoplax) (k^1) is seen passing obliquely from the front to the distal side. (See the dotted line k^1 , k^1 , in *figs. 82* and *83*.)

Fig. 82 (175 diam.). A combined outline and sectional view from the distal side of a young anchor (from *fig. 84*). The nematocystophore (α^2) in the distance. The dotted line (k^1) indicates the course of the edge of the opsomyoplax (k^1) as it crosses the distal side of the base of this organ. The distal end of a partition (ψ^2) is seen through the thick mass of the aboral side of the umbella. The arrow lies in the intercameral passage-way. (See ψ^1 , *fig. 83*.)

Fig. 83. Profile section of the same as *fig. 82*, with a part of the umbella. The dotted line (k^1) is the same as in *fig. 82*, continued onward to the circumoral floor, where it becomes a part of the true umbellar opsomyoplax (m^1). In the anchor it is marked m^3 .

PLATE VIII. *Figures 85 to 93.*

Fig. 85 (750 diam.). Portion of the opsophragma (n) and the underlying opsomyoplax (m) of the circumoral floor, in profile.

Fig. 86. Face-view of the cells of *fig. 85*.

Fig. 87 (750 diam.). Face-view of the cells of the ectophragma of the aboral side of the umbella, remarkable for the accumulation of pigment granules (d^1) about the nucleus.

Fig. 88 (750 diam.). Profile section of the outer wall of the globose tip (nematocystophore) of a young tentacle, with the imbedded nematocysts (l the larger and l' the smaller).

Fig. 89. End view of the same as *fig. 88*.

Fig. 90 (750 diam.). A combined longitudinal sectional and surface view of a part of the shaft of a tentacle. At n^1 the opsophragma is in profile, and at $1n^1$ it is presented as seen at the surface, extending partly across the field. At $1m^2$ the opsomyoplax is in profile, and at $2m^2$; $3m^2$ are the fibrils of the same, nearer the eye, underlying the opsophragma ($1n^1$) and overlying the chondromyoplax (b^1) and the gastrophragma ($1i^2$) in the distance. Next within the muscular layer lies the chondromyoplax, which is seen partly in section (at b^1), and a small portion at the exterior surface (b^1) as it curves over and rises, toward the observer, from the distance. The innermost wall (gastrophragma) is seen, also, partly in profile (i^2) and partly at the surface ($1i^2$), the cells being presented endwise.

Fig. 91. Transverse section of *fig. 90*, representing a little more than a quadrant of the cylinder. At m^2 the muscular fibrils are cut across. The wedge-shaped character of the cells of the gastrophragma (i^2), as they diverge from the central cavity (ϕ^2), is quite evident.

Fig. 92 (750 diam.). Face view of the cells of the outer wall (d) and the underlying muscular fibres (m^2), to show the linear arrangement of the former when the tentacle is contracted.

Fig. 93. Profile of *fig. 92*, to compare with the cells of the same wall (in *fig. 90*, n^1) when the tentacle is extended.

PLATE IX. *Figures 94 to 108.*

Fig. 94 (750 diam.). The innermost wall (gastrophragma) of the anchor of a three-quarters grown animal, exhibiting its enormous thickness at one part (B), and its gradual thinning out (A to D); as well as the great masses of pigment (d^1) in the cells.

Fig. 95. Face-view of the same as *fig. 94*.

Fig. 96 (350 diam.). The outer wall and the imbedded colletocysts (a) of an anchor. At a^1 the pit in which such as a are sunken.

Fig. 97 (750 diam.). More highly magnified views of a part of the same as *fig. 96*; a part of the cells are omitted so as to expose more clearly the structure of the colletocyst (a), particularly its clear periphery (a^2).

Fig. 98 (175 diam.). A combined surface and longitudinal sectional view of a digitulus and a genital sac. At A and B the opposing flat sides are seen edgewise, meeting along the midline of the figure; at A, distinguished by the crowded colletocysts, and at B and C, by the nematocysts. At D is a section of the thickness from face A to face B. The mouth (s^6) of the genital sac is quite wide open.

Fig. 99 (550 diam.). The colletocystic side of a portion of *fig. 98*, partly at the surface ($1a$) and partly so as to expose the underlying muscular fibrillæ (h) and the layer of colletocysts in profile (at a).

Fig. 100. Transverse section of the same as *fig. 99*, displaying on one side the nematocysts (l), and the very long vibratile cilia (co), and on the other the crowded layer of colletocysts (a).

Fig. 101 (750 diam.). More highly magnified view of a part of the adjoining nematocystic (l) and colletocystic (a) faces of the same as *fig. 98*.

Fig. 102 (750 diam.). Colletocysts with the periphery drawn out to various lengths (a^2).

Fig. 103 (350 diam.). A part of *fig. 99*, after treatment with fresh water; the colletocysts adherent after the cells of the wall have fallen away, and exposed the fibrillæ (h) of the gastromyoplax.

Fig. 104 (750 diam.). Some gastrophragmic cells (i) and fusiform fibrils (r^2) of the muscular layer at the point where it passes into the cords of the peduncle.

Fig. 105 (750 diam.). The innermost wall (gastrophragma) (i^5) lining two adjoining, nearly completed, irregular passage-ways between the tubes of the peduncle. Near A, new cells are forming between B and C, pushing their way through the solid mass of chondrophys (c^1), and eventually becoming the face-wall of the passage (τ^3), here in process of excavation.

Fig. 106 (350 diam.). Face-view of the fibro-cellular chondrophys of a very young specimen (*fig. 82*).

Fig. 107. Profile of one of the fibro-cellular elements of *fig. 106*, taken near the thinning edge of the chondrophys (see *figs. 82, 83*).

Fig. 108 (750 diam.). A more highly magnified egg, from *fig. 74*. The mulberry-like character of the yolk (*vi*) is remarkable.

PLATE X. *Figures 109 to 129.*

Fig. 109 (1050 diam.). Profile section of the outer wall (oöphragma) of a genital sac, principally to illustrate the relation of the vibratile cilia (*co*) to the cells of this wall, and the interstitial cytolabstema in which the cilia-bases are imbedded.

Fig. 110 (1050 diam.). Surface view of the same as *fig. 109*, the large pigment and colorless granules lying nearest the observer. From an unusually large individual.

Fig. 111 (350 diam.). From the same layer as in *figs. 109, 110*, acted upon by fresh water, which has resolved the elements into separate cells.

Fig. 112 (1050 diam.). E to K. Vibratile cilia from diverse regions of the interior. E is from the surface of the genital sac (*fig. 109*), and the rest from the inner face of the circumoral floor, near the margin of the umbella. They are represented in various attitudes, as they move with the cilium in front of the swollen basal portion.

Fig. 113 (200 diam.). Portion of the proximal face of a peduncular cord, showing the deep furrows ($\frac{1}{3}$, $\frac{1}{3}$) and the intervening ridges ($\frac{1}{4}$).

Fig. 114 (750 diam.). A small portion of *fig. 113*, more highly magnified, showing an apparently clear cellular structure, with large homogeneous interspaces. Its true nature is seen in *fig. 116*. The tissue is strongly contracted.

Fig. 115 (750 diam.). Some loosened cells from *fig. 114*.

Fig. 116 (750 diam.). Showing the fibrillæ (r^3 , $1r^3$, $2r^3$) and cells of the peduncular cords; from the same individual as *fig. 114*, but in a highly extended condition, just after death has ensued.

Fig. 117 (470 diam.). Transverse section of one of the main subdivisions of a muscular cord of the peduncle, next the median furrow ($\frac{1}{3}$) of *fig. 113*, showing the deep minor furrows.

Fig. 118 (750 diam.). Profile section of the outer wall of the adherent disk of the peduncle, with its imbedded adherent vesicles (*a*).

Fig. 119 (750 diam.). Inner face-view of the same as *fig. 118*, displaying only the cells (f^1) and the nematocysts (*l*) in the distance.

Fig. 120 (750 diam.). Outer surface view of the same as *figs. 118, 119*, showing only the crowded colletocysts (*a*) and the very minute nematocysts (*l*).

Fig. 121 (24 diam.). Front view of a very young individual ($\frac{1}{8}$ of an inch across the umbella alone). The different groups of tentacles vary considerably in the number of their components. The numbers 1, 2, 2^a, 3, 3^a, etc., refer to tentacles of successively younger development; and the capital letters A, A¹, B, B¹, C, C¹, refer to the groups which have respectively, four, or five, or six tentacles. The tentacular nature of the colletocystophore (*a*) is quite marked, as yet.

Fig. 122 (45 diam.). A, B, C, D. Various developed groups of tentacles and an anchor from *fig. 121*. Group A, of four tentacles seen endwise. Group B, of five tentacles seen in front. Group C, of six tentacles also seen in front. No. 1 is the oldest and No. 4^a the youngest tentacle of these groups. They are numbered and lettered to correspond with the same in *fig. 121*. The anchor (D) is seen in profile, fully extended.

Fig. 123 (85 diam.). An anchor, the same as *fig. 122, D*, slightly contracted. A surface view, showing the interior in the distance.

Fig. 124. Natural size of a very young animal.

Fig. 125 (40 diam.). View of the aboral or distal side of a group of tentacles from *fig. 124*. The numbers 1 to 6^a refer to successively younger tentacles.

Fig. 126. Front view of the same as *fig. 125*, less magnified.

Fig. 127 (175 diam.). Basal view of part of the adherent disk of the peduncle, of a very young individual (*fig. 124*). Remarkable for the abrupt termination of the muscular cord (*r*) and the disconnected tubes (τ^3).

Fig. 128 (175 diam.). Portion of a transverse section of the peduncle of *fig. 124*, at a point half-

way between its two ends. Remarkable for the horse-shoe form of the section of the hollow muscle (*r*), as in the last figure (*fig. 127, r*).

Fig. 129 (350 diam.). Portion of a space between two adjoining peduncular tubes (*fig. 128*), showing the irregular form and granulation of the young fibrillæ (*c*²) in the homogeneous cytoblastema of the chondrophys.

PLATE XI. *Figures 130 to 145.*

Figs. 130, 131, 132 (1050 diam.). Spermatic particles at the moment of escape from the genital sac.

Figs. 133 to 141. Larger kind of nematocysts from the tentacles, in various degrees of eversion, or at rest. *Figs. 138 and 141*, of diagramatic size, and the rest, from *fig. 133 to 140*, magnified 1050 diameters. *Fig. 133.* Not fully grown nematocyst, closed. A part of the coil omitted to expose the central shaft (*sl*). *Fig. 134.* Fully developed cyst, but not the largest, closed. A sectional view, the coil in the distance (*lc*). *Fig. 135.* The basal half of the shaft (*bl*) everted. *Fig. 136.* The whole shaft (*bl, dl*) everted. *Fig. 137.* The whole shaft (*bl, dl*) and a part (*A*) of the hollow thread everted. *Fig. 138.* Partly everted thread, showing the manner of its sliding within itself. *Fig. 139.* A completely everted cyst, showing the spiral rows of bristles on the shaft and the twisted triangular thread (*tl*). At *D*, the blunt tip of the thread. *Fig. 140.* The end of a shaft rapidly tapering into the thread after eversion. *Fig. 141.* Diagramatic view of the base of the thread, showing the spiral course of the edges of the twisted trihedral, and the abrupt termination of the rows of setæ of the shaft.

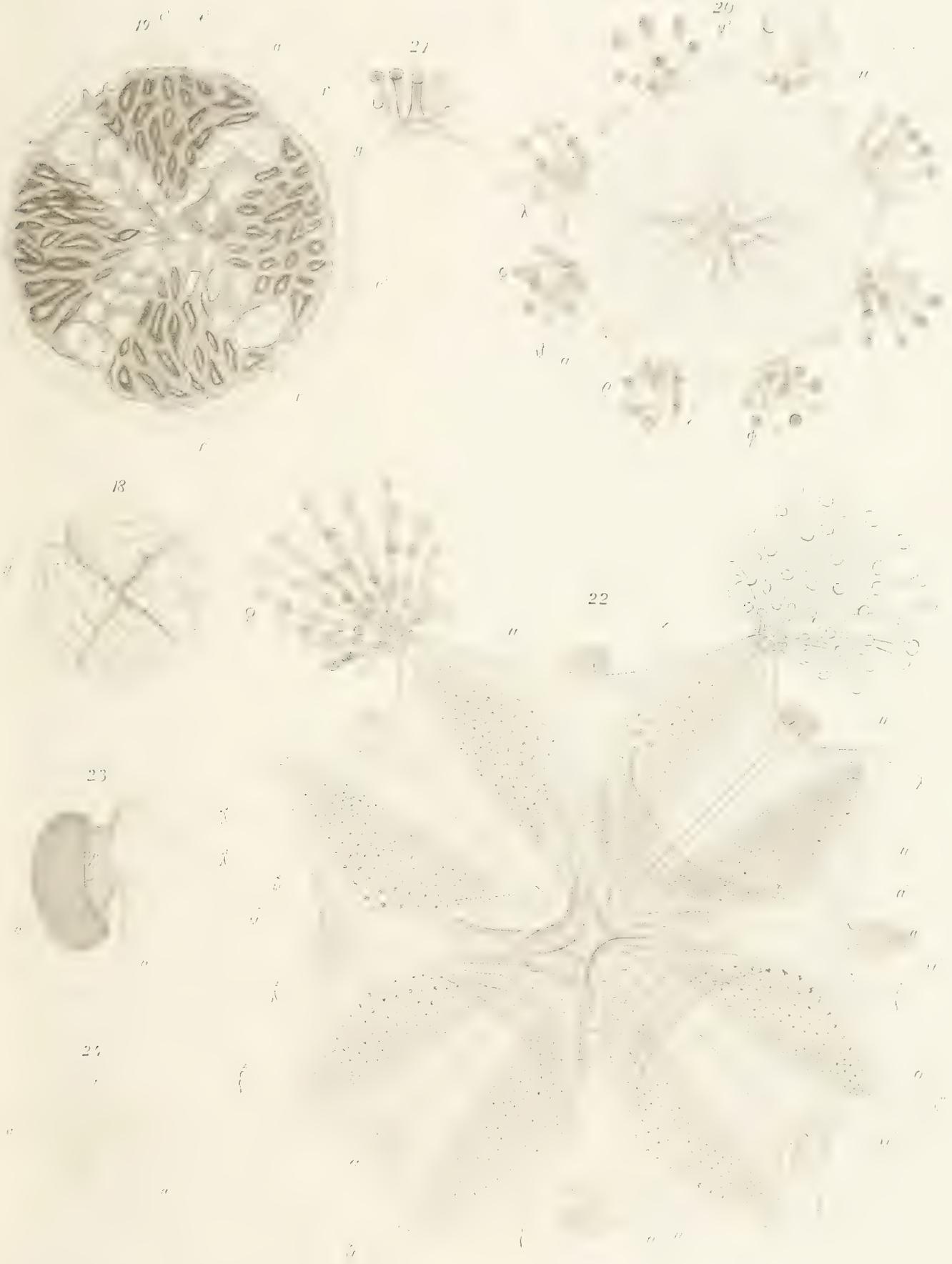
Figs. 142 to 145. The smaller nematocysts, from the tentacles (1050 diam.). *Fig. 142.* Fully developed cyst, closed. The coil partly omitted, not to confuse the connection of the shaft (*sl*) with the thread. *Fig. 143.* View from the side opposite to the one seen in *fig. 142*, showing the termination (*lc*) of the thread, and its mode of coiling. *Fig. 144.* View at ninety degrees from that of *fig. 143.* *Fig. 145.* The thread totally everted.



Walt. del. Auster.

Debray sc.

Haliclystus auricula, Jas. Cl. (Fig. 1-17.)



Haliclystus auricula. Jas. Cl. (Fig. 18-24.)



Del. nat. del. auctor.

DeGray sc.

Halichytus auricula. Das. Ct. (Fig. 25-37)



Ad. nat. del. Auctor

Debray sc.

Haliclystus auricula Jac. Cl. (Fig. 38-62.)

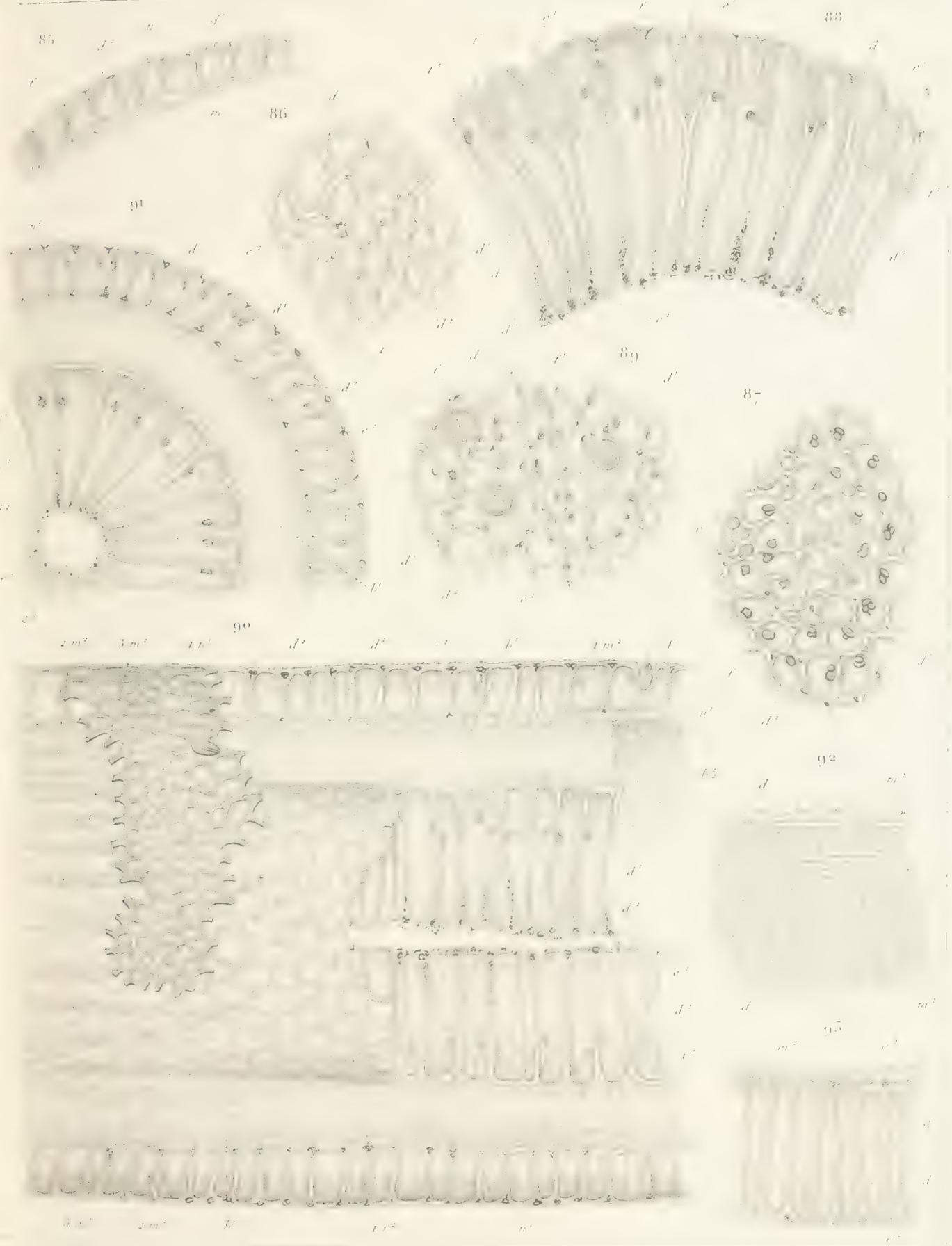


Halichystus auricula, Jas Cl. (Fig. 52-60.)



Debray sc.

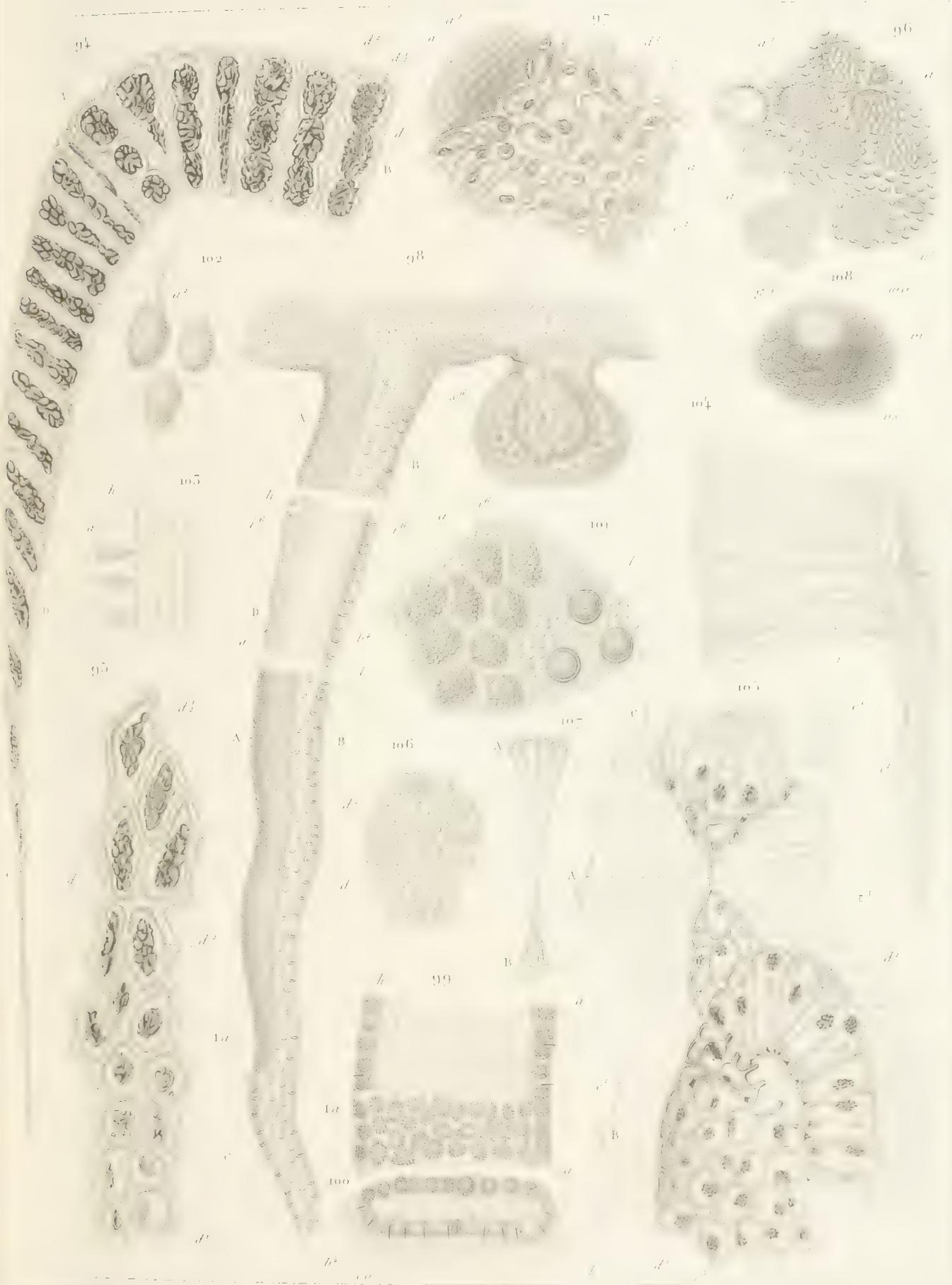
Halichystus auricula, Des Cl. (Fig. 67-84.)



Ad. nat. del. Auctor

Debray sc.

Halichystus auricula, Jas. Cl. (Fig. 85-93)



Haliclystus auricula, Saw Cl. (Fig. 94-108.)

Debray co.



Debray sc.

Habclystus auricula, Jas Cl. (Fig. 109-129)



Aut. del. Autor.

Debray sc.

Halichustus auricula. Jac. (1. (Fig. 130-145.)

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.

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ON THE

GEOLOGY OF LOWER LOUISIANA

AND THE

SALT DEPOSIT ON PETITE ANSE ISLAND.

BY

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[ACCEPTED FOR PUBLICATION, OCTOBER, 1871.]

ADVERTISEMENT.

THIS memoir, with others referred to in the text, relating to the Delta of the Mississippi, and adjacent regions, is the result of a series of investigations commenced at the expense and made under the direction of the Smithsonian Institution by Professor E. W. Hilgard, with assistance contributed by the New Orleans Academy of Sciences, and the Commissioners of Immigration for the State of Louisiana.

JOSEPH HENRY,

Secretary S. I.

WASHINGTON, June, 1872.

ON THE
GEOLOGY OF LOWER LOUISIANA,
AND THE
SALT DEPOSIT ON PETITE ANSE ISLAND.

THE discovery, in May, 1862, of a deposit of rock-salt on the coast of Louisiana, was a fact so unexpected to geologists, that, at any other time, a detailed investigation of the circumstances of its occurrence would quickly have followed its first announcement. Under the circumstances then existing, such great practical importance attached to it, that the Confederate government promptly caused official examinations to be made. This, however, was of an exclusively practical character, and resulted in the establishment of a system of exploitation which, while perhaps necessary at the time in order to supply without delay the pressing want of salt in the blockaded section, was illy calculated to endure for any great length of time, or to give information as to the extent or geological character of the deposit. For a considerable time these mines, together with the brine wells of Northwestern Louisiana, supplied the whole of the Southwest; until, in April, 1863, on the taking of the island of Petite Anse by the Federal forces, the works were destroyed.

Information gathered during the war from soldiers residing in the region had satisfied me that the hypothesis of the volcanic origin of the island, set forth by Mr. Thomassy in 1860,¹ was unfounded. An analysis of a specimen of the salt which I obtained in 1863, showed its only impurity to consist of 0.120 per cent. of gypsum.

The first scientific investigation of the salt region, which has come to public knowledge, was made by Prof. Richard Owen, in November, 1865.² He ascertained the sedimentary character of the deposits forming the island, attributing their formation, however, to "the combined action of the winds and waves of the ocean." The rock-salt mass he conceives to have been formed by saline inundations caused by storm tides.

In summer, 1866, I received an invitation from Prof. Henry to undertake a geological examination of the Louisiana salt region, the travelling expenses to be defrayed by the Smithsonian Institution. While most anxious to avail myself of this opportunity of extending my knowledge of the geology of the Gulf coast, want of time, as well as the epidemic prevailing in the region, compelled me to defer the excursion until November, 1867.

¹ *Geologie pratique de la Louisiane*, 1860, p. 77.

² *Proc. Acad. St. Louis*, II. 250; *Amer. Journ. Science*, July, 1866, p. 120.

Meanwhile, in November, 1866, an investigation of the salt deposit was undertaken by Dr. Chas. Goessmann, under the auspices of the American Bureau of Mines.¹ Its object was chiefly, of course, to ascertain the probability of economical success in working the mine; the geological relations of the bed coming into consideration mainly with a view to this object. Dr. Goessmann's able report is exhaustive as regards the practical part of the subject. The notes, specimens, maps, and hypsometrical observations, with which he kindly furnished me, were of essential assistance. They led me to believe, at the time, that the predominant surface formation of the island was the equivalent of the "Orange Sand," the prevalent surface formation of the uplands of Mississippi, which I consider as contemporary, and substantially identical with the "Modified Drift" of the Northwest.² I thought that the chain of elevations or "islands," mentioned by Thomassy and Dr. Goessmann, might be of a similar origin as those frequently observed in level portions of the State of Mississippi,³ which are manifestly outliers of the main body, that have resisted denudation by the greater firmness of their material. This supposition, however, rested merely upon lithological resemblance, while later fluvial deposits might exhibit a very similar aspect.

The solution of the problem involved, of necessity, a general examination of the ancient and modern deposits as well as the delta formations of the Mississippi Valley, and adjacent Gulf coast; and this work had to be commenced from some point where the formations were previously known and identified. In conformity with this requirement, I proceeded from Vicksburg, the most southerly outcrop of the fossiliferous marine tertiary, to the present mouths of the Mississippi, landing at intermediate points where observations were needed. After this I went up the coast to the islands, of which the examination formed the original object of the expedition.

The unusually low stage of water, as well as the magnificent weather enjoyed in these latitudes during the early part of the winter, gave me advantages, without which the brief space of time at my command would not have sufficed to carry out my plan of operations; for the successful prosecution of which I am also largely indebted to the courtesy and generous liberality, both of private individuals, and transportation companies.⁴

¹ Report of the American Bureau of Mines on the Rock-salt Deposit of Petite Anse; New York, 1867.

² Amer. Journ. Science, May, 1866, p. 311; *Ibid.*, Nov. 1866; *Ibid.*, Dec. 1871.

³ Report on the Geology and Agriculture of Mississippi, 1860, p. 8.

⁴ I have to acknowledge favors in the way of free transportation, both for myself and my travelling companion (Dr. E. Fontaine, Secretary of the New Orleans Academy of Sciences), on the part of Mr. Moulton, of the Cromwell line of steamers; Capt. Ed. Yorke, of the Towboat Association; Capt. Andrews, of the dredgeboat at the S. W. Pass; Capt. Bayley, Superintendent of the Opelousas Railroad, and Capt. Trinidad, of the Steamer Anna E., on the Bayou Tèche. In my examination of the Passes and Mudlumps of the lower delta, I have had the assistance of Capt. Day, with a boat's crew, of the U. S. coast survey schooner Varina, moored at the head of the Passes. For information, hospitality, and other favors, I am indebted to Dr. Copes, President of the New Orleans Academy of Sciences, and other members of that body; to Gen. Beauregard; to Capt. Tilford and others, of the Pilot Association; to Judge Avery, the proprietor of the salt mine, and his amiable

FROM VICKSBURG TO PORT HUDSON.

At Vicksburg, in consequence of extreme low water, I was enabled to examine the portion of the noted profile at this place not usually exposed, viz., the whole of the lignite bed, and fully four feet of the underlying materials. The latter consist of bluish sandy clays, or clayey sands,¹ not at all similar to the blue clay found in the section exposed in the canal attempted to be cut across the neck of land below the city during the war. It will be remembered that the tenacity of the clay in question not only rendered the process of excavation exceedingly laborious, but also prevented the anticipated washing out of a broad channel or "chute" during high water. No such resistance would have been experienced from the materials underlying the lignite bed at the foot of the bluff. The clay in the canal is doubtless of the same age and origin as that observed farther up, according to Humphreys and Abbot,² in the beds and bottoms of the Mississippi, Sunflower and Yazoo Rivers; and whose wide diffusion over the alluvial area of the Lower Mississippi I have had abundant opportunity of observing.

Having on a previous occasion³ minutely examined the bluff at Grand Gulf, to which that at Rodney, according to late observations by Dr. Geo. Little (the present State geologist of Mississippi), is substantially similar, I directed my attention to the Natchez bluff, where marine shells have also been reported as occurring.

The Natchez profile, essentially the same as that at Fort Adams,⁴ is as follows:—

FEET.		No.
100	Gray calcareous silt of the Loess or Bluff formation, with Helices and calcareous concretions.	5
2	Brown Loam, resembling surface subsoil, but calcareous.	4
50—60	Orange and yellow sands, with some gravel,	} Orange Sand.
15	Ledges of ferruginous puddingstone and coarse sandstone,	
15 visible.	Blue clayey sand and sandy clay, of the Grand Gulf group.	1

family, as well as his son-in-law, E. McIlhenny, Esq.; to Dr. Dungan, of Jeannerettes P.O., who placed his time and conveyance at our disposal for several days, in visiting Weeks' Island and Côte Blanche. Also to Judge Robertson, of New Orleans, the author of a valuable report to the State Legislature, on the resources of Louisiana; and to other gentlemen who manifested so much interest in the objects of my expedition, as to make it a matter of surprise that a full geological survey of the State has not sooner been set on foot

¹ In the profile presented in my Report on the Geology of Mississippi, p. 141, I have given "white limestone" as underlying the lignite, on the authority of Prof. W. D. Moore. As the water was not as low during his visit as at my late one, I presume that one of the numerous landslides misled Prof. Moore, the rock having doubtless fallen from above.

² Report on the Physies and Hydraulics of the Mississippi River, 1861; pp. 84 and 85.

³ Miss. Rep. 1860, p. 148.

⁴ Ibid., p. 150.

The most obvious difference between the two profiles just referred to, is in the quality and quantity of the material of the Grand Gulf age; the latter being represented at Fort Adams, by a stratum of a hundred and seventy feet of a knotty argillaceous sandstone. But at neither of the points mentioned, *nor at any other now known between Vicksburg and the mouths of the Mississippi, is there any outcrop of a marine fossiliferous deposit above low water.*

The existence of a thin stratum of yellow calcareous loam beneath the Loess, at this point, was the first instance of the kind with which I became acquainted. According to observations since made by Dr. Little, this layer is the representative of a stratum thirty feet thick, which, at Nevitt's bluff, two miles above Natchez, intervenes between the Loess and the Orange Sand, or Stratified Drift; being there divided into fifteen feet of yellow loam with calcareous concretions, and the same thickness of bluish-gray calcareous clay, beneath.

At Ellis' Cliffs, twelve miles south of Natchez, the Orange Sand alone, according to Dr. Little, forms a profile of seventy-six feet, capped by thirty feet of the Loess.

My previous observations in the interior of Mississippi, in addition to those just mentioned, rendered superfluous any farther examinations of the older formations above Fort Adams, which lies on the State line.

Below the latter point, the exposure of the Grand Gulf rocks, mentioned above, continues for several miles, with apparently a gradual decrease of thickness and elevation. It has been traced southward, by Dr. Little, as far as the crossing of Thompson's Creek, on the Woodville and Clinton, Louisiana, road—about Lat. $31^{\circ} 10'$.

The Stratified Drift proper is visible, near the river, as far south as Jackson, Louisiana, but farther inland extends to a somewhat lower latitude. No trace of it, or of the Grand Gulf rocks, appears at the next exposure on the Mississippi River, viz. at Port Hudson.

As for the Loess, it appears fully developed and with all its characteristic features, at Fort Adams, and for eight or ten miles below. Facing southward we perceive, from the summit of the Blockhouse Hill at this place, a wilderness of the characteristic sharp ridges, often foreshortened into veritable peaks, usually between three and four hundred feet above the river, but sometimes as high at least as four hundred and fifty.

But, according to Dr. Little's observations, these phenomena become more and more modified as we advance southward. The Loess deposit thins out, its materials becoming poorer in lime and fossils, and assuming more and more the character of a common fine-grained indurate silt or hardpan; the transition being by insensible degrees, while the two extremes are very obviously distinct. At the same time the clayey substrata which, farther up stream, appear only in patches, are here seen more frequently and continuously until, at Port Hudson, they become predominant.¹

¹ A detailed description of this region of transition will be given by Dr. Little hereafter.

PORT HUDSON.

The entire exposure of the strata at Port Hudson, from Sandy Creek above the town to Fontania Landing, one and a half miles below, is about three miles long, running nearly north and south. In its southern half, its base is washed by the river, which is continually encroaching upon the land; as observed by Bartram, Carpenter, and Lyell, and proved by the remains of houses and graveyards, that lie scattered on the face of the bluff. The northern half is now nearly a mile inland, a sandbar, already covered with a luxuriant growth of willows, having changed the course of the river, and covered the base of the cliff.

The subjoined profiles, of which the correspondence was ascertained by actual tracing of the stratification lines, embody most of the features and materials observed. The strata are disposed horizontally or basin fashion, and vary a good deal in thickness. The two sections are about a mile apart.

FEET.	NEAR SAWMILL, PORT HUDSON.	No.	MIDWAY BETWEEN PORT HUDSON AND FONTANIA.	FEET.
4—6	Yellow surface Loam.	6	Yellow Loam, sandy below.	8—10
25	Yellow Hardpan.	5	White and yellow hardpan. ----- Orange and yellow sand, sometimes ferruginous sandstone, irregularly stratified.	18 8—15
7	Heavy greenish Clay.	4	Heavy, greenish or bluish Clay.	7
6	Gravel, sand, and clay in irregular bands, like river alluvium; with pebbles, drift-wood, leaves, and Mastodon bones.	3	White indurate silt, or hardpan.	18
25 visible.	Heavy, greenish or bluish, massy clay, similar to No. 4.	2	Heavy green clay, with porous calcareous concretions above, ferruginous ones below; some sticks and impressions of leaves.	30
		1	Brown muck ----- White or blue clay } with cypress stumps.	3—4

At the stage of extreme low water¹ prevailing at the time, the tops of the uppermost of the stumps of stratum No. 1 were from ten to twelve feet above water at the highest point, serving as convenient seats for fishermen. These stumps evidently represent three or four successive generations, growing at higher levels as the surface of the swamp was raised by deposition. The greater number, however, are very near low water level. The roots are buried in a somewhat sandy, yet very tenacious,

¹ Low-water level at Port Hudson is about three feet above mean Gulf level.

bluish or whitish clay; while around their tops, alternating layers of muck and clay deposit mark the annual fall of leaves, and succeeding overflows. Some of these stumps are of large dimensions, and their wood remains sufficiently solid to render it troublesome to detach a large chip with the hatchet. Few retain more than twelve inches of trunk above the junction of the roots.

The stump stratum emerges from the talus at the lower steamboat landing, ten feet visible above low water; then gradually sinks, and a quarter of a mile below disappears under the water.

Stratum No. 2, the main clay deposit, varies but little in its general character. Although at many points so solid and tenacious as to render it difficult to detach a specimen, it cleaves and crumbles into prismatic fragments upon the least change from wet to dry. It is unsafe to walk near the edge of the vertical face washed by the ripple of the river, and it is rarely necessary to wait more than a few minutes for the splash which announces the fall of another prismatic fragment. At a point about a quarter of a mile above Fontania, exfoliation by drying takes place to such an extraordinary extent, as to raise the level surface of the stratum into dark-tinted hillocks of loose material, which excite the curiosity of passers-by on the river. There occur in this stratum flattened ferruginous concretions, of menilitic forms, smooth and of concentric structure—a ferruginous claystone; also a few very distinct impressions of leaves.

In the upper portion of this stratum, near the southern end of the exposure, there occur abundantly, chiefly on the stratification lines, strings of calcareous nodules. These are sometimes hard and crystalline, but mostly rather of the character of Agaric mineral; of a flattened shape, and often of concentric structure, and quite different from the contorted "Loess puppets" of the Bluff formation. Fragments of sticks and impressions of leaves occur occasionally, but so far as observed, no trace of zoogene fossils.

No. 3, the interesting fossiliferous stratum, is extremely variable both in composition and thickness. It first appears near the northern end of the outcrop, as a narrow band of purplish-gray, semi-indurate silt, containing lignitized sticks and leaves. As its thickness increases, its composition becomes more variable, and at the first of the profiles given above, it is clearly an ancient sandbar. Farther south, near the upper steamboat landing, it takes the character of a swamp deposit, consisting of heavy, dark-tinted clays and lignite bands, regularly stratified, and about eight feet thick. Again, at the locality of the second profile, we find it formed of a white, indurate silt, without a trace of vegetable remains. But lower down, a dark-colored band appears at its base, and in this we find, imbedded in a mixture of sandy clay and swamp muck, the acorns of *Quercus aquatica*, nuts of *Fagus sylvatica* and *Carya aquatica*? burrs of *Pinus taeda*, *Taxodium distichum* and *Liquidambar styraciflua*, the most abundant trees of the present swamps. The leaves (except some of the bottom pine) are too much decayed to be recognized.

Still farther down, near Fontania, the stratum resumes the character of a river alluvion—sandy deposits showing the sandbar bedding-lines, filled with drift-wood of large size and a great variety of species. Amongst these, the cypress is perhaps the most abundant; but oaks, pine, hickory, cottonwood, ash, and beech appear all

to be largely represented. There were some upright fragments, but no stumps in place.

There is a striking difference in the state of preservation of this drift-wood imbedded in sand, as compared with the well-preserved cypress stumps in the clay below. The wood here is in a soft, spongy condition, so that when soaked with water it is visibly flattened by its own weight when lying on the ground. A stroke of the hatchet will thus sever a trunk twenty inches or more in diameter; but when exposed to continuous sunshine in this water-logged condition, the mass not only loses its water, but itself contracts into hard shining lignite of conchoidal fracture, exhibiting to the eye scarcely a trace of the original structure; a trunk six or eight inches in diameter being represented by a contorted band of coal, not over half an inch thick. While the projecting end of a trunk is thus transformed, the portion remaining imbedded retains its original condition; suggesting forcibly the enormous amount of vegetation required to form a coal stratum out of drift-wood, or spongy *Calamites* resembling it; and how difficult it must always be to identify the vegetable structure of the product of such a process. It shows, moreover, how little weight can attach to the state of preservation of fossil wood in determining the relative age of deposits; a point of special importance in connection with the geology of the late alluvial and littoral formations.

As for the green clay stratum No. 4, it varies but little either in thickness or composition. It forms, therefore, a convenient level of reference, since it seems to be as consistently represented even at distant points, as the lower stump stratum, and fossils are most abundant immediately beneath it, where they occur at all.

The "hardpan" stratum, No. 5, also exhibits here the two main facies which I have elsewhere observed, viz., either of uniformly fine, semi-indurate silt or hardpan, light yellowish-gray, mottled with irregular ochreous spots; or else, of deposits greatly resembling, at first sight, many of those of the Stratified Drift, but in most cases distinguishable from the latter both by position and composition. So far as I have seen, it is void of any trace of fossils; but for this, and for the interposition of the clay stratum No. 4, it would often be undistinguishable from the hardpans of No. 3. By exposure to the atmosphere, it becomes eroded into curious pinnacled forms, representing in an instructive manner the gradual formation of valleys of denudation, as in relief maps.

It is interesting to compare the present condition of the bluff, as above described, with the descriptions given at previous periods by three other observers, viz.: Bartram, in 1777; Dr. Carpenter, in 1838; and Sir Chas. Lyell, in 1846.

Bartram, without giving a detailed description of the upper strata, alludes to the variety of material and colors they present. He mentions more specially the stump stratum, No. 1, the material of which he states to be "of the same black mud or rich soil" as that of existing cypress swamps; and that the trunks, limbs, etc., of the trees lie in all directions about the stumps. This description does not apply at present; no trunks or branches (save minute twigs mingled with the leaf mould) are now visible around the stumps; nor is their soil stratum at all comparable to swamp muck.

Dr. Carpenter examined a section several hundred feet to the eastward of that

seen by Bartram; his description agrees substantially with that given by the former, but he mentions the bed of vegetable mould about the tops of the stumps, as distinct from the clay in which the roots are buried; he also found in the former layer a variety of fruits, the same, so far as they go, as those I have collected from the upper stratum No. 3. He states that "the stump stratum (No. 1) is covered with a bed of clay twelve feet thick, and is followed by another bed of superimposed vegetable matter four feet thick, containing logs and branches half turned into lignite, and erect stumps, among which there are none of the large cypress, as in the lower bed. Among the logs, the Water Oak was recognizable, and a pine with a great deal of bark" (doubtless *P. glabra* Walt.) "and the strobiles of *Pinus taeda*. . . . Above the upper layer of erect stumps are various beds of clay, with two thin layers of vegetable matter intercalated; and above the whole, more than twenty feet of sand, the lower part of which included siliceous pebbles derived from some ancient rocks, and containing the marks of Eocrinities and Corals."

At the present time, the clay bed of stratum No. 1, is in no place less than twenty-five feet in thickness, and at several points it extends thirty feet. Moreover, it appears that Dr. Carpenter found stumps, *in situ*, in the upper stratum, No. 3, of my section, where I have vainly sought for them; where he observed no cypress, I saw an abundance of it, as well as of the trees of the higher swamps mentioned by him. But the nature of the stratum as now observable at the upper landing (see above) shows that it has in part been formed as a swamp deposit, the non-occurrence of stumps in which would be a matter of local accident.

Lyell, in 1846, found the stump stratum, No. 1, twelve feet under water. He distinctly describes, however, strata Nos. 2, 3, and 4, and mentions the occurrence of fossil trees in No. 3, but not of stumps.

The variability of the latter stratum, as now exhibited in the three miles of north and south exposure, and recorded in the successive observations as equally existing in an east and west direction, is interesting as a proof of the exact analogy of the present state of things, with that existing at that distant period. The variable thickness of the stratum, the alternation of sandbar and drift-wood deposits with those derived from swamps partly high, partly low, and others of fine silt free from, or superimposed upon, vegetable mould, the result of quiet overflow—all this is what any deep canal now dug across the Mississippi Bottom would exhibit.

Not so the lower stump stratum and superincumbent clay bed. Both in thickness and nature of materials, these vary but slightly, whether in a vertical or horizontal direction; not only here, but elsewhere in the level belt bordering the Gulf coast. They testify to the wide-spread prevalence, at the time of their deposition, of quiet, shallow fresh-water lagoons and swamps of various degrees of elevation, through which, perhaps, at that time the continental waters found an outlet without a definite channel to represent the Mississippi River of to-day.

THE LOWER MISSISSIPPI.

From Natchez down to New Orleans blue clay is frequently seen at low water level, forming the base of the river banks, and sometimes reaching to within a few feet

of the top. Such is the case at New Texas Landing, for example, where the clay is abundantly traversed by cypress roots, though no large stumps are visible. At Proffit's Island, a few miles below Port Hudson, the Stratified Drift is seen on the river for the last time, in the gravel beds of that locality, near low-water level. At Walker's Landing, near Pass Manchac, several generations of cypress stumps appear, one above the other, for some twelve feet above low-water level, in clay similar to that of the stump stratum at Port Hudson. They are overlaid by eight to ten feet of more sandy deposits, from which a streamlet had washed an abundance of whitened shells of *Planorbis*, *Paludina*, *Helix*, *Helicina*—all species now living in the lakes of the bottom. The cypress wood here is in a better state of preservation than that of the stumps at Port Hudson, thus appearing to indicate a more recent origin. Little value, however, can attach to this circumstance, upon which, within certain limits, differences of the matrix and position seem to exert a greater influence than time.

It will be difficult, on this account, to distinguish in every case the equivalents of the Port Hudson stump stratum from similar and more recent deposits, now demonstrably in course of formation in cypress swamps, which in their turn may become covered with river or lake deposits. It is mainly where the superincumbent strata have not been removed by denudation, or where continuity can be proven, that we can readily and positively identify these equivalents.

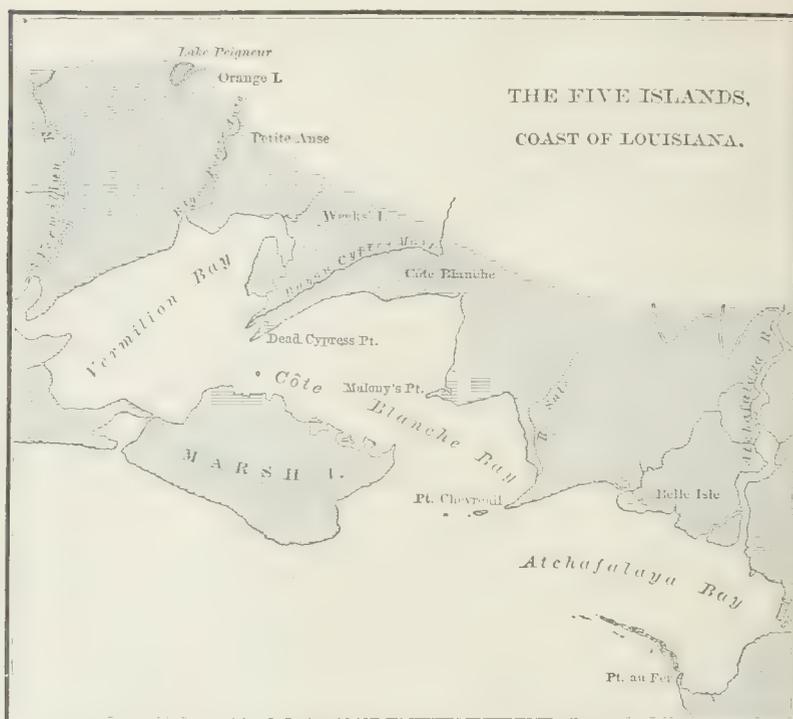
Even below New Orleans, clays opposing considerable resistance to denudation, and differing in aspect from those of modern cypress swamps, occasionally appear in the river's banks. But the main body is evidently below tide-level, forming the "blue clay bottom" of the Gulf coast. A special discussion of this portion of the region explored, however, is given in a separate paper.¹

THE FIVE ISLANDS.

The chain of five "islands" rising, partly from the sea, partly from the surrounding marsh, has been described by Mr. Thomassy (*l. c.*) from personal observation—somewhat fancifully, it is true, since in all of them he thought he found proofs of "powerful volcanic convulsions." But notwithstanding his preconceived idea of comparing these elevations to the extinct "mudlumps" of the passes of the Mississippi, his description is sufficiently faithful to show the general resemblance of their geological structure; so that after examining the three middle ones, I thought it superfluous to visit the first and fifth of the chain, viz., Belle Isle, and Miller's Island or Orange Grove. The former appears as a promontory west of the mouth of the Atchafalaya; the latter forms the southeastern shore of Lake Peigneur; but neither of them is usually mentioned on maps. A line laid from the first-mentioned point to the last touches, in succession, Côte Blanche, Grande Côte or Weeks' Island, and Petite Anse or Avery's Island, the general trend being about northwest. (See Map.)

¹ "On the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi;" Amer. Journ. Sci., March, April, and May, 1871. See also "Report on the Age of the Mississippi Delta," in Rep. U. S. Engineer Dep't. for 1870.

² May, 1872.



CÔTE BLANCHE.

Of these Islands, Côte Blanche affords on its sea-face the best exposure of the lower strata of the series. It is a regular mammillary elevation, somewhat elliptical in outline; its highest point, near the centre, rises one hundred and eighty feet above mean level of the Gulf, according to the Coast Survey determinations. Its area embraces about two thousand acres of excellent upland, possessing an amber-colored loam subsoil. It was originally covered with a fine growth of Magnolia, Ash, Live and Black Oak, as well as tall cane; but it is now almost entirely denuded of timber, and under cultivation for sugar-cane and cotton. About three-fourths of a mile of its southern and southwestern front is washed, and continually encroached upon, by the sea; on all other sides it is bordered by sea marsh. A causeway three-fourths of a mile long connects it with the mainland, *i. e.*, the cypress swamp of bayou Cyprès Mort.

The southern face, towards the sea, presents a perpendicular bluff about fifty feet high, with but little talus; from its foot there extends seaward at low-tide level, for some forty to sixty yards, a shelving terrace of blue clay dotted with cypress stumps and small patches of lignitic matter. The cypress roots are in rather a better state of preservation than at Port Hudson, though when dry they become as light as cork. Wherever exposed, the teredo and barnacle, as well as occasionally the oyster, have taken possession of them.

The following section shows the strata exhibited; which, however, vary greatly in character at different points, and are no doubt continually changing, as at Port Hudson, in consequence of the rapid encroachment of the Gulf waters upon the "caving" land; the entire area of the clay-shelf, now covered by the tide, having within the memory of the inhabitants formed part of the upland. The section is taken at about the middle of the exposure.

No.	PROFILE AT CÔTE BLANCHE.	Feet.
10	Soil and (brown loam) subsoil.	3
9	Stiff greenish-brown clay with dendrites.	6
8	Stiff brown clay with black streaks.	7
7	Reddish-gray loam with ferruginous spots and calcareous nodules.	8-18
6	Hardpan, mottled white and yellow.	4
5	Tough greenish clay with calcareous concretions.	
4	Same, non-calcareous.	2
3	Gray loam (partly hidden by talus) about	8
2	Reddish, orange, gray or mottled loam, with ferruginous concretions.	2
1	Cypress muck and lignite about tops of stumps.	$\frac{1}{2}$
	Blue and green sandy clay with cypress roots—1 foot visible.	

If we compare this section with that at Port Hudson, starting from the stump stratum as a level of reference, we find here a much greater variety, and in general a greater proportion of loam and silt materials; both circumstances indicating a deposition in water possessing some flow, rather than in quiet lagoons or swamps. The same state of things is indicated by the waviness, on the large and small scale, of the stratification lines; for the bluff exhibits on its face not less than two synclinals and anticlinals, the inclination being mostly of a few degrees only, and very obviously conforming to the present surface undulations.

At Port Hudson we find the main clay stratum, No. 2, characterized by the occurrence of ferruginous nodules in the lower and calcareous ones in the upper portion. Similarly we find at Côte Blanche, in stratum No. 2, an abundance of ferruginous nodules; and towards the west end of the exposure, stratum No. 7, here from fifteen to eighteen feet thick, shows on the stratification lines flattened calcareous nodules, in strings from twelve to fifteen inches apart, precisely as is the case at Fontania. While at the latter place, however, the calcareous mass is mostly of a *chalky* texture, it is here prevalently *crystalline*, so as to form a very ancient-looking limestone; tons of which lie scattered on the shelving beach. Such,

doubtless, are the "strata" of limestone mentioned by Thomassy¹ as occurring at Belle Isle, and whose "shattered" condition he attributes to volcanic explosions.

Towards the east end of the bluff, stratum No. 5 descends to tide-level by a sudden curve (whether owing to a basin-shape or a landslide, does not clearly appear). Here the ferrugino-calcareous concretions begin to assume definite shapes, and for a few yards there is a kind of clay marl, filled with casts and much decayed shells of fresh-water mollusks. With the exception of a *Paludina*, resembling (but not identical with) *P. subpurpurea* of SAY, I found it impossible to preserve any specimens of these in a condition fit for subsequent determination. But the shape and hinge enabled me to recognize at least four species of *Unio*, a *Cyclas*, the thin shell of an *Anodonta*, and a longitudinal section of a *Potamides*. There are also some ferruginous casts of plants, badly preserved.

Doubtless, the lime of the nodules has been derived from the shells of fossils, which have been destroyed by a process of dissolution and recrystallization, from which but a few spots have remained exempt.

There is not, on this island, another exposure showing more than the surface loam with greenish clay beneath. Remains of the Mastodon have, in times past, been found on the island; but I have been unable to ascertain the precise locality. The stump clay has, however, been observed on several sides, in digging trenches for drainage in the marsh.

WEEKS' ISLAND.

A ride of six miles carries us from Côte Blanche to Weeks' Island, which is reached from the southeast, by a causeway a mile in length, traversing the almost bottomless Cyprès Mort swamp, swarming with alligators. On all other sides the island is surrounded by sea-marsh. Its form is nearly circular, area about two thousand three hundred acres; highest elevation, according to Thomassy, one hundred and sixty feet above tide-level. Its surface is not as unbroken as that of Côte Blanche; both on the outer slopes and in the centre, there are deep ravines which render the formations accessible. The soil and original vegetation are the same as at Côte Blanche.

The ravines in the central portion exhibit on their sides, in the most unmistakable manner, the characteristic stratification and materials of the *Orange Sand*, or Stratified Drift formation—chiefly the brownish-red, semi-indurate sand, consisting of rounded quartz grains incrustated with iron rust, together with a greater or less proportion of grains of white pipe-clay. Here and there, also, layers and fanciful concretions of the well-known brown sandstone of Mississippi; while at some of the lower points, the pebble-bed appears, with its usual variety of well-worn rocks from higher latitudes, and some large and rough ones of Grand Gulf sandstone. The stratification lines are horizontal on the large, but wavy and discordant on the small scale, with flakes of white pipe-clay to mark them. So far as lithological and

¹ Geol. prat., p. 80.

stratigraphical characters go, the identity is therefore complete. (See Miss. Rep., 1860, p. 6 and ff.)

The materials forming the highest portion of the central hills are nowhere visible. As we approach the outer slope, there is a change. Heavy greenish or bluish clays, with ferruginous and calcareous concretions and obscure casts of shells and plants, alternate with loamy materials and hardpans undistinguishable from those at Côte Blanche; while nearer the edge of the marsh thick strata of indurate silt or hardpan, similar to those of stratum No. 6, at Port Hudson, are alone visible. Here, as at Côte Blanche, the stratification lines are seen roughly to conform to the undulations of the surface; so that the clay and hardpan strata are distinctly inclined away from the highest portion of the island.

It thus seems that the latter consists of a more or less horizontally stratified nucleus of Drift materials, upon which the Port Hudson strata have been deposited in a position roughly corresponding to the shape of the nucleus; there being, however, a marked increase of thickness towards the base of the slope, as might be expected. The blue clay stratum with cypress stumps, also, is known to exist in the beds of the bayous and under the sea-marsh, and has been found in cutting ditches; although in some portions of the contiguous Cyprès Mort swamp, a twenty foot pole does not find solid bottom.¹

Near Cyprès Mort Point, south of Weeks' Island, an attempt to find salt water was, during the war, made by Mr. John Gordy. He found at five feet a grayish loam with very perfect crystals of gypsum, now in the possession of Dr. Dungan, of Jeanerets P. O. The thickness of this stratum was about two feet; then came two and a half feet of water-bearing quicksand, then the "blue clay bottom." The water was a weak brine, from which some salt was boiled; but it was abandoned as unprofitable. The salt water was probably nothing more than Gulf water somewhat concentrated by evaporation; the locality being a portion of the level Cyprès Mort Woods.

A similar attempt was made about midway between Côte Blanche and Belle Isle, on Salt Point, near Bayou Salé, by Mr. Carey. He bored some thirty odd feet, when, striking "an oyster bank," he became discouraged and abandoned the well. Unfortunately I have been unable to obtain the detailed record of this boring, which, being in the level country, must have reached considerably below the sea-level. The oyster-bed is precisely what, under similar circumstances, might have been found on the coast of Mississippi Sound.²

¹ There are several small lakes or ponds on this island, to which Mr. Thomassy ascribes the character of "sunk craters." They do not, however, offer any unusual characteristics, requiring subterraneous disturbances to produce them. The "round lakes" in the prairies, of which he speaks in this connection, are universally attributed by the inhabitants to the action of cattle, which, when frequenting water-holes in the dry season, not only deepen and enlarge them by *pawing* (hence "bull-holes"), but also each time they drink carry off some of the tough prairie mud adhering to their feet; and thus slowly but surely extend the basin into a pond. Under this point of view, their round form, in a level country, is readily explained upon the basis of the law of probabilities.

² Miss. Rep., 1860, p. 154 and ff.

PETITE ANSE.

Petite Anse cannot readily be reached by a direct route from Weeks' Island, there being almost impassable marshes, as well as cypress, live-oak, and palmetto swamps between. It is necessary to make a circuit northward through the prairie bordering upon the Bayou Tèche (Jeanerets' Prairie).

Dr. Goessmann has given an excellent description of the surface conformation, and a map of Petite Anse, which would render a repetition on my part superfluous, were Dr. Goessmann's report more generally accessible. I shall therefore briefly recapitulate the main points, which will be better understood by referring to the accompanying map.

As seen from the prairie near New Iberia, Petite Anse appears as a short ridge, rising rather abruptly from the marsh to the westward of it, and the Bayou Petite Anse which bathes the western half, nearly, of the base. A causeway, about two miles in length, across the marsh bordering the bayou, connects the island with the mainland on the north side, while on the south, likewise, it is bordered by sea-marsh; on the east and southeast, by the Cyprès Mort woods, and cypress swamps.

The island proper is nearly round, with a prominence towards the southeast, where there is a large body of level land, cultivated in cotton and cane. Its area is two thousand two hundred and forty acres.

Near the northeast extremity of the island is Prospect Hill, the highest elevation, one hundred and eighty feet above tide-level. Southward of Prospect Hill, and connected with it by an elevated ridge, is another high point; on its eastern slope, towards the Cyprès Mort woods, there is a cypress pond, which, perhaps, represents the "central crater of elevation" of Thomassy. This main ridge forms the head of the valley which is underlaid by the rock-salt, and which drains southwestward into the marsh. Judge Avery's residence stands on a high knoll at the west end of the island, which is connected by a low ridge with Prospect Hill; while another intervenes between it and the salt valley. Salt springs appear on both sides of the last mentioned ridge, but rock-salt has not been found north of it.

Up to the time of Dr. Goessmann's visit, all the borings and pits which had reached the salt, had been sunk in detrital material washed down from the surrounding hills, and frequently inclosing the vestiges of both animal and human visits to the spot. Mastodon, buffalo, deer, and other bones; Indian hatchets, arrow-heads, and rush baskets, but above all, an incredible quantity of pottery fragments, have been extracted from the pits. The pottery fragments form at some points veritable strata, three to six inches thick; this is especially the case where Mr. Dudley M. Avery found what appeared to have been a furnace for baking the ware (a process very imperfectly performed), and near it three pots of successive sizes, inside of each other. The pots must be presumed to have subserved the purpose of salt-boiling; for although human handiwork has been found so close to the surface of the salt as to render it probable that its existence in mass was once known,¹

¹ It is very positively stated, that Mastodon bones were found considerably *above* some of the human relics. In a detrital mass, however, this cannot be considered a crucial test.

yet the boiling process alone has been resorted to within even traditional times, until the discovery, at the bottom of a salt well, of solid rock-salt, by Mr. J. M. Avery.

Borings and pit-workings, extensively prosecuted during the war, have demonstrated that the surface of the salt is very undulating, varying to some extent in conformity with the surface of the ground. Borings made at a higher level have, therefore, repeatedly struck the salt at nearly the same, or a slightly greater, relative depth than excavations made lower down.

The surface of the salt explored up to the time of Dr. Goessmann's visit, lies mostly below tide-level; at one point only it was found one and three-quarters feet above, at another as much as thirty-two feet below, as shown by the instructive profile given in his report and reproduced on the map. The salt stratum has now been penetrated to the depth of fifty-eight feet below its surface, without any material change in character; being remarkably free from the usual impurities, viz., gypsum and magnesian salts. Minute laminae of the former sometimes exist between the larger crystals; and in the shaft now worked there was found, thirty-eight feet beneath the surface of the salt, a dark-colored vein about a foot thick, running north-west and southeast, and consisting of an aggregate of crystals of rock-salt and gypsum. This seems clearly, however, to have been a subsequent infiltration.

Occasionally, cavities occur in it containing large and beautiful cubes; but usually the mass consists of crystals more or less deformed by mutual interference, one-eighth to one-quarter of an inch in diameter. Dense granular or fibrous salt has never yet, so far as I am aware, been found at Petite Anse.

Since Dr. Goessmann's visit, another pit has been sunk by Mr. Chas. Chouteau, of St. Louis, assisted by Mr. Dudley M. Avery, son of Judge Avery, whose intelligent observations have greatly facilitated my researches, and to whom I am indebted for a record (verified from the materials at the pit) of the strata penetrated. It appears that in order to avoid the troublesome quicksand always met with a few feet above the salt, Mr. Chouteau selected a spot on a hill-side, above the level of any previous bore, and where the semi-indurate sand strata, exhibited in a ravine near by, seemed to promise greater facility in sinking a shaft.

No.	PROFILE OF CHOUTEAU'S UPPER PIT.	FEET.
6	Soil.	$\frac{1}{2}$
5	Yellow and brown loam.	2
4	Ferruginous sand, rather loose above, more coherent below; grains rounded, and white pipe-clay intermixed.	18
3	Gravel, small above, large below.	2
2	Bluish pipe-clay and sand, interstratified.	6
1	Rock-salt.	

The last six feet were penetrated with the auger. So much water flowed in (through the gravel apparently) that it became necessary to exclude it if possible. This was attempted by cementing the curbing to the salt with pitch; but the presence of the water prevented a thorough adhesion being attained, and thus the shaft, at the time of my visit, was "drowned."

The surface of the salt where struck was estimated to be perhaps as much as seven feet above tide-level; higher than at any point previously reached.

The semi-indurate sandy material, No. 4 of the section, is the same as that which crops out in several neighboring ravines, and is precisely similar to the material of the Drift at Weeks' Island. The under-lying pebble-bed, with subjacent bluish pipe-clay, is likewise characteristic of the same formation.

There can, therefore, be no reasonable doubt that the salt deposit underlies, and is older than, the Orange Sand or Stratified Drift Formation.

It is true that the identification of this formation here, as well as at Weeks' Island, rests merely upon stratigraphical and lithological characters. But these, in the case of these deposits, are so well defined and characteristic everywhere, that even the coincidence of fossils could add but little weight to the evidence. Silicified wood, nevertheless, the almost constant concomitant of the formation, is quite common on the island, and the pebbles speak of high northern origin.

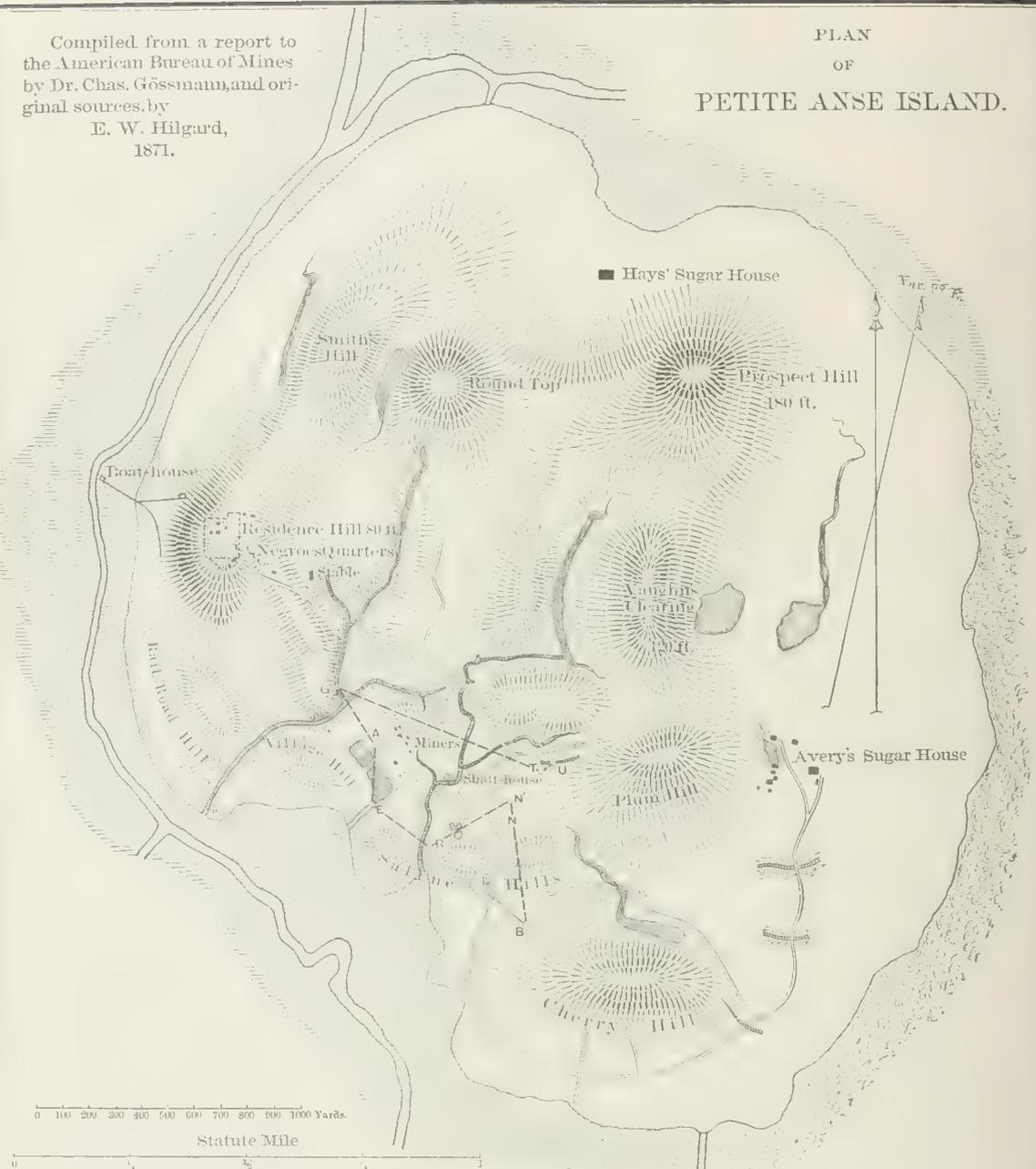
It must be remembered, too, that we are here dealing, not with a wide range of possible formations, but with small and partly local sub-groups of a comparatively short epoch, which are well known to be characterized by differences of origin, mode of deposition, and material, rather than by a diversity of living forms; save such as may result from their special and local character. None of the deposits likely to occur in the locality before us could be expected to contain other than *living* forms in a fossilized state. The consistent *absence* of any such forms is one of the distinctive features of the Orange Sand group. Another, is its stratification; a third, its current-worn, peroxidized, non-calcareous materials; excepting alone the case of angular fragments of silicified wood, which evidently came down originally as drift-wood, and has subsequently suffered silicification *in situ*. (Miss. Rep., 1860, p. 20 and ff.)

Lastly, the pebble-stratum everywhere found overlying the salt, and also occurring at higher levels, establishes some important points in the identification. The average size is from that of a large hen's egg to that of a guinea-fowl's; some of the quartz-pebbles, however, weighing a pound and over. Some of the latter, as well as some large sandstone pebbles, appear to be derived from the Grand Gulf rocks, distant about sixty miles to the northward. The majority, however, consist of brown or yellowish hornstone with impressions of palæozoic fossils—crinoids, corals, etc., of both silurian and carboniferous types. Jasper, agate, carnelian; also graphic granite, syenite, mica schist, and siliceous schist, are not uncommon. The latter rocks, evidently of high northern origin, are almost unknown in the south-western Drift, outside of the main pebble-belt of the Mississippi Valley.

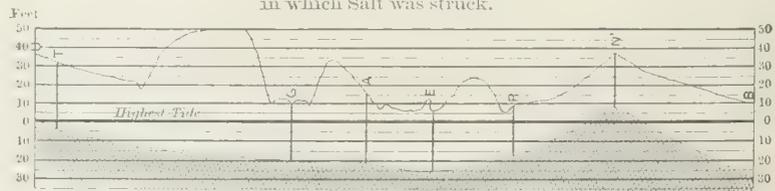
Dr. Goessmann mentions the occurrence of a large boulder of porphyritic diorite. I have in vain sought, among the pebble-beds, for another sample of this rock, whose home seems to have been Missouri or Arkansas. As it was found in the

Compiled from a report to
 the American Bureau of Mines
 by Dr. Chas. Gössmann, and ori-
 ginal sources, by
 E. W. Hilgard,
 1871.

PLAN
 OF
 PETITE ANSE ISLAND.



Levels of the eight bore-holes.
 in which Salt was struck.



detrital beds above the salt, and in the absence of all analogy with the other pebbles, either as to size or mineral composition, I am inclined to consider this stone (a faithful drawing of which, made by Rev. E. Fontaine, is subjoined) rather as an



Greenstone boulder found in the salt pits, Petite Anse. Weight 70 pounds.

implement transported in a canoe, than as an erratic floated down by ice. As an anvil upon which to fashion spear or arrow-heads of either stone or metal, its place could not well be supplied by any rock occurring much nearer at hand; and the aboriginal tribes, that evidently resorted to this place in great numbers, might well deem it worth while to carry with them a good-sized block of the refractory material out of which their axes, found on the same spot, have likewise been fashioned.

But at Petite Anse, as at Weeks' Island, the "Orange Sand" strata form only a nucleus, upon and around which the materials of the Port Hudson group have been more or less thickly deposited. The latter appear characteristically at numerous points where ravines have cut into the hill-sides, both on the higher elevations in the interior, and on the external slopes. Here, too, as at the other islands, they conform, to a not inconsiderable extent, to the undulations of the surface. This circumstance, probably, induced Thomassy to consider local upheavals as having been instrumental in their conformation. But unless we were to assume a separate effort for each hillock on the island, this hypothesis would nowise explain the facts. Indeed, the extent to which the Port Hudson strata are sometimes tilted rather staggers the observer, who is not prepared to admit the possibility of their deposition, in parallel bands, on such a heavy slope.

There can be no doubt that *local subsidence* subsequent to deposition has, in most cases, contributed largely towards producing these extravagant dips. Thus, in the loose gravelly and sandy strata which appear overlying the characteristic blue calcareous clay, as we ascend Prospect Hill, the dislocation and contortion of bedding lines show clearly that movements have taken place within the mass, which must have changed the dip of superincumbent strata. Moreover, it is noticeable that

where the more coherent strata immediately overlie the solid Drift nucleus, the dips are moderate or *nil*; while these same strata near the circumference of the island show a dip of twenty-five and more degrees, not explicable without some subsequent disturbance. Now, we know that around these islands, as elsewhere in the littoral belt, there is a floor stratum of blue clay with cypress stumps and muck, whose gradual conversion into the more compact form of lignite (such as we find at Côte Blanche) would of necessity be accompanied by a considerable diminution of bulk, followed by a corresponding subsidence of the superincumbent deposits.

Some of the clayey strata, moreover, exhibit a phenomenon somewhat resembling the movement of a glacier down a mountain slope; a prominent example of which occurs on the eastern slope of the hill on which Judge Avery's residence stands. Although distinctly stratified, this clay (which is filled with fossil impressions) has an uncontrollable tendency to cleave into angularly conchoidal forms, the cleavage planes being so smooth as to glisten when dry. When wet, of course they are so exceedingly slippery that even large masses give way under slight pressure, and it thus happens that the whole stratum, so far as exposed, is now bodily moving down hill; having, for example, completely overflowed a deposit of brickbats, and yet preserved in a great measure its stratification. In consequence of this disturbance, it is very difficult to ascertain the true thickness and position of this stratum, which in all respects greatly resembles No. 5 of the Côte Blanche section, as well as the corresponding deposits of Weeks' Island. It contains an abundance of calcareous concretions, mostly with a ferruginous nucleus, and also purely ferruginous ones. Numerous impressions of plants occur, among them the leaves of grasses and reeds, of *Salix*, *Myrica cerifera*, *Quercus virens*, *aquatica*, and *phellos*—verified by comparison on the spot; as the specimens are excessively perishable.

Somewhat lower down, we find in it badly preserved shells of *Paludina*, of several species of *Unio*, and a *Cyelas*. In consequence of the great tendency of the matrix to cleave, it has been impossible to preserve specimens for determination; it would be difficult to determine them specifically even on the spot. The *Paludina* is clearly, however, identical with that found at Côte Blanche.

This is the only fossiliferous locality I have observed in this formation at Petite Anse, although the equivalent of the fossiliferous clay occurs at several other points, containing, however, only calcareous concretions. On the opposite slope, *i. e.* a short distance northwest of Judge Avery's house, the following profile, typical of the *exterior* slopes of the island, is shown in a gully. The strata are nearly horizontal at the highest point, but near the foot of the hill acquire a dip of twenty-five degrees northwest; while a few hundred yards off, the blue clay with cypress stumps forms the bed of Bayou Petite Anse.

No.	PROFILE NORTHWEST OF JUDGE AVERY'S HOUSE.	Feet.
6	Light-brown Loam.	5
5	"Black Gravel" (Bog Ore).	1
4	Tough greenish Clay.	3
3	Sandy Loam or Hardpan, mottled gray and yellow.	7
2	Heavy gray or greenish Clay.	15—20
1	Grayish Sand? (doubtful).	?

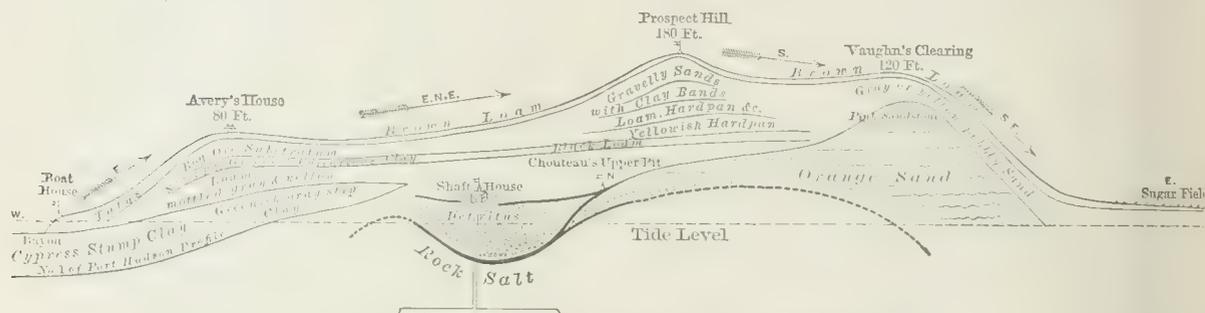
No. 4 of this section doubtless corresponds to the fossiliferous clay stratum on the opposite slope. The latter appears to be underlaid by sandy strata, which from their composition and bedding might be presumed to belong to the Drift, and cover the slopes of most of the interior hills. The clay band, No. 4, is traceable, with several undulations, to the southwest slope of Prospect Hill, where it appears at about the same level as the fossiliferous clay, but is only twelve to twenty inches thick, contains some calcareous concretions, and, after showing an "up-hill" slope for a short distance, passes out of sight horizontally, into the body of the ridge. It is directly underlaid by the sands just mentioned, often (here as elsewhere) containing strings of pebbles; lower down appear the outcrops of the unequivocal Drift materials. Above the clay band appears grayish-white hardpan, which at other points overlies directly the pebbly sands, and sometimes seems to replace them. The lower clay bed (No. 2 of the above section) does not seem to exist in the interior of the island, any more than the cypress stump stratum; which, however, forms the bed of bayou Petite Anse, and doubtless underlies the surrounding marsh, as it does the Attakapas prairies themselves.

Ravines and washes on the higher portion of Prospect Hill, above the level of the clay band, repeatedly exhibit irregular veins and lenticular masses of similar greenish calcareous clay, in gravelly sand. But the manifest dislocation by subsidence which has taken place here, obscures the stratigraphical relation between these materials and the profile below. Occasionally, ferruginous veins and concretions also occur, producing locally very much the appearance of a Drift outcrop. On the summit of the hill there is a level platform, abruptly elevated several feet, which I presume to be a work of art; although, according to the observations of my traveling companion, the Rev. Ed. Fontaine, its materials are regularly stratified. But they (variegated clays) are not of such a character as to make it probable that they could have resisted the atmospheric influences through several geological ages. Its obvious adaptation as the foundation of a "lookout" suggests itself more forcibly to me; but excavations alone can determine the point. Everywhere else, the usual brown surface loam overlies, with a thickness of four to six feet.

Not far below the summit of the high ridge mentioned as existing to the southward of Prospect Hill, we find large fragments of a pinkish sandstone, such as sometimes occurs, likewise, in the Drift hills of South Mississippi. The quartz grains are well rounded, and mingled with grains of whitish pipe-clay, while the cement is siliceous. It appears to occur in a ledge fifteen to eighteen inches thick, overlaid by a bluish or greenish clay, the outcrop of which I could not discover.

This is by many feet the highest point at which I have found, on the Louisiana coast, materials belonging, apparently, to the Drift. At the foot of this ridge are the most characteristic outcrops of the Orange Sand, near Chouteau's upper pit; but higher up on the slope, we find the same doubtful sand as on Prospect Hill; not, however, any of the greenish calcareous clay, unless it be that overlying the pink sandstone just referred to.

The accompanying (somewhat ideal) section of the island, chiefly along a line running east from the boat-house on the bayou to Judge Avery's house, thence in an east-northeast direction to Prospect Hill, and thence curving southward, exhibits



Geological Section of Petite Anse Island, Louisiana.

the general geological structure, as deduced from my observations; the vertical elevation being, of course, much exaggerated. Its location will be best understood by referring to the map (see above).

It will be seen that, starting from the stump stratum, No. 1, as a point of reference, the section of the strata on the western slope shows a general correspondence to that of the southern portion of the Port Hudson bluff, where the clay stratum, No. 4, may also be traced along the entire outcrop.

BELLE ISLE AND ORANGE ISLAND.

I will here briefly give the data I possess concerning the geology of these two extreme members of the group of five.

According to Thomassy, the uppermost strata at Belle Isle consist of "sands similar to those of the Red River country"—perhaps a reddish loam similar to No. 7 of the Côte Blanche profile. Beneath lie others "identical with those of the Sabine Hills" (whitish hardpan?); finally, lower down we have a formation of "calcaire grossier," "crumbled to pieces"—doubtless the crystalline calcareous nodules seen at Côte Blanche, according to the description given me by others.

Divers kinds of mineral springs seem to exist there. The area of the island is only about three hundred and fifty acres, maximum elevation one hundred and twenty feet; like the rest, it is surrounded by sea-marsh.

Dupuy, Miller's or Orange Island, possesses about the same area as Petite Anse, its maximum elevation above Gulf level being eighty-five feet. Thomassy describes, as situated on the summit of the island, a "crater lake," exhibiting on its sides an upper stratum of fine gray sand, and a lower one of rather angular quartz pebbles. Mr. Dudley Avery, who described the island to me, could not locate this central lake, but states that bluff banks exhibit precisely the same materials as the interior of Petite Anse. On the shore of Lake Peigneur, which borders the island on the northwest, there is at one point an appearance as of a ledge of greenish, not very solid sandstone, two feet below water level; it is coarser than the surrounding sand strata. This would seem to indicate the presence of the coarse conglomeratic, semi-indurate sandstones so commonly overlying the pebble-bed of the Stratified Drift.

THE ATTAKAPAS PRAIRIES.

As already stated, the blue clay stratum underlies also the Attakapas prairies, south of Bayou Tèche. In cuts made in the prairie northward of Petite Anse, the succession of strata, according to Mr. D. Avery, is as follows:—

No.		FEET.
4	Brownish-black surface soil.	1
3	Ferruginous or calcareous gravel, concretionary.	$\frac{1}{2}$ — $\frac{2}{3}$
2	Bluish-white silt, mottled with yellow, and bog ore spots.	2 $\frac{1}{2}$ —3
	Blue clay, "similar to that in the bed of Bayou Petite Anse."	Not known.

The structure of some of the level lands of Petite Anse is quite similar, although the black prairie soil is now wanting, while the calcareous gravel is very prominent. The same is the case in the prairie off Côte Blanche, where the thickness of the concretionary stratum often exceeds a foot. The average elevation of the Iberia prairie above tide-water is six to eight feet; which would place the top of the blue clay stratum somewhat above Gulf level. But no stumps have been found in the shallow prairie cuts, so that it is quite likely that the stump stratum exhibited at Côte Blanche has not been reached in them.

THE PORT HUDSON GROUP.

The data above recorded, as will be perceived, were insufficient by themselves to serve for the determination of the age of the rock-salt deposit. At the same time,

however, they led to the conclusion that the long-known outcrop at Port Hudson was but the representative of a wide-spread formation, playing an important part in the configuration of the Gulf coast region, and to which, in publications made since, I have attached the name of its typical locality.

More extensive observations for which I have had opportunity since then, while extending greatly the scope of the group so designated, have also compelled a modification of the definition given in the abstract, first published, of the results of my first exploration.¹ And as the data are nowhere given in their entirety, I shall here recapitulate those not included in the preceding record.

So far as my own observations extend, and so far as I have been able to gather from those of others (especially from the valuable Report on the Mississippi River, by Humphreys and Abbot), a blue clay stratum, usually containing stumps or trunks of the cypress, or other lowland trees, extends not only over the entire alluvial plain of the Mississippi, as high as Memphis at least; of Red River, as high as Shreveport, and correspondingly in other larger tributaries both of these rivers and of the Gulf of Mexico; but also over the entire coast region of Texas, Louisiana, Mississippi, and Alabama, from the Rio Grande to the Escambia, and doubtless farther, along the coast of Florida. It forms, along these coasts, the "blue clay bottom" so well known to navigators, that generally, at a distance varying from seven to twenty miles out from the mainland, breaks off into deep water.

I must here recall to mind my observations on the coast of Mississippi Sound, made in 1859, and published in my report on the Geology of Mississippi, pp. 154 to 156. I found that while at a few points deposits apparently belonging to the age of the Stratified Drift, extend to within a few miles of the coast, the greater part of a littoral belt about twenty miles wide is underlaid by a solid, tenacious blue or bluish-black clay, which is everywhere struck in wells, crops out on the sea-beach, and forms the "blue clay bottom" off the coast. Cypress stumps, as well as logs of various kinds, are constantly found in it; when penetrated, it is frequently found to be underlaid by sandy marine deposits, and at one point I found marine shells in it. Higher up (at Saucier's, on Wolf River). I found a deposit precisely similar to the stump stratum at Port Hudson, with cypress stumps and knees; as well as, not far off, a deposit containing twigs and burs of Bottom Pine (*Pinus taeda*). Similar deposits are reported to occur frequently in the region. And the same has been repeatedly asserted to be the case on Mobile Bay, by Hale and others.

Port Hudson lies nearly due west of the locality above referred to. The level tract of country in which it occurs, is bordered northward by a rather abrupt shoreline of Drift hills.² The same, according to Dr. Little's late observations, is the case northward of Port Hudson; while eastward of that place, a level or slightly undulating plateau extends, with a gradual slope, towards Pearl (and Wolf) River. This region has lately been explored by Dr. Hopkins,³ who fully confirms the identity

¹ Amer. Journ. Sci., Jan. 1869.

² Miss. Rep. 1860, p. 385.

³ Second Annual Report of the Geol. Survey of Louisiana.

of its formation with that of the Port Hudson bluff; including even (at the proper level) the characteristic calcareo-ferruginous nodules.

West of the Mississippi we have, opposite Port Hudson, where the Côte Gelée and the Grand Coteau des Opelousas abut upon the Bayou Cocodrie, outcrops, and profiles in wells, corresponding closely to that of Port Hudson; especially as regards the blue clay with stumps and trunks of trees, near low-water level.

Few outcrops or well profiles in the Opelousas and Attakapas prairies, from bayou Cocodrie to the Calcasieu river, reach below what are doubtless the equivalents of the upper portion of the Port Hudson bluff, viz. gray, yellow, or mottled siliceous silts or loams; beneath which, at depths varying from ten to twenty feet, water, mostly very hard from carbonate of lime, and frequently tinged and flavored with vegetable matter, is obtained. The dead uniformity in the conformation of the whole prairie region, can leave no doubt as to the continuity of the underlying formation; whose clay members approach nearer the surface as we advance westward and coast-ward, preventing the percolation of the atmospheric waters, and thus causing the wet glades and prairies that have, to a most unwarrantable degree, impressed themselves upon almost all the maps of Calcasieu and the western coast of Louisiana. In reality, neither canoes nor mudstilts would be of any special use in the Calcasieu prairie, away from the heads of streams; the wide belts of marsh represented as flanking the latter on their course to the sea being, as a rule, neither better nor worse than other river bottoms in the Gulf States usually are.

Near the latitude of Lake Charles, the soil of the Calcasieu prairie is directly derived from the stiff clay with calcareous nodules, that crops out in the beds of streams; it resembles closely the more clayey strata at Côte Blanche and Weeks' Island, while on Lake Charles, near the town of that name, there are outcrops of the reddish silt and loam which forms a conspicuous feature in the Côte Blanche profile. Wells at Lake Charles strike these materials, and not unfrequently also the common oyster of the coast, as well as logs—precisely as is the case farther east; on Bayou Salé, at Bonnet Carré, New Orleans, and on the Mississippi coast; and showing, here as there, an increase of the marine facies as we approach the coast.

The thickness of the formation is shown in the bores made for petroleum and sulphur, near the West Fork of Calcasieu river. Having been deposited on a deeply denuded surface of Drift beds, it varies, within seven hundred yards, from one hundred and sixty to three hundred and fifty-four feet; marine shells having, apparently, been found only in the upper portion.

The belt of coast prairies continues, with little change of character, into Texas, where the conformation of the coast seems to be almost exactly parallel to that prevailing in Mississippi and Alabama; viz. long sandy islands, off the mainland, on whose beach blue clay with stumps is washed by the surf; while near the heads of the bays, there are bluff banks exhibiting outcrops of blue or variously tinted clays. Outcrops almost precisely corresponding to those at Côte Blanche and on Lake Charles, have lately been studied by Mr. R. H. Loughridge, my Assistant, on Lavaca Bay. The occurrence of similar clays on Aransas Bay, and on the Laguna

Madre, is mentioned by Humphreys and Abbot;¹ but the additional statement that it is there overlaid by calcareous sandstone, a rock quite foreign to the formation on the northern Gulf shore, made me hesitate about assigning them to the same age. Mr. Loughridge has, however, found this sandstone near Lavaca, associated with the characteristic clays; the great predominance of lime in the deposits on the Texan coast (abundantly exemplified by his collection) explaining the substitution of calcareous sandstone for the loose sands which, farther north, are interstratified with the clays.

As for the occurrence of the characteristic materials of the formation in the more immediate valley of the Mississippi and the Delta-plain proper, I cite the following data.

Blue clay containing sticks and leaves is found in wells in the Mississippi bottom in the latitude of Greenwood, Miss., where it overlies water-bearing gravel, being itself overlaid by "red" (*i. e.* orange-yellow) clay. Its thickness there is but a few feet, perhaps on account of its proximity to the edge of the bottom. It crops out in low places between McNutt and Sunflower River, and contains calcareous concretions; it seems to be the material out of which the rich "Buckshot soil" is formed, which soil is abundant also in the more northerly portions of the bottom. The beds of the Yazoo, Sunflower, and Mississippi are themselves frequently cut into this blue clay. At Bluck's mill, near the mouth of the Yazoo River, it has been found forty feet thick (as at Port Hudson), and is underlaid by quicksand; it contains many sticks and leaves.

The above data, taken from Humphreys' and Abbot's Report, have been fully confirmed by the late investigations of Dr. E. A. Smith, of the Mississippi Geological Survey.² Numerous characteristic profiles examined by him, on the Yazoo, Sunflower, and their tributaries, clearly exhibit the non-fluviatile character of these deposits, and their close correspondence, in every respect, with the Port Hudson series. At the same time, the occurrence of the characteristic "buckshot soil" resulting from their disintegration, renders their occurrence to within a few miles of Memphis almost a matter of certainty.

The existence of the blue clay opposite Vicksburg has been proven in digging the canal; but the materials of the Vicksburg *bluff* are of a totally different character.

At all the points just mentioned, it appears only at or near low-water level. But at Nevitt's bluff near Natchez (see above, p. 4), we have a profile corresponding to that of the wells near Greenwood. Moreover, Dr. Little has observed that the beds of the larger streams below Vicksburg, as Bayou Pierre, Coles' Creek, and Homochitto, are frequently cut into similar bluish or greenish clay, containing vegetable remains, and not unfrequently Mastodon and other bones. These deposits appear to underlie the Loess, and may be outliers or, rather, branches of the main body of the deposit in the more immediate valley of the Mississippi.

Opposite Natchez, according to Humphreys and Abbot, a thick stratum of blue clay not only underlies the entire bottom, but between the Washita and Black bayou

¹ Report on the Mississippi River, p. 101.

² On the Geology of the Mississippi Bottom, Proc. Am. Ass'n Adv. Science, Indianapolis meeting, 1871.

it frequently crops out on the surface, forming the "buckshot land" at a level considerably above high water.¹

The same state of things obtains in the Tensas bottom, opposite Rodney. A large portion of the best lands of that region is almost a prairie soil, filled with calcareous concretions, and totally unlike any alluvium now forming. I have also found outcrops of this material in the banks of the bayous of that region.

According to Hopkins, the Avoyelles prairie belongs chiefly if not wholly to the same category; being an outlier, as it were, of the Attakapas prairies.

Humphreys and Abbot give the following additional data regarding the occurrence of blue clay strata in the lower portion of Louisiana. At the head of bayou Lafourche, and at Thibodeauxville; in the canal between Lockport and Lake Field; at all of which points it occurs at about mean Gulf level. It forms the bottom of Grand Lake, and in the same region has lately been found in a well at the residence of Capt. Kerr, opposite Jeannerette's P.O. on the Tèche; here also at tide-level. It also occurs on the line of the Opelousas railroad, both east and west of bayou Lafourche, a few feet below Gulf level.

When it is considered how rare are the opportunities for observing the strata underlying at a depth exceeding a few feet, in a level country where wells and cellars are almost unknown, the fact that the blue clay stratum has been found in almost every case when a greater depth was reached, must be taken as strong proof that its prevalence is a general one; always excepting, of course, the old river channels. It may be that in some cases, modern cypress swamps filled up by river deposit have been struck. But there is no ground, either historical or natural, for supposing that since the Terrace epoch of elevation, when the present Mississippi valley was cut into the Loess deposits, the whole bottom or delta plain has ever been one vast swamp. This could not have happened without a subsequent re-depression, of which there is not the slightest proof; while, on the other hand, the lithological and stratigraphical connection with the Port Hudson series is exceedingly cogent.

If, however, this ancient cypress swamp stratum in the Mississippi bottom be really the representative of an era anterior to the Terrace epoch, similar vestiges of the slow depression which could have produced it, must exist in the larger tributary valleys. That this is the case in that of Red River, I have already stated. My own observations have, it is true, been confined to the portion of the river lying between Grand Bayou and Coushatta Chute Landing; but I have the most direct testimony that all the way below, and above as high as Shreveport, the banks of Red River exhibit precisely the same aspect.

I give below two sections of the banks of Red River at a medium stage of water. They represent fairly the general condition of things, profile No. 2 being, however, by far predominant; *i. e.* the clay strata, whether red or blue, with strings of calcareous concretions on the stratification lines, occupy, as a rule, the bed of the river; their thickness being sometimes, as I am informed, twenty-five to thirty feet and over.

¹ Report on the Mississippi River, p. 98.

SECTION OF RED RIVER BANKS.

FEET.	I.—SIX MILES ABOVE COUSHATTA.	II.—FOUR MILES ABOVE COUSHATTA.	FEET.
5	Reddish-gray, sandy Loam—river deposit?	Reddish-gray Loam.	7
2	Gray, indurate loamy Sand.		
3	Loam, like top stratum.	Stiff red Clay.	$\frac{1}{2}$
		Reddish-gray Loam.	1
2	Heavy red Clay.	Stiff red Clay.	$1\frac{3}{4}$
3	Gray Loam.	Yellowish-gray Loam.	$1\frac{3}{4}$
10	Red Loam, consolidated, to water's edge.	Stiff red and bluish Clay, with calcareous concretions; alternating in layers from one to three feet thick.	17

Whether the upper portion of these profiles be of modern or ancient date, may be a debatable question. The deposits now formed by Red River during its overflows are altogether predominantly of a light, loamy character. Sheets of reddish clay are, it is true, deposited locally by the back water, at the present time. But the well-known rapid rise and fall of the river as it now exists, render it impossible that a uniformity of deposits should be maintained for any great length of time in any given place, save along the main channels. Where newly formed bayous cut through the modern cypress swamps, this rapid alternation in the nature of the deposits may be seen as clearly as in the Mississippi bottom itself. In view of these facts, it is impossible to escape the conclusion that the heavy, uniform clay beds, continuous for miles, into which the river has cut its bed, owe their origin to a state of things totally different from the present, and quite analogous to that which gave rise to the clay beds at Port Hudson, and their wide-spread equivalents on the Gulf coast.

It would be unreasonable to suppose, that the swampy inlets roughly representing our present rivers during the Port Hudson period, were not traversed, more or less, by definite channels carrying off the rain-fall. Such channels would, doubtless, be represented by beds of loam like that in profile No. 1, or, occasionally, by coarser materials derived from the bordering hills. So far as I am aware, Red River in Louisiana is not now known ever to carry gravel in its main channel. Yet basin-shaped beds of gravel do occasionally occur near low-water edge; and in one of these (lying about a mile below profile No. 2, given above), which was considerably consolidated, I found well-preserved fresh-water shells, such as *Unio* and *Paludina*. No locality from which these materials could have been derived occurs nearer than six to eight miles, at right angles to the river.

Not far below the locality last mentioned, we find in the bank one of those

buried cypress swamps so common on the Mississippi. Huge stumps, five to eight feet high, have their roots buried in a stratum of brown clay continued below water level, twenty-four feet below the top of the bank. Their tops are surrounded by a similar clay stratum, while a yellow silt envelops the middle portion, and a reddish loam, possibly modern deposits, forms the superincumbent bed, to the surface.

Similar profiles are found in the lake region lying chiefly north of the main river, and not now forming a portion of its immediate valley; *blue* clays, however, predominate there, as might be expected.

It is impossible to overlook the great similarity of these deposits of the Red River valley, to those of the Tèche, of bayou Vermilion, Côte Blanche, and even Lake Charles. The peculiar red tint to which the river owes its name is almost unknown in the Mississippi bottom above Red River, and eastward. On the other hand, the rivers of Texas heading in the same geological region as upper Red River (*e. g.* the Brazos and Colorado), seem to have cut their immediate valleys into materials quite similar to those just described.¹ The curious alternation of Mississippi and Red River deposits in the alluvial banks of bayou Atchafalaya have been repeatedly noticed by observers.

The data thus far given clearly indicate as succeeding the Drift epoch, a period of slow depression, during which the valleys of the larger rivers, already impressed upon the surface previously, were transformed into inlets reaching far into the country; where the slow drainage of the continental waters, depositing their suspended matter, gave rise to the formation of extensive swampy areas largely overgrown with cypress, and traversed by meandering and frequently changing drainage channels. As this depression gradually became more rapid, the paludal character of the deposits changed into that of the silts, such as form the higher portion of the Port Hudson profile; and ultimately, the period of depression closed with the deposition, inland, of the calcareous Loess or Bluff formation of the upper Mississippi, and the overlying loams, now constituting the upland subsoils of the Gulf States.

We have here, beyond a doubt, the counterpart of the "Champlain" depression of Dana. But in order to establish full parallelism, it will be necessary to consider the previous geological history of the Gulf of Mexico.

I have in another paper² sketched the outlines of this history, from palæozoic times, as recorded by the formations which, successively, have contributed toward the filling up of the great Mississippi embayment, from Cairo southward. For the purposes of the present communication, I need refer only to a few prominent points discussed in that paper, viz:—

1st. The existence of a cretaceous ridge, or axis of upheaval, marked by a series

¹ Much has been said about the fertility of Red River valley as connected with the gypsum region above. It is a remarkable fact, that the analyses made by Mr. R. H. Loughbridge, of Red River soils and deposits from Louisiana, do not exhibit any unusual amount of sulphates; nor does gypsum occur in the clay beds. Probably the decomposing effect of the former upon the soil, through the agency of atmospheric carbonate of ammonia, is the true cause of the great thriftiness.

² Proc. Amer. Assoc. Adv. Sci., Indianapolis meeting, 1871; Am. Jour. Sci., Dec. 1871.

of outliers protruding through the Tertiary, that traverses Louisiana, from its northwest corner, in the direction of Vermilion Bay.

2d. The remarkable gap in the tertiary series, the entire interval between the Eocene and Drift periods being represented only by the almost non-fossiliferous brackish or fresh-water beds of the "Grand Gulf" rocks; showing that during that time, the Gulf of Mexico was not a marine basin, but probably cut off from communication with the Atlantic by an upheaval in the Antilles, or Caribbean sea.

3d. The continuity of the "stratified" or "modified" Drift of the Northern States, with the great stratified Drift or "Orange Sand" formation of the South, now identified from Baltimore, Maryland, around the Appalachian upheaval to the Colorado of Texas.

As regards the first mentioned point, its influence upon succeeding formations has been, as regards the early Tertiary, the replacement, to a large extent, of the marine strata observed in Alabama and Mississippi, by lignitic fresh or brackish-water equivalents in northern Louisiana. Red River valley evidently marks a deep gap in that ridge, wherein the Grand Gulf rocks have been deposited without any notable variation of character. A short distance southward from Red River, however, we find the cretaceous outlier near Chicotville; and following the general trend of the outcrops, we meet, on Vermilion Bay, the remarkable elevations of the Five Islands, whose geological structure I have above discussed. The Drift which in the Calcasieu bores is struck at a depth from one hundred and sixty to three hundred and fifty feet below the sea-level, and disappears beneath the Port Hudson series at Proffit's Island near Port Hudson, and above Chicotville, is here found at and above the Gulf level; while again at New Orleans, in the axis of the Mississippi embayment, no Drift has been reached at six hundred and thirty feet.

It is scarcely credible that while heavy pebbles were carried from beyond Cairo to the shores of Vermilion Bay, no corresponding deposits should have been made in nearly the same latitude, in the axis of the valley; unless, indeed, deep water checked the transporting power of the current. But if deep water prevailed at New Orleans at the time of the Drift, then of course the deposits that have since filled up the trough are posterior to the Drift—in other words, are the equivalents of the Port Hudson series, which elsewhere along the coast is found overlying the drift, and could not very well be unrepresented in the deepest part of the valley. Only we should expect the character of the deposit here to be very predominantly marine (not *altogether*, since it was the main outlet of the continental waters); and so I have found it to be, in my examination of the specimens from the New Orleans artesian well.¹

It is stratigraphically almost impossible that the strata penetrated here should be of an age anterior to the Drift, *i. e.* pleiocene; a few unknown (or possibly extinct) species occurring in them to the contrary notwithstanding. Whether or not the drift be actually underlying these marine strata, will, I hope be settled before long, in the interest of the water-supply of the city of New Orleans. But if in Calcasieu,

¹ Rep. U. S. Engineer Dep't for 1870.

at a distance from any great channel, the drift pebbles occur at a depth of four hundred and fifty feet: it cannot be surprising that at the grand outlet of the continental waters, they should lie a few hundred feet deeper.

THE DRIFT PERIOD, SOUTH AND WEST.

Assuming for the present that the four hundred and fifty feet represent the maximum depth at which the drift is found on the Gulf coast, it would seem necessary to assume, in order to account for the transportation of the northern pebbles to that latitude, *an elevation of the Gulf coast* by nearly that amount above the general sea-level, at the time the transporting currents began to flow. So far as I am aware, the transportation of large pebbles is practically confined to streams of shallow water. Deep currents *might*, of course, assume a velocity sufficient to transport them; but I fail to remember any actual case of the kind, save perhaps in the sudden breaking of dykes, natural or artificial. And even then, transportation must substantially cease so soon as a large reservoir, or the sea, is reached.

It might be said that, since just before the Drift period the Gulf of Mexico was disconnected from the ocean, its level may have been different from that of the latter. Such may have been the case; but if so, the level of the Gulf, forming the common reservoir of the continental waters, could only have been *higher*, but not possibly lower, than that of the ocean. The above estimate of the amount of upheaval cannot, therefore, but be a minimum. And whatever may ultimately be found to be the maximum depth at which the drift pebbles lie beneath the Gulf level, must be assumed as representing, approximately, the amount of elevation during the Drift epoch. Moreover, in order to account for the transportation of coarse materials, the general southward slope of the country must be assumed to have been greater than is the case at the present time. How far these phenomena of elevation may go to account for a glacial epoch at the North, we can at present but conjecture; yet it cannot be questioned that even the minimum of probable uprising might have essentially aided in accomplishing the result, which a cutting off of the Gulf stream or Kuro Siwo from the Arctic ocean might, alone, have been inadequate to bring about.¹

As regards the origin of the great flood which has been instrumental in covering so large a portion of the States bordering on the Lower Mississippi, with sand and shingle derived from higher latitudes, Tuomey and myself have early suggested that it might have been the result of the melting of the northern glaciers; in consequence, perhaps, of a rather rapid depression. In the former portion of the hypothesis I still substantially believe; for it is obvious, from both the lithological and palæontological features of the southern Drift, that no *marine* current could have been concerned in its formation. But as regards the second part of the sug-

¹ Some of the Western geologists are emphatic in stating that they "find no reason to suppose an elevation of the continent during the Drift period." It is not easy, indeed, to see how direct proofs of such an event could exist, to a very obvious degree, in the interior of a continent.

gestion, I now feel satisfied that the maximum of solar heat available at one and the same time would have been utterly inadequate to produce such masses of water as have manifestly been active in the formation of the Southern Drift. Moreover, if it be true, as Western geologists assert, that the main body of the Drift of the Northwest is the result of iceberg transportation, while the deposits are altogether destitute of contemporary marine fossils: the conclusion is inevitable that the icebergs floated in a vast inland glacier-lake.

What might have been the northern shores of this fresh-water Mediterranean under the circumstances then existing, I must leave to those better acquainted than I am with the topographical features of that region, to discuss. Possibly the glaciers themselves may have formed a sufficient barrier. Towards the east, southeast and southwest, it would have been defined by the Alleghany, Cumberland, and Ozark ranges, its main outlet lying, doubtless, in the axis of the Mississippi Valley, the gap between the Ozark and Cumberland highlands, not having as yet been eroded to its present level. Any somewhat sudden break in this lowest portion of the barrier, such as is apt to occur even where erosion is the only agent (leaving out of consideration the very possible agency of earthquakes precisely in the critical region about New Madrid) would then produce precisely the phenomena we now observe at the South, viz., the action, at first, of violent currents plowing up and re-depositing the material of the more ancient formations; carrying down in the main channel rocks of high northern derivation, far out into the Gulf; re-stratifying or "modifying," towards the end, a good portion of the iceberg drift of the Northwest, *in loco*; and simultaneously, as the velocity of the currents diminished (either from exhaustion of the reservoir or incipient depression), covering over the pebble-streams and eroded surface of the South, with the peculiar "Orange Sand," which characterizes the delta-shaped mass covering the States of Mississippi and Louisiana, as well as part of the adjoining ones of Tennessee, Alabama, Arkansas, and Texas.

One of the characteristic features of this "Orange Sand" (a name it might be desirable to retain as descriptive of a peculiar facies of the southern Stratified Drift) is the complete peroxidation and lixiviation of its materials.¹ Protoxides of iron and manganese, as well as lime, magnesia, and alkalis, are reduced to their minimum in this most barren formation. All this argues, so far as it goes, long subaërial exposure, such as has manifestly not acted upon the Northwestern Drift; and this again confirms the argument upon purely geological grounds, tending to prove the elevation of the southern slope above the sea-level, even subsequent to the Drift epoch proper.

If the hypothesis here advanced be deemed too bold, or premature, I submit that at least it subsumes among its possibilities all the phenomena now known concerning the Drift of the interior and Gulf States; and in this point of view may serve at least as a definite basis for investigation, until a better one be found. So far as I am aware, there is nothing in the geological structure of the region between the Cumberland and Ozark highlands, to compel the assumption that its degradation is not of comparatively modern date. The rocky channel of the Mississippi, from St.

¹ Miss. Rep., 1860, pp. 15, 23, 27.

Louis to within a few miles above Cairo, is manifestly a modern erosion; the huge masses of (siliceous) carboniferous pebbles bordering the Tennessee on the west, and reaching far down into Alabama, speak of great degradation of beds forming the southern edge of the carboniferous basin; and the divergence of the great Drift delta from the head of the ancient Mississippi embayment, is itself a fact of no small cogency. I trust that a thorough geological and topographical examination of this interesting region will soon enable us to come to more definite conclusions regarding its history during the Drift epoch.

THE "TERRACE" EPOCH.

The precise extent of the maximum depression of the Gulf States at the end of the Champlain period of depression, must be determined by more accurate measurements than we now possess. Yet we may approximate to a minimum.

Commencing at a level now at least four hundred and fifty feet below the present tide-water (as shown in the Calcasieu bores), the depression, slow at first and more rapid afterwards, continued until the summits of the highest hills bearing aqueous deposits formed in quiet water (*i. e.* not by rapid streams) were, not merely *at*, but some depth *below*, the Gulf level; it being remembered that the present elevation of these hills, degraded as they have been for ages by atmospheric agencies, do not, themselves, represent their original maximum height, perhaps by many feet.

The highest elevation now existing on the banks of the Mississippi River, *viz.* at Fort Adams, near the line between Mississippi and Louisiana, is about three hundred and fifty feet above tide-water. But summits obviously higher are visible from this point, southeastward; and there is a decided ascent as we proceed inland from the river, so as to render it probable that the present maximum elevation of the Loess deposits proper, above tide-water, is not less than four hundred and fifty feet in the latitude of Fort Adams.

But the Loess is overlaid (wherever denudation has not removed it) by the yellow Loam stratum, which exists equally in the interior of the Gulf States, on all but the very highest ridges. It is widely developed in North Mississippi and West Tennessee, and according to the railroad surveys, much of this region is elevated between five hundred and fifty and seven hundred feet above the Gulf. In view of these facts, I think *one thousand feet* the minimum at which we can estimate the entire amount of depression during the Champlain epoch, from data existing south of Cairo. It would not require much more to transform the prairies of Illinois into the fresh-water glades to which Mr. Lesquereux attributes their origin; and Prof. E. B. Andrews' observations in southern Ohio seem to justify the assumption of a depression greater by several hundred feet than the minimum called for by mine.

The reverse motion during the Terrace epoch has, of course, compensated the greater portion of the depression; at least, all that part remaining as a difference after deducting, substantially, the maximum depth at which drift materials

manifestly transported in rapid, shallow water, shall be found beneath the level of the Gulf.¹

ORIGIN OF THE FIVE ISLANDS, AND AGE OF THE SALT DEPOSIT.

It is only by the light of the observations and considerations given above, bearing on the geological history of the Gulf region, that we can usefully approach the problem of the age of the Salt deposit of Petite Anse.

Since the lowest (clay and pebble) strata of the Stratified Drift are found overlying the rock-salt mass, its age is at once removed beyond the limits of the quaternary period. And, in fact, unless we resort to legerdemain hypotheses of local upheavals, salt springs miraculously evaporated *in loco*, or a lagoon arrangement resembling that of the "salt-plantations," it is not easy to refer the formation of so large and pure a mass of salt even to a period as modera as the tertiary, with its very slow and regular emergences, and frequent alternations of character. Its existence where it is, however, is scarcely more anomalous than that of the chain of five elevations whereof Petite Anse forms one, on a coast otherwise monotonously flat for seven hundred miles each way.

It is but fair to assume, *à priori*, that the chain of islands and the rock-salt mass are genetically related, until the contrary be proven.

In seeking for an adequate cause, there are two circumstances which render the position of these islands exceptional, viz:—

1. They lie diagonally across the shortest line by which the continental waters could reach the sea, right in the axis of the Mississippi embayment.

2. They lie also directly in the line of a cretaceous axis of upheaval, indicated by a group of outliers traversing the State in a south-southeast direction; the last characteristic one occurring only sixty miles (on a direct line) inland of Petite Anse.

Given a solid, resisting cretaceous nucleus: the accumulation on it of Drift materials, the deposition of the Port Hudson series at a higher level here than elsewhere, and the greater resistance to denudation during the Terrace epoch is readily accounted for.

It might be thought that these elevations represented the bar, as it were, of the great central Drift current of the Mississippi Valley, where its velocity was checked by the sea. Indeed, the large-sized pebbles of high northern origin found on Petite Anse, prove that the main pebble stream was not altogether deflected to the southeast (as is the case with the Mississippi and its bayous, in the lower part of the river's course); and it is quite credible that the predominant accumulation of coarse materials in this main axis may, in a great measure, account for the unusual resistance to denudation offered by these islands. For it can hardly be doubted that the whole of the Attakapas prairies was originally covered with deposit to a similar extent as is still the case in their northern portion, and at Port Hudson; and that the removal of the higher, silty materials down to the "stump clays," in the

¹ *I. e.* four hundred and fifty feet, so far as at present observed in the Calcasieu bores.

southern portion, was effected by denudation during the Terrace epoch of elevation, when the flood plain of the Mississippi was excavated into the deposits of the Champlain era of depression. Such portions of the ridge as were sustained by a resisting nucleus (whether cretaceous rock, or heavy drift gravel overlying it), would remain untouched by the denuding currents; while large gaps would be formed where the resistance was less.

It remains to be shown that the rock-salt mass may, with a considerable degree of probability, be claimed as a cretaceous outlier; and reasoning by exclusion, I think this can be done, by considering successively the formations to which it might be referred.

As regards the Grand Gulf group, though much impregnated with salts of various kinds, its general character as a fresh or brackish-water formation renders it peculiarly ill adapted to the genesis of rock-salt deposits. It is, moreover, a very predominantly littoral formation, whose deep water equivalents appear to be so thin that the Drift currents have in most cases destroyed them. They have not been found in any bore near the coast. The Vicksburg rocks even (which are thinner and of less resisting material in Louisiana than in Mississippi) have been removed in a great measure by the Drift, which in Calcasieu seems to be immediately underlaid by the Jackson group of the Eocene.¹

But the marine groups of the older Eocene are of such inconsiderable thickness, each so variable in its nature, and so scantily supplied with salt, that to attribute to either of them the formation of so large and pure a mass of rock-salt, seems to involve an utter incongruity.

Not so with the cretaceous formation that underlies them. Not only is salt-water the invariable feature of the cretaceous outcrops of North Louisiana, whence, during the war, heavy supplies were furnished to the blockaded section; but it is there accompanied by that almost necessary complement, gypsum, which thickens to the southward until, as demonstrated by the Calcasieu bores, it passes beneath the Gulf with the surprising thickness of over six hundred feet.

It is well known that the end of the cretaceous period on this continent was characterized by a "wholesale" conversion of ocean into inland lakes and dry land. What was, at that time, the condition of the Mexican Gulf basin, we have not the data to determine. But inasmuch as even in early eocene times, water connection still existed between the interior and the Gulf: so of course the same must have been true of the cretaceous inland sea, which by a continuance of elevation inland, was gradually receding toward the Gulf. The existence of the great gypsum formation, both in the interior, and beneath the Gulf, argues the concentration and evaporation of a vast amount of sea water as a consequence of the general emergence; and it is but reasonable that the other chief ingredient—salt—should be found somewhere in connection with the great gypsum beds. And the great rock-salt bed of Petite Anse, now known to exceed seventy feet in thickness, without such

¹ Hopkins's researches have proven the Sabinetown equivalents of the oil-bearing rock of Calcasieu to belong to the Jackson and not (as conjectured by me) to the Vicksburg group.

change of character, as must characterize any deposit formed on a small scale, seems a fit counterpart to the great gypsum bed of Calcasieu, with which the general dip of the formation would naturally connect it.

In a country whose geological structure is less simple than that of the Gulf States, such reasoning might seem trivial and of little weight. But there is in the simplicity of the general features of conformation in the whole of the Gulf border, an irrepressible cogency that can neither be ignored nor evaded. There are but few reasonable possibilities in the explanation of any of its phenomena, albeit there is no limit to fancies.

The question of *age* has a most important bearing upon that of the *extent* of the salt deposit. If of comparatively modern date, it must be accounted as more or less the result of local accident, and therefore of small extent. If of cretaceous age, and therefore resulting from causes acting over great areas, its original extent might have to be measured by hundreds of square miles; although its present, and above all its available, mass would be seriously less, in consequence of its long exposure to the action of water, from early eocene times to that of the Drift. The borings show that, like all other formations that have been subject to the action of the Drift currents, it is deeply denuded, forming "hills within hills." It is my belief that on some points of the island of Petite Anse, it could be reached by level adits; and, as worked at the present time, I think there is much less danger of "knocking the bottom out" by deepening the mine, than there is of "getting to the jumping-off-place" by extending the galleries. So long as the purity of the mass is not seriously impaired by admixture of gypsum, there is little likelihood that the floor of the stratum is at hand.

The borings thus far made with a view to determining, either the area of the Petite Anse mass, or the existence of rock-salt on the neighboring islands, have remained far within the limits beyond which its extraction would become too costly. And although a mass of salt one hundred and forty-four acres in extent and seventy feet thick may be considered a handsome specimen, yet industry is too deeply interested in the cheapness and abundance of this fundamental article, not to render its discovery at other points a matter of very great importance. And this importance will be greatly enhanced if, as I venture to predict, the great sulphur bed of Calcasieu (the probable contemporary and congener of the rock-salt mass of Petite Anse), shall be found, from analogous causes, of a correlative magnitude.

ON THE

INTERNAL STRUCTURE OF THE EARTH

CONSIDERED AS AFFECTING THE

PHENOMENA OF PRECESSION AND NUTATION,

SUPPLEMENTARY TO ARTICLE UNDER THE ABOVE HEAD, SMITHSONIAN
CONTRIBUTIONS TO KNOWLEDGE, VOL. XIX., No. 240

BEING THE THIRD OF THE

PROBLEMS OF ROTARY MOTION.

BY

J. G. BARNARD, U. S. ARMY,

MEMBER OF THE NATIONAL ACADEMY, ETC

[ACCEPTED FOR PUBLICATION, MAY, 1877.]

ADVERTISEMENT.

THE following paper, a supplement to the previous communication from General Barnard, was read before the National Academy of Sciences, and subsequently presented to the Smithsonian Institution for publication.

JOSEPH HENRY,
Secretary Smithsonian Institution.

ON THE
INTERNAL STRUCTURE OF THE EARTH CONSIDERED AS AFFECTING
THE PHENOMENA OF PRECESSION AND NUTATION.

‘ EXPERIENCE shows that physical problems of difficulty are never solved in a satisfactory manner but after reiterated attempts,’ says Mr. Ivory, in commencing his Memoir (Phil. Trans., 1839) “On the Conditions of Equilibrium of an Incompressible Fluid.”

I quote the remark not only for its general truth but for its special application to the subject before us. If the conditions of fluid *equilibrium* be a problem of so much difficulty that “reiterated attempts” of the great physical investigators—Newton himself leading the way—have been needed, shall no the more transcendently difficult problem of fluid *motion, a fortiori*, need repeated attempts with perhaps repeated failures, finally, “in a satisfactory manner,” to “solve” it?

In an address before the British Association, delivered in September last, Sir Wm. Thomson, alluding to recent occurrences, commencing within the walls of this very building,¹ which had “forced him to give all his spare thoughts ever since to Hopkins’ problem of precession and nutation, assuming the earth a rigid spheroidal shell filled with fluid;” requests his hearers and his readers to strike out from copies under their control paragraphs 23-31 of his paper on “The Rigidity of the Earth” (Phil. Trans., 1863), and 847, 848, 849 of Thomson and Tait’s “Natural Philosophy.”

In consequence of the “practical rigidity conferred by rotation” (Addendum to Problems of Rotation,” Smithsonian Contributions, Vol. XIX, p. 46) I had long before (see Notes to pp. 38 and 48) expressed *non-concurrence* with the paragraph 848. It is clear then that ignorance of the “quasi-rigidity induced in a liquid by vortex motion” is not a plea I am entitled to make, even though I have to confess the neglect to recognize its legitimate effects in framing some important conclusions.

In the paper bearing the title cited at the head of this, after quoting the statement of Sir Wm. Thomson (“Rigidity of the Earth”), “That the effective tidal rigidity, and what we call the precessional effective rigidity of the earth, may be several times as much as that of iron (which would make the phenomena, both of

¹ The Session of the Academy of Sciences, at which this was read, was held (April 18, 1877) in the office of the Secretary of the Smithsonian Institution.

the tides and precession, sensibly the same as if the earth were perfectly rigid), it is enough that the actual rigidity should be several times as great as the actual rigidity of iron throughout 2000 or more miles thickness of crust;" I continue as follows:—

"A theorem fundamental to the establishment of the above propositions is, that a revolving spheroid destitute of rigidity, a homogeneous fluid one, for instance, would have no precession. Sir Wm. Thomson does not mathematically demonstrate this theorem, but by use of an hypothesis gives an elegant illustration of its truth, for which, though to me it is convincing, I prefer to substitute the following demonstration."

The demonstration referred to consists in investigating for the diurnal tide of a homogeneous fluid spheroid, as it is expressed by Laplace, *Méc. Cél.* Book IV [2316] (Bowditch), the analytical expression for the "couple" due to the "centrifugal force" exerted upon the material particles which constitute that tide; showing the same to be exactly equal and *opposite* to the precession-producing couple exerted on the oblate spheroid itself by the foreign attraction (*e. g.* of the sun).

The method of computing this counteracting couple is identically that used by Laplace in determining the effect of the centrifugal force exerted by the tides in the chapter (*Méc. Cél.*) on the "Pressure and Attraction of the Sea." I go on to draw the following general conclusion:—

"By parity of reasoning the truth of Sir Wm. Thomson's propositions concerning a solid but yielding spheroid is made evident; for exactly in the same ratio to the tides of a fluid spheroid that the solid tidal elevations are produced (the actual ellipticity of the earth being nearly that of equilibrium with the centrifugal forces), will the precessional couple due to the tide-producing attraction be neutralized by their centrifugal action."¹

Circumstances, referred to on another page, have caused me to reconsider these opinions; but as the considerations on which they were founded not only were considered demonstrative by myself, but furnished for ten or fifteen years an unsuspected basis of belief for the author of "The Rigidity of the Earth" (*Phil. Trans.*, 1863); of the "Natural Philosophy" (1867); of the letter to Mr. G. Poulett Scrope (1873),² it seems pertinent to inquire how far those considerations were in harmony

¹ This reasoning may be put in a little different form to illustrate not only the weight of the argument but what I shall have to set forth in subsequent pages. Two different effects, *each complete in itself*, are separately attributed to the "couple" exerted by the foreign attraction; *one* is precession (*i. e.* angular motion of the earth's mass considered as a rigid solid); the *other*, that distortion of the mass-figure denoted by the diurnal tide. The "cause" is adequate to either effect, separately. Will it produce *both*? The argument and the mathematical "demonstration" was that the latter effect *must* neutralize the former. Subsequent pages will show that I now regard the former to neutralize, in great degree, the latter; or, more accurately speaking, the latter to be *partially transformed into the former*.

² "When those passages were written," says the author, "I knew little or nothing of vortex motion * * * * I had never once thought of this subject in the light thrown on it by the theory of the quasi-rigidity induced in a liquid by vortex motion." (Glasgow Address.) Professor Tait's Translation of Helmholtz, on Vortex Motion (*Crelle's Journal*, 1858), appeared in *Phil. Mag.*, 1867, with a postscript by Sir Wm. Thomson, scarcely that of a novice; and was followed by com-

with facts of nature; or rather to exhibit their plausible claims to be so. I will content myself with remarking that if we turn to any treatise on the figure of the earth (regarded as fluid) we find the motion of rotation disregarded and for it, what is in reality though not in name, the repulsive force of Sir Wm. Thomson's fixed "repelling line" substituted.¹ If the problem be what superimposed form a foreign attraction (*e. g.* of the sun or moon) will develop, we encounter again as the sole and (alleged) sufficient substitute for the rotary *motion* this same representative of "centrifugal force." This last problem is not one of pure equilibrium; for the sought-for forms are incessantly shifting, involving thereby other *motions* than the conventional centrifugal-force-generating one of rotation. Nevertheless, the required configurations on a fluid spheroid are sought for on the repelling-line theory and are in fact nothing else but the "small elliptic deviation superimposed on the great polar and equatorial ellipticity" of the hypothetical case in § 25 "Rigidity of the Earth." Nay more, we find it admitted (*Méc. Cél.*, Vol. II., Ch.

munications on "vortex rings" in the same magazine. In the Transactions R. S. Ed., 1868 and 1869, are papers "On Vortex Motion" by the same author. It is, however, the latter mentioned consideration, the "quasi-rigidity," by which the "light" is thrown; "vortex rings" are certainly not without noticeable exhibitions of that quality.

¹ I believe there to be no physicist who has not had occasion sometimes to fault the uses of, and attributes conferred upon, this "centrifugal" force, so called; which proceeds from a special manifestation of the quality of matter we call inertia; *i. e.*, that manifestation offered by the resistance of a *moving* body to *deflection* from its rectilinear path, creating an *exigency for force* which may explicitly, but invertedly, enter into our analysis, or *not*, according as the *amount of deflection* is, or is not, a datum. In (*e. g.*) the problem of equilibrium of figure of a rotating fluid, the *exigency* is for force to *compel the deflection* belonging to the rotary or circular *motion* of the fluid particles; which requirement is *given* in terms of distance of the particle from axis and of the angular velocity of rotation. Disregarding *the motion* (and hence *its exigency*) we *create* an equivalent exigency by *introducing* an equal and opposite "centrifugal force, so called," and thus determine the *figure* which furnishes by its integral attraction the required deflecting force.

The resistance to deflection to *given* curvature is measured by $\frac{v^2}{r}$; but if the radius of curvature r (the reciprocal of the deflection), be unknown, the force of inertia cannot be thus expressed. We have then to use the more general forms (for rectangular co-ordinates) $\frac{dv_x}{dt}$, $\frac{dv_y}{dt}$, $\frac{dv_z}{dt}$ (or $\frac{d^2x}{dt^2}$ etc.), which express the inertia of deflection towards the plane normal to the co-ordinate axis indicated, *from any linear direction of the velocity, v*. A study of these expressions, in connection with the value and direction of v , will show that they are (like the explicit form of the centrifugal force) the equivalents of an inertia measured by the deflection *into* the square of the velocity. *Their* use excludes the introduction of the first expression even where it is known. (See also Airy, "Tides and Waves," § 79.)

Whatever idea we may attribute to that mysterious thing called "force," there can be no doubt that, *as used* by all the authorities on mechanics, as something which has *direction*, measurable *intensity*, and which implies an equivalent *reaction*, the so-called centrifugal force possesses all these attributes. Hence we find in the Nat. Philos. of Thomson and Tait not only the "repulsion from the axis in simple proportion to distance" (*i. e.*, the identical *repelling line* force of "The Rigidity of the Earth" article), but we find, § 800, "the *potential* of the centrifugal force;" and § 813, the same problem "dealt with by the potential method;" and this not merely where it is a question of equilibrium of form when the only motion is that which exacts a so-expressed deflecting force; but when it is one which involves the identical "small elliptic deviation" or superimposed tidal form of § 25 of the above treatise. Cf. Prof. Tait's lecture on "Force" ("Nature," Feb. 28, 1877).

iv., par. xii.) that for a rotating spheroid *wholly* fluid, or even for what are relatively to the earth's radius, inconsiderable ocean depths, submerging a solid nucleus, the tidal protuberance *will* be developed; and that it *will* be identical with that of the equilibrium theory and hence with "small elliptic deviation" of paragraph referred to. The to-be-expunged paragraphs, of the "Rigidity of the Earth," were, therefore, simply a paraphrase of other forms of expression universally adopted in recognized authorities and which had become axiomatic; and deductions therefrom which were irrefragable.

Although the "practical rigidity conferred by rotation" is explicitly announced in Addendum (p. 38) to my paper cited at the head of this, and although the whole scope of that Addendum is to prove that within an infinitely rigid envelope "the rate of precession would not be affected by fluidity (whether homo, or hetero-geneous), or imperfect rigidity;"² and although there are determinations in it (p. 43 and *note*) as to the *modus* of formation of the diurnal tide which should have shown me that there could from it result no "couple due to the centrifugal force," it was not until quite recently that I was brought, through a question suggested by Prof. Newcomb (at Buffalo meeting of A. A. A. S., Aug. 1876), to a new study of my own results and the present development of their legitimate bearings.

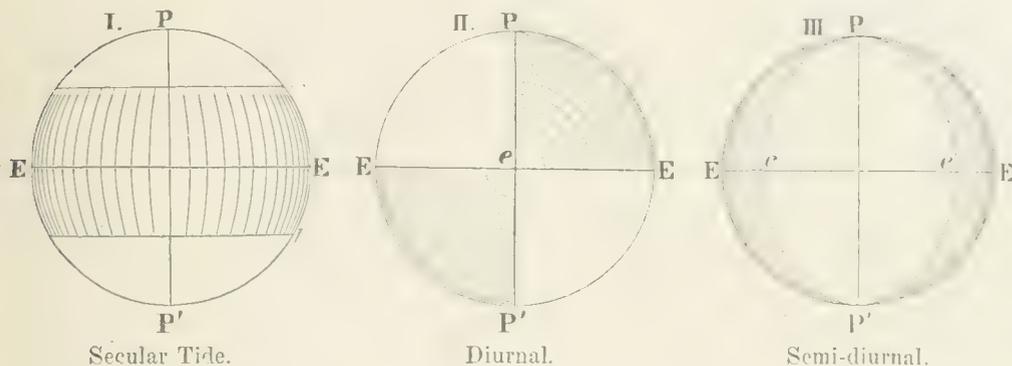
Tidal development is, as well as precession, the effect of a foreign attraction; and before proceeding further I must refer to the theoretical tidal developments of the equilibrium theory. The well-known classification into "secular" (*i. e.*, semi-annual or semi-monthly), "diurnal," and "semi-diurnal" tides, embraces three specific tidal deformations which, together, make up the "small elliptic deviation" (as elsewhere spoken of), which constitutes the "tide." Regarding the spheroid as a perfect sphere (an assumption, for convenience, always made in computing the tidal development), the "semi-annual" tide is an *equatorial* protuberance accompanied with depression at the poles. The "semi-diurnal" consists of two diametrically opposed meridional protuberances, occupying two opposite quarters of the globe, with similar depressions occupying the two intermediate quarters. Developed symmetrically, as regards the equator, neither they, nor the parts of the solar or lunar attractions which produce them, have any disturbing effect on the axis of

¹ Sir Wm. Thomson's phrase is "*quasi-rigidity induced in a liquid by vortex-motion*"—a variation of words only; and it is in place to remark that there is no special virtue in *vortex* motion over *motion in general* to induce *quasi-rigidity* in a fluid. There can be no *continuous* motion of the particles which make up a fluid figure, compatible with preservation of that figure, composed of the *same particles, but* rotation or (in other words) vortex-motion. Hence a *quasi-rigidity*, which motion confers upon a fluid figure, becomes the special attribute of "vortex-motion." Moreover, though this phrase vortex-motion, of recent origin in this connection, is not used, "*quasi-rigidity*" is brought out as a *result* by the investigations (Sections 7-15) of the late Wm. Hopkins, of the pressures exerted and reactions experienced by a revolving fluid within a revolving shell ("Researches in Physical Geology," Phil. Trans., 1839), where he shows that the fluid receives an angular motion "precisely as if it were solid," and, in Sec. 30, where he develops the relative (to the shell) motions of the quasi-rigid fluid; calling this, rightly, "a case of rotary motion which has not before been investigated."

² Although I *disprove* Mr. Hopkins' conclusion that heterogeneousness would affect precession, his argument as well as mine not only concedes *but proves* that the rigid-shell-inclosed fluid would "perform gyration." The remark is made with reference to supposed crucial experiments, with water-gyroscopes (unavoidably endowed with *rigid envelopes*), as to points at issue.

figure (and rotation). Looking to the internal motion of particles required to produce them, it is easily seen that the first (diagram I. Fig. 1, where shaded portions are protuberant; unshaded, depressed; and where the attracting body is supposed *on the right, and above the equator*) indicates an infinitesimally (almost) slight squeezing together of the parallels of latitude or planes of rotation; the other (diagram III), a minute approximation of meridional planes to that in which lies the attracting body, *and* an eloignement of these planes from a meridian normal to the first; a slight slackening of rotary motion in the approximated planes—an acceleration in the others.

Fig 1.



In neither case is the deviation of the particle from its normal plane of rotation more than a quantity of the second order of minuteness; regarding the developments themselves as minute in the first order. These disturbances are symmetrically disposed equatorially, and whether or not “vortex-motion” hinders in any degree their development, is immaterial. Neither of these two disturbances, nor the components of foreign attraction which induce them, have any influence on precession.

The case is very different for the diurnal tide (diagram II). The disposition of the disturbance is unsymmetrical both as to the equator and the earth’s axis, and cannot be effected without some disturbing effect on that axis. To discuss it I must dismiss the impossible *sphere* and pass at once to the actual figure of equilibrium (Fig. 2) of a homogeneous rotating fluid, implied by Sir Wm. Thomson’s § 26 (“Rigidity of the Earth”). Such a figure has an equatorial oblateness of which the ellipticity, c , is $\frac{5}{4} \frac{n^2}{g}$ ($n^2 =$ angular velocity of rotation; $g =$ gravity at the equator).

The expression for the tidal disturbance in question is, taken on a meridian directly under the sun (*i. e.*, the line on which lie both the maximum elevations and depressions).

$$(a) \quad y = \frac{15S}{2r^3g} \sin v \cos v \sin \theta \cos \theta$$

$v =$ sun’s declination, θ polar distance of locality, S , sun’s mass, r its distance.

(The radius of the earth being taken as unity.)

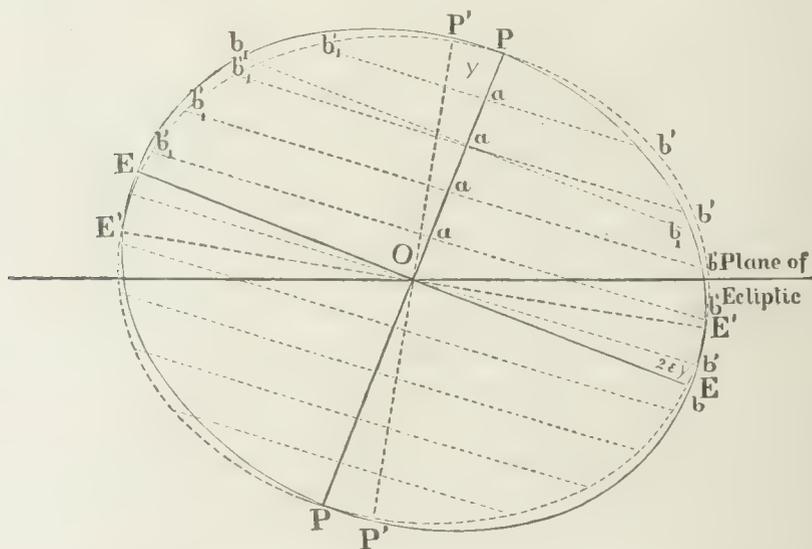
It is easily shown that a slight turning of the normally oblate ellipsoid around an

equatorial axis, O , perpendicular to the solstitial line (*i. e.*, a tilting of the equator towards the sun) through an angle measured by

$$(b) \quad \frac{3S}{r'n^2} \sin v \cos v^*$$

will, *relatively to the normal position* of surface, produce exactly the disturbance denoted by above expression (*a*). In the case of Sir Wm. Thomson's hypothetical body acted on by *mere* centrifugal (*i. e.*, *repelling-line*) force *without* the "vortex-motion" which produces that force, the above computed *turning of the entire body* (or what is equivalent to it since motion, as such, is disregarded) would actually ensue. Or, to state the matter a little differently, the tidal developments of the equilibrium theory express not *merely* "deformations" (such as are the "secular" and "semi-diurnal" tides), but, in the "diurnal" tide, an actual *tilting* under the precession-producing "couple" of the foreign attraction; a tilting which is checked very intelligibly on the *fixed* repelling line hypothesis, by its repulsion, which, unchangeably normal to the unchanged direction of the line, finds in the changed position of the body the conditions requisite to the production of a neutralizing couple. We find here a reason why the earth should be but minutely drawn from its angle of obliquity, *coupled with a reason* why there should be no precession.

Fig. 2.



Is the above the true mechanical exhibition of the matter? Is the centrifugal force, like that of the hypothetical repelling line, thus unchangeably constant in origin and in the planes of its direction? Or, if its axis of origin and its planes of direction shift at all, do they shift with the totality of the figure? The *latter* sur-

* The angle through which the figure must be turned so that the *displaced* surface will have an elevation above the original surface represented by the expression (*a*) will result from dividing (*a*) by $\frac{dr}{d\theta}$ for an ellipse of ellipticity e ; or by $2e \sin \theta \cos \theta$. Performing the division and substituting $\frac{5}{4}n^2$ for ge , we get the above expression (*b*).

mise would make the fluid—not a “quasi” but—an absolute *rigid* body, in which case we know that the *rotation* would introduce, in connection with this tilting, the usual phenomena of gyration, and hence of unmodified *precession*. But a fluid, even under influence of vortex-motion, is not *actually* a rigid body, and hence an answer must be sought for in studying the *internal motions* by which, under the influence of rotation, the protuberance is developed. These have already been indicated for the secular and for the semi-diurnal tide. Let us turn now to the *diurnal*.

It is a result of Mr. Hopkins' investigation that, *given* a fluid rotating *within a shell*, internally an oblate ellipsoid of revolution of small ellipticity, e , with uniform angular velocity, n , about the axis of figure; if the axis of the shell be tilted, Fig. 2, from coincidence with that of the fluid through any very small angle, γ , the induced derangement of the fluid will be a *tilting of the planes of rotation* through a still slighter angle, viz., through the very minute angle $2e\gamma$. (A reference to an ellipse of small ellipticity, e , will illustrate the converse fact that a slight and equal tilting (say $2e\gamma$) of the longer diameter and of all parallels to it, about their middle point will produce a magnified tilting of figure equal to $\frac{2e\gamma}{2e} = \gamma$.) Now, as I have already shown, the diurnal tidal development is precisely that which such a tilting (through γ , putting expression (b) = γ) of the external surface (*regarding that surface as a rigid but infinitely thin shell*) would cause. Hence the *internal motion* of the fluid mass by which this diurnal development takes place is discovered to be *this slight change of direction, $2e\gamma$, of the planes of rotation**—the centres a, a, a , etc., of each rotating circular area still remaining steadfast in the fixed axis of the fluid mass. Mr. Hopkins further shows that the resistance to this distortion is a couple measured by $2e\gamma$ into $\frac{4}{15}\pi n^2$.* We have found γ for the diurnal tide to be (see expression (b)), $\frac{3S}{r^3 n^2} \sin v \cos v$. The resisting couple is therefore, $= \frac{24}{15} \pi e \frac{S}{r^3} \sin v$

* Mr. Hopkins' conclusion has reference exclusively to the *shell-enveloped* fluid; the angle γ not only having no reference to foreign attraction but being entirely arbitrary. I applied it immediately (note p. 2 of Addendum to paper already cited) to the diurnal tidal development of the earth considered as *wholly fluid*. Mr. Hopkins enters into a supplemental investigation (Phil. Trans., 1839, § 33) to ascertain the “degree of approximation,” finding that the *possible* disturbance cannot differ materially from that described above. It is moreover the *least possible* derangement by which the requisite change of *figure* can be produced; and, in fact, the fluid cannot move otherwise and preserve its *vis viva* of rotation. How “slight” the change of direction required for these planes will be appreciated, when it is said that the angle γ (see expression b) is but $1\frac{1}{2}$ seconds of arc for the sun; and 3 seconds for the moon. $2e\gamma$, the change of direction of the planes is therefore $\frac{1}{15\frac{1}{5}}$ of these small arcs. The pressure couple on the shell due to the angular displacement γ is found by Mr. Hopkins to be $\frac{4}{15}\pi e a^5 n^2 \sin 2\gamma$; which may be written $\frac{4}{15}\pi a^5 \gamma e n^2$. Since a (mean radius of earth) is unity, and γ very minute, the above expression results. The above may be written $An^2\gamma e$ (A being the moment of inertia). The last three factors are self evidently such, since the couple would vanish with either; and the moment of inertia is obviously another. Mr. Hopkins finds, too, that for homogeneity this is also the couple exerted *on the confined rotating fluid* by the *diverted* “centrifugal force.” It is, however, but the “reaction” on the fluid of the shell against the above pressure couple exerted on it by the fluid. His failure to recognize an identity which for homogeneity is exhibited by his own analysis, is the clue to the fallacy of his most important results. (See Appendix.)

$\cos v = \frac{3S}{r^3} (C-A) \sin v \cos v$, [since $e = \frac{15}{8\pi} (C-A)$], which is identically the expression for the tilting couple exerted on the earth by the sun's attraction—the couple which causes *precession*; and to which, also, the above distortion (*if it likewise take place*) is due. Hence this tilting of the planes is exactly the distortion the solar couple is capable of producing, and the proper exponent of the intensity of the sun's effort.

But, if the tidal protuberance—the “small elliptic deviation”—be thus the result of a slight tilting of the planes of rotation, it follows that the centrifugal forces of the fluid particles moving in these planes *must shift direction* with the planes themselves; in other words, the planes of repulsive action of the “infinite repelling line” must be regarded as diverted from perpendicularity to the repelling line. A couple, neutralizing the solar couple, will *not* be generated, hence my demonstration founded upon it fails. In fact if we refer to the actual phenomena as I now exhibit them (see Fig. 2),¹ we find that *each circle of revolution of the normal figure is still a perfect circle* (or very nearly so) *in the distorted figure*. The centrifugal forces, exactly balanced before distortion, are no less so *after* distortion.

The planes, then, in which lie the repulsive force produced by rotation, neither remain *stationary*, as the repelling line paraphrase of authoritative usage leaves them; nor do they shift correspondingly with the shifting of *the figure*; but they actually (*while the repelling line itself remains stationary*) undergo a much slighter change of direction by which, as effectually as if they shifted equally with the shifting of the figure while continuing normal to its axis, they frustrate the development of a precession-neutralizing “couple.”²

Having, in what precedes, shown the plausible basis on which my demonstration of the absence of precession in a non-rigid spheroid was founded, and having now explained precisely where the defect of the demonstration lies, I need scarcely say that I find myself compelled to withdraw my conclusion as regards a “solid but yielding spheroid,” viz., that “exactly in the same ratio to the tides of a fluid spheroid that the solid tidal elevations are produced (the actual ellipticity of the earth being nearly that of equilibrium with the centrifugal forces), will the precessional couple due to the tide-producing attraction be neutralized by their centrifugal action;” a withdrawal which requires an “expunging” of considerable portions of article cited at head of this paper, or at least a disclaimer of their virtue as demonstrative of the above dictum.

¹ In Fig. 2 the full periphery is the meridional section of the rotating fluid earth: PP the axis of rotation (answering to the *repelling-line*, which continues *still* the axis of rotation after distortion); $b_1 b_1$ (parallel to equator EE) the normal planes of rotation (only *one* of which is drawn); $b'_1 b'_1$, etc., the same planes as tilted (about a, a, a , etc.) through the minute angle $2e\gamma$, causing a motion of the *axes of figure*, though the whole angle γ , from E to E' , and from P to P' , and a distortion of *figure* (or tidal development), represented by the broken periphery.

In the analytical expressions above C and A are the *moments of inertia* with reference to polar and equatorial axes, respectively.

² The above demonstration refers to the homogeneous fluid spheroid; but we may infer, I think, for heterogeneity whether fluid, or solid but imperfectly rigid, that, however the internal motion of their distortion be thereby modified, the above will hold true.

The observed precession of the earth's axis corresponds very closely (Thomson and Tait, § 828) with that due to a spheroid of its external ellipticity and probable law of internal density; but the fact does not afford, therefore, the supposed argument for rigidity. I have, in the memoir cited at the head of this paper, illustrated by the case of the steel rod how very great must be the rigidity of a solid earth which should exhibit no sensible tidal distortion; and it follows that a mere *thin crust* must be of almost *infinitely* unyielding material to effectually suppress such distortion. And, conceding the (implied) infinite rigidity to a shell or crust, I have furthermore demonstrated (Addendum to paper cited) the fallacy of Mr. Hopkins' conclusion that a minimum thickness of 800 or 1000 miles must be assigned to it. There can be, therefore, no propriety in attributing (with Sir Wm. Thomson) to Mr. Hopkins "the discovery of the earth's solidity." Masterly as is much of his investigation, the vague formula he presents as his final result will bear no such ponderous weight of conclusion as he lays upon it, even if the specific errors I have elsewhere pointed out did not vitiate it; while the preternatural rigidity required for his shell abstracts from its merits as a genuine "Research in Physical Geology."¹ Moreover, Mr. Hopkins' argument loses whatever claims to decide the point which accuracy conceded to his theorem would give, when, instead of the considerable discrepancy (8 to 7, he supposes it to be) in the calculated and of observed precessions (on which he founds his conclusions) there is, as we *now* know, none; or, at least, none assignable.

My conclusion concerning Mr. Hopkins' celebrated problem (see "Addendum"), and my criticism of his results, are fully sustained by the language of Sir Wm. Thomson when he says "a very slight deviation of the inner surface of the shell" (supposed perfectly rigid) "from perfect sphericity would suffice, in virtue of the quasi-rigidity due to vortex-motion, to hold back the shell from taking sensibly more precession than it would give to the liquid, and to cause the liquid (homogeneous or heterogeneous) and the shell to have sensibly the same precessional motion as if the whole constituted one rigid body." (That there is *not* "sensibly the same precessional motion" for the *case of heterogeneity*, forms the main burden of Mr. Hopkins' results.)

Allusion has already been made (note 1, p. 4) to Mr. Hopkins' "case of rotary motion not before investigated." It is that of the small reciprocal oscillation of shell (considered as *perfectly* rigid) and the internal fluid. By direct action on the shell itself, and by *induced* pressure of the fluid on the shell, the whole precessional effect of the foreign attraction takes effect *primarily* on the shell alone; from which ensues a divergence of axes of shell and fluid (as represented in Fig. 2), and a development of reactive force in the fluid (through the displacement of its planes of rotation), by which, "precisely as if it were solid," the fluid reacts upon the shell and adds its moment of inertia to that of the shell, reducing the mean rate of precession to that corresponding to the entire mass. This common *mean*

¹ It is true that physicists had not thought of the exigencies of *rigidity* in this connection until Sir Wm. Thomson pointed them out; nevertheless a "Research into the physical geology" of the case, viewed as to its mathematical requirements, *ought* to have suggested such exigencies.

precession of shell and fluid is, therefore, necessarily attended with minute *relative* oscillations which manifest themselves as a slight periodical "inequality" in the rate of precession of the shell, and also more noticeably as an equally slight periodical "nutations" of its axis. They are, even for a thin shell, and, *à fortiori*, for a thick one (excepting always the special cases alluded to in what follows), *very minute*, "not rising to magnitudes greater than those of the order of solar nutation"¹ (*i. e.*, about one-half second of arc).

The *period* of these oscillations, as generalized from Mr. Hopkins' expressions, is equal to that fraction of the number of days denoted by the reciprocal of the internal ellipticity of the shell, which expresses the ratio of moment of inertia of shell to that of the whole mass. The period, therefore, for a *given* internal ellipticity, varies directly with the moment of inertia of the shell, which, itself, is greater or less as its *thickness* is greater or less.

A critical value for this period, discussed by Mr. Hopkins, is one which differs but slightly from that of solar (semi-annual) nutation (implying a crust thickness of something over 1000 miles); in which case there is, as might be expected from the synchronism, a secular inequality in the solar nutation which may reach great magnitude. A corresponding critical value may happen for the (to observation inappreciable) lunar semi-monthly nutation (which does not enter into Mr. Hopkins' results, and is not discussed by him); but there can be (as I understand the matter) no critical value of this kind connected with the *chief* and sole recognized astronomical nutation (the lunar nineteen yearly), unless the interior ellipticity be *much* less than the $\frac{1}{360}$ (that of the earth's surface), and practically *nil*.² These critical

¹ The *astronomical* nutations with which comparison is made are totally distinct in their origin from these theoretical nutations arising from reciprocal oscillations of shell and fluid, of which the rationale has just been given; as they are, also, from the "slight nutations" mentioned in subsequent pages. *They* (the astronomical) are but subsidiary manifestations of the general *gyratory* motion caused by the sun and moon in their varying relations of declination to the earth's equator.

² Unless the internal ellipticity be such as to constrain the liquid and shell to the same *mean* precessional motions the phenomenon of "precession" passes beyond the range of our power of prediction. The separation of the rotation axes (supposed initially coincident) of shell and fluid becomes greater and greater. *Friction* or viscosity come into powerful action with results we cannot define, *except* indeed to predict a gradual wasting of "vortex-motion" of fluid, and loss of rotation of solid shell. With diminution of internal ellipticity the independent precessional co-efficient of the shell becomes greater than that of the whole mass; the "deviations first sensible" when the ellipticity becomes too small to constrain to unison of precession, would appear to me to be those of *acceleration*.

The case of an *infinitely thin* crust (of *nil* moment of inertia, of course) is *identically* that of the *wholly fluid spheroid* discussed in the text; the deductions to be made referring not to *internal* motion but to *figure*-motion of the surface (see p. 7). The "infinitely thin rigid shell" moves through the

whole angle γ ; that is, it moves through $\frac{1}{2e}$ times the angle to which the fluid planes of rotation must tilt to develop the diurnal tide. The angle γ we have found to be about $1\frac{1}{2}$ and 3 seconds for, respectively, the sun and moon. Such a motion, if *fully* developed (see p. 13 and note), could only obtain as a fluctuation of short (daily) period; but reason has been given (*ibid.*) why this angle cannot be fully developed. If the theorem of this present paper is correct, *precession* and the *astronomical* nutations (which are but parts of precession) would be wholly unaffected. In the foregoing deductions concerning the secondary phenomena of (rigid) *shell* precession and nutation, I am not in entire unison with Sir Wm. Thomson, in his Glasgow Address.

periods, as they are thus determined, are not independent of the thickness of the shell; though for the semi-monthly (lunar) nutation they would correspond, about, to the conventional 40 or 50 miles of the "thin crust" of geologists, and hence should produce sensible effects in connection with that otherwise insensible nutation. Hence the last paragraph of the "Addendum" to paper cited, and one of its summary "conclusions," affirms that "noticeable nutational movements" would be the concomitants of a "thin and rigid shell;" for which even the *ordinary* small oscillations might be distinguishable, and from which by the probable approximation of period to that of semi-monthly nutation, extraordinary magnitudes might ensue. That "conclusion," therefore (the 5th), expressed a *test*, even though not declared, "absolutely decisive against the geological hypothesis of a thin rigid shell full of liquid;" while it had no such test-application to a *thick* one for which the ordinary magnitudes of oscillation would be undistinguishably minute, while extraordinary ones due to coalescing in period with the semi-annual solar nutation require particular values of shell-thickness restricted to narrow limits.

I have already stated that a revision of my published investigations was undertaken in consequence of suggestions made by Prof. Newcomb, last August. He suggested that the law of "conservation of areas" would be found to carry with it an identical precession for solid and liquid spheroid. Quite familiar with the law in this connection, I was nevertheless prompted to inquire how far the *internal motion* of the fluid in forming the tidal protuberances would affect the "areas." I had already discovered (as they have been now described in preceding pages) what these motions must be (p. 43 and note "Problems," etc.); but I have to thank Prof. Newcomb for directing my thoughts toward this matter again. I soon perceived that these internal motions, *by changing the direction of the repelling force*, completely upset my demonstration of *nil* precession; and this without direct reference to the "conservation of areas."

To appreciate now the application of *that* principle; conceive the sun in the equinox—when v (the declination) is zero—the deviation of the planes of rotation are then zero, and the precessional motion is *assumed to be zero*. *No areas* are now generated save those of the earth's diurnal rotation, Cn ; the component of which about the line of the sun's attraction is zero. Now as the sun's right ascension and declination increase, this component of the diurnal-rotation-area develops itself, *pari passu*, in magnitude. But a (with declination acquired) tilting force would be also exerted by the sun; the earth, if perfectly rigid, will *yield to it*, to the impairing of this component, causing an *area-compensating* movement, *gyration* (which is elementary precession), to ensue. Suppose now instead of the body's yielding as a perfectly rigid body, the *planes of rotation individually tilt*. I have shown, elsewhere ("The Gyroscope analytically examined"), that while the *initial* motion of gyration is an actual *tilting*, this latter effect is quickly checked by its own offspring, *gyration*. So it will be also with reference to the tilting of these planes, which may or may not reach the limit of angular displacement denoted by the minute angle ($2\epsilon\gamma$) required to develop the diurnal tide of the equilibrium theory. The principle of "areas" would, therefore, involve for the fluid spheroid, what it does in a rigid earth (as the fact is set forth in the first of the "Problems of Rotary Motion," pp. 6

and 13), viz., almost or quite insensibly minute nutations; but in this latter case, on account of *non-rigidity*, they take the form of internal motion, or fluctuating distortion, rather than of *axial* nutations.

But while it is indisputably true that the actual angular motion of "precession" is at any instant just so much rotation-area converted into gyration-area, and while the principle of areas is, in my opinion, a much surer basis on which to found an *a priori* judgment as to the integrity of the precession of a fluid spheroid than that of the quasi-rigidity conferred by vortex-motion; yet even *this* basis may not seem quite so solid for such a judgment, when we reflect that precession, in its universal acceptation (for a rigid body), as an angular movement always exactly normal to the plane of a variable (in direction and intensity), tilting couple, has no relation *but* of antagonism to the principle of areas; and that all our *demonstrations* of precession, which commence with expounding the *elementary gyration* (e. g., Airy, "Figure of the Earth," Encyc. Met.; Art. "Precession," Encyc. Britta., etc.), demonstrate, *apparently* at least, something that is thus antagonistic: *i. e.*, that an attractive force produces motion directly *normal to its own direction*; that it generates areas about the line connecting its origin with the centre of inertia of the attracted body.¹

I have alluded to this anomaly in the note to page 44 of "Addendum," cited, and the 5th and 6th pages of the first of the "Problems of Rotary Motion;" remarking that precession can at no instant be *exactly* what it is computed to be, and that, either in the whole as a rigid solid, or in the parts, as a yielding one, there must be always going on "slight nutations"—the necessary concomitants of fluctuating transfer of rotary into gyratory area (and the reverse), which must result from the fluctuation in direction of plane and intensity of the tilting couple.

Incidentally it may be interesting to inquire how much these slight nutations may amount to. For the earth, considered as *perfectly* rigid, a *maximum* limit can be announced. Suppose at any instant the sun's declination be ν , and the instantaneous axis and axis of figure (or diurnal rotation) to be at rest; in other words, that they *coincide*. Commencing with this initial state of things, the earth will first *yield* to the sun-couple; *rotation*-area thus lost will transform itself into gyration-area; and the path of the earth's axis of figure will be a continued cycloid (see first of the "Problems of Rotary Motion," p. 3, and note; where ω and θ are *polar* distances) of which the *sagittæ* will be the excessively minute quantity $\frac{1}{2\nu^2}$

¹ The demonstrations referred to in preceding paragraph (said to originate with Frisi), prove really, and *only*, what must be the *incipient* motion, starting from rest, of the *instantaneous axis* of the rotating spheroid subjected to a tilting action like that of the sun's attraction on the earth; which incipient motion they mistake for what it is not (though in the case of the earth the actual things differ inappreciably), its *mean* motion; and hence for the "Measure of the mean motion of the Earth's axis." Starting with a conceded and dynamically calculated *motion* of the *axis of figure*, they lose sight of *that* axis entirely, and *apparently* prove that this fundamental motion never took place, but was really something else. The resulting expression for precession is made *formally* wrong, by having as a factor the reciprocal of the moment of inertia about an equatorial axis instead of about the axis of diurnal rotation; and the above "measure" would be quite inaccurate if applied to planets as oblate as Jupiter, Saturn, and Uranus (see paragraphs 3, 4, and 5, p. 4; those of 6th page, and note 2 to p. 3 of "Addendum," "Problems of Rotary Motion").

$\cos v$; or (referring to value of β , when it is interpreted for the case of the earth's precession in the note, putting $\frac{C-A}{C} = e$.)

$$(c) \quad \frac{6S}{r^3 n^2} e \sin v \cos v.$$

This, by what seems a singular coincidence, is identically the product of our angle γ (see expression (b)) by $2e$; in other words, it is exactly the angle $2e\gamma$ to which our planes of rotation of a fluid spheroid must tilt to form the diurnal tide; the precession affecting part of the tidal protuberance.

This very minute angle (at its greatest about $\frac{1}{50}$ second of arc for the moon, half that for the sun) is the maximum to which the *rigid* earth could be actually *tilted*; but the axis of figure is *never* (except at the equinoxes) in this supposed initial state of rest. It (see "Problems," etc., p. 6) always has *approximately* the gyratory motion (*i. e.*, parallel to the *chord* nearly of the cycloid) in which the tilting effect is suppressed, viz., that of the *mean* gyration due to the sun's relative position. The small nutations will be then but infinitesimal fractions of the minute angle $2e\gamma$, or (c), which we have found to be that of the tilting of the planes of rotation necessary to the production of the diurnal tide.

When we turn now to the *fluid* spheroid we have found that the distortion just mentioned, and which constitutes the diurnal tide, is necessary to the *full* action of the sun-couple *as* upon a *solid and perfectly rigid spheroid*. It would seem, therefore, that the diurnal tide (as *are* the other forms of tide) would be, as Sir Wm. Thomson conjectures, fully developed—*i. e.*, "practically the same as that of the equilibrium theory."¹ On the other hand, this tilting of the fluid planes of rotation involves precisely the same *transfer of rotation into gyration area* as the equal tilting of the rigid spheroid; and this is *double*² the amount due to the *mean* gyration corresponding to the sun's declination; for when (see "Problems," etc., where above cited) the axis of figure is at the lowest point of the cycloid its gyratory velocity is double the *mean* value.

The precessional motion *thus* generated is a *fluctuation*; it waxes from zero to *double* its mean value and again wanes; the axis of figure making synchronously

¹ This dictum, however, seems hardly a legitimate revelation of the light cast by the "theory of quasi-rigidity;" for the tidal distortion of the equilibrium theory being *all* that follows perfect fluidity, it renders "quasi-rigidity" a "nomen inane."

² This may be directly demonstrated: The normal component of rotation-area per unit of time about the solstitial line, is $Cn \sin v$. By the tilting of the planes this would be reduced to $Cn \sin (v - \frac{6S}{r^3 n^2} e \sin v \cos v)$, *i. e.*, a *decrement of area*, (since $e = \frac{C-A}{C}$), of $\frac{6S}{r^3 n} (C-A) \sin v \cos^2 v$.

This requires a compensating *gyration* (*i. e.*, motion about the solstitial line of $\frac{6S}{r^3 n} \frac{C-A}{C} \sin v$, which is double the mean gyration (elementary precession) of the earth (see 20, p. 7, "Problems," etc.). It must be observed that were such a tilting of the planes momentarily to have place (*i. e.*, that the diurnal tide be fully developed), it could only be as a phase of a *periodic fluctuation* corresponding to the cycloidal movement of the rigid spheroid ("Problems," etc., pp. 3 and 13), the "period" being about one day, differing, however, in character from the diurnal *tide*.

the nutations corresponding to the cycloidal path. But if, at the instant indicated, p. 12, the axis of figure, instead of being at rest, be already moving with the proper *mean* motion, that mean motion will be *simply maintained* (as demonstrated p. 6, Note I, "Problems," etc.); and without *sensible* nutation, though the intensity of the tilting couple *slowly* wax or wane. Since, however, gyration-area is but transformed rotation-area, it follows that the (rigid) earth's rotation-axis must have been tilted (from where it was at the equinox) sufficiently to furnish by transformation the required (mean) gyration-area; that is through *half* the angle $2\epsilon\gamma$. For exactly similar reason, if the mean gyration proceeds from the diversion of the planes of rotation, *that* tilting, proceeding from a very slowly waxing force, could ensue only to the *half* amount necessary to formation of the diurnal tide. But though the requisite gyration-area be originally acquired by the tilting of the planes, there is no reason that I can perceive why the resulting distortion should not, *pari passu*, approximately rectify itself (there being, see end of *note*, p. 7, a self-rectifying force, proportionate to the distortion, always acting) to the annulling, nearly, of the tide.

And, moreover, for Laplace's case (a continuous ocean of uniform small depth) the absence of the diurnal tide may be something more than a mere suppression of *elevations* through the counteracting pressure its relative motion develops; it may be this partial absence of *these motions even*; the fluid shell having at the same time *its own precession*.¹ In fact, a fluid *shell* of uniform thickness is certainly as subject to precessional motion, as an *entire* spheroid of fluid.

From the foregoing it appears that though I no longer find a "counteracting-couple" arising from the centrifugal forces acting on the substance of the diurnal tide, by which the precession of a fluid spheroid is neutralized, yet I do find that, "checked by the counteracting effect of induced gyration" (i. e., *precession*) the tide itself is in great degree neutralized; that the "*practical rigidity*" by which (as I showed, Appendix, p. 48, "Problems," etc.) a rotating fluid reacts upon a *shell*, to maintain the integrity of precession, is equally efficacious though there be no shell. This "*practical rigidity*" exhibits itself only in connection with the *diurnal* tide.

The celebrated result of Laplace, just now alluded to, that for a continuous ocean of uniform depth, the diurnal tide—so closely associated as I have shown it to be with the precessional movement—will have no development in *elevation*; but will present itself simply as a determinate relative *motion* of the water—has been treated by me elsewhere (see Proceedings of the Amer. Association, Buffalo meeting, 1876). I have shown that this relative motion (relative as concerns the solid nucleus) is simply what belongs to a shifted position of the diurnally rotating fluid shell, *as if it were a solid* shell, the angle of separation of axes of fluid shell and solid nucleus being the identical angle elsewhere denoted by γ .

Disregarding, as the illustrious author does, the motion of the sun in right ascension and declination, such a shifted position, *initially given*, would generate

¹ This is hinted at in last paragraph of "Addendum" to note to article cited at head of this paper; but in obscure and erroneous language.

pressures exactly counteracting the elevating or depressing force of the attraction, and would maintain the quasi-solidity of the fluid by thus neutralizing internal strains.

I have shown also that, this state supposed once initially established, there is nothing to maintain its *adaptation* to the motion in right ascension and declination of the attracting body, and that the alleged discovery "is not of anything which could have place in nature, even if we concede to 'nature' such an ocean as the theory prescribes; but of a purely mechanical theorem alien to the conditions under which 'tides' are generated."¹

Tidal theories treat the earth as a perfect sphere, disregarding oblateness. When we couple the hypothetic ocean of uniform small depth with the actual oblateness which must belong to the nucleus, we have a shell of uniform thickness and small equatorial ellipticity; fluid, it is true, but rotating (in order to exhibit Laplace's result) *as if it were solid*. The laws of "vortex-motion" have been superadded, in what precedes, to the arguments used in paper cited (Proc. A. A. A. S.), and forbid the self-adaptation which Laplace's theorem requires of the fluid shell to the sun's position, and sustain my assertion that it is only a *mechanical theorem*. I have nevertheless suggested in the paper referred to that the inconspicuousness of this tide in our *actual oceans* (which ought, on the equilibrium theory, to have a development in height equal to two-thirds that of the semi-diurnal) might, perhaps, be accounted for through an imperfect obtaining of some of the conditions (*e. g.*, the meridionally elongated elliptical, horizontal orbits described by the particles in the production of this tide) of Laplace's theorem.

I will conclude by saying that while the correction of grave errors of conclusion in papers of mine published under the sanction of the Smithsonian Institution, and ostensibly deserving the ascription of "Contributions to Knowledge," is a peremptory motive, a secondary object of this memoir is to show that in those papers are to be found essential elements now indicated and brought together (for this paper does little more than to push to their true issue conclusions based on facts there developed), of the "coherently worked out" solution which Sir Wm. Thomson desiderates (Glasgow Address) of the "full problem of precession and nutations, and what is now necessarily included in it, the tides, for a continuous revolving liquid spheroid, whether heterogeneous or homogeneous."

¹ Mr. D. D. Heath ("Deep Sea Tides," etc., Phil. Mag., vol. xxxiii., 1867) has, in an admirable exposition of the *conditions* on which depend the attainment of dynamic tidal solutions, shown that the solution of Laplace's for the diurnal tide is "a *singular* possible case in the midst of impossible ones," "singular in its algebraical no less than in its physical character." Absence of right ascension and declinational motions of the attracting body being the imperious *condition*. The solution is analytically "discontinuous" and therefore not admissible as an expression of phenomena in which its indispensable *condition* is wanting; hence "a purely mechanical theorem" (as I have characterized it) "alien to the conditions under which tides are generated." But though Mr. Heath refers to the "physical character" of the solution, its real physical characteristics, as pointed out by me (from which I arrived at identical conclusions), had not previously been indicated by any of the tidal investigators.

APPENDIX I.

(Note to Page 10.)

It is curious that the demonstration of Hopkins, Sections 10–13 (Phil. Trans., 1839), taken in all the abstractness (not fully realized on first reading) which really belongs to it, involves a mechanical paradox, a real analogue of that in the last clause of § 25 of Sir W. Thomson's "Rigidity of the Earth."

The planes of fluid diurnal rotation being slightly tilted by the displacement of the shell, we have the "repelling line" again, *but* one of which, the radiating repulsion, is exerted in parallel planes *slightly oblique to the line in which lies their origin*. Now in *all* its generality Mr. Hopkins' demonstration is this: A fluid (the rotation of which is like that of the § 23 of the "Rigidity of the Earth" "stopped" and repulsive force substituted for the rotary motion) inclosed in an envelope *of any form*, subjected to the *divertel* force just described, will be acted on at each point by a rotational force for which an analytical expression is found. The demonstration flows from the received laws of "equilibrium" of inclosed fluids, and here we see again the anomalous results to which the substitution of a *force* for the *motion* to which it is due may lead. *If* the fluid takes up this rotation while *everything else remains unchanged*, the action is "perpetual;" and indefinite, thus induced, rotational velocities ensue.

But in reality the rotational force so found is *reaction* of the envelope against the *reverse* rotational motion impressed on *it* by the centrifugal force of the fluid. That reaction *pushes* the planes of rotation into their deviation, and, as if by action of a *spring*, causing the incidental subsequent rotation "as a solid." In fact the fluid cannot yield otherwise than by this yielding of rotational planes, *as such*, and at the same time preserve intact its diurnal rotation.

Overlooking this relation between the impressed rotations on shell and fluid, which must be *in the inverse ratio of their respective moments of inertia* (since the "action" and "reaction" to which they are due are equal)—a relation which is actually realized (though not *recognized*) in Mr. Hopkins' results for homogeneous shell and fluid—he failed to detect the error of his integrated pressures (the integrals of $\int_0^r R dr$ separately computed, pp. 199–201, Phil. Trans., 1840) exerted on the shell by the heterogeneous fluid—unrecognized errors on which (as I have pointed out in Addendum to "Problems," etc.), his conclusions as to the precession of heterogeneousness internally fluid earth are based. The error of estimating *as pressure on the shell* the *total* of the above integrals, lies in the fact that a *part* is consumed in maintaining special configurations in the strata of equal density; configurations which Hopkins himself (in another connection) investigates and defines.

A

CLASSIFICATION

AND

SYNOPSIS OF THE TROCHILIDÆ.

BY

DANIEL GIRAUD ELLIOT, F.R.S.E., ETC.

[ACCEPTED FOR PUBLICATION, JANUARY, 1878.]

P R E F A C E.

IN the following Synopsis, I have given every species of Humming-bird known to me, that in my opinion is entitled to a separate rank, and even of these, it is not impossible that future information will compel us to place some of them among the synonymes of others. Although the Family contains a certain number of groups, composed of species having more or less relationship with each other, I have not seen my way clear to the recognition of any subfamilies, as has been done by other writers.—The *Phæthornithinae*, which constitute Mr. Gould's first subfamily, cannot be considered (as restricted by that Ornithologist) as having all the genera particularly related, either in the form, color of plumage, or habits of their different members; witness, *EUTOXERES*, *GRYPUS*, and *PHÆTHORNIS*; nor are any of these so essentially different from all the rest of the Family as to necessitate their separation into a subfamily. Mr. Gould does not give any characters to distinguish the *Phæthornithinae* from the *Trochilinae*, and I am unable to find any. The fact is, that the Trochilidæ is composed of so many groups, whose species have but little in common, that if it is deemed desirable to institute Subfamily divisions, many would be requisite, and I do not see any advantage that could possibly accrue from such a procedure. I have, therefore, not recognized any subfamilies, but have considered all the species as members of one great united Family. Generic division has been carried probably to a greater extreme among these birds than in any other group known in Ornithology, and there remain but comparatively few species that have not been made to stand at one time or another, as the representative of some so-considered distinct generic form. In the present Synopsis, the recognition of genera has been carried to the farthest limit that seemed practicable, and in every case it has been attempted to give structural characters for the genera which have been acknowledged. Of course, to those Ornithologists who consider that color of plumage is sufficient to establish genera, my treatment will not be acceptable, but in this Family at least, when it is not infrequently observed, that individuals of the same species vary from each other in the hues of their plumage to a great degree, color unsupported cannot be regarded

as worthy of any consideration as a GENERIC character, and, if structural ones exist sufficient for the establishment of a genus, then the hue of the plumage is immaterial. The arrangement here given of the species composing this Family is, I am well aware, very different from all those heretofore proposed. It is not, however, the result of guess or imagination, but has been arrived at by a careful comparison of the different species themselves, for of the 426 acknowledged as distinct in this Synopsis, about 380 are contained in the great collection, by the assistance of which this book has been written, and of the remaining ones, with but few exceptions, I have carefully examined the types. As has already been said by others, no perfect arrangement of the Family is possible at present, so many links being still needed to fill up the gaps, but the discoveries of late years have given us a much better idea of the Trochilidæ than was ever before possible, and many needed desiderata have been obtained, so that for the largest proportion of the Family a tolerably satisfactory arrangement can now be made. Between such genera as PILETHORNIS and EUPETOMENA, EUSTEPHANUS and AITHURUS, THALURANIA and MELLISUGA, SPARGANURUS and OXYPOGON, and some few others, constituting the end and beginning of their respective sections as given in this Synopsis, we cannot at the present time supply the connecting links, but within the last ten years so many extraordinary and unlooked-for forms have been obtained, that it does not seem too much to believe that among the vast unexplored regions of South America, many of the desired links between the genera mentioned will yet be forthcoming. Although one of the largest groups of birds known in Ornithology, it cannot be considered that we are yet acquainted with all the existing species of the Trochilidæ, and it is most probable that perhaps even more gorgeously plumaged and wonderful forms than any known, still remain to be discovered.

As some of the conclusions in this Synopsis, particularly in the matter of synonymy, may be contrary to the views of some Ornithologists, I would suggest that the various papers published by me in the Ibis upon this Family be consulted, as my reasons for many of the determinations will be there found given at length. The following is a list of these papers:—

Those written with the co-operation of Mr. Salvin.

1. (1873). The Genus PILETHORNIS, p. 1.
2. (1873). The Genera PYGMORNIS, GLAUCIS, and THRENETES, p. 269.
3. (1873). On two species of Trochilidæ of the Genus LOPHORNIS, p. 279.
4. (1873). The Genus THALURANIA, p. 353.

Those of which I alone am the author.

5. (1872). The Humming-birds of the West Indies, p. 345.
6. (1874). Description of a new species of EUCEPHALA, with a list of the known species, p. 87.
7. (1874). Remarks on some Typical Specimens of the Trochilidæ, with a description of one new Genus, p. 261.

8. (1874). The Genus *HELIANTHEA*, p. 330.
9. (1875). The Genera *CHLOROSTILBON* and *PANYCHLORA*, p. 149.
10. (1876). Remarks on some Type Specimens of Trochilidæ from the Museums of Neuchatel and Florence, p. 5.
11. (1876). The Genus *LAMPROPYGIA*, p. 54.
12. (1876). The Genera *CYANOMYIA* and *HELIOTRYPHA*, p. 311.
13. (1876). The Genera *HELIOTHRIX*, *CALLIPHLOX*, *CATHARMA*, and *PETASOPHORA*, p. 394.
14. (1877). Review of the Specimens of Trochilidæ in the Paris Museum brought by D'Orbigny from South America, p. 133.
15. (1878). The Genus *THAUMATIAS*, Gould (nec Eeshsh., 1829, nec Bon., 1850), p. 35.

As some of these Genera will not be met with in the present Synopsis, having been obliged to give way to others possessing the right to priority, or else deemed unnecessary, it will be understood that, as employed in the various papers above mentioned, they are intended to represent the Genera used by Mr. Gould in his Monograph of the Trochilidæ. The memoirs having been written for the purpose of critically reviewing the *species* that had been described, the Genera were taken as given by the above-mentioned Ornithologist. In the present work, both Genera and Species have been critically examined, and it has been found necessary to make some important and very unexpected changes, especially in the first of these divisions; but it is believed that in every instance a satisfactory explanation is given for thus deviating from the course, which, when judged by the law of priority, had been ascertained to be incorrect, although perhaps sanctioned in some degree by custom.—In every case also, a genus that was in use has been dropped, when found to have been previously employed in some other branch of zoology. The synonymy is that which, in the majority of cases, refers to a passage in the work cited, that gives some desirable information regarding the species. I have not endeavored to make this “exhaustive,” as the term is used now-a-days in many instances, and consequently many lists of names and nothing else, and also works where the name of the species alone occurs without any information of importance attached to it, will not be found quoted. The chief exceptions to this are the lists of Bonaparte and Reichenbach, which, on account of the many genera first proposed in them, could not be passed over. The value of synonymy has not been deemed to consist in its great length.—The same may be said of the descriptions of the species. Usually one of a genus has been pretty thoroughly described, but I have thought it best, in the majority of instances, to give simply the differences that may exist in allied species, instead of going over the entire plumage, as this merely necessitates endless repetitions that would speedily become wearisome, and serve no useful purpose. Verbose and complicated descriptions have been carefully avoided, for it is not impossible that, after plodding through such a one, the bewildered reader on arriving at the termination has lost all track of the

beginning. Like lengthened useless synonymy, such descriptions if possible should be shunned.

Humming-birds vary greatly in their dimensions, even among members of the same species, and therefore a specimen cannot be decided to be something else because it does not agree exactly with the measurements of some described species, to the eighth of an inch. The total length means from the point of the bill to the end of the tail. Wing, from the shoulder to end of the longest primary. Tail, from the termination of the caudal vertebræ to the end of longest rectrices measured on top. Culmen, from the termination of the frontal feathers to the point.

When considerable difference exists in the dimensions of the sexes, those of the female are given as well as those of the male. In the majority of instances, however, they are too nearly the same to make it necessary that more than one should be recorded, and then that of the female is omitted.

The asterisk, placed before the names of certain species, indicates that it is not contained in my collection.—Those who may possess any of these desiderata, and are willing to dispose of them, would oblige me by informing me of the fact, as I am naturally desirous of making the collection as perfect as possible.

The drawings which illustrate the generic characters are, with but few exceptions, all made from specimens contained in my collection.

D. G. E.

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CLASSIFICATION AND SYNOPSIS OF THE TROCHILIDÆ.

Class AVES.

DIVISION PSILOPÆDES.

Young at birth, helpless, and up to the period of the growth of the feathers, entirely naked, the down being very slight, and not covering the skin. Incapable of feeding themselves, life is sustained by the introduction of food into the throat by means of the parents' bill. The nest is occupied until the birds are full grown.

Order MACROCHIRES.

Picarian birds, with the palate nearly œgithognathous;¹ possessing but one carotid artery, the sinistra; a nude oil-gland, and no cœca. The femoro-caudal, and ambiens muscles, are alone present; the flexor longus hallucis, independent of the flexor perforans digitorum; tensor patagii brevis, pterylosis, and sternum, characteristic. Second, third, and fourth toes directed forwards, the hallux backwards.

FAMILY TROCHILIDÆ.

Body small, sometimes minute, bill varying from feeble to rather stout, generally longer than the head (in one instance exceeding the entire length of the body), usually straight (in one case curved to the extent of a third of a circle), with the tomia inflected, and a short gape devoid of bristles. Nostrils basal, linear, covered by an operculum, sometimes hidden in frontal feathers. Tongue slender, capable of great extension (the cornua of the hyoid curving around and over the back of the skull), and consists of two minute parallel tubes. Wings narrow, pointed, falcate; the primaries (which are ten in number), stiff and long, the secondaries very short. The manus is very long and the humerus extremely short, enabling the wing to be moved with great rapidity. Sternum large with an extremely deep

¹ Humming-birds and Goatsuckers are *Insessomial Schizognaths*. Parker, Trans. Linn. Soc., Vol. I. Zool., 2d ser. p. 100, 1876.

keel. Tail, always of ten feathers, various in shape and size, in some cases exceeding the body in length, in others so short as to be hardly perceptible; the rectrices varying from broad and even, to the shape of spines; tips sometimes spatulate. Tarsi short, either naked, moderately clothed, or completely hidden in tufts of downy feathers. Feet small, toes usually short, the claws curved, sharp, and rather large. Feet used for perching, not for progression, the wings being the instruments employed for almost every change of position. Plumage from plain, even sombre tints, to the most gorgeously brilliant metallic hues known among created things; the iridescent feathers, however, being, in the majority of instances, observable only in the males.¹

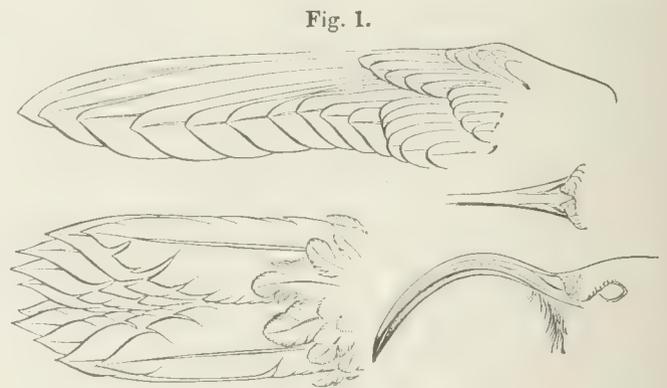
I commence my arrangement of the Family with the genus *EUTOXERES*, which is an aberrant form, not especially allied to any of the known genera, the curious bills of the different species giving them a position apart from the rest of the Trochilidæ. They are large birds, with but little metallic coloring upon any part of their plumage.

Genus I.—*EUTOXERES*.

Eutoxeres. REICH., Syst. Av. Nat., t. xl (1849).
Myiastina, BON., Rev. Mag. Zool. (1854), p. 249.

TYPE.
T. aquila, Bourc.
T. aquila, Bourc.

Ch. Bill greatly curved, forming nearly one-third of a circle; wide at base, narrowing suddenly and becoming compressed laterally; mandible entirely hidden in maxilla, except at the point. Cutting edges of bill, not serrated. Tail cuneate, feathers pointed. Feet large, tarsi bare. Sexes alike in plumage.



Eutoxeres aquila. Bogota. Gould.

Range. Costa Rica, Veragua, Columbia, Ecuador.

Three species are here recognized.

Key to the species.

- | | |
|---|--------------------------|
| A. Striæ on feathers of the throat and breast buffy-white, on abdomen pure white. | 1. <i>E. aquila</i> . |
| B. Striæ on lower parts light buff. | 2. <i>E. heterura</i> . |
| C. Tail, with lateral rectrices deep buff. | 3. <i>E. condamini</i> . |

These birds are remarkable for their greatly curved bills. The plumage is generally sombre, and nearly devoid of metallic hues.

¹ See Appendix, p. 249, for Key to the Genera.

1. *Eutoxeres aquila*.

Trochilus aquila, BOURC., Proc. Zool. Soc. (1847), p. 42.

Eutoxeres aquila, REICH., Syst. Av. Nat., t. xl (1849).—ID., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enumer., p. 12 (1855).—GOULD, Mon. Troch., vol. i, p. 111.—ID., Intr. Troch., octavo ed., p. 36.—CAB. and HEIN., Mus. Hein. Th., iii, p. 3 (note) (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 27.

Polytmus aquila, GRAY, Gen. B., vol. i, p. 108, sp. 39 (1844-49).

Myiadelphia aquila, BON., Rev. and Mag. Zool. (1854) p. 249.

Eutoxeres salvini, GOULD, Ann. Mag. Nat. Hist., 4th ser., vol. i, p. 458 (1868), ex Veragua.

Hab. Costa Rica (eastern side), Veragua, Columbia.

Adult. Top of head and occiput brownish-black, feathers tipped slightly with buff. Upper parts dark shining green; wings purple; under parts brownish-black, striated with buffy-white on the throat and breast, pure white on abdomen and flanks. Median rectrices shining dark green tipped with white. Lateral ones dark green on outer webs, brownish-green on inner, and broadly tipped with white. Maxilla black; mandible flesh-color. Total length, $5\frac{5}{6}$ in. Wing, 3 in. Tail, $2\frac{3}{6}$ in. Culmen, $1\frac{3}{6}$ in.

I cannot perceive that the difference of coloration pointed out by Mr. Gould is of sufficient importance to separate the Veraguan birds specifically from those of Columbia, and have therefore placed the *E. salvini* as a synonym of *E. aquila*.

2. *Eutoxeres heterura*.

Eutoxeres heterura, GOULD, Ann. Mag. Nat. Hist., 4th ser., vol. i, p. 455 (1868).

Hab. Ecuador.

Exactly like the preceding, *E. aquila*, except that the striæ upon the feathers of the under parts are bright buff. This difference is apparently constant. Dimensions the same.

3. *Eutoxeres condamini*.

Trochilus condamini, BOURC., Compt. Rend., tom. 32, p. 186 (1851).—ID., Rev. and Mag. Zool. (1851), p. 186.

Myiadelphia condamini, BON., Rev. and Mag. Zool. (1854), p. 249.

Eutoxeres condamini, GOULD, Mon. Troch., vol. i, pl. 4.—ID., Intr. Mon. Troch., octavo ed., p. 37.—REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enumer., p. 12 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 3 (note 2), (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 29.

Hab. Ecuador.

Easily distinguished from the other two species of the genus, by the coloring of the rectrices. The median ones are dark shining green, tipped with white; next on either side, blackish-brown tipped with white, remainder deep buff, graduating into white at the tips. Total length, $6\frac{5}{6}$ in. Wing, 3 in. Tail, $2\frac{3}{6}$ in. Culmen, $1\frac{5}{6}$ in. Description taken from the type in my collection.

Genus II.—RHAMPHODON.

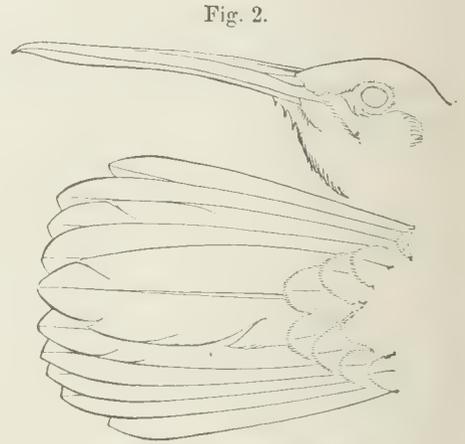
Grypus, SPix. (nec Germ., 1817, Coleop.), Av. Spec. Nov. (1824), p. 79.
Rhamphodon, LESS., Ind. Gen. Ois. du Genre. Troch. (1832), p. viii.

TYPE.
T. nævius, Dumont.
T. nævius, Dumont.

Ch. Bill nearly twice the length of the head, curved; edges of mandibles in the male serrated near the tip which is hooked: culmen compressed at base. Mandible of female curving slightly upwards near the tip, leaving an open space between it and the maxilla at this part. Tail slightly rounded. Wings long and ample. Size large. * Sexes alike in plumage.

Range. Southern Brazil.

The term *Grypus*, bestowed upon the *T. nævius*, Dumont, having been employed seven years previously for a genus of Coleoptera, cannot be again used here, and therefore, RHAMPHODON of Lesson is the one to be adopted. The species, included in the present genus and in the one following, are closely allied. They are large birds, with bills strongly serrated near the tips, and have but little metallic coloring. Indeed RHAMPHODON does not possess any.

1. *Rhamphodon nævius*.

Trochilus nævius, DUMONT, Dict. Sc. Nat., tom. xvii, p. 432.

Grypus ruficollis, SPix., Av. Bras., vol. i, p. 79, tab. 80, fig. 3 (1824).

Rhamphodon maculatum, LESS., Colib., p. 18, t. i (1831).—ID., Ind. Gen. Ois. du Genre. Troch. p. viii (1831).

Rhamphodon nævius, REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enum., p. 12 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 3 (1860).

Grypus nævius, GOULD, Mon. Troch., vol. i, pl. 1.—ID., Intr. Troch., octavo ed., p. 35 (1861).—GRAY, Gen. B., vol. i, p. 105.—BON., Consp. Av., vol. i, p. 147 (1850).—ID., Rev. and Mag. Zool. (1854), p. 249.

Hab. Southeastern Brazil.

Male. Top of head dark brown, superciliary stripe buff; ear-coverts and lores blackish-brown. Upper surface greenish-brown, each feather margined with light brown. Wings purple. Chin and a line down the centre of the throat black, each feather margined with pale buff. Sides of throat reddish-buff. Under parts black, the feathers on the upper part of the breast conspicuously edged with white; abdomen and flanks blackish-brown, feathers edged with buff. Under tail-coverts buff, streaked with dark brown in the centre. Median rectrices reddish-bronze darkest at the tip, next also bronze tipped with buff, which runs in an oblique direction, is most extensive on the outer webs, and occupies the half of the outermost feather. Total length, 6 in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $1\frac{7}{16}$ in.

There is no difference in the plumage of the sexes, but the female has a more slender bill, without hook or serrations.

Genus III.—ANDRODON.

Androdon, GOULD, Ann. Mag. Nat. Hist. 3d ser. (1863), p. 247.

TYPE.

A. æquatorialis, Gould.

Ch. Bill twice as long as head, straight, broad at base, tapering to a point. Cutting edges serrated, tip hooked. Wings long, reaching nearly to the end of the tail, which is rather short, broad, and rounded. Feet moderate; tarsi naked. Size large.

Range. Ecuador.

Fig. 3.



Androdon æquatorialis ♂ Ecuador. J. Gould, type.

1. *Androdon æquatorialis*.

Androdon æquatorialis, GOULD, Ann. Mag. Nat. Hist. 3d ser. (1863), p. 247.

Grypus æquatorialis, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 32, pl. —.

Hab. Ecuador.

Male. Bill long, straight, hooked at point, serrated on the edges of both maxilla and mandible. Forehead dark gray, feathers tipped with metallic grass-green; occiput and nape metallic dark blue. Back, bright metallic light grass-green. Rump white, a few dark blue feathers on the edge of the green of the back. Under parts white, edges of feathers blackish-brown. Under tail coverts olive-green, central part and tips of feathers white. Wings dark purple. Tail, median feathers greenish-gray, tipped with dark green; lateral feathers greenish-gray, with a subterminal bar of dark green, tips white. Maxilla black, mandible flesh-color. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $1\frac{3}{4}$ in.

The female differs in the coloration of the head, which has the forehead dark purplish-brown, top of head bronze, occiput dark metallic green.

The genus GLAUCIS naturally follows ANDRODON. The species comprised in it are birds of moderate size, and of plain plumage. I have placed in it some species heretofore separated under the term THRENETES, as, with the exception of color, by which, indeed, they themselves were not at all assimilated (witness *antoniae* and *leucurus*), they do not possess, so far as I can see, any characters to give them a distinctive generic rank.

Genus IV.—GLAUCIS.

TYPE.

T. hirsutus, Gmel.

T. leucurus, Linn.

T. antoniae, Bourc. and Muls.

Glaucis, BOIE, Isis (1831), p. 545.

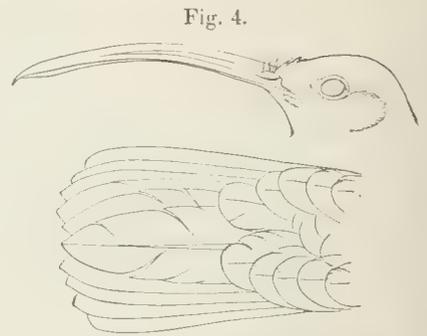
Threnetes, GOULD, Intr. Troch., octavo ed. (1861), p. 40.

Dnophera, HEINE, Journ. für Ornith. (1863), p. 175.

Ch. Bill long, much curved, stout, high at base. Wings long, narrow. Tail moderate, rounded, feathers pointed in young. Sexes alike in plumage.

Range. Central America, Venezuela, Guiana, Brazil, Columbia, and Ecuador.

Six species belong to this genus, according to my views.



Glaucis hirsutus. Merida, Venezuela. Goering.

A. Under parts buff.

a. Tail chestnut, with a subterminal black bar, tips white. Median rectrices shining green, tip white.

b. Tail reddish-bronze, tip whitish.

B. Throat black.

a. Tail green with light edges.

b. Tail with central feathers green, tips white, lateral ones white margined more or less with blackish-brown.

c. Tail, median feathers green, rest buff margined with blackish-brown on the outer ones.

d. Tail, median feathers dark green, lateral ones pure white, with a very broad subterminal black band.

1. *G. hirsuta.*

2. *G. dorhni.*

3. *G. antoniæ.*

4. *G. leucurus.*

5. *G. cervinicauda.*

6. *G. ruckeri.*

1. *Glaucis hirsuta.*

Trochilus hirsutus, Gmel., Syst. Nat., tom. i. p. 490 (1788).

Trochilus brasiliensis, Lath., Ind. Orn., vol. i. p. 308, sp. 23 (1790).

Trochilus ferrugineus, Wied., Beitr., vol. iv., p. 120, sp. 21.

Trochilus mazepa, Less., Troch., p. 18, pl. 3 (1831).

Trochilus superciliosus, Less., Colib., t. 6. ♀? (1831).

Glaucis hirsuta, Boie, Isis (1831), p. 545.—Reich., Aufz. der Colib. (1853), p. 15.—Id., Troch. Enum. (1855), p. 12.—Bon., Rev. and Mag. Zool. (1854), p. 249.—CAB. and HEIN., Mus. Hein. Th., iii, p. 4 (1860).—Gould, Mon. Troch., vol. i, pl. 5.—Id., Intr. Troch., octavo ed., p. 38 (1861).—SALV. and ELLIOT, Ibis (1873), p. 276.—Muls., Hist. Nat. Ois. Mouch., tom. i. p. 39.

Trochilus dominicus, Licht. (nec Linn.), Doublt., p. 10, sp. 110.

Polytmus hirsutus, Gray, Gen. B., vol. i, p. 108, sp. 83 (1844-49).

Glaucis mazepa, Gould, Mon. Troch., vol. i, pl. 6.—Id., Intr. Troch., octavo ed., p. 38.—Reich., Aufz. der Colib., p. 15.—Id., Troch. Enum., p. 12.—Bon., Rev. and Mag. Zool. (1854), p. 249.

Glaucis melanura, Gould, P. Z. S. (1860), p. 364.—Id., Mon. Troch., vol. i, pl. 9.—Id., Intr. Troch., octavo ed., p. 39 (1861).

Glaucis lanceolata, Gould, Mon. Troch., vol. i, pl. 8.—Id., Intr. Troch., octavo ed., p. 39.

Glaucis aenea, Lawr., Proc. Acad. Nat. Sc., Phil. (1867), p. 232.

Hab. Costa Rica to Rio de Janeiro, along the eastern coast of South America. Islands of Tobago and Trinidad.

Adult. Entire upper surface and sides of the neck, shining green, suffused with dark brown on the head. Wings purplish-brown; under surface varying from chestnut-red to buff. Tail rounded; median rectrices shining green tipped with white. Bill, maxilla black, mandible flesh-color. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $1\frac{1}{8}$ in.

The young birds have the tail feathers sharply pointed, and the black subterminal

bar is very conspicuous, but as they grow older the rectrices lose their pointed tips, and become more and more rounded, and the black bar grows narrower, sometimes becoming obsolete.

2. **Glaucis dornhi*.

Trochilus dornhi, BOURC., Ann. Soc. Sci., Lyon (1852), ♀.

Grypus spixi, GOULD, P. Z. S. (1860), p. 304.—ID., Mon. Troch., pl. 2, vol. i.—ID., Intr. Mon. Troch., p. 35, ♂.

Glaucis dornhi, GOULD, Mon. Troch., vol. i, pl. 1.—ID., Intr. Mon. Troch., octavo ed., p. 39, ♀?—SALV. and ELLIOT, Ibis (1873), p. 276.—REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enum., p. 12 (1855).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 44.—CAB. and HEIN., Mus. Hein. Th., iii, p. 4 (note 2).—BON., Rev. and Mag. Zool. (1854), p. 249.

Hab. Brazil.

I place this species in the present genus, because the bill does not appear to have the peculiar hook, characteristic of *Rhamphodon*, nor do the mandibles possess more serration on their edges than is perceived in the majority of humming-birds. See our remarks in the Ibis, 1873, p. 276. This bird is easily distinguished by the colouring of the tail; it resembles the *G. hirsuta*, but has all the rectrices reddish-bronze, the females tipped with white, most extensive on the outermost feather. Total length, $4\frac{7}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $1\frac{1}{2}$ in.

3. *Glaucis antoniæ*.

Trochilus antoniæ, BOURC. and MULS., Ann. Soc. Agric., Lyon (1846), p. 329.

Lampornis antoniæ, BON., Consp. Gen. Av., vol. i (1850), p. 72

Aphantochroa antoniæ, REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enum., p. 12 (1855).

Polytmus antoniæ, GRAY, Gen. Birds, vol. i, p. 108, sp. 37.

Threnetes antoniæ, GOULD, Mon. Troch., vol. i, pl. 15.—ID., Intr. Troch., octavo ed., p. 40.—SALV. and ELLIOT, Ibis (1873), p. 278.

Dnophera antoniæ, HEINE, Journ. für Ornith. (1863), p. 175.

Glaucis antoniæ, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 46.

Hab. Cayenne.

Throat black, sometimes a light band across the upper part of breast, entire rest of plumage very dark greenish-bronze, in some specimens almost black. Central rectrices shining dark green; lateral ones purplish-brown glossed with green. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{5}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, 1 in.

4. *Glaucis leucurus*.

Trochilus leucurus, LINN., Syst. Nat. (1766), vol. i, p. 190.—GMEL., Syst. Nat. (1788), vol. i, p. 487.—D'ORB, and LAFRES, Syn. Av. ii, p. 32, sp. 29 (1838).

White-tailed Humming-bird, LATH., Gen. Syn., vol. ii, p. 757.—ID., Gen. Hist. Birds, vol. iv, p. 308.

Polytmus leucurus, GRAY, Gen. Birds, vol. i, p. 108 (1844-49).

Glaucis leucurus, BON., Consp. Gen. Av., p. 67 (1850).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 49.

Threnetes leucurus, GOULD, Mon. Troch., vol. i, pl. 13.—ID., Intr. Troch., octavo ed., p. 40.—BON., Rev. and Mag. Zool. (1854), p. 249.—REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enum., p. 12 (1855).—SALV. and ELLIOT, Ibis (1873), p. 277.—ELLIOT, Ibis (1877), p. 142.

Hab. Surinam.

Upper surface and median rectrices shining green. Wings purple, lateral feathers white, margined and stained more or less with dark brown, most extensive on the

outermost feather. Lores and auriculars brown. Chin and throat black, bordered on each side by a line of white. A band of reddish-buff crosses the lower part of the throat. Breast and flanks shining green, abdomen grayish-buff. Under tail coverts olive-green margined narrowly with buff. Maxilla black, mandible flesh-color, tip black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, 1 in.

5. *Glaucis cervinicauda*.

Threnetes cervinicauda, GOULD, P. Z. S. (1854), p. 109.—ID., Mon. Troch., vol. i, pl. 14.—ID., Intr. Troch. octavo ed., p. 40.—SALV. and ELLIOT, Ibis (1873), p. 278.

Hab. Upper Amazon, Ecuador, Columbia.

This species is almost precisely the same as the preceding, and it is rather difficult to tell them apart. The chief and only difference is that the tail of this bird is buff, where the other is white, but I have specimens from Surinam of *G. leucurus*, which also have buff on the rectrices. I think that with a sufficiently large series of specimens to enable a satisfactory opinion to be formed, it will be found that individuals of the two species, as usually considered, are in reality but representatives of a single one, with a wide dispersion. Total length, 5 in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $1\frac{1}{4}$ in.

6. *Glaucis ruckeri*.

Trochilus ruckeri, BOURC., P. Z. S. (1847), p. 46.

Polytmus ruckeri, GRAY, Gen. Birds, vol. i, p. 108.

Threnetes ruckeri, REICH., Aufz. Colib., p. 15.—ID., Troch. Enum., p. 12.—BON., Rev. and Mag. Zool. (1854), p. 249.

Glaucis ruckeri, GOULD, Mon. Troch., vol. i, pl. 11.—ID., Intr. Troch., octavo ed., p. 40.—CAB. and HEIN., Mus. Hein. Th., iii, p. 4 (note 3) (1860).—SALV. and ELLIOT, Ibis (1873), p. 278.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 47.

Glaucis fraseri, GOULD, Mon. Troch., vol. i, pl. 12.—ID., Intr. Troch., octavo ed., p. 40 (1861).

Hab. Central America, Ecuador.

Upper parts shining green, brown on the head; upper tail feathers margined with buff. Wings purple. Chin and upper part of throat blackish-brown; lower part bright rufous, a buffy stripe behind the eye, another below. Lores and ear-coverts black. Under surface brownish-gray; under tail coverts bronzy-green. Median rectrices shining green tipped with white, remainder white, with a very broad subterminal black bar. Maxilla black, mandible flesh-color, tip black. Total length, $4\frac{1}{2}$ in. Wing, $1\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $1\frac{1}{8}$ in. Some examples are bright bronze-green above, and they seem to vary in color on the upper parts as is observed among specimens of *G. hirsuta*.

Genus V.—DOLEROMYA.

Doleromya, BON., Rev. and Mag. Zool. (1854), p. 249.

Dolerisca, CAB. and HEIN., Mus. Hein. (1860), Th., iii, p. 6.

TYPE.

T. fallax, BOURC.

T. fallax, BOURC.

Ch Bill longer than the head, straight, broad, and flat at base. Wings long, primaries rather broad, the first slightly pointed. Tail even, feathers rather broad and slightly pointed. Feet large, tarsi partly feathered. Sexes alike.

Range. Venezuela.

One species is known.

Fig. 5.



Doleromya fallax Venezuela. Verreaux.

1. *Doleromya fallax.*

Trochilus fallax, BOUCE., Rev. Zool. (1843), p. 103.

Trochilus (Lampornis) fulviventris, GOULD, P. Z. S. (1846), p. 88.

Polytmus fallax, GRAY, Gen. B., vol. i, p. 108, sp. 55.

Leucippus fallax, BON., Consp. Gen. Av., p. 73, sp. 1 (1850).—REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 8, pl. 783, figs. 4820-21 (1855).—GOULD, Mon. Troch., vol. ii, pl. 56.—ID., Intr. Troch., octavo ed., p. 56 (1861).

Doleromya fallax, BON., Rev. and Mag. Zool. (1854), p. 249.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 206.

Dolerisca fallax, CAB. and HEIN., Mus. Hein., Th., iii (1860).—SCLAT. and SALV., Nomencl., p. 79 (1873).

Dolerisca cervina, GOULD, Intr. Troch., octavo ed., p. 56 (1861).

Hab. Venezuela.

Adult. Top of head olive-brown tinged with green; upper surface light green; four central tail feathers bronzy-green; lateral ones bronze-green at base, passing into black, and largely tipped with white, most extensive on external feathers. Throat, breast, abdomen, and flanks reddish-buff. Under tail-coverts white. Wings purplish-brown. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

Genus VI.—PILEOPTILA.

TYPE.

C.? *sordida*.

Phæoptila, GOULD, Intr. Mon. Troch., octavo ed., p. 169 (1861).

Ch. "Bill longer than the head, fleshy at the base and slightly arched; wings of medium length; tail the same, and slightly forked; feet rather stout; hind toe and nail shorter than the middle toe and nail." (Gould, loc. cit.)

Range. Mexico.

But one species is known, which I consider should follow *DOLEROMYA*, as being far more naturally its position than when placed next to *IACHE*, where it has usually been left, and with which genus I cannot perceive that it has anything in common.

Fig. 6.



Phæoptila sordida. Oaxaca. Gould.

1. *Phæoptila sordida*.

Cyanomyia? sordida, GOULD, Ann. Mag. Nat. Hist. (1859), p. 97, vol. iv, ♂.

Uranomyia sordida, CAB. and HEIN., Mus. Hein. Th., iii, p. 41 (note) (1860).

Phæoptila sordida, GOULD, Mon. Troch., vol. v, pl. 340.—ID., Intr. Troch., octavo ed., p. 169.

Phæoptila zonura, GOULD, Intr. Troch., octavo ed., p. 170, ♀ (1861).

Doleromyia sordida, MULS., Hist. Ois. Mouch., tom. i, p. 207.

Hab. Mexico (Oaxaca).

Male. Upper surface bronzy-green, brown on top of the head, under parts dark grayish-brown. Ear-covers blackish-brown. Vent white. Tail bronzy olive-green. Wings pale purplish-brown. A white spot behind the eye. Bill flesh-color, tip black. Feet black. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{7}{8}$ in.

Female. Differs in being lighter beneath, and in having a subterminal blackish-brown band on the lateral rectrices, which are also tipped with grayish-white. Dimensions the same as the male.

One of the most extensive of the genera of Humming-birds is now reached: viz. PLETHORNIS, comprising no less than twenty-two species. The majority are plainly attired, without any metallic coloring, and all are chiefly remarkable for their peculiarly shaped tails, the middle feathers of which extend beyond the rest, and are always longest in the females. I have included in this genus those birds usually separated under the term PYGMORNIS, as I do not find that they really possess any characters to entitle them to a distinct generic rank, and it is impossible to ascertain where PLETHORNIS ends and PYGMORNIS begins. All the species are closely related and form one natural group.

Genus VII.—PLETHORNIS.

Phæthornis, SWAINS, Zool. Journ. (1827), p. 357.

Phæthornis, BOIE, Isis (1831) p. 548.

Phæthornis, LESS., Ind. Gen. and Syn. Genr. Troch. (1832), p. xiv.

Ptyonornis, REICH., Aufz. der Colib., p. 14 (1853).

Eremita, REICH., Aufz. der Colib., p. 14 (1853).

Ametornis, REICH., Aufz. der Colib., p. 14 (1853).

Orthornis, BON., Rev. and Mag. Zool. (1854), p. 249.

Guyornis, BON., Rev. and Mag. Zool. (1854), p. 249.

Pygmornis, BON., Rev. and Mag. Zool. (1854), p. 250.

Toxateuches, CAB. and HEIN., Mus. Hein. (1860), Th., iii, p. 11.

Mesophila, MULS. and VERR., Class. Troch. (1865), p. 17.

Momus, MULS. and VERR., Class. Troch. (1865), p. 19.

Pygornis, MULS. and VERR., Class. Troch. (1865), p. 18.

Anisoterus, MULS., Hist. Nat. Ois. Mouch. (1873), tom. i, p. 72.

Milornis, MULS., Hist. Nat. Ois. Mouch. (1873), tom. i, p. 77.

TYPE.

T. superciliosus, Linn.

T. superciliosus, Linn.

T. superciliosus, Linn.

T. eurynome, Less.

T. pygmaeus, Spix.

T. bourcierii, Less.

T. bourcierii, Less.

T. guyi, Less.

T. intermedius, Less.

T. guyi, Less.

T. yarouqui, Bourc.

T. idaliæ, Bourc.

T. striigularis, Gould.

T. pretrii, Less.

T. squalidus, Temm.

Ch. Bill curved, sometimes straight, much longer than the head, slender, terminating in a sharp point. Median pair of rectrices prolonged far beyond the rest, this elongation greatest in the females and young. Tail cuneate, or rounded. Wings long and pointed. Feet rather small, tarsi bare. Sexes alike.

Range. Southern Mexico to and including Bolivia on the west coast of South America, and to the southern parts of Brazil on the east. Not found in the West Indies.

Twenty-two species of this genus are here recognized. They have been separated into many genera by various authors, as the list above given will show, but according to my view, the species constitute only a single genus, composed of various groups, no one of which exhibits generic characters of sufficient importance to separate it from the rest.

Key to the species.

- | | |
|--|-------------------------------|
| A. Bill nearly straight. | |
| a. Pale buff beneath. | 1. <i>P. bourcierii</i> . |
| b. Deep rufous beneath. | 2. <i>P. philippi</i> . |
| B. Bill curved. | |
| a. Dark gray or iridescent green beneath; adult males with the extremity of median rectrices reduced to a point. | |
| a'. Base of rectrices black. | 3. <i>P. yaruqui</i> . |
| b'. Rump and base of rectrices green. | 4. <i>P. guyi</i> . |
| c'. Rump and base of rectrices bluish-green. | 5. <i>P. emiliae</i> . |
| b. Gray or rufescent beneath. | |
| a'. Rectrices next to median very long. | |
| a''. Grayish-white beneath. | 6. <i>P. augusti</i> . |
| b''. Rufescent beneath. | 7. <i>P. pretzii</i> . |
| b'. Central rectrices far exceeding the rest in length. | |
| a''. Species with median gular stripe. | |
| a'''. Buff beneath. | |
| 1. Rump narrowly edged with fulvous. | 8. <i>P. superciliosus</i> . |
| 2. Rump broadly edged with fulvous. | 9. <i>P. longirostris</i> . |
| b'''. Gray beneath. | |
| 1. Rump banded with gray. | 10. <i>P. hispidus</i> . |
| c'''. Rufescent beneath. | |
| 1. Upper tail-coverts clear rufous. | 11. <i>P. serratophorus</i> . |
| b''. Species with scale-like markings on the throat. | |
| a'''. Whitish beneath. | 12. <i>P. anthropilus</i> . |
| b'''. Rufescent beneath. | |
| 1. Large size. | 13. <i>P. eurynome</i> . |
| 2. Small size. | 14. <i>P. squalidus</i> . |
| c'. Central rectrices of females longer than the rest. Tail of male rounded. | |
| a''. Rump rufescent or bright rufous. | |
| a'''. Tail feathers very broad, central ones acute. | 15. <i>P. longuemareus</i> . |
| b'''. Tail feathers narrow. | 16. <i>P. adolphi</i> . |

Fig. 7.



Phæthornis superciliosus. ♂. Conisjata, Peru. Whitely.

- | | | | |
|------|---|-----|---------------------------|
| c''' | Median tail feathers subterminally black. | 17. | <i>P. griseigularis</i> . |
| d''' | Throat gray striated with black. | 18. | <i>P. strigularis</i> . |
| b'' | Rump green, same color as the back. | 19. | <i>P. idaliæ</i> . |
| e'' | With prominent pectoral band in the male. | | |
| a''' | Mandible basal half yellow. | | |
| | 1. Lateral rectrices bronzy-brown tipped with buff. | 20. | <i>P. pygmæus</i> . |
| | 2. Lateral rectrices black. | 21. | <i>P. episcopus</i> . |
| b''' | Mandible three-fourths yellow. | 22. | <i>P. nigricinctus</i> . |

The birds composing this group are moderate to almost minute in size, with usually slightly curved bills, and a plumage generally wanting in metallic hues. They are dwellers of the thick forests, apparently preferring dark and gloomy situations. The sexes are alike in plumage.

1. *Phæthornis bourcieri*.

- Trochilus bourcieri*, LESS., Trochil. (1832), p. 62, t. 18.—BON., Consp. Gen. Av., vol. i, p. 67 (1850).
Phæthornis bourcieri, GRAY, Gen. Birds, vol. i, p. 104, sp. 9.—GOULD, Mon. Troch., vol. i, pl. 25.—ID., Intr. Troch., octavo ed., p. 43 (1861).—SALV. and ELLIOT, Ibis (1873), p. 13.
Ametrornis abnormis, REICH., Journ. für Ornith. (1853), p. 14.—PELZ., Orn. Bras., pp. 27, 56.—REICH., Aufz. der Colib., p. 14.—ID., Troch. Enum., p. 12.
Ametrornis bourcieri, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 10 (1860).
Orthornis bourcieri, BON., Rev. and Mag. Zool. (1854), p. 249.
Phæthornis bourcieri, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 85.—BON., Consp. Av., p. 67.

Hab. Pebas, Peru (Hauxwell), Marabitanas (Natt).

Adult. Upper surface bronze-green. Upper tail coverts tipped with buff, and have a subterminal bar of dark brown. Wings purple. Under surface grayish-buff. Tail bronze-green at base deepening to black towards the extremities and tipped with buff. The median rectrices elongated, with their ends pure white. Bill straight, maxilla black, mandible flesh-color, the point dark brown. Total length, $5\frac{1}{4}$ in. Wing, 2 in. Tail, $2\frac{1}{2}$ in. Culmen, 1 in.

2. *Phæthornis philippi*.

- Trochilus philippi*, BOURC., Ann. Sc., Lyon (1847), p. 623.—BON., Consp. Gen. Av., vol. i, p. 68.
Trochilus philippi, BOURC., Rev. Zool. (1847), p. 401.
Phæthornis philippi, GRAY, Gen. Birds, vol. i, p. 104, sp. 18.—GOULD, Mon. Troch., vol. i, pl. 21.—ID., Intr. Troch., octavo ed., p. 43.—SALV. and ELLIOT, Ibis (1873), p. 13.
Phæthornis philippi, BON., Consp. Av., p. 68 (1850).
Orthornis defilippii, BON., Rev. and Mag. Zool. (1854), p. 249.
Ametrornis Defilippii, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).—CAB. and HEIN., Mus. Hein. Theil., iii, p. 10 (note) (1860).
Phæthornis defilippii, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 87.

Hab. Bolivia.

Head and back bronzy-green. Upper tail coverts shining green, with a subterminal dark brown bar, and largely tipped with dark rufous, this last color giving the predominant hue to this part. Wings purplish-brown. Entire under parts rich dark buff. Median rectrices have the base bronzy-green, graduating into

brownish-black, with their elongated tips white. Lateral feathers shining bronze-green, at base succeeded by a broad black bar, and tipped with rufous. Bill straight. Maxilla black, mandible flesh-color, tip brown. Total length, $5\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{3}{4}$ in. Culmen, $1\frac{1}{4}$ in. Description taken from the unique type in my collection.

3. *Phæthornis yaruqui*.

Trochilus yaruqui, Bourc., Compt. Rend., tom. xxxii. p. 187 (1851).

Phæthornis yaruqui, Gould, Mon. Troch., vol. i. pl. 27.—ID., Intr. Troch., octavo ed., p. 44.—SALV. and ELLIOT, Ibis (1873), p. 11.—REICH. Aufz. der Colib., p. 14.—ID., Troch. Enum., p. 12.

Phæthornis yaruqui, Muls., Hist. Nat. Ois. Mouch., tom. i, p. 56.

Guyornis yaruqui, Bon., Rev. and Mag. Zool. (1854), p. 249.

Toxateuches yaruqui, Cab. and Hein., Mus. Hein. Th., iii. p. 11 (note) (1860).

Hab. Ecuador.

Top of head very dark brown. Entire body dark shining green. Superciliary stripe and one at base of mandible buff. Tail black, central feathers tipped with white. Young birds have these quite long, but they become shorter with age, until in the adult males, they are but little longer than the lateral feathers. The white portion also becomes less, until it is reduced to little more than a spot. Maxilla black, mandible flesh-color, tip black. The females apparently always retain their elongated median rectrices, which do not become shortened by age, and the under surface of the body is not of so dark a color as is observed in the males. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{3}{8}$ in.

4. *Phæthornis guyi*.

Trochilus guyi, Less., Hist. Troch., p. 119. t. 44 (1831).

Phæthornis guyi, Gray, Gen. Birds, vol. i, p. 104, sp. 6.—Bon., Consp. Gen. Av., vol. i. p. 67 (1850).—Gould, Mon. Troch., vol. i, pl. 26.—ID., Intr. Troch., octavo ed., p. 44.—SALV. and ELLIOT, Ibis (1873), p. 12.

Phæthornis guyi, Reich., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).

Guyornis typus, Bon., Rev. and Mag. Zool. (1854), p. 249.

Phæthornis guyi, Muls., Hist. Nat. Ois. Mouch., tom. i. p. 58.

Hab. Trinidad, Venezuela, Eastern Peru.

Upper surface shining green. Wings purplish-brown. Upper tail coverts shining dark green, edged with white, and barred subterminally with black. Stripe above and behind the eye, another below it, and a third in the centre of the throat, dark buff. Auriculars and lores black. Under surface ash-gray; flanks glossed with green; abdomen buff. Tail shining green at base, remaining portion black tipped with white. Maxilla black, mandible flesh-color tipped with black. Total length, 6 in. Wing, $2\frac{1}{2}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $1\frac{5}{8}$ in.

5. *Phæthornis emiliae*.

Trochilus emiliae, Bourc., Ann. Soc. Sc., Lyon (1846), p. 317.

Trochilus apicalis, "Licht.," Cab., Tsch. Fann. Per., p. 243 (1844).—Hein., Journ. für Ornith. (1863) p. 177.

Phæthornis emiliae, Bon., Consp. Av., vol. i, p. 68 (1850).—ID., Rev. and Mag. Zool. (1854), p. 249.

Phæthornis apicalis, Bon., Consp. Av., vol. i, p. 68 (1850).

Phæthornis emiliae, Gray, Gen. B. vol. i, p. 104, sp. 7.—Reich., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).—Gould, Intr. Troch., octavo ed., p. 44 (1861).—SALV. and ELLIOT, Ibis (1873), p. 12.

Hab. Costa Rica, Veragua, Columbia.

Precisely like the *P. guyi*, but the upper tail coverts and base of tail are blue instead of green. Dimensions the same.

6. *Phaethornis augusti*.

Trochilus augusti, BOUCE., Ann. Sc. Phys. etc., Lyon (1847), vol. i, p. 623.

Phaethornis augustæ, BON., Consp. Gen. Av., vol. i, p. 68.

Phaethornis augusti, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).—GOULD, Mon. Troch., vol. i, pl. 29.—BON., Rev. and Mag. Zool. (1854), p. 249.—GOULD, Intr. Troch., octavo ed., p. 45 (1861).—WYATT., Ibis (1871), p. 376.—SALV. and ELLIOT, Ibis (1873), p. 10.

Phaethornis augusta, GRAY, Gen. B., vol. i, p. 104.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 75.

Hab. Venezuela, Columbia (Wyatt).

Top of head dark brown; back grayish-bronze; upper tail coverts shining green in the centre of the feathers, broadly margined with red, this being the predominant color of this part of the body. Line above and behind the eye and one beneath, white. Under parts ashy-gray, feathers of the throat lighter and with a central mark of dark brown. Tail bronzy at base, succeeded by a black bar and tipped with white. Central feathers bronze graduating into white, which latter hue occupies fully a third of the feathers. Median pair longest, the rectrices on either side longer than the others, but not quite so elongated as the middle pair. Maxilla black, mandible flesh-color, tip black. Total length, $6\frac{1}{2}$ in. Wing $2\frac{1}{4}$ in. Tail $3\frac{1}{8}$ in. Culmen, $1\frac{1}{4}$ in.

7. *Phaethornis pretrei*.

Trochilus pretrei, LESS. et DELATTE., Rev. Zool. (1839), p. 20.

Trochilus superciliosus, MAX., Beitr., vol. iv (1832), p. 116.

Phaethornis pretrei, GRAY, Gen. Birds, vol. i, p. 104, t. 35, sp. 16.—GOULD, Mon. Troch., vol. i, pl. 28.—REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).—BON., Rev. and Mag. Zool. (1854), p. 249.—SALV. and ELLIOT, Ibis (1873), p. 11.

Phaethornis pretrei, BON., Consp. Gen. Av., vol. i, p. 68 (1859).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 72.

Phaethornis superciliosus, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 9.—GOULD, Intr. Troch., octavo ed., p. 45 (1861).

Hab. Brazil, Minas Geræs, Bahia.

Top of head dark brown, back bronze-green. Wings purple. Upper tail coverts rust-red. Auriculars blackish-brown. Superciliary stripe and one below the eye, buff. Throat light buff in the centre, rest of under parts deep buff. Median rectrices bronze-green, their elongated tips pure white. Next one on either side longer than the other lateral feathers, and like them is bronze-green at base, succeeded by a broad black band, and tipped with white. Maxilla black, mandible red, tipped with black. Total length, 6 in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{7}{8}$ in. Culmen, $1\frac{1}{8}$ in.

8. *Phaethornis superciliosus*.

Trochilus superciliosus, LINN., Syst. Nat. (1766), tom. i, p. 189.—VIEILL., Ency. Meth., vol. ii, p. 549, sp. 5.—LESS., Hist. Nat. Colib., p. 35, pl. 6 (1831).—ID., Trait. Orn., p. 288 (1831).—D'ORB. and LAFRES, Syn. Av., ii, p. 32, sp. 27 (1838).

Brin blanc, MALE, VIEILL., Ois. Dor., tom. i, p. 37, pl. 17 (1802).

- Phathornis superciliosus*, SWAIN, Class. B., vol. ii, p. 330 (1837).—GRAY, Gen. B., vol. i, p. 104.—REICH., Troch. Enum., p. 12 (1853).—ID., Aufz. der Colib., p. 14 (1855).—GOULD, Mon. Troch., vol. i, pl. 17.—SALV. and ELLIOT, Ibis (1873), p. 4.—ELLIOT, Ibis (1877), p. 141.
- Phæthornis malaris*, NORDEN., Erm. Reise. Alt., pl. 2 (1835).—GRAY, Gen. B., vol. i, p. 104, sp. 2.—BOX., Consp. Av., vol. i, p. 67 (1850).—CAB. and HEIN., Mus. Hein. Th., iii, p. 9 (1860).—GOULD, Intr. Troch., octavo ed., p. 41, sp. 17 (1861).
- Phathornis superciliosus*, BOX., Consp. Av., p. 67 (1850).—ID., Rev. and Mag. Zool. (1854), p. 249.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 61.
- Phathornis malaris*, BOX., Consp. Av., p. 67 (1850).—ID., Rev. and Mag. Zool. (1854), p. 249.
- Phathornis consobrinus*, "BOURC." REICH., Aufz. der Colib., p. 17 (1853).—GOULD, Intr. Troch., octavo ed., p. 42.
- Phathornis fraterculus*, GOULD, Mon. Troch., vol. i, pl. 18.—ID., Intr. Troch., octavo ed., p. 42 (1861).
- Phathornis moorci*, LAWRE., Ann. N. Y. Lyc. Nat. Hist., vol. vi, p. 258 (1858).

Hab. Guiana, Brazil, Columbia, Ecuador, and Peru.

The adult has top of head dark brown, sometimes glossed with dark green. Nape and back shining green or bronze; rump has all the feathers narrowly edged with rufous, with a subterminal bar of dark brown, and the remaining portion like those of the back. Tail shining green at base, succeeded by a jet black band and tipped with buff. Central pair of rectrices much longer than the rest, extend to a point, and are pure white for nearly their entire length beyond the lateral feathers. Occasionally some of the lateral rectrices are edged with white. Under parts dark gray on breast and throat, changing to buff on the abdomen and lower tail coverts. Some specimens have a median buff gular stripe, others have the entire throat blackish-brown. Stripe over the eye, and one from the maxilla going under the eye, buff. Bill black on the maxilla, flesh-color on the mandible. Total length, 6 in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $1\frac{3}{8}$ in.

The colors of the upper parts vary considerably, ranging from a dark green to almost a bronzy-red, and the shades on the under portion are also different in individuals, and this, without sufficient examples to show these variations, has been the main reason that so many specimens have been described as distinct, and the synonymy so greatly increased.

9. *Phæthornis longirostris*.

- Ornismya longirostris*, LESS. et DE LATRE, Echo du Monde Savant (1843), no. 45, p. 1070.
- Trochilus cephalus*, BOURC. et MULS., Rev. Zool. (1848), p. 269.
- Ptyonornis cephalus*, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).
- Phathornis cephalus*, BOX., Rev. and Mag. Zool. (1854), p. 249.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 64.
- Phathornis cassini*, LAWRE., Ann. N. Y. Lyc. Nat. Hist., vol. viii, p. 347.
- Phathornis cephalus*, GOULD, Mon. Troch., pl. 19.
- Phathornis longirostris*, CAB. and HEIN., Mus. Hein. Th., iii, p. 9 (1860).—GOULD, Intr. Troch., p. 42.—SALV. and ELLIOT, Ibis (1873), p. 5.
- Phæthornis boliviana*, GOULD, Intr. Mon. Troch., octavo ed., p. 42.

Hab. Central America from Southern Mexico to the lower portion of the valley of the Magdalena, and western Ecuador.

This bird is hardly separable from the preceding. As a rule the buff edging on the feathers of the rump and lower back are rather clearer and more conspicuous, and the gular stripe is a brighter buff, without the tendency to assume the blackish-brown throat observed in some specimens of *superciliosus*. Otherwise in their general size and coloration the two forms are about the same.

10. Phæthornis hispidus.

Trochilus hispidus, GOULD, P. Z. S. (1846), p. 90.

Phæthornis hispidus, GRAY, Gen. Birds, vol. i, p. 104, sp. 14 (1844-49).—GOULD, Mon. Troch., pl. 22.—ID.,
Intr. Troch., octavo ed., p. 43.—SALV. and ELLIOT, Ibis (1873), p. 7.

Trochilus oseryi, BOURC. and MULS., Ann. Sc., Lyon, vol. iv (1852), p. 139.

Ptyonornis hispida, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).

Ametornis oseryi, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).

Phæthornis oseryi, GOULD, Mon. Troch., vol. i, pl. 23.—ID., Intr. Troch., octavo ed., p. 43.

Orthornis oseryi, BON., Rev. and Mag. Zool. (1854), p. 249.

Phæthornis hispidus, BON., Rev. and Mag. Zool. (1854), p. 249.—ID., Consp. Av., p. 68.—MULS., Hist. Nat. Ois.
Mouch., tom. i, p. 70.

Phæthornis villosus, LAWRE., Ann. N. Y. Lyc. Nat. Hist., vol. vi, p. 259.

Hab. Columbia to Bolivia.

This species is distinguishable from all the others of the genus by being gray beneath. Top of head dark brown, back shining dark green shading into bronze-brown on the upper tail coverts. Above and below the eye is a line of buffy-white. A white line down the centre of the throat, rest of under surface brownish-gray. Wings purple. Tail dark green at base, then brownish-black, tipped with white; the median pair much longer than the rest. Maxilla black, mandible flesh-color, tip black. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{1}{2}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $1\frac{3}{8}$ in.

11. Phæthornis syrmatophorus.

Phæthornis syrmatophorus, GOULD, Contr. Ornith. (1851), p. 139.—REICH., Aufz. der Colib., p. 14 (1853).—
ID., Troch. Enum., p. 12 (1855).—GOULD, Mon. Troch., pl. 20.—ID., Intr. Troch., octavo ed., p. 43 (1861).

—SALV. and ELLIOT, Ibis (1873), p. 8.

Phæthornis syrmatophorus, BON., Rev. and Mag. Zool. (1854), p. 249.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 68.

Hab. Peru, environs of Quito. Pallatanga (Fraser).

Top of head brownish-black, feathers tipped with buff. Back metallic-green, edged with buff. Rump and upper tail coverts deep buff. A buffy-white line over the eye going to the neck. Auriculars blackish-brown. Chin white, bordered with a few blackish-brown feathers on either side. Entire under parts deep buff. Base of tail green, followed by a black bar, the lateral feathers tipped with dark buff, the median pair, which are greatly elongated, have their tips pure white. Wings purple. Maxilla black, mandible orange-red, tip black. Total length, 6 in. Wing, $2\frac{7}{16}$ in. Tail, $2\frac{3}{4}$ in. Culmen, $1\frac{9}{16}$ in.

12. Phæthornis anthophilus.

Trochilus anthophilus, BOURC., Rev. Zool. (1843), p. 71.—BOURC. and MULS., Ann. Sc., Lyon (1843), p. 47.

Phæthornis anthophilus, GRAY and MITCH., Gen. Birds, vol. i, p. 104, sp. 15.—GOULD, Mon. Troch., vol. i, pl.

24.—ID., Intr. Troch., octavo ed., p. 10 (1861).—SALV. and ELLIOT, Ibis (1873), p. 10.—CAB. and HEIN.,

Mus. Hein. Theil., iii, p. 8 (1860).—URICÆCHIA, Contr. a. las Cierce (1861), p. 7.—REICH., Troch. Enum.,

p. 12.—ID., Aufz. der Colib., p. 14.

Phæthornis anthophilus, BON., Consp. Av., p. 68.—ID., Rev. and Mag. Zool. (1854), p. 249.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 83.

Hab. Upper valley of the Magdalena. Tibacuy. Venezuela (Göering).

Top of head dark brown, upper parts bronzy-green, upper tail coverts margined

with buff. Stripe over and behind the eye buffy-white; auriculars dark brown. Under parts grayish-white tinged with buff on abdomen and flanks. Feathers of chin and throat with a central streak of dark brown. Wings purplish-brown. Tail pale shining green, with a subterminal black bar, and tipped with an arrow-headed mark of white; central feathers having their prolonged tips all white. Maxilla black, mandible flesh-color, tip black. Total length, $5\frac{3}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $1\frac{5}{16}$ in.

13. *Phæthornis eurynome*.

Trochilus eurynome, LESS., Troch., p. 91, t. 31 (1831).

Phæthornis eurynome, GRAY, Gen. Birds, vol. i, p. 104, sp. 5.—GOULD, Mon. Troch., vol. i, pl. 16.—ID., Intr. Troch., octavo ed., p. 41.—CAB. and HEIN., Mus. Hein. Th., iii, p. 9, sp. 12 (1860).—SALV. and ELLIOT, Ibis (1873), p. 8.—VON PEIZ., Orn. Bras., p. 27.

Phæthornis melanotis, REICH., Troch. Enum., p. 12 (1855).

Ptyornornis eurynome, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).

Phæthornis eurynomus, BON., Rev. and Mag. Zool. (1854), p. 249.—ID., Consp. Av., p. 69, vol. i (1850).

Phæthornis eurynome, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 80.

Hab. Brazil, southern portion.

Top of head blackish-brown, each feather margined with bright rufous, nape nearly clear rufous in some specimens, in others like the top of head. Upper surface shining green, feathers edged with brown and rufous, giving this part a scaly appearance. A buff line above and behind the eye, and a broader one down the sides of the throat. Cheeks and ear coverts brownish-black. Throat brownish-black margined with buff. Breast grayish-brown, rest of under parts buff. Tail has the basal portion shining green, same color as the back, succeeded by black, and the tips edged with white in the form of an inverted V. Apical half of median rectrices, which are longer than the rest, white. Maxilla black. Mandible flesh-color, tip black. Total length, $6\frac{1}{2}$ in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{7}{8}$ in. Culmen, $1\frac{1}{4}$ in.

14. *Phæthornis squalidus*.

Trochilus squalidus, TEMM., Pl. Col., 120, fig. 1 (1823), ex Natt. MS.

Phæthornis leucophrys, GRAY, Gen. Birds, vol. i, p. 104, sp. 10.—REICH., Aufz. der Colib., p. 14 (1853).

Phæthornis brasiliensis, GRAY (nec LATH.), Gen. Birds, vol. i, p. 104, sp. 10 (1844-49).

Trochilus leucophrys, "LICHT," NORDM., Reis. Att., p. 2, sp. 18.

Phæthornis intermedius, GOULD (nec LESS.), Mon. Troch., vol. i, pl. 30.

Phæthornis squalidus, BON., Rev. and Mag. Zool. (1854), p. 249.—ID., Consp. Av., p. 68.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 77.

Phæthornis squalidus, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 8 (1860).—GOULD, Intr. Troch., octavo ed., p. 45.—SALV. and ELLIOT, Ibis (1873), p. 9.

Ptyornornis intermedia, REICH., Aufz. der Colib., p. 14.—ID., Troch. Enum., p. 12 (1855).

Hab. Southern Brazil.

Head dark brown; rest of upper surface bronzy-brown; feathers of upper tail coverts margined with buff. Wings purple. A line above and behind the eye buff. Throat dark brown. Entire under surface buff, darkest on sides of the neck and flanks. Base of tail feathers bronze-green, succeeded by a black band, and tipped with buff. The green on the middle pair graduates into brown, and this

into pure white. Maxilla black, mandible flesh-color, tip black. Total length, $4\frac{3}{4}$ in. Wing, $1\frac{7}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, 1 in.

15. *Phæthornis longuemareus*.

- Trochilus longuemareus*, LESS., Troch., p. 15, pl. 11 (1831).—BOX., Consp. Gen. Av., vol. i, p. 67 (1850).
Phæthornis longuemareus, GRAY, Gen. Birds, vol. i, p. 104.—GOULD, Mon. Troch., vol. i, pl. 31.—REICH., Aufz. der Colib., p. 14.—ID., Troch. Enum., p. 12 (1855).
Phæthornis intermedius, BOX., Consp. Av., p. 67 (1850).
Phæthornis longuemareus, BOX., Consp. Av. (1850), vol. i, p. 67.
Pygmornis intermedius, BOX., Rev. and Mag. Zool. (1854), p. 250.
Pygmornis longuemareus, CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 12) (1860).—GOULD, Intr. Troch., octavo ed., p. 46 (1861).—SALV. and ELLIOT, Ibis (1873), p. 271.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 93.

Hab. Guiana, Trinidad (Léotaud).

Top of head dark brown; upper surface bronzy-brown. Wings purple. Lores and ear coverts dark brown; superciliary stripe, and one from base of maxilla, buff. Chin and upper part of throat black. Under parts buff. Tail feathers bronzy-green, fading into gray near the tips. Lateral rectrices tipped with buff or buffy-white, central ones with white tips. Median rectrices of female considerably longer than the rest. Maxilla black. Basal half of mandible flesh-color, rest black. Total length, 4 in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

16. *Phæthornis adolphi*.

- Phæthornis adolphi*, GOULD, Mon. Troch., vol. i, pl. 35.—Pl. xiv (1857).
Pygmornis adolphi, CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 10) (1860).—GOULD, Intr. Troch., octavo ed., p. 47.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 102.—SALV. and ELLIOT, Ibis (1873), p. 271.

Hab. Mexico and Central America to Panama.

Upper parts bronzy-brown. Upper tail coverts rufous. Wings purple. Ear coverts dark brown. Superciliary stripe buff. Under surface dark buff, grayish on the throat and breast. Tail bronze-green tipped with buff on lateral feathers, white on middle pair, and has a rounded shape in the male; the median rectrices are elongated in the female. Maxilla black. Basal half of mandible flesh-color, rest black. I notice that specimens from Mexico are much lighter in color beneath, than those from Central America; but this evidently has no specific importance. Total length, $3\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

17. *Phæthornis griseigularis*.

- Phæthornis griseigularis*, GOULD, P. Z. S. (1851), p. 115.—ID., Mon. Troch., vol. i, p. 36.
Pygmornis griseigularis, BOX., Rev. and Mag. Zool. (1854), p. 250.—GOULD, Intr. Troch., p. 47 (1861).—SALV. and ELLIOT, Ibis (1873), p. 272.
Eremita griseigularis, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 11 (1855).
Trochilus aspasie, BOIRE and MULS., Ann. Soc. Linn., Lyon (1856), vol. viii.
Phæthornis zonura, GOULD, P. Z. S. (1860), p. 305.—ID., Mon. Troch., vol. i, p. 34.
Pygmornis griseogularis, CAB. and HEIN., Mus. Hein. Th., iii, p. 8 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 99 (partim).
Pygmornis zonura, GOULD, Intr. Troch., octavo ed., p. 47 (1861).

Hab. Columbia.

Upper parts bronzy-brown. Upper tail coverts rufous. Wings purple. Stripe over the eye buff. Auriculars black. Under surface buff, chin grayish. Tail feathers black, or black with a greenish shade, tipped with buff on the lateral ones, and with white on central pair. Maxilla black; basal half of mandible flesh-color, remainder black. Total length, 3 in. Wing, $1\frac{1}{4}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

In his description Mr. Gould speaks of a black crescent across the breast. This is a mistake, there is no such mark, and his figures are correctly portrayed without any black on the breast.

18. *Phæthornis striigularis*.

Phæthornis striigularis, GOULD, Mon. Troch., vol. i, pl. 37.—Pt. vii (1854).

Pygmornis amaaura, BOURC., Rev. Zool. (1856), p. 522.—CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 11).

Pygmornis striigularis, GOULD, Intr. Troch., octavo ed., p. 48 (1861).—SALV. and ELLIOT, Ibis (1873), p. 273.—

CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 9).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 96.

Phæthornis atrimentalis, LAWR., Ann. Lyc. Nat. Hist. N. Y., vol. vi, p. 260.

Phæthornis amaaura, GOULD, Mon. Troch., vol. i, pl. 32.

Pygmornis amaaura, GOULD, Intr. Troch., octavo ed., p. 46 (1861).

Hab. Columbia and Ecuador.

Upper parts bronze-brown. Rump and upper tail coverts rufous. Wings purple. Ear coverts black; a stripe of buff above and below the eye. Throat and breast gray, the former striated with brownish-black. Abdomen deep buff. Under tail coverts gray tipped with buff. Tail greenish-bronze, tipped with white. Maxilla black; basal half of mandible yellow, rest black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

19. *Phæthornis idaliæ*.

Trochilus idaliæ, BOURC. and MULS., Ann. Soc. Linn., Lyon (1856), vol. iii.

Phæthornis obscura, GOULD, P. Z. S. (1857), p. 14.

Phæthornis obscura, GOULD, Mon. Troch., vol. i, pl. 38.

Pygmornis obscura, CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 7) (1860).

Phæthornis viridicaudata, GOULD, Mon. Troch., vol. i, pl. 33, ♀.—CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 5) (1860).

Pygmornis idaliæ, GOULD, Intr. Troch., p. 48 (1861).—SALV. and ELLIOT, Ibis (1873), p. 270.

Pygmornis aspasix, GOULD, Intr. Troch., p. 47 (1861).

Hab. South Brazil.

Head dark brown above; upper surface shining green. Wings purple. Buff stripe behind the eye; ear coverts black. Buffy-white stripe along the side of the throat. This last is black, becoming chestnut on the breast, dark gray on the abdomen, and white on the vent. Under tail coverts grayish-white. Tail dark bronze-brown tipped with white. Maxilla black, mandible flesh-color, tip brownish-black. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{3}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female has the throat and under parts buff, palest on abdomen. Tail bronze-green, passing into blackish-brown and tipped with white. The throat and under surface of the males vary greatly in their coloration, some specimens being very much darker than others.

20. Phæthornis pygmæus.

- Trochilus pygmæus*, SPIX, Av. Bras., p. 78, pl. 80, fig. 1 (1824).
Phæthornis rufigaster, LESS., der Colib., t. 9, p. 43 (1831).
Trochilus davidianus, LESS., Troch., p. 50, pl. 13 (1832).
Trochilus brasiliensis, D'ORB. and LAFRES (nec LATH.), Syn. Av., ii, p. 32, sp. 28 (1828).
Phæthornis davidianus, GRAY, Gen. Birds, vol. i, p. 108, sp. 13 (1848).
Phæthornis eremita, BON., Consp. Av., vol. i, p. 68 (1850).
Phæthornis pygmæus, BON., Consp. Av., vol. i, p. 68 (1850).
Eremita rufigaster, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 11 (1855).
Eremita davidianus, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 11 (1855).
Eremita pygmæa, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 11 (1855).
Pygmornis davidianus, BON., Rev. and Mag. Zool. (1854), p. 250.
Phæthornis pygmæus, GOULD, Mon. Troch., vol. i, pl. 41 (1861).
Pygmornis pygmæa, GOULD, Intr. Troch., octavo ed., p. 49.—CAB. and HEIN., Mus. Hein. Th., iii, p. 6 (1860).—
 SALV. and ELLIOT, Ibis (1873), p. 273.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 105.
Phæthornis eremita, GOULD, Mon. Troch., octavo ed., vol. i, pl. 40 (1861).
Pygmornis eremita, GOULD, Intr. Troch., octavo ed., p. 49 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 7
 (note 8) (1860).
Pygmornis rufiventris, BON., Rev. and Mag. Zool. (1854), p. 250.—GOULD, Intr. Troch., octavo ed., p. 48 (1861).
Pygmornis pygmæus, ELLIOT, Ibis (1877), p. 141.

Hab. Guiana, Brazil.

Adult. Top of head dark brown; back bronze-brown, rump and upper tail coverts rust-red. A buff stripe above and behind the eye. Ear coverts black. Chin white, rest of under surface deep buff, crossed on lower part of breast by a line of black. Tail bronzy-brown, tipped with buff. Wings dark purplish-brown. Maxilla and apical half of mandible black, rest of mandible flesh-color. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{1}{4}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

21. Phæthornis episcopus.

- Phæthornis episcopus*, GOULD, P. Z. S. (1857), p. 14.—ID., Mon. Troch., vol. i, pl. 39, fig. 2.
Pygmornis episcopus, GOULD, Intr. Troch., octavo ed., p. 48.—CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 4)
 (1860).—SALV. and ELLIOT, Ibis (1873), p. 274.

Hab. Guiana.

Precisely like the *P. pygmæus*, except that the lateral tail feathers are broader, and black instead of bronzy-brown. Dimensions similar.

22. Phæthornis nigricinctus.

- Phæthornis nigricinctus*, LAWR., Ann. Lyc. Nat. Hist. N. Y., vol. vi, p. 260 (1858).—GOULD, Mon. Troch., vol. i, pl. 39, fig. 1.
Pygmornis nigrocincta, CAB. and HEIN., Mus. Hein. Th., iii, p. 7 (note 6) (1860).
Pygmornis nigrocinctus, GOULD, Intr. Troch., octavo ed., p. 48.—SALV. and ELLIOT, Ibis (1873), p. 274.—MULS.,
 Hist. Nat. Ois. Mouch., tom. i, p. 108.

Hab. Upper Amazons, Pebas, Peru, Eng. do Gama, Brazil.

This species in its plumage resembles very closely the two preceding ones, but may be recognized by the mandible being flesh-color for its entire length, excepting at the extreme tip, which is brownish-black. The tail is like *pygmæus*, perhaps a little darker. Total length, $2\frac{1}{4}$ in. Wing, 1 in. Tail, 1 in. Culmen, $1\frac{3}{16}$ in.

The birds composing the three following genera are characterized by having the shafts of the primaries more or less developed, and in the males these are broad and flattened. The majority of the species have a portion of their plumage composed of metallic feathers. The genera are mainly distinguished by the shape of the tail, this being long and deeply forked in EUPETOMENA, cuncate in SPHENOPROCTUS, and rounded in CAMPYLOPTERUS. Having been unable to perceive any satisfactory generic characters to separate *cuvieri* and *roberti* from CAMPYLOPTERUS, I have kept them in that genus, the fact that the shafts of the primaries are less flattened than is observed in other species of the genus not being sufficient, in my opinion, to cause their removal to a distinct one.

Genus VIII.—EUPETOMENA.

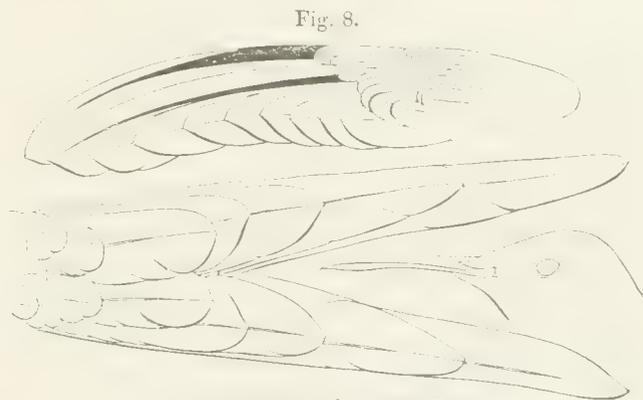
TYPE.

Eupetomena, GOULD, Mon. Troch., pl. vi (1853).—Intr. Troch., octavo ed., p. 50.
Prognornis, REICH., Aufz. der Colib. (1853), p. 11.

T. macrourus, Gmel.
T. macrourus, Gmel.

Ch. Bill long as the head, slightly curved. Tail very long, deeply forked, outermost rectrices much longer than the rest, turning slightly outward at tip. Shaft of primaries in the male, broad and flattened. Sexes alike.

Range. Guiana, Brazil, Peru.



Eupetomena macroura. ♂. Cayenne. Bourcier.

Key to the species.

- A. Tail steel-blue, body shining green.
- | | |
|--|-------------------------|
| a. Head and breast shining prussian-blue. | 1. <i>E. macroura</i> . |
| b. Head and breast shining dark cobalt-blue. | 2. <i>E. hirundo</i> . |

1. *Eupetomena macroura*.

Trochilus macrourus, GMEL., Syst. Nat. (1788), vol. i, p. 487, sp. 27.—VIEILL., Ency. Méth., p. 566, sp. 69.

Trochilus forcipatus, LATH., Ind. Orn., vol. i, p. 304, sp. 9 (1790).

Ornismya hirundinacea, LESS., Ois. Mouch., p. 98, pl. 25.—ID., Suppl., p. 79, pl. 39 (1829).

Polytmus macrourus, GRAY, Gen. Birds, vol. i, p. 107, sp. 9 (1844-59).

Prognornis macroura, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9, t. 806, fig. 4873-75.

Eupetomena macroura, BON., Rev. and Mag. Zool. (1854), p. 254.—CAB. and HEIN., Mus. Hein. Th., iii, p. 14.

—GOULD, Intr. Troch., octavo ed., p. 50 (1861).—BON., Rev. and Mag. Zool. (1854), p. 254.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 111.—ELLIOT, Ibis (1877), p. 134.

Eupetomena hirundinacea, GOULD, Mon. Troch., vol. ii, pl. 42.

Hab. Cayenne, Brazil.

Head, neck, and breast deep shining prussian-blue; plumage of body dark shining green; some feathers on the rump tipped with dark purple. Upper and under tail coverts, and all the rectrices, dark steel-blue. Wings purplish-brown. Bill black. Total length, $6\frac{2}{3}$ in. Wing, 3 in. Tail, $3\frac{3}{4}$. Culmen, $\frac{7}{8}$ in.

2. *Eupetomena hirundo*.

Eupetomena hirundo, GOULD, Ann. Mag. Nat. Hist. (1875), ser. 4, vol. 16.—SCLAT. and SALV., P. Z. S. (1876), p. 18.

Hab. Peru, Huiro valley of Santa Ana (Whitely).

Head, neck, and breast shining dark cobalt-blue; plumage of body shining grass-green, lighter than in *E. macroura*. Wings purple-brown. Tail with its upper and under coverts steel-blue; some of the feathers of upper tail coverts edged with purple. Bill black. Total length, $6\frac{7}{8}$ in. Wing, 3 in. Culmen, 1 in. Tail, $3\frac{1}{2}$ in.

For the species that are now reached, but two generic terms have ever been proposed: viz., PAMPA and SPHENOPROCTUS. The first of these has the priority by seven years. Neither of them were defined by their respective authors, and therefore, according to the views of some ornithologists, have really no right to any consideration. The first is objectionable from the fact that it is a specific name elevated to a generic rank, especially objectionable in this case, because the *Ornismya pampa*, Less., has never had a second specific appellation bestowed upon it, and therefore if *Pampa* is accepted the species must stand as *Pampa pampa* (a very undesirable combination), or a new specific name be given to it. The one bestowed by Reichenbach, if adopted, of *Pampa campyloptera*, would but complicate matters unfavorably, because the genus with which these birds are very closely allied is CAMPYLOPTERUS. Under these circumstances I have adopted the name given by Cabanis and Heine of SPHENOPROCTUS, for there is no necessity whatever that a new specific name should be given to one of the birds, a proceeding that would but increase the confusion tenfold.

Genus IX.—SPHENOPROCTUS.

Pampa, REICH., Aufz. der Colib., p. 11 (1853).

Sphenoproctus, CAB. and HEIN., Mus. Heim. Th., iii, p. 11 (1860).

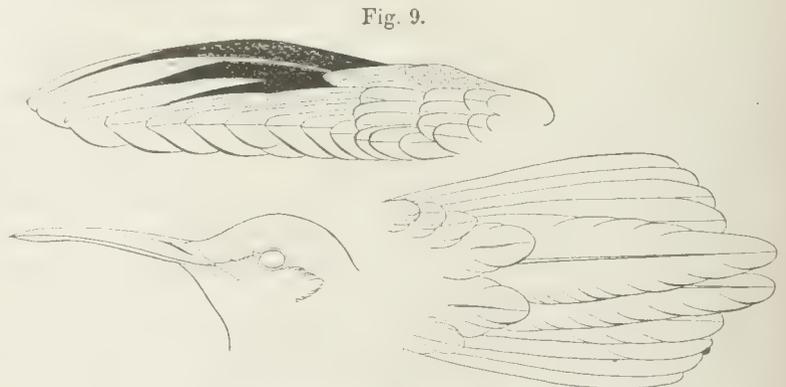
TYPE.

O. pampa, Less.

O. pampa, Less.

Ch. Bill nearly straight, long as head; nostrils covered by a membrane. Wings long, shafts of first three primaries in the males, broad and flattened; the first primary falcate. Tail cuneate. Sexes alike.

Range. Mexico and Guatemala.



Sphenoproctus pampa. Guatemala. Boucard.

Key to the species.

A. Under surface grayish-white.

a. Top of head deep metallic purplish-blue.

1. *S. pampa*.

b. Top of head pale metallic blue.

2. *S. curvipennis*.**1. *Sphenoproctus pampa*.***Ornismya pampa*, LESS., Ois. Mouch. Suppl., p. 127, t. 15 (1829).*Polytmus pampa*, GRAY, Gen. Birds. vol. i. p. 107, sp. 7.*Pampa campyloptera*, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9, pl. 600, fig. 4861-62 (1855).*Campylopterus pampa*, GOULD, Mon. Troch., vol. ii, pl. 43.—BON., Consp. Gen. Av. vol. i, p. 71.—ID., Rev. and Mag. Zool. (1854), p. 250.—MCLS., Hist. Nat. Ois. Mouch., tom. i. p. 115.*Sphenoproctus pampa*, GOULD, Intr. Troch., octavo ed., p. 51.—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 11 (partim).*Hab.* Guatemala.

Top of head and occiput brilliant metallic purplish-blue. Upper surface shining grass-green; wings purplish-brown. Under surface grayish-white. Ear coverts brown, under tail coverts buffy-white. Four central rectrices dark bronze-green; lateral ones dark purple, glossed with green at the base. Bill black, feet brown. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{7}{8}$ in.

2. *Sphenoproctus curvipennis*.*Trochilus curvipennis*, LICHT., Preis-Verz. Mex. Their. (1830), no. 32.*Sphenoproctus pampa*, CAB. and HEIN., Mus. Hein. Th., iii, p. 11 (partim) (1860).*Sphenoproctus curvipennis*, GOULD, Intr. Troch., octavo ed., p. 51 (1861).*Hab.* Mexico.

Top of head pale blue glossed with purple; in some specimens brownish on the forehead. Upper parts shining green. Wings purplish-brown. Under parts grayish-white. Four central tail feathers dark green, rest purple glossed with green at base. Bill black. Total length, $5\frac{5}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $1\frac{3}{16}$ in.

Genus X.—CAMPYLOPTERUS.

TYPE.

Campylopterus, SWAIN, Zool. Journ. (1826), p. 358.*T. largipennis*, Bodd.*Polytmus*, GRAY (nec BRISS.), List. Gen. Birds (1848).*T. largipennis*, Bodd.*Sæpiopterus*, REICH., Aufz. der Colib., p. 11 (1853).*T. lazulus*, Vieill.*Platystylopterus*, REICH., Aufz. der Colib., p. 11 (1853).*C. rufus*, Less.*Loxopterus*, CAB. and HEIN., Mus. Hein. Th., iii, p. 13 (1860).*C. hyperythrus*, Cab.*Phæochroa*, GOULD, Intr. Mon. Troch., octavo ed., p. 55 (1861).*T. cuvieri*, Delatt. and Bourc.

Ch. Bill longer than the head, curved, broad, and flat at base. Wings ample, shafts of primaries in the male, broad and flat on their basal half. Tail ample, rounded, feathers broad. Size large.

Range. Mexico, Central America, Tobago, Venezuela, Guiana, Northern Brazil, Columbia, Ecuador, and Peru.—Ten species are acknowledged.

Fig. 10.

*Campylopterus largipennis*. Cayenne. Verreaux.

Key to the species.

- | | |
|--|------------------------------|
| A. Entire under surface dark gray, not metallic. | |
| a. Lateral rectrices largely tipped with white. | 1. <i>C. largipennis</i> . |
| b. Lateral rectrices slightly tipped with white. | 2. <i>C. obscurus</i> . |
| B. Under parts entirely rufous, not metallic. | |
| a. Lateral rectrices buff with a subterminal black bar. | 3. <i>C. rufus</i> . |
| b. Lateral rectrices uniform buff. | 4. <i>C. hyperythrus</i> . |
| C. Under parts metallic. | |
| a. Tail chestnut tipped with green. | 5. <i>C. lazulus</i> . |
| b. Tail. Lateral feathers, basal half black, rest white. | |
| a'. Upper and under surface violet-blue. | 6. <i>C. hemileucurus</i> . |
| b'. Upper and under surface golden-green. Throat blue. | 7. <i>C. ensipennis</i> . |
| D. Under surface dark gray. Throat blue. Top of head of both sexes metallic-green. Lateral rectrices steel-blue. | 8. <i>C. villavicencio</i> . |
| E. Under surface dull bronzy-green. | |
| a. Lateral rectrices greenish-bronze tipped with white. | 9. <i>C. cuvieri</i> . |
| b. Lateral rectrices, base green, remainder black tipped with white. | 10. <i>C. roberti</i> . |

1. *Campylopterus largipennis*.

Trochilus largipennis, BODD., Tab. Plan. Enlum. d'Aubent, pl. 672, fig. 2 (1783).

Trochilus cinereus, GMEL., Syst. Nat. (1788), p. 490, sp. 41.

Trochilus campylopterus, GMEL., Syst. Nat. (1788), vol. i, p. 499.

Trochilus latipennis, LATH., Ind. Orn., vol. i, p. 310 (1780).—VIEILL., Nouv. Dict. Hist. Nat., tom. vii, p. 365.

Ornismya latipennis, LESS., Ois. Mouch., p. 121, pl. 34 (1829).

Polytmus largipennis, GRAY, Gen. Birds, vol. i, p. 107.

Campylopterus latipennis, BON., Consp. Gen. Av., vol. i, p. 71.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 9, t. 802, fig. 4865-66.—BON., Rev. and Mag. Zool. (1854), p. 250.—GOULD, Mon. Troch., vol. ii, pl. 48.—ID., Intr. Troch., octavo ed., p. 53.

Campylopterus largipennis, CAB. and HEIN., Mus. Hein. Th., iii, p. 12 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 119.

Hab. Guiana.

Adult. Head, upper surface, and flanks grass-green. Wings purplish-brown. Median rectrices dark green, next on either side, green at base, remaining part

black; rest of tail feathers black broadly tipped with white. Under surface gray. Maxilla black, mandible flesh-color. Total length, $5\frac{1}{4}$. Wing, $3\frac{1}{8}$. Tail, $2\frac{1}{8}$. Culmen, 1.

2. *Campylopterus obscurus*.

Campylopterus obscurus, GOULD, P. Z. S. (1848), p. 13.—ID., Mon. Troch., vol. ii, pl. 49.—ID., Intr. Troch., octavo ed., p. 54.—BON., Consp. Gen. Av., vol. i, p. 71.—ID., Rev. and Mag. Zool. (1854), p. 250.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 9.

Campylopterus æquatorialis, GOULD, Intr. Troch., octavo ed., p. 54 (ex Ecuador).

Hab. Valley of the Amazon to Peru, and Ecuador.

Adult. Upper parts grass-green. Under surface dark gray. Middle rectrices green, three lateral ones black tipped with white.

This species only differs from the *C. largipennis* in the small amount of white upon the tips of the tail feathers. I have placed as a synonym the *C. æquatorialis*, Gould, as I cannot really perceive any grounds for separating them; and it would even seem that the specific characters distinguishing the present bird from *largipennis* are of the most trivial kind.

3. *Campylopterus rufus*.

Campylopterus rufus, LESS., Rev. Zool. (1840), p. 73.—GOULD, Mon. Troch., vol. ii, pl. 50.—ID., Intr. Troch., octavo ed., p. 54.—BON., Consp. Gen. Av., vol. i, p. 71.—ID., Rev. and Mag. Zool. (1854), p. 250.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 135.

Polytmus rufus, GRAY, Gen. Birds, vol. i, p. 107.

Platystylopterus rufus, REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 8, pl. 789, fig. 4834-35.

Hab. Guatemala.

Head and upper parts bronzy-green. Wings purplish-brown. Entire under parts dark buff. Four central rectrices bronzy-green, remainder rufous, and all but the median pair with a subterminal black bar and tips buff. The black bar increases in width towards the outer rectrices, but on the outermost only appears on the inner web. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, 2 in. Culmen, 1 in.

4. **Campylopterus hyperythrus*.

Campylopterus hyperythrus, CAB., Schomb. Reise. Brit. Guiana (1848), vol. iii, p. 709, no. 202.—BON., Rev. and Mag. Zool. (1854), p. 250.—GOULD, Mon. Troch., vol. ii, pl. 51.—ID., Intr. Troch., octavo ed., p. 54.

Platystylopterus hyperythrus, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 8, pl. 790, fig. 4836-38 (1855).

Loxopterus hyperythrus, CAB. and HEIN., Mus. Hein. Th., iii, p. 13 (1860).

Hab. Guiana.

The principal difference that distinguishes this species from the *C. rufus*, is, that the lateral rectrices are uniform rufous without any black bar. More specimens are required (the type being still unique) to enable us to ascertain if the example is really entitled to a distinctive rank, or if the absence of the bar is merely an individual peculiarity.

5. *Campylopterus lazulus*.

- Trochilus lazulus*, BONNATT, Ency. Meth., vol. ii, p. 557 (1791).
Trochilus falcatus, LESS., Ois. Mouch., p. 126, pl. 36 (1829).—SWAIN., Ill. Zool., vol. ii, pl. 83.
Polytmus lazulus, GRAY, Gen. Birds, vol. i, p. 107 (1844-49).
Sayopterus lazulus, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9, pl. 801, fig. 4863-64 (1855).
Campylopterus lazulus, BON., Rev. and Mag. Zool. (1854), p. 250.—ID., Consp. Gen. Av., p. 71.—GOULD, Mon. Troch., vol. ii, pl. 44.—ID., Intr. Troch., octavo ed., p. 51.—CAB. and HEIN., Mus. Hein. Th., iii, p. 13.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 131.

Hab. Venezuela, Columbia, Ecuador.

Male. Entire upper surface glittering grass-green. Wings purplish-brown. Throat and breast dark metallic-blue with a purple lustre, blending into the glittering green of the abdomen and flanks. Under tail coverts chestnut. Rectrices deep chestnut, tipped with shining green. Bill black. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail 2 in. Culmen, 1 in.

Female has the under surface brownish-gray, lateral tail feathers chestnut, margined with black. Upper parts similar to the male.

6. *Campylopterus hemileucurus*.

- Trochilus hemileucurus*, LICHT., Preis-Verz. Mex. Thier. (1833), no. 33.
Ornismya (Campylopterus) Delattrei, LESS., Rev. Zool. (1839), p. 14.
Mellisuga delattrei, GRAY, Gen. Birds, vol. i, p. 113.
Campylopterus delattrei, GOULD, Mon. Troch., vol. i, pl. 45.—BON., Consp. Gen. Av., vol. i, p. 71.—ID., Rev. and Mag. Zool. (1854), p. 250.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 9, t. 804, fig. 4869-70.
Campylopterus hemileucurus, CAB. and HEIN., Mus. Hein. Th., iii, p. 13.—GOULD, Intr. Troch., octavo ed., p. 52.

Hab. Mexico to Veragua in Central America.

Male. Top of head and lores dull black. A small spot of white behind the eye. Occiput black, and entire under surface bright violet-blue. Rump and upper tail coverts green. Wings brown. Under tail coverts, blue-black glossed with green. Tail steel-black, middle feathers glossed with green, and the outer ones largely tipped with white. Bill black. Total length, $5\frac{3}{4}$ in. Wing, $3\frac{1}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $1\frac{1}{16}$ in.

Female. Head brown. Upper surface and flanks brilliant green, inclining to blue on the upper tail coverts. Throat greenish-blue. Under surface gray. Median rectrices dark green, rest black, three lateral ones tipped with white. The size is about the same as that of the male.

7. *Campylopterus ensipennis*.

- Trochilus ensipennis*, SWAIN., Zool. Illust., vol. ii, pl. 107.
Campylopterus ensipennis, LESS., Ois. Mouch., p. 124, pl. 35 (1829).—ID., Trait. Orn., p. 289.—GOULD, Mon. Troch., vol. ii, pl. 46.—ID., Intr. Troch., octavo ed., p. 53.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 9, pl. 803, fig. 4867-68.—BON., Consp. Gen. Av., vol. i, p. 71.—ID., Rev. and Mag. Zool. (1854), p. 250.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 122.—CAB. and HEIN., Mus. Hein. Th., iii, p. 12.
Polytmus ensipennis, GRAY, Gen. Birds, vol. i, p. 107.

Hab. Island of Tobago. Venezuela.

Male. Chin and throat shining dark lazuline-blue. Entire rest of body glittering metallic golden-green. Wings purplish-brown. Median rectrices dark green, next on either side black, remainder black at base, rest white. Bill black. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, 1 in.

Female. Differs in having the centre of the throat only, blue, and the centre of breast and abdomen gray. In size the sexes do not differ much.

8. *Campylopterus villavicencio.*

Trochilus villavicencio, BOURC., Compt. Rend., vol. 32, p. 187.—ID., Rev. and Mag. Zool. (1851), p. 97.

Heliomaster villavicencio, REICH., Anz. der Colib., p. 13 (1853).—BOX., Rev. and Mag. Zool. (1854), p. 251.

Selasphorus (Heliomaster) villavicencio, REICH., Troch. Enum., p. 11 (1855).

Campylopterus splendens, LAWR., Ann. N. Y. Lyc. Nat. Hist., vol. vi, p. 262 (1858), ♀.—GOULD, Intr. Troch., octavo ed., p. 53.

Campylopterus villavicencio, GOULD, Mon. Troch., vol. ii, pl. 42.—ID., Intr. Troch., octavo ed., p. 53.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 130.

Hab. Ecuador, Rio Napo.

Male. Top of head metallic golden-green. Upper parts and flanks dark green. Wings purplish-brown. Throat deep metallic purplish-blue. Under surface dark greenish-gray. Median rectrices dark green, remainder steel-blue. Bill black. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, 1 in.

Female. Top of head metallic golden-green. Upper parts golden-green. Under surface ashy-white. Tail like the male, with the lateral feathers tipped with grayish-white. Maxilla black, mandible flesh-color.

This species is remarkable, in that both sexes have metallic crowns.

9. *Campylopterus cuvieri.*

Trochilus cuvieri, DELATR. and BOURC., Rev. Zool. (1846), p. 310.

Campylopterus cuvieri, BOX., Consp. Gen. Av., p. 71, sp. 9 (1850).—GOULD, Mon. Troch., vol. i, pl. 52.—REICH., Troch. Enum., p. 9, t. 805, fig. 4871 (1855).

Aphantochroa cuvieri, BOX., Rev. and Mag. Zool. (1854), p. 250.—CAB. and HEIN., Mus. Hein. Th., iii, p. 14 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 13.

Phæochroa cuvieri, GOULD, Intr. Troch., octavo ed., p. 55 (1861).

Hab. Costa Rica, Panama, Venezuela, Columbia.

Adult. Upper surface shining grass-green. Wings purplish-brown. Under surface dull bronze-green, feathers tipped with gray. Centre of abdomen buff. Under tail coverts brown fringed with white. Tail greenish-bronze, outer feathers tipped with white. Maxilla black, mandible flesh-color. Total length, $4\frac{5}{8}$ in. Wing, $2\frac{7}{8}$ in. Tail, 2 in. Culmen, $\frac{7}{8}$ in.

This species and the succeeding one have generally been placed in the genus *Phæochroa*, Gould; but as they have (in a less degree) the flattened broad shafts on the primaries, which are the chief distinction of *CAMPYLOPTERUS*, and no different character that is strictly generic, I have not employed the term *Phæochroa*. As the members of the genus *APHANTOCHROA* have very differently shaped shafts to the primaries, this bird and the *C. roberti* should not be placed with them, as has been done by M. Mulsant.

10. *Campylopterus roberti*.

Aphantochroa roberti, SALV., P. Z. S. (1861), p. 203.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 138.

Campylopterus roberti, GOULD, Mon. Troch., vol. ii, pl. 53.

Phaeochroa roberti, GOULD, Intr. Troch., octavo ed., p. 55 (1861).

Hab. Guatemala.

This species differs from the *C. cuvieri*, in having the lateral rectrices black tipped with white (the extreme basal portion being green); and also in the entirely black bill. In size the two species are alike.

Genus XI.—APHANTOCHROA.

Aphantochroa, GOULD, Mon. Troch., pt. vi. (1852).—ID., Intr. Troch., octavo ed., p. 55.

Agapeta, HEIN., Jour. für Ornith. (1863), p. 178.

Placophorus, MULS., Catal. Ois. Mouch. (1875), p. 6.

TYPE.

T. cirrhochloris, Vieill.

A. gularis, Gould.

A. gularis, Gould.

Fig. 11.

Ch. "Bill stout, rather longer than the head, and slightly arched; wings broad and moderately long; tail square and moderately large; tarsi clothed; hind toe rather short. Sexes alike in plumage." (Gould, loc. cit.)

Range. Brazil, through the Amazonian valley to Ecuador.



Aphantochroa cirrhochloris. ♂. Brazil. Gardner.

Key to the species.

A. Upper parts dark grass-green.

a. Metallic spot of lilac on the throat.

b. Throat and breast dark gray, glossed with green.

c. Under parts white, spotted with green.

1. *A. gularis*.

2. *A. cirrhochloris*.

3. *A. hyposticta*.

These species, with the exception of *gularis*, which has a bright throat mark, are plain unpretending birds, of moderate size, and clothed in a rather dull plumage.

1. **Aphantochroa gularis*.

Aphantochroa gularis, GOULD, P. Z. S. (1860), p. 310.—ID., Mon. Troch., vol. ii, pl. 55.—ID., Intr., Troch., octavo ed., p. 55.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 142.

Hab. Rio Napo, Ecuador.

Upper parts shining grass-green. Under parts also grass-green, excepting a metallic-lilac spot on the throat, and the centre of abdomen, thighs, and under tail coverts, which are white. Median rectrices grass-green, remainder purplish-green. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{1}{4}$ in. Bill, $1\frac{1}{8}$ in.

2. *Aphantochroa cirrochloris*.

- Trochilus cirrochloris*, VIEILL., Nouv. Dict. Hist. Nat., tom. 23, p. 430.
Ornismya simplex, LESS., Ois. Mouch., p. 119, pl. 33 (1829).
Polytmus cirrochloris, GRAY, Gen. Birds, vol. i, p. 107, sp. 4.
Trochilus campylostylus, LICHT., Verzich. Doubl., p. 14.
Campylopterus cirrochloris, BON., Consp. Gen. Av., vol. i, p. 71 (1850).
Aphantochroa cirrochloris, GOULD, Mon. Troch., vol. i, pl. 54.—ID., Intr. Troch., octavo ed., p. 55.—BON., Rev. and Mag. Zool. (1854), p. 250.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 139.—CAB. and HEIN., Mus. Hein. Th., iii, p. 14.—REICH., Aufz. der Colib., p. 15.—ID., Troch. Enum. p. 12.
Campylopterus campylostylus, BURM., Th. Bras., vol. ii, p. 329, sp. 2 (1856).

Hab. Brazil.

Adult. Upper surface dark green. Wings purplish-brown. Throat and breast grayish-brown, feathers tipped with green. Abdomen grayish-brown with a band of white just above the vent. Under tail coverts dark brown edged with whitish. Median rectrices green, rest dark purplish-brown. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{8}$ in.

3. *Aphantochroa hyposticta*.

Aphantochroa hyposticta, GOULD, P. Z. S. (1862), p. 124.

Hab. Ecuador.

Upper parts dark green. Wings purplish-brown. Feathers of throat, breast, and abdomen white at base and tipped with green. Flanks green; under tail coverts green edged with white. Median rectrices green, remainder green at base shading into black and edged with white. Bill black, except base of mandible, which is flesh-color. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{7}{8}$ in. Culmen, 1 in.

Genus XII.—CÆLIGENA.

- | | |
|---|------------------------------|
| <i>Cæligena</i> , LESS., Ind. and Syn. Gen. Ois. du Genr. Trochilus (1832), p. xviii. | TYPE. |
| <i>Delatiria</i> , BON., Consp. Gen. Av., vol. i (1850), p. 70.—ID., Compt. Rend. (1850), p. 380. | <i>O. clemenciae</i> , LESS. |
| <i>Chariessa</i> , HEIN., Journ. für Ornith. (1863), p. 178. | <i>O. henrica</i> , LESS. |
| <i>Himelia</i> , MULS., Cat. Ois. Mouch. (1875), p. 7. | <i>O. henrica</i> , LESS. |
| | <i>O. henrica</i> , LESS. |

Ch. Bill longer than the head, straight. Wings very long and ample. Tail rounded, feathers broad. Tarsi clothed. Sexes unlike in plumage.

Range. Mexico, Guatemala, and Costa Rica.

I consider that there are four species which should be placed in this

Fig. 12.



Cæligena clemenciae. ♂. Mexico, Salvia.

genus, as I cannot perceive any generic character to separate *henrici* and *viridipallens* from *clemenciæ*, nor the species usually known as *Oreopyra hemileuca* from those just named. They are handsome birds, the males possessing bright metallic throats.

Key to the species.

- | | |
|-------------------------------|------------------------------|
| A. Under parts grayish-brown. | |
| a. Throat metallic-blue. | 1. <i>C. clemenciæ</i> . |
| b. Throat metallic lilac-red. | 2. <i>C. henrici</i> . |
| B. Under parts white. | |
| a. Throat metallic-green. | 3. <i>C. viridipallens</i> . |
| b. Throat metallic-amethyst. | 4. <i>C. hemileuca</i> . |

1. *Cæligena clemenciæ*.

Ornismya clemenciæ, LESS., Ois. Mouch., p. 216, pl. 80 (1829).

Lampornis clemenciæ, LESS., Trait. Orn., p. 279 (1831).—BON., Rev. and Mag. Zool. (1854), p. 250.

Cæligena clemenciæ, LESS., Ind. Gen. Syn. Ois., Genr. *Trochilus*, p. 18 (1831).—GOULD, Intr. Troch., octavo ed., p. 59.—REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 3, t. 687, fig. 4516-17 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 15 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 180.

Mellisuga clemenciæ, GRAY, Gen. Birds. vol. i, p. 112, sp. 16 (1844-49).

Delatiria clemenciæ, BON., Consp. Gen. Av., p. 70 (1850).—GOULD, Mon. Troch., vol. ii, pl. 60.

Hab. Mexico.

Male. Upper parts bronzy-green. Behind the eye a stripe of white. Throat metallic azure-blue. Under surface dark ash-gray. Under tail coverts greenish-gray bordered with grayish-white. Upper tail coverts greenish-black. Tail black, two outermost feathers tipped with white. Maxilla brownish-black, mandible flesh-color. Total length, $4\frac{3}{4}$ in. Wing, $3\frac{1}{2}$ in. Tail, 2 in. Culmen, $\frac{7}{8}$ in.

Female has the crown dark brown, and entire under surface dark gray.

2. *Cæligena henrici*.

Ornismya henrica, LESS. and DELATTR., Rev. Zool. (1839), p. 17.

Topaza henrici, GRAY, Gen. Birds. vol. i, p. 110.

Delatiria henrica, BON., Consp. Gen. Av. (1850), p. 70.—ID., Rev. and Mag. Zool. (1854), p. 253.—GOULD, Mon. Troch., vol. ii, pl. 62.—ID., Intr. Troch., octavo ed., p. 60 (1861).

Lamprolaima henrica, REICH., Aufz. der Colib., p. 9 (1853).—ID., Enum., p. 6, pl. 742, fig. 4701, 4703 (1855).

Cæligena henrici, CAB. and HEIN., Mus. Hein. Th., iii, p. 15 (note) (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 182.

Chariessa henrici, HEINE, Journ. für Ornith. (1863), p. 178.

Hab. Guatemala.

Male. Upper parts bronzy-green fading into brownish on the rump. Wings purplish-brown. Throat metallic lilac-red. Under surface grayish-brown. Tail blackish-brown tipped with grayish on the lateral feathers. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $3\frac{3}{4}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

Female has the under parts pale brown, slightly tinged with buff, without any metallic spot on the throat; rest of plumage like the male.

3. *Cæligena viridipallens*

Trochilus viridipallens, BOIRE, and MULS., Ann. Soc., Lyons (1846), p. 321.

Polytmus viridipallens, GRAY, Gen. Birds, vol. i, p. 108.

Delatiria viridipallens, BON., Consp. Gen. Av., p. 70 (1850).—GOULD, Mon. Troch., vol. ii. pl. 63.—Id., Intr. Troch., octavo ed., p. 60 (1861).

Agytria viridipallens, REICH., Aufz. der Colib., p. 10 (1853).—Id., Enum., p. 7, pl. 758, fig. 4746.

Thaumantias viridipallens, BON., Rev. and Mag. Zool. (1854), p. 255.

Chariessa viridipallens, HEINE, Journ. für Ornith. (1863), p. 173.

Cæligena viridipallens, MULS., Hist. Nat. Ois. Mouch., vol. i, p. 185.

Hab. Guatemala.

Male. Upper parts bronzy-green, changing to coppery-green on the rump. White line behind the eye. Throat pale metallic-green. Under parts white, flanks green. Under tail coverts greenish-gray margined with white. Upper tail coverts purplish-black. Median rectrices brownish-gray, pale on the lateral rectrices. Bill black. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{1}{2}$ inch. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in. Description taken from type specimen in my collection.

Female has the throat white, and the lateral rectrices almost white. (Type.)

Young male. Median rectrices purplish-black. Throat and breast very dark gray.

4. *Cæligena hemileuca*.

Oreopyra hemileuca, SALV., P. Z. S. (1864), p. 584.

Hab. Costa Rica.

Male. Entire upper parts grass-green. White line behind the eye. Throat metallic-amethyst. Under parts pure white. Under tail coverts grayish-white. Wings purple-brown. Tail bronzy-green, all the feathers but the median pair, with a subterminal blackish-brown bar; tips buffy-white. Bill black. Total length, 4 in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female. Same as the male, excepting the throat, which is white spotted with green.

This species was described and placed in the genus OREOPYRA by Mr. Salvin, but it differs from the members of that genus in various ways, and is apparently more properly placed in the present one. I can find no characters to separate it from CÆLIGENA. From the species of OREOPYRA it differs, in having a rounded tail instead of a forked one, and also the sexes are alike, except that the female has no metallic throat spot; while the females of OREOPYRA are reddish-buff beneath—a style of coloration entirely different from the males.

Genus XIII.—LAMPROLÆMA.

Lamprolaima, REICH., Aufz. der Colib. (1853), p. 9.

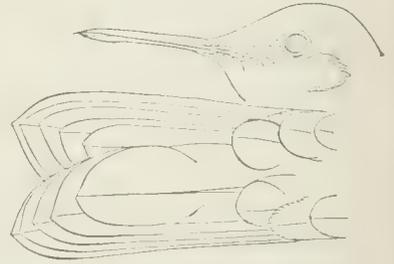
TYPE.
O. rhami, LESS.

Ch. Bill straight, slender, tip acute, about equal in length to the head. Wings long, ample. Tail long, slightly forked, feathers broad. Feet rather large; tarsi clothed to the toes. Sexes dissimilar in plumage.

Range. Mexico and Guatemala.

This genus, comprising but a single species, is closely allied to both the members of *CÆLIGENA* and *OREOPYRA*, and finds its natural position here, as a connecting link for the two genera just mentioned. The *L. rhami* is a very beautiful bird, about equal in size to the *C. clemenciae*, and like that species has a brilliant throat, but differs from it in its lustrous metallic breast, which equals in beauty that of the *Oreopyra calolæma*, next to which species I have placed it.

Fig. 13.



Lamprolaima rhami. ♂. Oaxaca. Salle.

1. *Lamprolæma rhami*.

Ornismya rhami, LESS., Rev. Zool. (1838), p. 315.

Mellisuga rhami, GRAY, Gen. Birds, vol. i, p. 112.

Lampornis rhami, BON., Consp. Gen. Av., p. 72 (1850).

Lamprolaima rhami, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum, p. 6, pl. 746, fig. 4712-13 (1855).

Delaltria rhami, BON., Rev. and Mag. Zool. (1854), p. 253.

Heliodoxa rhami, REICH, Troch. Enum., p. 6 (1855).

Lamprolæma rhami, GOULD, Mon. Troch., vol. i, pl. 61.—ID., Intr. Troch., octavo ed., p. 59 (1861).

Lamprolæma rhami, CAB. and HEIN., Mus. Hein. Th., iii, p. 30 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 218.

Hab. Mexico, Guatemala.

Male. Entire upper surface grass-green. Greater wing coverts, secondaries, and basal two-thirds of primaries chestnut-red, remainder purplish-brown. Throat metallic amethyst-red, surrounded by black. Breast metallic dark blue. Rest of under surface blackish-brown spotted with green. Tail deep rich purple. Bill black. Total length, $4\frac{5}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, 2 in. Culmen, $\frac{5}{8}$ in.

Female has the entire under surface grayish-brown; and the outer tail feathers are tipped with gray.

Genus XIV.—OREOPYRA.

TYPE.

Oreopyra, GOULD, P. Z. S. (1860), p. 312 (desc. null.)—ID., Intr. Troch., octavo ed., p. 141 (desc.).

O. leucaspis, Gould.

Fig. 14.



Oreopyra calolæma, ♂ ad. Veragua. Arcé.

Ch. "Bill longer than the head, straight or very slightly arched; wings long and rigid (?); tail moderately long and forked; tarsi clothed; feet rather small." (Gould, loc. cit.)

Key to the species.

- A. Throat metallic-purple.
- B. Throat white, not metallic.
 - a. Tail black.
 - b. Tail grayish-white.

- 1. *O. calolæma*.
- 2. *O. leucaspis*.
- 3. *O. cinereicauda*.

The males of this genus are clothed in brilliant metallic plumage, one species having a metallic spot upon the throat, while the other two strangely enough have this part pure white. They are of moderate size, of graceful form, and the sexes are entirely different in the coloring of their plumage.

1. *Oreopyra calolæma*.

Oreopyra calolæma, SALV., P. Z. S. (1864), p. 584.

Hab. Costa Rica (Volcan de Cartago), Veragua.

Male. Top of head shining bluish-green. Upper parts dark grass-green. Entire throat metallic violet-red. Auriculars black; white line behind the eye. Breast shining bluish-green. Abdomen ashy-brown. Under tail coverts the same margined with white. Wings purplish-brown. Tail bluish-black. Bill black. Total length, 4 in. Wing, 2½ in. Tail, 1½ in. Culmen, ¾ in.

Female. Upper parts grass-green. Entire under parts reddish-buff. Median rectrices dark green; base of lateral ones dark green, remaining parts steel-black, the two outermost feathers tipped with white.

2. *Oreopyra leucaspis*.

Oreopyra leucaspis, GOULD, Mon. Troch., vol. iv, pl. 264.—ID., Intr. Troch., octavo ed., p. 141 (1861).

Metallura castaneiventris, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5 (1855).

Anthocephala castaneiventris, GOULD, Mon. Troch., vol. iii, pl. 203.—ID., Intr. Troch., octavo ed., p. 115. ♀.

Hab. Chiriqui.

Male. Top of head brilliant metallic light green. Upper part dark grass-green. Breast shining bright green. Throat pure white. Abdomen and under tail coverts grayish-brown, the latter margined with grayish-white. Wings purple-brown.

Tail steel-black. Bill black. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts grass-green. White line behind the eye. Auriculars black. Entire under parts reddish-buff. Median rectrices bronze-green. Lateral ones bronze-green at base graduating into black, with white tips. Bill black.

3. *Oreopyra cinereicauda.*

Oreopyra cinereicauda, LAWRE., ANN. N. Y. Lyc. Nat. Hist., vol. viii, p. 485, vol. ix, p. 125.

Oreopyra castaneiventris, LAWRE., ANN. N. Y. Lyc. Nat. Hist., vol. ix, p. 124 (partim).

Hab. Costa Rica.

Male. This species differs from *O. leucaspis* in the coloring of the tail, which is ashy-white. The under tail coverts are also paler. The bill is also longer. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{7}{8}$ in.

The female is exactly like that of *O. leucaspis*, but has a longer bill.

The next genus is composed of species remarkable for their coloration, and the high elevations at which they live. They are robust birds, the majority nearly pure white beneath, and all possessing brilliant throats. The sexes are very different in coloration, and the females of two of the species are so much alike that it is impossible to distinguish them apart, rendering it absolutely necessary that their correct localities should be given, to enable the birds to be satisfactorily determined.

Genus XV.—OREOTROCHILUS.

Oreotrochilus, GOULD, P. Z. S. (1847), p. 10.

Orotrochilus, CAB. and HEIN., Mus. Hein. Th., iii, p. 15 (1860).

TYPE.

O. estelleæ, D'Orb.

O. pichincha, Bourc.

Ch. "Bill longer than the head, almost cylindrical, but slightly curved downwards; wings rather large and powerful; tail large and rounded, the feathers narrow, rather pointed and rigid; feet strong, the hind toe and nail about equal in length to the middle toe and nail; tarsi clothed with feathers." (Gould, l. c.)

Range. West coast of South America, from Ecuador to Chili, along the Andes at considerable elevations.

Six species are known.

Fig. 15.



Oreotrochilus pichincha. ♂. Quito. Whitely.

Key to the species.

- | | |
|---|-----------------------------|
| A. Under parts white. | |
| a. Head and throat shining violet-blue. | 1. <i>O. pichincha</i> . |
| b. Head violet-blue, throat metallic-green. | 2. <i>O. chimborazo</i> . |
| c. Head brown, throat metallic-green, abdomen chestnut. | 3. <i>O. estellæ</i> . |
| d. Head brown, throat green, abdomen steel-blue. | 4. <i>O. leucopleurus</i> . |
| B. Under parts black, throat metallic-green. | 5. <i>O. melanogaster</i> . |
| C. Under parts deep chestnut, central line of black, throat metallic-green. | 6. <i>O. adelæ</i> . |

1. Oreotrochilus pichincha.

Trochilus pichincha, BOURC. and MULS., Ann. Acad. Sc., Lyon (1849), p. 427.

Oreotrochilus jamesonii, JARD., Contr. Ornith. (1849), p. 42.

Oreotrochilus pichincha, BON., Consp. Gen. Av., vol. i, p. 76 (1850).—ID., Rev. and Mag. Zool. (1854), p. 250.
—GOULD, Mon. Troch., vol. ii, pl. 68.—ID., Intr. Troch., octavo ed., p. 63.—REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enum. (1855), p. 12.

Oreotrochilus pichincha, CAB. and HEIN., Mus. Hein. Th., iii, p. 15.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 162.

Hab. Ecuador, volcanoes of Pichincha and Cotopaxi.

Male. Head and throat violet-blue, bounded beneath by a line of black. Upper parts olive-green. Wings purple-brown. Under parts pure white; a line of greenish-black down the centre of abdomen. Under tail coverts olive-green with light brown margins. Upper tail coverts bright green. Median rectrices dark green; outermost ones white at base, greenish-black for the remainder of their length; rest of tail feathers white, margined on outer webs with brownish-black. Bill and feet black. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female. Entire upper parts olive-green; throat white, each feather tipped with olive, under parts olive-brown, the feathers margined with brownish-white. Median rectrices dark green, remainder greenish-brown, white at base, and a white spot on the inner web at its tip.

2. Oreotrochilus chimborazo.

Trochilus chimborazo, DELATT., BOURC., Rev. Zool. (1846), p. 305.

Oreotrochilus chimborazo, GOULD, Mon. Troch., vol. ii, pl. 69.—ID., Intr. Troch., octavo ed., p. 62.—GRAY, Gen. Birds, vol. i, p. 104, sp. 3.—REICH., Aufz. der Colib., p. 15.—ID., Troch. Enum., p. 12.—BON., Consp. Gen. Av., vol. i, p. 66.—ID., Rev. and Mag. Zool. (1854), p. 250.

Oreotrochilus chimborazo, CAB. and HEIN., Mus. Hein. Th., iii, p. 15 (note 5).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 166.

Hab. Ecuador, volcano of Chimborazo.

Male. This species differs from the *pichincha* in having a triangular spot of brilliant metallic-green on the throat. In all other respects the two are very similar in color and dimensions.

The female is so much like that of *pichincha* that it is impossible to tell them apart, and an authentic locality is necessary to enable one to arrive at a correct determination.

3. *Oreotrochilus estellæ*.

Trochilus estella, D'ORB and LAFRES., Syn. Av., no. 31, p. 32 (1838).

Orthorhynchus estella, D'ORB, Voy. Amer. Merid., t. iv (1835-44), p. 376, pl. 61, fig. 1.

Trochilus ciciliæ, LESS., Rev. Zool. (1839), p. 43.

Oreotrochilus estellæ, GOULD, Mon. Troch., vol. ii, pl. 70.—ID., Intr. Troch., octavo ed., p. 63.—BON., Consp.

Gen. Av., vol. i, p. 76.—ID., Rev. and Mag. Zool. (1854), p. 250.—GRAY, Gen. Birds, vol. i, p. 104, sp. 1.

—REICH., Aufz. der Colib., p. 15.—ID., Troch. Enum., p. 12.—ELLIOT, Ibis (1877), p. 142.

Orotrochilus estellæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 16.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 169.

Hab. Bolivia, Peru.

Male. Head and upper parts olive-brown, passing to coppery-green on the upper tail coverts. Throat brilliant grass-green, bordered beneath by a line of black. Flanks olive-brown; breast and abdomen white, in the centre of the latter a line of deep chestnut. Under tail coverts olive-brown. Median rectrices dark green with bronze reflections; remainder white, bordered on the outer webs with black. Wings purplish-brown. Bill black. Total length, 5 in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female differs from the male in having the throat white, spotted with brown; under parts rufous-brown; and the lateral tail feathers white, crossed with a band of green in the centre. Dimensions the same as those of the male.

4. *Oreotrochilus leucopleurus*.

Oreotrochilus leucopleurus, GOULD, P. Z. S. (1847), p. 10.—ID., Mon. Troch., vol. ii, pl. 71.—ID., Intr. Troch., octavo ed., p. 63.—GRAY, Gen. Birds, vol. i, p. 104, sp. 2.—REICH., Aufz. der Colib., p. 15 (1853).—ID., Troch. Enum., p. 12.—BON., Consp. Gen. Av., vol. i, p. 76 (1850).

Orotrochilus leucopleurus, CAB. and HEIN., Mus. Hein. Th., iii, p. 16.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 172.

Hab. Chili.

Male. This species differs from the *estellæ* mainly by having the centre of the abdomen bluish-black instead of chestnut; and perhaps there is less of the blackish-brown margin on the white lateral rectrices. In dimensions the two species are about the same.

Female. The remarks already made regarding the females of *pichincha* and *chimboraço* may be repeated here; as without a knowledge of the locality the female of the present bird cannot be determined from that of *estellæ*.

5. *Oreotrochilus melanogaster*.

Oreotrochilus melanogaster, GOULD, P. Z. S. (1847), p. 10.—ID., Mon. Troch., vol. ii, pl. 72.—ID., Intr. Troch., octavo ed., p. 64.—GRAY, Gen. Birds, vol. i, p. 104.—BON., Consp. Gen. Av., vol. i, p. 76.—REICH., Aufz. der Colib., p. 15.—ID., Troch. Enum., p. 12.

Orotrochilus melanogaster, CAB. and HEIN., Mus. Hein. Th., iii, p. 15 (note 6).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 176.

Hab. Peru (Maraynioc, Jelski).

Male. Upper parts olive-brown; throat metallic grass-green; under parts bluish-black. Upper tail coverts shining green, under coverts olive-brown margined with

buff. Tail steel-blue with green reflections. Bill and feet black. Total length, $4\frac{3}{8}$ in. Wing $2\frac{7}{8}$ in. Tail, 2 in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts light brown with a greenish lustre. Upper tail coverts shining green. Throat white, unspotted. Under parts brownish-white tinged with buff. Under tail coverts buffy-brown. Tail shining green, all the lateral feathers tipped with white.

6. *Oreotrochilus adelæ*.

Trochilus adela, D'ORB and LAFRES, Syn. Av. (1838), no. 32, p. 33.

Orthorhynchus adela, D'ORB, Voy. Amer. Merid. Atl., pl. 61, fig. 2, p. 377, vol. iv.

Oreotrochilus adelæ, GOULD, Mon. Troch., vol. ii, pl. 73.—ID., Intr. Troch., octavo ed., p. 64.—GRAY, Gen. Birds, vol. i, p. 104, sp. 4.—BON., Consp. Gen. Av., vol. i, p. 76.—REICH., Aufz. der Colib., p. 15.—ID. Troch. Enum., p. 12.—ELLIOT, Ibis (1877), p. 142.

Orotrochilus adelæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 15 (note 4).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 174.

Hab. Bolivia

Male. Upper surface olive-brown. Throat metallic grass-green. Under parts deep chestnut, with a central line of black. Under tail coverts olive-brown edged with buff. Tail cuneate shape; median feathers dark brown, remainder pale buff margined with olive-brown; outer webs almost wholly of this color. Shafts white. Bill and feet black. Total length, $5\frac{3}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail $2\frac{1}{8}$ in. Culmen, 1 in.

Female differs by having the throat white, spotted with olive-brown; under parts wholly rufous; and the lateral tail feathers buff with a subterminal black bar, and tipped with white on the inner web.

Genus XVI.—LAMPORNIS.

Lampornis, SWAINS., Zool. Journ., vol. iii (1827), p. 358.

Anthracothonax, BOIE, Isis (1831), p. 546.

Smaragdites, BOIE, Isis (1831), p. 547.

Floresia, REICH., Aufz. der Colib. (1853), p. 11.

Hypophania, REICH., Aufz. der Colib. (1853), p. 11.

Margarochrysis, REICH., Aufz. der Colib. (1853), p. 11.

Endoxa, HEIN., Journ. für Ornith. (1868), p. 179.

TYPE.

T. mango, Linn.

T. violicauda, Bodd.

T. dominicus, Linn.

T. porphyryrus, Shaw.

T. dominicus, Linn.

T. dominicus, Linn.

T. mango, Linn.

Ch. Bill longer than the head, curved; wings long as median rectrices. Tail slightly forked. Feet moderate, tarsi bare. Sexes unlike in plumage.

Range. Mexico, Central America, West India Islands of Hayti, Porto Rico, Jamaica, and St. Thomas. Venezuela, Guiana, Brazil, and Columbia.

Eight species are known.

The genus LAMPORNIS, Swainson (l. c.), had for types the *T. mango*, Linn., *T. pella*, Linn., and the *T. niger*, Swain.,

Fig. 16.



Lampornis violicauda. ♂. Caracas. Sallé.

Ill. Zool. The second of these is the type of *Topaza*, Gray, the third under its proper name of *FUSCUS*, Vieill., is the type of *FLORISUGA*, Bon., leaving the *T. mango*, Linn. (= *porphyryrus*, Auct.), as the type of *LAMPORNIS*, Swains.

The genus *SMARAGDITES*, Boie (l. c.), is a composite one. The first species cited by him is *Trochilus viridissimus*, but as no author's name is given, it is impossible to say what species is intended. The next is *T. aurulentus*, Vieill. (= *T. dominicus*, Linn.), and this I have adopted as the type of his genus.

Key to the species.

- | | |
|--|----------------------------|
| A. Throat black. | |
| a. Under surface black. | |
| a'. The green flanks separated from the black abdomen by a line of blue. | 1. <i>L. violicauda</i> . |
| b'. Sides of neck metallic purplish-red. | 2. <i>L. mango</i> . |
| b. Under surface golden-green, centre of abdomen bluish-green. | 3. <i>L. prevosti</i> . |
| B. Entire under surface shining green. | 4. <i>L. viridis</i> . |
| C. Throat metallic-green, breast blue. | 5. <i>L. veraguensis</i> . |
| D. Throat metallic grass-green. | |
| a. Middle of breast and abdomen black, flanks green. | 6. <i>L. gramineus</i> . |
| b. Breast and under surface purplish-black. | 7. <i>L. calosoma</i> . |
| E. Throat metallic yellowish-green, breast and under surface black. | 8. <i>L. dominicus</i> . |

Green and black are the principal hues in the plumage of these birds. They are moderate in size, and their metallic colors are chiefly confined to the throat and breast.

1. *Lampornis violicauda*.

Trochilus violicauda, BODD., Tab. Plan. Enlum. d'Aubent, no. 671, fig. 2 (1783).

Trochilus albus, GMEL., Syst. Nat. (1788), vol. i, p. 488, sp. 34.?

Trochilus punctulatus, GMEL., Syst. Nat. (1788), vol. i, p. 488, sp. 33. ?—LATH., Ind. Orn., vol. i, p. 306, sp. 15.?

Trochilus nitidus, LATH., Ind. Orn., vol. i, p. 305 (1790).

Trochilus nigricollis, quadricolor, atricapillus, and punctatus, BONNT., VIEILL., Ency. Méth., pp. 553, sp. 20; 555, sp. 28; 553, sp. 22; 550, sp. 9.

Trochilus fasciatus, SHAW, Gen. Zool., vol. viii, p. 303.

Trochilus lazulus, LESS., Trait. Orn., p. 290 (1832).

Trochilus mango, D'ORB. and LAFRES, Syn. Av., ii, p. 32, sp. 26 (1838).

Polytmus mango, GRAY, Gen. Birds, vol. i, p. 107, sp. 10 (1844-49).

Anthracothorax mango, REICH., Aufz. der Colib. (1853), p. 11.—ID., Troch. Enum. (1855), p. 8, t. 791, figs. 4839-41.

Lampornis mango, GOULD, Mon. Troch., vol. ii, pl. 74.—ID., Intr. Troch., octavo ed., p. 64, et Auct.

Lampornis iridescens, GOULD., Intr. Troch., octavo ed., p. 65 (1861).

Lampornis violicauda, ELLIOT, Ibis (1872), p. 351, and (1877) p. 141.

Hab. Brazil, Guiana, Venezuela, Panama, and Columbia.

Male. Upper surface and flanks golden-green. Throat and abdomen black, separated from the green of the flanks by a line of blue; under tail coverts violet-brown, or green varying in different specimens. Median rectrices bronzy-green, lateral ones violet-red, margined with steel-blue. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{7}{8}$ in.

Female differs in having the centre of the throat, breast, and abdomen black, bordered with white. Under tail coverts bronzy-green edged with grayish-white;

median rectrices bronze-green, lateral ones steel-blue, glossed with green on the outer webs, and tipped with white.

Obs. I have examined Mr. Gould's type of *L. iridescens*, and in my opinion the difference in color that it exhibits is too slight and unimportant to entitle it to a separate rank.

2. *Lampornis mango*.

Mango-bird, ALBIN, Birds, vol. iii, p. 45, t. 49, fig. 6.

Trochilus mango, LINN., Syst. Nat., p. 191, sp. 10 (1766).—GMEL., Syst. Nat. (1788), p. 491.

Trochilus porphyurus, SHAW, Nat. Misc., vol. ix, pl. 333, et Auct.

Polytmus porphyurus, GRAY, Gen. Birds, vol. i, p. 108, sp. 20.

Lampornis mango, GOSSE, Birds, Jamaica (1847), p. 88.—ELLIOT, Ibis (1872), p. 350.

Lampornis floresii, BON., Rev. and Mag. Zool. (1854), p. 250.—ID., Consp. Av., vol. i, p. 72 (1850).

Floresia porphyura, REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 8, t. 795, fig. 4849-50 (1855).

Anthracothorax porphyurus, REICH., Troch. Enum., p. 8, pl. 795, fig. 4849-50 (1855).

Lampornis porphyura, CAB. and HEIN., Mus. Hein. Th., iii, p. 19 (1860).

Endoxa porphyura, HEINE, Journ. für Ornith. (1863), p. 179.

Lampornis porphyurus, GOULD, Mon. Troch., vol. ii, pl. 81.—ID., Intr. Troch., octavo ed., p. 67.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 163.

Hab. Jamaica.

Adult. Upper parts dark olive-brown, becoming greenish on the upper tail coverts, and glossed with purple on the nape. From the bill on each side of the neck is a broad band of metallic-purple, very brilliant. Throat and breast velvety-black, becoming brownish-black on abdomen and flanks. Under tail coverts dark green. Median rectrices brownish-black, lateral ones rich shining purple margined with steel-blue. Bill black. A white spot on each flank. Total length, 5 in. Wing, $2\frac{3}{4}$ in. Tail, 2 in. Culmen, $\frac{7}{8}$ in.

Some specimens have the chin green and the throat purplish-green. Mr. Gould says these are females. I have not been able to ascertain that this is a fact from any one who has dissected the specimens.

3. *Lampornis prevosti*.

Trochilus prevosti, LESS., Nat. Hist. Col., p. 87, pl. 24 (1831).

Polytmus prevosti, GRAY, Gen. Birds, vol. i, p. 108, sp. 15.

Anthracothorax prevosti, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 8, pl. 792, fig. 4842-44 (1855).

Lampornis prevosti, GOULD, Mon. Troch., vol. ii, pl. 75.—ID., Intr. Troch., octavo ed., p. 65 (1861).—BON., Consp. Av., vol. i, p. 72 (1850).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 160.—BON., Rev. and Mag. Zool. (1854), p. 250.

Hab. Mexico, and Central America to Costa Rica.

Male. Upper surface, sides of neck, flanks, and abdomen bright golden-green. Chin and throat velvety-black. Centre of breast and abdomen bluish-green. Vent white. Under tail coverts purple. Median rectrices bronze-green; lateral ones purplish-red or bright violet margined with brownish-black. Bill black. Total length, $4\frac{7}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, 1 in.

Female. Similar to the female of *L. violicauda*, but the lateral rectrices are chestnut-red with a subterminal bar of steel-blue and tipped with white.

4. *Lampornis viridis*.

Trochilus viridis, AUD. and VIEILL., Ois. Dor. (1802), vol. i, p. 34, pl. xv.

Agrytria viridis, REICH., Troch. Enum., p. 7, pl. 765, figs. 4771-72 (1855).

Chalybura viridis, REICH., Aufz. der Colib., p. 10 (1853).

Lampornis viridis, GOULD, Mon. Troch., vol. ii, pl. 78.—ID., Intr. Troch., octavo ed., p. 66.—ELLIOT, Ibis (1872), p. 348.—BON., Consp. Av., vol. i, p. 71 (1850).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 172.

Hab. Porto Rico.

Male. Upper surface bronzy-green. Entire under surface shining grass-green. Wings purplish-brown. Tail deep blue, with green reflections, and edged at tip with white. Bill black. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{5}{16}$ in. Tail, $1\frac{1}{2}$ in. Culmen, 1 in.

Female. Head brown. Upper parts golden-green. Under parts grayish-white, tinged with green on the flanks. Median rectrices bronze-green, lateral ones steel-blue on their inner webs, bronzy-brown on the outer, and tipped with white. Bill black.

5. *Lampornis veraguensis*.

Lampornis veraguensis, GOULD, Mon. Troch., vol. ii, pl. 76.—ID., Intr. Troch., octavo ed., p. 65 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 18 (1860).—BON., Rev. and Mag. Zool. (1854), p. 250.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 146.

Sericotes veraguensis, REICH., Aufz. der Colib., p. 11 (1853).

Anthracothorax (Sericotes) veraguensis, REICH., Troch. Enum., p. 9, pl. 793, fig. 4848 (1855).

Hab. Veragua.

Male. Upper surface golden-green. Throat glittering grass-green. Breast shining blue, which color also reaches to the centre of the abdomen, flanks golden-green. Under tail coverts purple. Middle tail feathers bronzy-green, lateral ones bright purple margined with steel-blue. Wings purplish-brown. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{7}{8}$ in.

Female has the centre of the throat and abdomen dark green, bordered with white. Lateral tail feathers chestnut, with a subterminal steel-blue bar, and tipped with white. Rest like the male.

6. *Lampornis gramineus*.

Trochilus gramineus, GMEL., Syst. Nat., vol. i, p. 488 (1788).

Trochilus maculatus, GMEL., Syst. Nat., vol. i, p. 488 (1788).

Trochilus pectoralis, LATH., Ind. Orn., vol. i, p. 306 (1790).

Trochilus gularis, LATH., Ind. Orn., vol. i, p. 563, Juv.

Trochilus marmoratus, VIEILL., Ency. Méth., p. 567, Juv.

Polytmus dominicus, GRAY, Gen. Birds, vol. i, p. 108, sp. 11 (nec Linn.).

Lampornis gramineus, GOULD, Mon. Troch., vol. ii, pl. 77.—ID., Intr. Troch., octavo ed., p. 65.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 148.

Lampornis graminea, CAB. and HEIN., Mus. Hein. Th., iii, p. 18 (1860).

Hab. Guiana, Venezuela.

Male. Upper parts golden-green. Wings purplish-brown. Throat brilliant grass-green; flanks golden-green, with a white spot on each side. Centre of breast and abdomen black. Under tail coverts purplish-green. Median rectrices dark brown.

with steel-blue reflections, lateral ones violet, margined and tipped with steel-blue. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $1\frac{1}{16}$ in.

Female differs in having the throat white, with the central portion black. Median tail feathers bronzy-green with black tips, lateral ones chestnut with a purple gloss, and a subterminal bluish-black bar and white tips.

The *young male* has the sides of the throat and abdomen chestnut; centre of throat shining green bordered with white; and the centre of abdomen black bordered with white. Tail similar to that of the female.

7. *Lampornis calosoma*.

Chrysolampis chlorolæmus, ELLIOT, Ann. Mag. Nat. Hist., 4th ser., vol. vi, p. 346 (1870).

Lampornis calosoma, ELLIOT, Ibis (1872), p. 351.—MELS., Hist. Nat. Ois. Mouch., tom. i, p. 177.

Hab. —?

Male. Top of head and neck pale metallic silvery-green, in some lights purplish; a black band across the back, rest of upper parts dark green; tail fiery copper color, feathers margined with blackish-purple; throat brilliant emerald-green; under parts purplish-black; spot of white on the flanks; under tail coverts chestnut. Bill black. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in. Description taken from the unique type in my collection.

Female. Unknown.

8. *Lampornis dominicus*.

Trochilus dominicus, LINN., Syst. Nat. (1766), p. 191, ♀.—GMEL., Syst. Nat. (1788), vol. i, p. 489.—LATH., Ind. Orn., t. i, p. 309.

Trochilus margaritaceus, GMEL., Syst. Nat., p. 490 (1788), ♀.

Trochilus aurulentus, VIEILL., Ois. Dor. (1802), pl. xii.—SHAW., Gen. Zool., t. viii (1811), p. 306.

Polytmus margaritaceus, GRAY, Gen. Birds, vol. i, p. 108, sp. 13 (1844-49).

Lampornis margaritaceus, BON., Consp. Gen. Av., vol. i, p. 72, sp. 5 (1850).

Margarochrysis aurulenta, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., t. 784, figs. 4822-23 (1855).

Hypophania dominica, REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 9, t. 795, figs. 4845-6.

Lampornis aurulentus, GOULD, Mon. Troch., vol. ii, pl. 79.—ID., Intr. Troch., octavo ed., p. 66.—MELS., Hist. Nat. Ois. Mouch., tom. i, p. 152.

Lampornis virginalis, GOULD, Mon. Troch., vol. ii, pl. 80.—ID., Intr. Troch., octavo ed., p. 66.

Eulampis aurulentis, BON., Rev. and Mag. Zool. (1854), p. 250.—BON., Consp. Av., vol. i, p. 71.

Lampornis dominicus, ELLIOT, Ibis (1872), p. 349.

Hab. St. Thomas, St. Domingo, Porto Rico.

Male. Upper surface dark yellowish-green. Throat metallic golden-green. Under surface black, with green flanks, and a spot of white on each. Under tail coverts dark purple. Wings purplish-brown. Median rectrices dark bronzy-green, lateral ones purple-violet bordered with steel-blue. Bill black. Total length, 5 in. Wing, $2\frac{5}{8}$ in. Tail, 2 in. Culmen, $\frac{3}{4}$ in.

Female differs in having all the under surface gray, and the lateral tail feathers purple-chestnut with a subterminal black bar and white tips.

Genus XVII.—EULAMPIS.

Eulampis, BOIE, Isis (1831), p. 547.

Culampis, LESS., Ind. Gen. et Synop. du Genr. Troch., p. vii (1832).

Sericotes, REICH., Aufz. der Colib., p. 11 (1853).

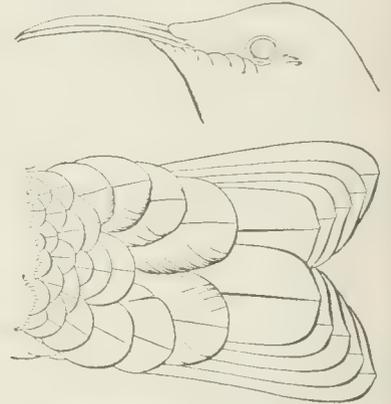
TYPE.

T. jugularis, Linn.

T. jugularis, Linn.

T. holosericeus, Linn.

Fig. 17.



Eulampis jugularis. ♂. 74010. Dominica.

Ch. Bill longer than the head; curved; feathers of forehead projecting upon the culmen; nostrils partly covered; wings very long. Tail moderate, even, or slightly forked. Tarsi bare. Sexes alike.

Range. Islands of the West Indies.

Key to the species.

- A. Breast and throat luminous green, bordered beneath with blue.
 B. Breast and throat shining vinous-purple.

1. *E. holosericeus*.
 2. *E. jugularis*.

The members of this genus are closely allied to those of LAMPORNIS; but, in addition to other characters, they possess luminous upper tail coverts, which render them very conspicuous. They are apparently more robust in form than the majority of the species of LAMPORNIS.

1. *Eulampis holosericeus*.

Trochilus holosericeus, LINN., Syst. Nat. (1766), vol. i, p. 191, sp. 11.—LATH., Ind. Orn., vol. i, p. 305.—LESS. Colib., p. 76, t. 20.

Polytmus holosericeus, GRAY, Gen. Birds, vol. i, p. 108, sp. 12 (1844-49).

Eulampis holosericeus, GOULD, Mon. Troch., vol. ii, pl. 83.—ID., Intr. Troch., octavo ed., p. 68.—BOX., Consp. Av., vol. i (1850), p. 72.—ID., Rev. and Mag. Zool. (1854), p. 250.—ELLIOT, Ibis (1872), p. 352.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 134.

Eulampis chlorolæmus, GOULD, Mon. Troch., vol. ii, pl. 84.—ID., Intr. Troch., octavo ed., p. 68.—BOX., Rev. and Mag. Zool. (1854), p. 250.

Sericotes chlorolæmus, REICH., Aufz. der Colib., p. 11 (1853).

Sericotes holosericeus, REICH., Aufz. der Colib., p. 11 (1853).

Anthracothonax (Sericotes) holosericeus, REICH., Troch. Enum., p. 9, t. 794, fig. 4847 (1855).

Anthracothonax chlorolæmus, REICH., Troch. Enum., p. 9 (1855).

Lampornis holosericeus, CAB. and HEIN., Mus. Hein. Th., iii, p. 19 (1860).

Lampornis chlorolæmus, CAB. and HEIN., Mus. Hein. Th., iii, p. 19 (note) (1860).

Eulampis longirostris, GOULD, Intr. Troch., octavo ed., p. 69 (1861).

Hab. St. Thomas, St. Croix, Martinique, Dominica, Santa Lucia.

Adult. Upper surface dark green. Wings purplish-brown. Throat and breast bright grass-green, bordered beneath by a patch of shining blue. Rest of under

parts black. Upper and under tail coverts glittering blue, some feathers with green reflections. Bill black. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

2. *Eulampis jugularis*.

Trochilus jugularis, LINN., Syst. Nat. (1766), p. 190, sp. 7.—LATH., Ind. Orn. (1790), vol. i, p. 305, sp. 12.

Trochilus auratus, violaceus, venustissimus, and cyanomelas, GMEL., Syst. Nat. (1788), vol. i, pp. 487, sp. 29; 488, sp. 41; 490, sp. 37; 498, sp. 62.

Trochilus cyaneus, granatinus, and bancrofti, LATH., Ind. Orn. (1790), vol. i, pp. 309, sp. 25; 305, sp. 11; 317, sp. 53.

Souimanga prasinoptère, VIEILL, Ois. Dor. (1802), vol. ii, p. 65.

Certhia prasinoptera, SPARR., Mus. Carlson, t. 81.

Trochilus (Culampis) auratus, LESS., Ind. Gen. Synop. Genr. Troch., p. vii (1831) (Lcs Trochilidæ).

Polytmus jugularis, GRAY, Gen. Birds, vol. i, p. 108, sp. 19 (1844-49).

Topaza violacea, GRAY, Gen. Birds, vol. i, p. 110, sp. 2.

Eulampis jugularis, GOULD, Mon. Troch., vol. ii, pl. 82.—ID., Intr. Troch., octavo ed., p. 67.—BON., Consp. Gen. Av., vol. i, p. 72 (1850).—ID., Rev. and Mag. Zool. (1854), p. 250.—REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9, t. 796, figs. 4851-52 (1855).—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 17.—ELLIOT, Ibis (1872), p. 352.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 131.

Hab. Islands of Nevis, Martinique, Dominica, and Santa Lucia.

Adult. Upper parts velvety-black; wings and their coverts glittering dark green. Chin, throat, and breast shining vinous purple. Abdomen black. Upper and under tail coverts shining bluish-green. Tail dark dull-green. Bill black. Total length, $4\frac{1}{2}$ in. Wing, 3 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

Genus XVIII.—LAFRESNAYA.

Calothorax, GRAY (nec 1840), Gen. of Birds, vol. i, p. 110 (1848).

Lafresnaya, BON., Compt. Rend. (1850) p. 380.

Entima, CAB. and HEIN., Mus. Hein. Th., iii, p. 51 (1860).

Euclosia, MULS. and VERR., Class. Troch. (1865), p. 63.

TYPE.

T. flavicaudata, Fras.?

T. flavicaudata, Fras.

T. gayi, Bourc.

T. flavicaudata, Fras.

Ch. Bill weak, slender, much curved, about one-half as long as the body. Wings long, pointed; primaries curving inwards; outer web on the first hardly perceptible, inner webs very narrow. Tail nearly even, feathers pointed. Under tail coverts reaching two-thirds the length of rectrices. Feet moderate, tarsi clothed. Sexes different in plumage.

Range. Venezuela, Columbia, and Ecuador.

Key to the species.

A. Breast green, abdomen black.

- a. Lateral rectrices buff, margined and tipped with bronzy-brown.
- b. Lateral rectrices white, tipped with bronze-green.

1. *L. flavicaudata*.

2. *L. gayi*.

Fig. 18.



Lafresnaya flavicaudata, ♂. Bogota. Whitely.

These birds are characterized by a rather stout form, slender curved bills, metallic green breast and black abdomens.

1. *Lafresnaya flavicaudata*.

Trochilus Lafresnayi, BOISSON, Rev. Zool. (1840), p. 8 (January).

Trochilus flavicaudatus, FRAS., P. Z. S. (1840), p. 18 (February).

Calothorax Lafresnayi, GRAY, Gen. Birds, vol. i, p. 110.

Lafresnaya flavicaudatus, BON., Consp. Gen. Av., vol. i, p. 68 (1850).

Lafresnaya flavicaudata, REICH., Aufz. der Colib. (1853), p. 11.—ID., Troch. Enum., p. 8, pl. 785, figs. 4824-25.

—GOULD, Mon. Troch., vol. ii, pl. 85.—ID., Intr. Troch., octavo ed., p. 69.—BON., Rev. and Mag. Zool. (1854), p. 252.

Entima Lafresnayi, CAB. and HEIN., Mus. Hein. Th., iii, p. 51 (1860).

Euclosia Lafresnaya, MULS., Hist. Nat. Troch., vol. ii, p. 187.

Hab. Columbia.

Male. Entire upper parts dark grass-green. Wings purplish-brown. Throat, breast, and flanks metallic grass-green; abdomen black. Median rectrices shining bronze-green. Lateral feathers buff, margined and tipped with bronzy-brown. Under tail coverts buff, tipped with bronze-green. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, 1 in.

Female has under surface deep buff, spotted on the throat with green. Flanks green; whitish on abdomen. Rest like the male.

2. *Lafresnaya gayi*.

Trochilus gayi, BOURC. and MULS., Ann. Soc. d'Agr., Lyon (1846), p. 325.

Trochilus saulæ, BOURC. and DELATT., Rev. Zool. (1846), p. 309.

Calothorax gayi, GRAY, Gen. Birds, vol. i, p. 110, sp. 2.

Calothorax saulæ, GRAY, Gen. Birds, vol. i, p. 110, sp. 3.

Lafresnaya gayi, BON., Consp. Gen. Av., vol. i, p. 68.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p.

8, t. 786, fig. 4826-27.—BON., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. ii, pl. 86.—

ID., Intr. Troch., octavo ed., p. 69.

Lafresnaya saulæ, BON., Consp. Av., vol. i, p. 68.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 8,

t. 786, fig. 4828-29.—GOULD, Intr. Troch., octavo ed., p. 70.

Entima gayi, CAB. and HEIN., Mus. Hein. Th., iii, p. 51 (1860).

Euclosia gayi, MULS., Hist. Nat. Troch., vol. ii, p. 190.

Hab. Venezuela and Ecuador.

Male. Precisely like the *L. flavicaudata*, except that the lateral rectrices are white tipped with black or greenish-bronze, and the under tail coverts are also white tipped with green. Dimensions the same.

Female has the under surface white spangled with green, rest like the male. The *L. saulæ*, BOURC., cannot be separated from the present species. Bourcier's types are in my collection, and I can see no difference whatever between them and specimens of *L. gayi*. The coloring of the tips of the rectrices varies, and evidently is not a specific character. The species inhabits Venezuela and Ecuador, having rather oddly the *L. flavicaudata* dwelling in Columbia, just between these two localities.

The CHALYBURÆ are distinguished from all known Humming-birds by the great development of their plume-like under tail coverts, which peculiarity is observed

to exist in both sexes, although the color of their plumage is quite different. The males with one exception are clothed in green, which hue is most luminous on the under surface. In the single species that differs from the rest, the under parts are blue. Although this genus is placed immediately after LAFRESNAYA as being the nearest to it of those known, it yet presents certain characters differing so greatly from any found in that genus, that we may reasonably suppose another form yet remains to be discovered, that will take its place between them, and make the chain more complete.

Genus XIX.—CHALYBURA.

Chalybura, REICH., Aufz. der Colib., p. 10 (1853).

Cyanochloris, REICH., Aufz. der Colib., p. 10 (1853).

Hypuroptila, GOULD, Mon. Troch., pt. vii (1853).—ID., Intr. Troch., octavo ed., p. 72 (1861).

Methon, MULS., Cat. Ois. Mouch. (1875), p. 7.

TYPE.

T. buffoni, Less.

T. cæruleiventris, Gould.

T. buffoni, Less.

T. cæruleiventris, Gould.

Fig. 19.



Chalybura buffoni, ♂ ad. Venezuela.
Goering.

Ch. Bill longer than the head, broad at base, slightly curving towards the tip. Wings long. Tail slightly forked. Under tail coverts greatly developed, plume-like. Sexes unlike in the color of their plumage.

Range. From Veragua through Central America, Venezuela, Columbia.

Five species are known.

Key to the species.

A. Under parts green.

a. Under tail coverts white.

a'. Tail bluish-black, sometimes glossed with bronze.

b'. Tail golden-bronze.

c'. Tail bronzy-purple.

b. Under tail coverts black.

B. Under parts blue.

1. *C. buffoni*.

2. *C. urochrysea*.

3. *C. isauræ*.

4. *C. melanorrhœa*.

5. *C. cæruleiventris*.

1. *Chalybura buffoni*.

Trochilus buffoni, LESS., Trochil., p. 34, pl. 15 (1831).

Polymus buffoni, GRAY, Gen. Birds, vol. i, p. 108.

Lampornis buffoni, BON., Consp. Gen. Av., p. 72.—ID., Rev. and Mag. Zool. (1854), p. 250.—MULS., Hist. Nat. Ois. Mouch., vol. i, p. 170.

Chalybura buffoni, REICH., Aufz. der Colib., p. 10 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 20 (1860).—GOULD, Intr. Troch., octavo ed., p. 72 (1861).

Agyrtia buffoni, REICH., Troch. Enum., p. 7, t. 766, figs. 4773-74 (1855).

Hypuroptila buffoni, GOULD, Mon. Troch., vol. ii, pl. 89.

Chalybura anecauda, LAWR., Proc. Acad. Nat. Sc., Phil. (1865), p. 38 (ex Venezuela).

Hab. Venezuela and Columbia.

Male. Upper surface bronze-green, becoming a brighter bronze on the upper tail coverts. Entire under surface shining emerald-green. Under tail coverts are pure white, and greatly developed. Wings purple-brown. Tail bluish-black, glossed with bronze, this latter color most conspicuous on the middle feathers. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{3}{4}$ in. Culmen, 1 in. Specimens from Venezuela have the tail feathers frequently very much glossed with bronze, and this style has been named *ancicauda* by Lawrence.

Female differs in having the chin grayish-white, rest of under surface gray, the feathers tipped with green. Median rectrices bronze-green, tips blue-black, lateral ones blue-black tipped with white. Rest like the male.

*2. *Chalybura urochrysea*.

Hypuroptila urochrysea, GOULD, P. Z. S. (1861), p. 198.—ID., Mon. Troch., vol. ii, pl. 90.

Chalybura urochrysea, GOULD, Intr. Troch., octavo ed., p. 72 (1861).

Lampornis urochrysia, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 176.—SALV., P. Z. S. (1867), p. 131.

Hab. Panama.

The type, which is unique, differs from the *C. buffoni* chiefly in the coloring of the tail, and as we know that specimens of the bird just named, from Venezuela, have frequently bronzy tail feathers, it is very questionable if the present is really a distinct species.

Mr. Gould's description is as follows:—

Head and upper surface dark-green, becoming of a bronzy-hue on the wing and upper tail covers: wings purplish-brown; tail rich golden-bronze both above and beneath; throat and breast grass-green; abdomen bronzy-green; thighs, vent, and under tail coverts pure white, upper mandible black, lower mandible fleshy-red with a black tip. Tarsi yellow or flesh-color. Total length, $4\frac{3}{4}$ in. Bill, $1\frac{1}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{7}{8}$ in.

3. *Chalybura isauræ*.

Hypuroptila isauræ, GOULD, P. Z. S. (1861), p. 199.

Chalybura isauræ, SALV., P. Z. S. (1867), p. 131, ♀.—GOULD, Intr. Troch., octavo ed., p. 72.

Lampornis isauræ, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 174.

Hab. Veragua, Costa Rica (Gould).

Head and back dark grass-green; rump and upper tail coverts purplish. Wings purplish-brown. Throat and breast very dark blue-green; flanks dark mouse-color glossed with green. Under tail coverts white. Tail dark bronze, purplish on the lateral rectrices. Maxilla black; mandible flesh-color, tip black. Feet and tarsi flesh-color. Total length, $4\frac{5}{8}$ in. Wing, $2\frac{5}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, 1 in. The above is taken from a fine adult male specimen, collected by Arcé in Veragua.

Female. Head and upper parts green. Rump and tail shining bronze. Wings brown. Under parts ashy, crissum white. Two lateral rectrices tipped with white. Maxilla brownish, mandible flesh-color, tip brown.

4. *Chalybura melanorrhoa*.

Chalybura melanorrhoa, SALV., P. Z. S. (1864), p. 585.

Chalybura carmioli, LAWR., Proc. Acad. Nat. Sci., Phila. (1865), p. 39.

Lampornis melanorrhoa, MELS., Hist. Nat. Ois. Mouch., tom. i, p. 174.

Hab. Costa Rica, Veragua.

Male. Head and upper parts dark grass-green. Rump purplish-bronze. Wings purplish-brown. Under parts very dark shining grass-green. Abdomen dark brown glossed with green. Under tail coverts black. Tail dark bronzy-purple. Maxilla black, mandible flesh-color. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{7}{8}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{7}{8}$ in.

5. *Chalybura cæruleiventris*.

Trochilus cæruleogaster, GOULD, P. Z. S. (1847), p. 96.

Polytmus cæruleogaster, GRAY, Gen. Birds, vol. i, p. 108, sp. 18.

Cyanochloris cæruleiventris, REICH., Aufz. der Colib., p. 10 (1853).

Agyrtia (chalybura) cæruleiventris, REICH., Troch. Enum., p. 7, pl. 767, figs. 4775-76 (1855).

Chalybura cæruleiventris, CAB. and HEIN., Mus. Hein. Th., iii, p. 20 (1860).

Hypuroptila cæruleogaster, GOULD, Mon. Troch., vol. ii, pl. 91.

Chalybura cæruleogaster, GOULD, Intr. Troch., octavo ed., p. 73 (1861).

Lampornis cæruleiventris, BON., Rev. and Mag. Zool. (1854), p. 250.—*Id.*, Consp. Av., p. 72.—*MELS.*, Hist. Nat. Ois. Mouch., tom. i, p. 168.

Hab. Columbia.

Male. Upper parts dark grass-green. Chin and throat shining green, graduating into a rich dark blue on the breast and abdomen. Flanks and lower parts of abdomen green. Under tail coverts pure white. Tail black, with steel-blue reflections. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, 2 in. Culmen, 1 in.

Female. Differs from the male in having the under surface pale gray. Median rectrices bronzy-green, remainder bluish-black, with the two outermost feathers tipped with white.

Genus XX.—FLORISUGA.

TYPE.

Orthorhynchus, Ill. Prod. Syst. Mamm., etc., p. 209 (1811) (nec LACÉPÈD., 1799-1800).

Lampornis, LESS. (nec SWAINS., 1827), Tab. Esp. Ois. Mouch. (1829), p. xxiii.

Florisuga, BON., Compt. Rend., p. 382 (1850).

T. mellivorus, Linn.

T. mellivorus, Linn.

T. mellivorus, Linn.

Fig. 20.



Florisuga mellivora. ♂. Bogota. Whitely.

Ch. Bill strong, nearly straight, about as long as the head. Tail ample, slightly rounded. Wings nearly as long as the rectrices. Upper tail coverts reaching nearly to the tips of the median rectrices. Sexes unlike.

Range. Central America from Guatemala, northern parts of South America and the Amazonian region of Brazil; island of Tobago, Columbia, Peru.

But two species are known.

Key to the species.

- A. Head and breast blue, back green, nape and abdomen white. 1. *F. mellivora*.
 B. Head and under parts black, back very dark green. 2. *F. fusca*.

These birds possess the general form of those composing the genus *CHALYBURA*, and with rather long under tail coverts; not, however, plume-like as in the others. The plumage is blue, green, and white, or black, and a peculiar feature is the pure white tail tipped with purplish-brown.

1. *Florisuga mellivora*.

- Trochilus mellivorus*, LINN., Syst. Nat. (1766), vol. i, p. 193.—GMEI., Syst. Nat., tom. i, p. 499.—LATH., Ind. Orn., vol. i, p. 310, sp. 34.
Trochilus fimbriatus, LINN., Syst. Nat. (1766), vol. i, p. 193.
Mellisuga surinamensis, STEPH., Gen. Zool., vol. xiv, p. 243, sp. 3.
Ornismya mellivora, LESS., Ois. Mouch., p. 90, t. 21-22 (1829).
Florisuga mellivora, BON., Consp. Gen. Av., vol. i, p. 73 (1850).—ID., Rev. and Mag. Zool. (1854), p. 253.—GOULD, Mon. Troch., vol. ii, pl. 113.—ID., Intr. Troch., octavo ed., p. 80.—REICH., Troch. Enum., p. 12 (1855).—ID., Aufz. der Colib., p. 14 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 29.—MELS., Hist. Nat. Ois. Mouch., tom. ii, p. 178.
Trochilus (—?), *flabellifera*, GOULD, P. Z. S. (1846), p. 45.
Topaza mellivora, GRAY, Gen. Birds, vol. i, p. 110, sp. 6.
Topaza fimbriata, GRAY, Gen. Birds, vol. i, p. 110, sp. 7.
Topaza flabellifera, GRAY, Gen. Birds, vol. i, p. 110, sp. 8.
Florisuga flabellifera, GOULD, Mon. Troch., vol. ii, pl. 114.—ID., Intr. Troch., octavo ed., p. 81.—BON., Consp. Gen. Av., p. 74, sp. 3.—REICH., Aufz. der Colib., p. 14.—ID., Troch. Enum., p. 12.—CAB. and HEIN., Mus. Hein. Th., iii, p. 29 (note).—BON., Rev. and Mag. Zool. (1854), p. 253.

Hab. Central America from Guatemala, southward through Columbia and Peru; islands of Tobago and Trinidad; Venezuela, Guiana, and the Amazonian region of Brazil.

Male. Head and neck dark shining cobalt-blue. Across the nape of the neck, a cuneate-shaped white band, rest of upper parts dark shining grass-green. Wings purplish-brown. Upper part of breast and flanks shining grass-green. Rest of under parts pure white. Upper tail coverts very long, same color as the back. Tail pure white, feathers margined and tipped with purplish-brown. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{7}{8}$ in.

Female. Upper parts bronzy-green, dullest on the crown. Throat and upper part of breast white spotted with dark brown, flanks and upper parts of abdomen grass-green: rest of under parts white. Under tail coverts blackish-brown tipped with white. Tail bronzy-green, with a subterminal bar of deep blue, and the tips white. I have placed the *F. flabellifera* of Gould among the synonyms of this species, as it has no claims whatever to be considered a distinct species, not being even a local variety.

2. *Florisuga fusca*.

- Trochilus fuscus*, VIEILL., Nouv. Dict. Hist. Nat. (1817), vol. vii, p. 348.
Trochilus ater, PR. MAX., Reis. Bras., vol. i, p. 366; vol. ii, p. 136.
Trochilus niger, SWAIN., Zool. Ill., 1st ser., vol. ii, pl. 82.
Ornismya lugubris, LESS., Hist. Nat. Ois. Mouch., tom. i, p. 132, pls. 38 ♂, 39 ♀ (1829).
Trochilus atratus, LICHT., Doubl., p. 14.

Trochilus leucopygius, SPIX., Av. Bras., t. i, pl. 81, fig. 3 (1824).

Mellisuga atra, SHAW, Gen. Zool., t. xiv, p. 243.

Topaza atra, GRAY, Gen. Birds, vol. i, p. 110, sp. 4.

Florisuga atra, BON., Consp. Av., vol. i, p. 74.—GOULD, Mon. Troch., vol. ii, pl. 115.—ID., Intr. Troch., octavo ed., p. 81.

Florisuga fusca, REICH., Aufz. der Colib., p. 14 (1853).—BON., Rev. and Mag. Zool. (1854), p. 253.—ID., Consp. Av., p. 74.—REICH., Troch. Enum., p. 12 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 29.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 183.

Hab. Brazil.

Male. Head, neck, upper parts of back, and entire under surface, black. Lower part of back and rump very dark grass-green. Upper tail coverts very dark green with purple reflections. Median rectrices dark green with purple reflections (the specimen before me is more purple than green); lateral rectrices white tipped with purplish-brown. Wings light purplish-brown. Bill black. Total length, $4\frac{2}{8}$ in. Wing, $3\frac{1}{16}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

Genus XXI.—PETASOPHORA.

Colibri, SPIX., Av. Bras. (1824), p. 80.

Petasophora, G. R. GRAY, List of Gen. Birds (1840), p. 13.

Coeligena, TSCHUD. (nec LESS., 1832), Faun. Per. (1844), p. 39, subgen. 3.

Lophornis, TSCHUD. (nec LESS., 1832), Faun. Per. (1844), p. 39, subgen. 6.

Praxilla, REICH., Aufz. der Colib., p. 13 (1853).

Colibri, BON., ex SPIX., Consp. Gen. Av. (1850), p. 69.

Telesiella, REICH., Aufz. der Colib. (1853), p. 13.

Telesiella, CAB., Mus. Hein. Th., iii, p. 27 (1860).

Delphinella, "REICH.," BON., Ann. Scien. Nat. (1854), p. 137.

TYPE.

T. serrirostris, Vieill.

T. serrirostris, Vieill.

R. anais, Less.

T. serrirostris, Vieill.

R. anais, Less.

T. cyanotis, Bourc.

O. delphinæ, Less.

O. delphinæ, Less.

O. delphinæ, Less.?

Fig. 21.



Petasophora anais. ♂. Antioquia, Columbia. Salmon.

Ch. Bill longer than the head, straight, equal in width until just at the tip, where it suddenly contracts to a sharp point. Feathers of the forehead project on to the culmen, covering the nostrils. Wings long, pointed, primaries slightly falcate. Tail broad, ample, and rounded. Feet rather large, strong; tarsi clothed. Hind toe and nail shorter than middle toe and nail. Sexes similar in plumage.

Range. Central America, Venezuela, Trinidad, Guiana, Brazil, Columbia, Ecuador, Peru, and Bolivia.

There are six species belonging to this genus.

Key to the species.

- A. General plumage green, metallic.
- a. Upper part of throat and chin, ear coverts and abdomen deep blue; lower part of throat and breast light metallic-green. 1. *P. anais*.
 - b. Throat and upper part of breast dark metallic green; ear coverts and abdomen dark blue. 2. *P. thalassina*.
 - c. Ear coverts violet-blue; throat and under parts metallic-green. 3. *P. cyanotis*.
 - d. Ear coverts, chin, and abdomen dark blue, throat with metallic-red reflections. 4. *P. coruscans*.
 - e. Ear coverts metallic purplish-red, under tail coverts white. 5. *P. serrirostris*.
- B. General plumage brown, not metallic.
- a. Ear coverts violet-blue; throat metallic-green. 6. *P. delphinæ*.

The PETASOPHORE are a strongly characterized group of birds, the species with one exception having a considerable resemblance to each other. They are of rather large size, distinguished by their metallic-blue ear coverts, metallic-green scaly-like breasts, and broad, ample bluish-green, barred tails. Their natural position in the Family is apparently after FLORISUGA.

1. *Petasophora anais*

Rhamphodon anais, LESS., Troch., p. 146, pl. 55 (1831).

Polytmus anais, GRAY, Gen. Birds, vol. i, p. 108, sp. 27.

Trochilus thalassinus, (nec SWAIN.), JARD., Humm.-B., vol. ii, p. 47.

Trochilus anais, JARD., Humm.-B., vol. ii, p. 73.

Colibri anais, BON., Consp. Gen. Av., vol. i, p. 69 (1850).

Praxilla anais, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).

Petasophora anais, GOULD, P. Z. S. (1847), p. 8.—ID., Mon. Troch., vol. iv, pl. 224.—ID., Intr. Troch., octavo ed., p. 124.—BON., Rev. and Mag. Zool. (1854), p. 250.—CAB. and HEIN., Mus. Hein. Th., iii, p. 26 (1860).—MULS., Hist. Nat. Ois. Mouch, tom. ii, p. 144.—ELLIOT, Ibis (1876), p. 403.

Petasophora iolata, GOULD, P. Z. S. (1847), p. 9.—ID., Mon. Troch., vol. iv, pl. 225.—ID., Intr. Troch., octavo ed., p. 124.—CAB., Mus. Hein. Th., iii, p. 26.

Polytmus iolata, GRAY, Gen. Birds, vol. i, p. 108, sp. 28.

Colibri iolata, BON., Consp. Gen. Av., vol. i, p. 69 (1850).

Petasophora rhodotis, "GOULD," Sauc. Mus. Hein.

Praxilla iolata, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).

Hab. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

Adult. Entire upper surface and flanks, shining grass-green. Chin, line under the eye, ear coverts, and centre of the abdomen purplish dark blue. Breast luminous green, each feather with a dark central green streak, giving this part the appearance of being scaly. Under tail coverts dark green margined with buff. Wings purplish-brown. Median rectrices bronze-green; lateral ones bluish-green, and all possessing a subterminal chalybeate bar. Bill black; feet brownish-black. Total length, $4\frac{2}{3}$ – $5\frac{1}{4}$ in. Wing, $2\frac{7}{8}$ – $3\frac{1}{4}$ in. Tail, $2\frac{1}{8}$ – $2\frac{1}{4}$ in. Bill on culmen, $\frac{7}{8}$ in.

In immature birds the chin is blue, and the feathers of the throat are black, margined with buff and with a few metallic green feathers interspersed. The green feathers of the upper surface and flanks are also margined with grayish-buff. In other respects they resemble the adult. Occasionally melanitic individuals are met with. One before me has the upper surface olive-brown. Chin and stripe under the eye blue-black. Breast luminous olive-green. Tail dark invisible green with a subterminal black bar.

2. *Petasophora thalassina*.

- Trochilus thalassina*, SWAINS., Phil. Mag. (1827), p. 441.
Ornismya anais, LESS., Colib., p. 104 (1831).—ID., Suppl. Ois. Mouch., t. 3.
Rhamphodon anais, LESS., Troch., p. 148, pl. 56 (1831-2).
Polytmus thalassinus, GRAY, Gen. Birds, vol. i, p. 108, sp. 26.
Petasophora thalassina, GOULD, P. Z. S. (1847), p. 8.—ID., Mon. Troch., vol. iv, pl. 227.—ID., Intr. Troch., octavo ed., p. 125.—REICH., Troch. Enum., p. 11 (1855).—BON., Rev. and Mag. Zool. (1854), p. 250.—CAB. and HEIN., Mus. Hein. Th., iii, p. 27 (1860).—MULS., Hist. Nat. Ois. Mouch., p. 148.—ELLIOT, Ibis (1876), p. 404.
Colibri thalassinus, BON., Consp. Gen. Av., vol. i, p. 69 (1850).
Praxilla thalassina, REICH., Aufz. der Colib., p. 13 (1853).

Hab. Mexico, Guatemala.

Adult. Resembles closely the *P. anais*, but besides its smaller size, it may be distinguished from that species, by lacking the dark blue on the chin, this being green like the breast. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

3. *Petasophora cyanotis*.

- Trochilus cyanotus*, BOURC., Rev. Zool. (1843), p. 101.—ID., Ann. Sci. Phys., Lyons, tom. vi (1843), p. 41.
Polytmus cyanotus, GRAY, Gen. Birds, vol. i, p. 108, sp. 25.
Ornismya anais, LESS., Troch., p. 151, pl. 57 (1831-2).
Petasophora cyanotus, GOULD, P. Z. S. (1847), p. 8.—ID., Mon. Troch., vol. iv, pl. 228.—REICH., Troch. Enum., p. 11 (1855).
Colibri cyanotis, BON., Consp. Gen. Av., vol. i, p. 69 (1850).
Praxilla cyanotis, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).
Petasophora cyanotis, BON., Rev. and Mag. Zool. (1854), p. 251.—GOULD, Intr. Troch., octavo ed., p. 125.—CAB. and HEIN., Mus. Hein. Th., iii, p. 26 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 150.—ELLIOT, Ibis (1876), p. 404.
Petasophora cabanidis, HEINE, Journ. für Ornith. (1863), p. 182.

Hab. Costa Rica, Veragua, Venezuela, Columbia, Ecuador, and Peru.

Adult. Distinguished from *thalassina* by having no blue upon the abdomen; this part being green like the back. Like *thalassina* the chin is green like the breast. Total length, $4\frac{2}{8}$ in. Wing, $2\frac{2}{8}$ in. Tail $2\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

4. *Petasophora coruscans*.¹

- Trochilus (Petasophora) coruscans*, GOULD, P. Z. S. (1846), p. 44.
Polytmus coruscans, GRAY, Gen. Birds, vol. i, p. 108, sp. 29.
Petasophora coruscans, GOULD, P. Z. S. (1847), p. 9.—ID., Mon. Troch., vol. iv, pl. 226.—ID., Intr. Troch., octavo ed., p. 125.—BON., Rev. and Mag. Zool. (1854), p. 251.—ELLIOT, Ibis (1876), p. 405.
Colibri coruscans, BON., Consp. Gen. Av., p. 69 (1850).
Praxilla coruscans, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).

¹ I give a description of the specimen mentioned by me in the Ibis, 1876, p. 405. Upper and under surface shining grass-green, with a faint tinge of blue in the centre of the abdomen. Line under the eye and ear coverts deep blue. Chin greenish-blue. Throat metallic pink. Under tail coverts bright buff. Wings purplish-brown. Tail light bronze-green, with a subterminal blackish-brown bar. Bill and feet black. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{5}{8}$ in. Tail 2 in. Culmen, $\frac{3}{4}$ in.

Should this prove eventually to represent a distinct species, I would propose the name of *Petasophora rubrigularis*.

Hab. Columbia?

Adult. Resembles the *P. anais*, but has the feathers of the throat shining green tipped with metallic-red, and the breast and centre of abdomen blue. In other respects like *anais*. Total length, $4\frac{5}{8}$ in. Wing, 3 in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{1\frac{3}{8}}{16}$ in. The type and one specimen in my collection are all that are known of this form.

5. *Petasophora serrirostris*.

Trochilus serrirostris, VIEILL., Nouv. Dict. Hist. Nat. (1817), vol. 7, p. 359.

Colibri crispus, SPIX., Av. Bras. (1824), vol. i, p. 80, t. 81, fig. 1.

Grypus vieilloti, STEPH., Gen. Zool., xiv, p. 256.

Trochilus petasophorus, PR. MAX., Reis. Bras., tom. ii, p. 191.—ID., Beitr., tom. iv, p. 76.—TSCHUD., Faun. Per., pp. 246-8 (1844).

Ornismya petasophora, LESS., Ois. Mouch., p. 37, pl. 1 (1829).—D'ORB. and LAFRES., Syu. Av., ii, p. 28, sp. 12 (1838).

Polytmus serrirostris, GRAY, Gen. Birds, vol. i, p. 108, sp. 24.

Petasophora gouldi, BON., Consp. Gen. Av., vol. i, p. 69 (1850).

Petasophora serrirostris, BON., Consp. Gen. Av., vol. i, p. 69 (1850).—ID., Rev. and Mag. Zool. (1854), p. 250.

—GOULD, Mon. Troch., vol. iv, pl. 223.—ID., Intr. Troch., octavo ed., p. 124.—REICH., Aufz. der Colib., p. 13.—ID., Troch. Enum., p. 11.—CAB. and HEIN., Mus. Hein. Th., iii, p. 25.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 153.—ELLIOT, Ibis (1876), p. 406.

Petasophora chalcotis, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).

Petasophora crispa, BURM., Th. Bras., tom. ii, p. 335 (1856).

Hab. Brazil, Bolivia (D'Orbigny).

This species has the ear coverts metallic-violet; and can be distinguished from all of the other members of this genus, by its under tail coverts which are pure white. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{1\frac{3}{8}}{16}$ in.

6. *Petasophora delphinæ*.

Ornismya delphinæ, LESS., Rev. Zool. (1839), p. 44.—ID., Ill. Zool. (1832), pl. 64.

Polytmus delphinæ, GRAY, Gen. Birds, vol. i, p. 108, sp. 30.

Colibri delphinæ, BON., Consp. Gen. Av., vol. i, p. 69 (1850).

Telesiella delphinæ, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).

Petasophora delphinæ, BON., Rev. and Mag. Zool. (1854), p. 250.—REICH., Troch. Enum., p. 11 (1855).—

GOULD, Mon. Troch., vol. iv, pl. 229.—ID., Intr. Troch., octavo ed., p. 125 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 157.—ELLIOT, Ibis (1876), p. 406.

Telesiella delphinæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 27 (1860).

Hab. Central America, Trinidad, Guiana, Venezuela, Columbia, Ecuador, and Peru.

Adult. Upper surface dark olive-brown; feathers of the rump and upper tail coverts margined with rufous. Ear coverts purplish-blue. Throat bronzy-green terminating in blue. Under parts light smoke-brown. Under tail coverts rufous with dark centres. Wings purplish-brown. Tail pale bronze-brown, with a sub-terminal dark brown band. Bill and feet black. Total length, $4\frac{1}{8}$ in. Wing, 3 in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{5}{8}$ in.

Young has the throat white with a central spot of metallic-green, and the under parts generally, brownish-white, darkest in the centre of chest and abdomen.

Following PETASOPHORA come the members of PANOPLITES. These, although possessing the same form, differ entirely from each other in plumage. Exhibiting brilliant metallic colors, they yet agree only in having their upper parts green; while the under surface is clothed in strongly contrasted colors of diverse hues.

Two generic names were proposed for the following three species: viz., *Boissonneaua*, Reich., and *Panoplites*, Gould, almost simultaneously, though the dates given would make the one first named have priority of about one year. Reichenbach's genus was never defined, and has not been employed by ornithologists except in a few instances. Mr. Gould did not give a definition of his genus until the Introduction to his Monograph of the Trochilidæ was published in 1861. It had, however, been generally accepted for the species he originally intended should be contained in it, and since it has been regularly defined by its author, while the other never has, I have employed the term of PANOPLITES, in place of *Boissonneaua*. The three known species being essentially generically the same, the other terms proposed by M. Mulsant do not require any consideration.

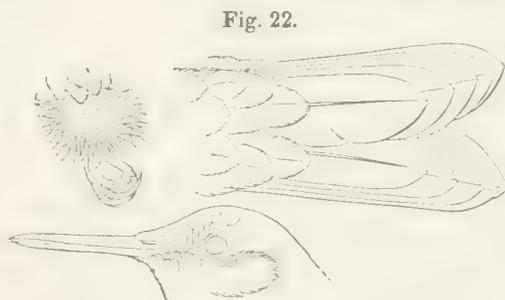
Genus XXII.—PANOPLITES.

- Boissonneaua*, REICH., Aufz. der Colib., p. 11 (1853).
Panoplites, GOULD, Mon. Troch., pt. viii (1854) (desc. null.).—ID., Intr. Mon. Troch., octavo ed., p. 79 (1861) (desc.).
Alosia, MULSANT., Cat. Ois. Mouch. (1875), p. 17.
Galenia, MULS. and VERR., Class. Troch. (1865), p. 47.
Callidice, MULS. and VERR., Class. Troch. (1865), p. 65.

- TYPE.
T. flavescens, Lodd.
T. jardini, Bourc.
T. matthewsi, Bourc.
T. jardini, Bourc.
T. flavescens, Lodd.

Ch. Bill stout, straight, longer than the head. Wings long, pointed. Tail square, when spread, feathers broad. Tarsi clothed. Hind toe as long as the middle one. Sexes similar in plumage.

Range. Columbia and Ecuador
 Three species are known.



Panoplites flavescens. ♂. Antioquia, Columbia. Salmon.

Key to the species.

- A. Upper parts metallic-green.
 a. Abdomen metallic blue. Lateral rectrices white, margined with purple. 1. *P. jardini*.
 b. Under surface metallic golden-green. Lateral rectrices buff margined with bronzy-green. 2. *P. flavescens*.
 c. Under surface deep chestnut-red. 3. *P. matthewsi*.

1. *Panoplites jardini*.

- Trochilus jardini*, BOURC., Compt. Rend. (1851), t. xxii, p. 187.
Florisuga jardini, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12.—BON., Rev. and Mag. Zool. (1854), p. 253.
Panoplites jardini, GOULD, Mon. Troch., vol. ii, pl. 110.—ID., Intr. Troch., octavo ed., p. 80.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 233.—CAB. and HEIN., Mus. Hein. Th., iii, p. 74 (note 3).

Hab. Ecuador.

Adult. Crown shining violet-blue. Rest of head, nape, sides of the neck, black. Upper parts brilliant metallic bluish-green. Wing coverts shining golden-green. Throat, breast, and abdomen shining violet-blue, flanks glittering green. Under tail coverts blackish, tipped with white; upper coverts dark purple. Median rectrices bronzy-purple; lateral ones white margined and tipped with purplish-black. Wings purplish-brown. Bill black. Total length, $4\frac{5}{8}$ in. Wing, 3 in. Tail, 2 in. Culmen, $\frac{3}{4}$ in.

2. *Panoplites flavescens.*

Trochilus flavescens, LODD., Proc. Committ. Corresp. Zool. Soc. (1832), p. 7.

Ornismya paradisea, BOISS., Rev. Zool. (1840), p. 6.

Mellisuga flavescens, GRAY, Gen. Birds, vol. i, p. 112, sp. 26.

Amazilia flavescens, BON., Consp. Gen. Av., vol. i, p. 78 (1850).

Boissonneaua flavescens, REICH., Troch. Enum., p. 8, pl. 787, figs. 4830-31.—ID., Aufz. der Colib., p. 11.

Clytolæma flavescens, BON., Rev. and Mag. Zool. (1854), p. 254.

Panoplites flavescens, GOULD, Mon. Troch., vol. ii, pl. 111.—ID., Intr. Troch., octavo ed., p. 80.—CAB. and HEIN., Mus. Hein. Th., iii, p. 74 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 335.

Hab. Columbia and Ecuador.

Adult. Crown of head and throat brilliant golden-green. Entire plumage of upper and under surface shining dark green. Thighs white. Under tail coverts pale green margined with buff. Wings purplish-brown, their under coverts rufous. Central tail feathers greenish-bronze, lateral ones light buff, margined and tipped with bronze-green. Bill black. Total length, $4\frac{1}{4}$. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

3. *Panoplites matthewsi.*

Trochilus matthewsi, BOURC., P. Z. S. (1847), p. 43.

Mellisuga matthewsi, GRAY, Gen. Birds, vol. i, p. 112, sp. 27.

Heliodoxa matthewsi, REICH., Aufz. der Colib., p. 9 (1853).

Clytolæma matthewsi, BON., Rev. and Mag. Zool. (1854), p. 254.

Boissonneaua matthewsi, REICH., Troch. Enum., p. 8, pl. 788, figs. 4832-33 (1855).

Panoplites matthewsi, GOULD, Mon. Troch., vol. ii, pl. 112.—ID., Intr. Troch., octavo ed., p. 80.—CAB. and HEIN., Mus. Hein. Th., iii, p. 74 (note 2) (1860).

Clytolæma (Alosia) matthewsi, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 230.

Hab. Western Ecuador, Peru.

Adult. Head, throat, and upper parts shining golden-green, darkest on the back. Under surface deep chestnut-red. Thighs and under tail coverts rich buff. Wings purplish-brown; their coverts shining grass-green. Central rectrices greenish-bronze, remainder cinnamon tipped with greenish-bronze. Bill black. Total length, $4\frac{5}{8}$ in. Wing, $2\frac{7}{8}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{5}{8}$ in.

An immature individual in my collection, obtained by Whitely at Huasaupilla, Peru, at an elevation of 9000 feet, had the upper surface dull green, and the under surface dark reddish-brown spangled with green. The central rectrices are reddish-bronze, and the rest reddish-buff, margined and tipped with reddish-bronze.

Genus XXIII.—PHÆOLÆMA.

Phaiolaima, REICH., Aufz. der Colib. (1853), p. 9.

TYPE.
T. rubinoides, Bourc.

Ch. Bill longer than the head, stout, slightly curved; nostrils covered by frontal plumes; wings long, narrow, and pointed; tail rather short, slightly forked. Tarsi partly covered, feet moderate. Sexes alike in plumage.

Range. Columbia and Ecuador.

Two species are known.

Fig. 23.



Phæolæma rubinoides. ♂ ad. Bogota. Gould.

Key to the species.

A. Under surface dark buff, glossed with metallic-green.

a. Centre of crown metallic grass-green.

b. Entire crown shining grass-green.

1. *T. rubinoides*.

2. *T. æquatorialis*.

1. *Phæolæma rubinoides*.

Trochilus rubinoides, Bourc. and Muls., Ann. Soc. d'Agr., Lyon (1846), p. 322.

Mellisuga rubinoides, Gray, Gen. Birds, vol. i, p. 112.

Heliomaster rubinoides, Bon., Consp. Gen. Av., p. 70 (1850).

Phaiolaima rubinoides, Reich., Aufz. der Colib., p. 9 (1853).—Id., Troch. Enum., pl. 743, figs. 4704-5 (1855).

Clytolaema rubinoides, Bon., Rev. and Mag. Zool. (1854), p. 254.

Heliodoxa rubinoides, Reichenb., Troch. Enum., p. 6, pl. 743, figs. 4704-5 (1855).

Phæolæma granadensis, Cab. and Hein., Mus. Hein. Th., iii, p. 30 (note) (1860).

Phæolæma rubinoides, Gould, Mon. Troch., vol. iv, pl. 268.—Id., Intr. Troch., octavo ed., p. 142.—Muls., Hist. Nat. Ois. Mouch., tom. ii, p. 221.

Hab. Columbia.

Male. Head dark grass-green, with the front and a line in the centre of the crown brilliant metallic-green. Upper parts dark green. Chin and sides of neck shining green. Centre of throat metallic-purple. Breast dark buff. Under parts dark buff glossed with green. Upper tail coverts coppery-red; under tail coverts olive-green margined with buff. Tail bronzy olive-green. Wings purple. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, 2 in. Culmen, $\frac{3}{4}$ in.

Female like the male, without metallic throat spot.

2. *Phæolæma æquatorialis*.

Phæolæma æquatorialis, Gould, Mon. Troch. (1860), vol. iv, pl. 264.—Id., Intr. Troch., octavo ed., p. 143.—

Cab. and Hein., Mus. Hein. Th., iii, p. 31 (note) (1860).

Phæolæma rubinoides, Sclat., P. Z. S. (1859), p. 145.

Phæolæma æquatorialis, Muls., Hist. Nat. Ois. Mouch., tom. ii, p. 223.

Hab. Ecuador.

Male. Precisely like the *P. rubinoides*, though slightly larger in size, and the entire top of the head is a rather dull dark green without the metallic lustre which

is visible on the centre of the crown in the allied species. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{7}{8}$ in. Tail, 2 in. Culmen, $\frac{7}{8}$ in.

The *female* differs only in not having the metallic throat mark.

Genus XXIV.—CLYTOLEMA.

Clytolæma, GOULD, Intr. Mon. Troch., octavo ed., p. 134, and Mon., pt. vi (1853).
Polyplancta, HEIN., Journ. für Ornith. (1863), p. 182.
Heliodoxa, REICH. (nec GOULD, 1849), Aufz. der Colib., p. 9 (1853).

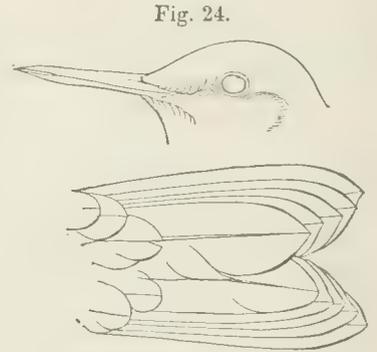
TYPE.

T. rubinea, Gmel.
T. aurescens, Gould.
T. rubineus, Gmel.

Ch. Bill stout, straight, longer than the head; nostrils covered by frontal plumes. Wings long, pointed. Tail forked. Tarsi partly clothed. Hind toe and nail shorter than fore toe and nail. Sexes dissimilar.

Range. Brazil, Ecuador, and Peru.

But two species belonging to this genus are known,



Clytolæma rubinea. ♂ . 24695. Brazil.

Key to the species.

- | | |
|---|--------------------------|
| A. Throat metallic-red, breast metallic-green. | 1. <i>C. rubinea</i> . |
| B. Chin black, throat metallic-green, upper part of breast dark rufous. | 2. <i>C. aurescens</i> . |

The style of coloration in these two species is very different, and by some has been deemed of sufficient importance to place them in separate genera. In their structural characters, so far as known, they agree, and for the present at all events it is far better to leave them in the present genus. They are closely related to *PHÆOLEMA* and lead on to *IOLÆMA*.

1. *Clytolæma rubinea*.

- Trochilus rubineus*, GMEL., Syst. Nat., vol. i, p. 493 (1788).—LATH., Ind. Orn., vol. i, p. 312 (1790).
Trochilus obscurus, GMEL., Syst. Nat. (1788), p. 495, sp. 50, juv.—LATH., Ind. Orn., vol. i, p. 314, sp. 44.
Trochilus ruficaudatus, VIEILL., Nouv. Dict., vol. xxiii, p. 422.
Ornismya rubinea, LESS., Ois. Mouch., p. 146, pls. 44, 45, 46 (1829).
Mellisuga rubinea, GRAY, Gen. Birds, vol. i, p. 112, sp. 22.
Heliomaster rubineus, BON., Consp. Gen. Av. p. 70 (1850).
Heliodoxa rubinea, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, t. 744, figs. 4706-9 (1855).
Calothorax rubineus, BURM., Th. Bras., vol. ii, p. 340 (1856).
Clytolæma rubinea, GOULD, Mon. Troch., vol. iv, pl. 249.—ID., Intr. Troch., octavo ed., p. 134.—BON., Rev. and Mag. Zool. (1854), p. 254.—CAB. and HEIN., Mus. Hein. Th., iii, p. 30.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 227.

Hab. Brazil.

Male. Forehead metallic grass-green, terminating in a point on the crown. Rest of crown and nape bronze-green. Remaining upper surface golden-rufous. Throat metallic-red; breast metallic light green; abdomen and flanks dull green.

Under tail coverts green edged with rufous. Wings purplish-brown; base of inner webs of secondaries rufous. Tail golden-brown, tipped with bronze-green. Bill black. Total length, $4\frac{7}{8}$ in. Wing, 3 in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper surface grass-green. Under parts rufous. Median rectrices bronze-green, next three deep rufous tipped with bronze, and the outermost pale rufous.

2. *Clytolæma aurescens*.

Trochilus (Lampornis) aurescens, GOULD, P. Z. S. (1846), p. 88.

Polytmus aurescens, GRAY, Gen. Birds, vol. i, p. 108, sp. 23.

Lampornis aurescens, BON., Consp. Gen. Av., vol. i, p. 72 (1850).

Margarochrysis aurescens, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 8 (1855).

Campylopterus aurescens, BON., Rev. and Mag. Zool. (1854), p. 250.

Clytolæma aurescens, GOULD, Mon. Troch., vol. iv, pl. 250.—ID., Intr. Troch., octavo ed., p. 134.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 225.

Hab. Ecuador and Peru.

Male. Forehead deep shining blue. All the upper surface and abdomen dark green. Chin black. Throat metallic grass-green. A broad band of deep rufous across the breast. Under and upper tail coverts grass-green. Median rectrices bronze-green; lateral ones chestnut-red tipped with bronze-green. Wings dark purple. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female. Unknown.

Genus XXV.—IOLEMA.

Ionolaima, REICH., Aufz. der Colib. (1853), p. 9.

Ionolæma, GOULD, Mon. Troch., pt. xiii (1857).

Iolæma, GOULD, Intr. Troch., octavo ed., p. 73.

TYPE.

T. schreibersii, Bourc.

T. schreibersii, Bourc.

I. frontalis, Lawr.

Fig. 25.



Iolama frontalis, ♂. Rio Napo. Verreaux.

Ch. Bill stout, longer than the head, straight; nostrils hidden by frontal feathers; wings long, reaching two-thirds the length of tail. Tail long and deeply forked. Tarsi clothed; feet small, hind toe shorter than middle toe. Sexes unlike in plumage.

Range. Ecuador, Peru.

8 August, 1878.

I think there are four species belonging to this genus, of which two have been placed together by authors, and one considered the immature dress of the other. They are all large fine birds, distinguished by their luminous throat marks, and generally shining plumage.

Key to the species.

- | | |
|---|----------------------------|
| A. No luminous spot on forehead. | |
| a. Centre of throat brilliant metallic-topaz, or flame-color. | 1. <i>I. luminosa.</i> |
| b. Centre of throat metallic violet-purple; buff stripe from gape to beneath the eye. | 2. <i>I. schreibersii.</i> |
| B. Metallic luminous spot on forehead. | |
| a. Breast black. | 3. <i>I. frontalis.</i> |
| b. Breast green. | 4. <i>I. whitelyana.</i> |

1. **Iolæma luminosa.*

Iolæma luminosa, ELLIOT, Ibis (1878), p. 188.

Hab. Unknown.

Top of head and nape dull dark green; chin and sides of the throat black; centre of throat most brilliant topaz, changing, according to the light, into a flame-color or a brilliant emerald-green; back bronzy-green, graduating into a rich purplish-red upon the upper tail coverts; breast, flanks, and abdomen brilliant metallic coppery-red; wings dark purple; tail has the median rectrices bronze; lateral ones dark purple, tinged with green upon the outer webs; under tail coverts reddish-bronze, margined with white; bill black; feet brownish-black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, 2 in. Bill, culmen, $\frac{1}{16}$ in., at gape 1 in.

The type of this species, the most beautiful of the genus, is unique, and in Mr. Gould's collection.

2. *Iolæma schreibersii.*

Trochilus schreibersii, BOURC., P. Z. S. (1845), p. 43.

Thalurania schreibersii, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—PELZ., Orn. Bras., p. 31.

Calothorax schreibersii, GRAY, Gen. Birds, vol. i, p. —.

Campylopterus schreibersii, BON., Rev. and Mag. Zool. (1854), p. 250.

Heliodoxa (Ionolaima) schreibersii, REICHENB., Troch. Enum. p. 6, pl. 745, fig. 4710-11 (1855).

Ionolaima schreibersii, GOULD, Mon. Troch., vol. ii, pl. 93.—REICH., Aufz. der Colib., p. 9 (1853).

Iolæma schreibersii, GOULD, Intr. Troch., octavo ed., p. 73.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 138.

Hab. Ecuador, Rio Napo.

Male. This differs from the *I. frontalis*, by having the entire upper part of the head shining grass-green, without any metallic spot on the forehead. Throat and breast as in *frontalis*, but beneath, this is more or less glossed with green upon the abdomen, leaving only the centre black. A buff stripe goes from the gape to beneath the eye.

Female. Upper parts bronze-green. Median rectrices bronze, rest steel-blue, two outermost ones tipped with gray. Under surface gray, each feather tipped with green. The dimensions of the two species are the same.

I have kept these apart as I cannot satisfy myself that this bird is only an immature stage of plumage of the *I. frontalis*.

3. *Iolæma frontalis*.

Iomolaima frontalis, LAWRE., Ann. Lyc. Nat. Hist., N. Y., vol. vi, p. 263.—GOULD, Mon. Troch., vol. ii, pl. 92.
Iolæma frontalis, GOULD, Intr. Troch., octavo ed., p. 73 (1861).

Hab. Ecuador, between the head waters of the Napo and Quito (Moore).

Male. Front has a brilliant metallic spot of grass-green. Rest of the top of the head and back dark grass-green. Chin and upper part of throat black; rest of throat metallic violet-purple, beneath which is a band of bright metallic-green. Rest of under parts black, flanks dark grass-green. Under tail coverts steel-blue. Upper tail coverts grass-green, lighter than the back. Tail dark brown, when the feathers are separated, with steel-blue reflections. Bill black. Total length, $5\frac{1}{2}$ in. Wing, 3 in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{7}{8}$ in.

The female I have not seen, but she is probably very similar to that of *I. schreibersi*.

3. **Iolæma whitelyana*.

Iolæma whitelyana, GOULD, Ann. and Mag. Nat. Hist., 4th ser. (1872), p. 4.—WHITELY, P. Z. S. (1873), p. 188.
 —MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 141.

Hab. Peru, Cosnipata, Province of Cusco.

Male. "Crown, all the upper surface and flanks deep grass-green; an obscure glittering mark on the forehead; chin, chest, and centre of the abdomen jet-black with a broad gorget of beautiful violet on the throat, the bill, which is stout and straight is black, as are also the legs and toes; the tail and under tail coverts steel-black; primaries and secondaries purplish-brown, the external edge of the outer primary reddish-brown. Total length, $5\frac{1}{4}$ in. Bill, $1\frac{1}{8}$ in. Wing 3 in. Tail, $2\frac{1}{4}$ in." (Gould, l. c.)

Genus XXVI.—STERNOCLYTA.

TYPE.

Sternoclyta, GOULD, Mon. Troch., pt. xvi (1858).—ID., Intr. Troch. octavo ed., p. 57. *T. cyaneipectus*, Gould.

Fig. 26.

*Sternoclyta cyaneipectus* ♂, Venezuela. Verreaux.

Ch. Bill long, stout, curved, longer than the head. Tail large, slightly forked, when open (not rounded as stated by Gould). Wing; very long, pointed. Tarsi partly clothed. Feet moderate. Sexes unlike. Size large.

Range. Venezuela.

1. *Sternoclyta cyaneipectus*.

Trochilus (Lampornis) cyanopectus, GOULD, P. Z. S. (1846), p. 88.

Polytmus cyanopectus, GRAY, Gen. Birds, vol. i, p. 108, sp. 22.

Lampornis cyanopectus, BON., Consp. Gen. Av., p. 72 (1850).

Sæpiopterus cyanipectus, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9 (1855).

Campylopterus cyanipectus, BON., Rev. and Mag. Zool. (1854), p. 250.

Sternoclyta cyaneipectus, GOULD, Mon. Troch., vol. ii, pl. 58.—ID., Intr. Troch., octavo ed., p. 57.—CAB. and HEIN., Mus. Hein. Th., iii, p. 13 (note).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 178.

Hab. Venezuela.

Male. Upper parts and flanks dark grass-green. Wings purplish-brown, base of innermost primaries and secondaries rust-red. Throat brilliant green; breast metallic dark blue. Tail bronzy-brown; outermost feathers slightly tipped with white. Under tail coverts green margined with grayish-white. Maxilla black, mandible blackish-brown. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $1\frac{1}{4}$ in.

Female. Upper parts like the male; under parts gray, feathers tipped with green.

Genus XXVII.—EUGENES.

Eugenes, GOULD, Mon. Troch., pt. xii (1856).—ID., Intr. Troch., octavo ed., p. 57 (desc). (1861).

TYPE.

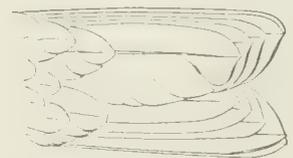
T. fulgens, Swains.

Fig. 27.

Ch. "Bill longer than the head, straight. Wings long and pointed; tail moderate and very slightly forked; tarsi clothed; feet rather small; hind toe about equal in length to the middle one." (Gould, loc. cit.)

Range. Texas, Mexico, Central America to and including Costa Rica.

Two species are known.



Eugenes fulgens. ♂. Oaxaca. Doucard.

Key to the species.

A. Breast black, lateral rectrices bronzy-green.

B. Breast dark green, lateral rectrices dark bronzy-brown.

1. *E. fulgens*.

2. *E. spectabilis*.

1. *Eugenes fulgens*.

Trochilus fulgens, SWAIN., Phil. Mag. (1827), p. 441.

Ornismya rivoli, LESS., Ois. Mouch., p. 48, pl. 4 (1829).

Mellisuga fulgens, GRAY, Gen. Birds, vol. i, p. 112, sp. 2.

Delatritia fulgens, BON., Consp. Gen. Av., p. 70 (1850).

Cæligena fulgens, REICH., Aufz. der Colib., p. 7 (1853)—ID., Troch. Enum., p. 3, t. 686, fig. 4513-14.—BON., Rev. and Mag. Zool. (1854), p. 252 (1855).

Eugenes fulgens, GOULD, Mon. Troch., vol. ii, pl. 59.—ID., Intr. Troch., octavo ed., p. 58.—CAB. and HEIN., Mus. Hein. Th., iii, p. 20 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 212.

Hab. Texas, Mexico, and Guatemala.

Male. Top of head and occiput metallic violet-blue. Upper and under parts shining bronze-green, back and breast black in most lights. Median rectrices bronze-green; remainder bronzy-brown, edged with white. Under tail coverts greenish-gray, fringed with grayish-white. Throat brilliant grass-green. Bill black. Total length, $4\frac{7}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{7}{8}$ in. Culmen, 1 in.

Female. Top of head brown. Upper surface light green. Under surface grayish-brown, feathers tipped with green. Median rectrices dark green; lateral ones green at base, with a subterminal blackish-brown bar, and tips white. A small white spot behind the eye. Bill black.

2. *Eugenes spectabilis*.

Heliomaster spectabilis, LAW., Ann. N. Y. Lyc. Nat. Hist. (1867), vol. 8, p. 472, juv.

Eugenes spectabilis, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 215, pl. —.

Hab. Costa Rica.

Male. Forehead dull green. Top of head and occiput brilliant dark violet. Upper parts dark grass-green, back appearing black in certain lights. Wings purple. Throat metallic dark green, bluish in some lights. Under parts dark grass-green, breast never appearing black in any light. Under tail coverts green tipped with buff. Median rectrices dark bronze-green, remainder bronze-green graduating into blackish-brown, and edged with white on the tips. Bill black. Total length, $5\frac{5}{8}$ in. Wing, 3 in. Tail, $1\frac{7}{8}$ in. Bill, $1\frac{1}{2}$ in.

Young, or possibly a *female*. Crown dull brown. Entire under parts dull grayish-brown with an ochreous tinge. Flanks dull green, with white pleural spot. Lateral rectrices green at base, a subterminal black bar and tips grayish-white.

Genus XXVIII.—UROCHROA.

TYPE.

Urochroa, GOULD, Mon. Troch., pt. xii (1856).—ID., Intr. Troch., octavo ed., p. 56.

T. bougueri, BOUC.

Fig. 28.

Ch. Bill much longer than the head, straight. Wings reaching nearly to the end of the rectrices. Tail square, feathers pointed at tip; tarsi partly clothed; hind toe as long as the middle toe.

Range. Ecuador.



Urochroa bougueri. Ecuador. Bourcier.

1. *Urochroa bougueri*.

Trochilus bougueri, BOUÏC., Compt. Rend., t. 32, p. 186, juv. (1851).

Caligena bougueri, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 3 (1855).—BON., Rev. and Mag. Zool. (1854), p. 252.

Urochroa bougueri, GOULD, Mon. Troch., vol. ii, pl. 57, juv.—ID., Intr. Troch., octavo ed., p. 56 (1861).—MULS., Hist. Nat. Ois. Mouch., vol. i, p. 192, pl. ad.

Urochroa leucura, LAWR., Ann. N. Y. Lyc. Nat. Hist., vol. 8 (1864), p. 43, ad.

Hab. Ecuador.

Adult. Upper parts grass-green, changing to bronze on the rump and upper tail coverts. Wings purple. Throat and breast metallic dark blue. Flanks shining green. Rest of under surface dark olive-brown. Under tail coverts green edged with white. Median rectrices dark green, remainder white, margined with blackish-brown. Bill black. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{7}{8}$ in. Tail 2 in. Culmen, $1\frac{1}{4}$ in.

Young differ in having a conspicuous reddish-buff stripe from gape to beneath the eye. Upper parts bronzy-green, and outermost rectrices blackish-brown. Blue of the throat less brilliant. Description from type specimen in my collection.

The female is not known.

Genus XXIX.—EUGENIA.

Eugenia, GOULD, P. Z. S. (1855), p. 192.

TYPE.

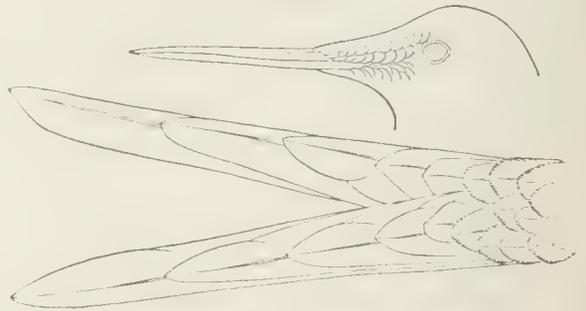
E. imperatrix, Gould.

Ch. Bill long, straight, stout. Nostrils covered with feathers. Wings long and pointed. Tail lengthened, much forked; feathers narrow, stiff. Tarsi feathered nearly to the toe. Sexes dissimilar.

Range. Ecuador.

But one species is known of this genus.

Fig. 29.



Eugenia imperatrix, ♂. Ansa. Ecuador. Gould.

1. *Eugenia imperatrix*.

Eugenia imperatrix, GOULD, P. Z. S. (1855), p. 192.—ID., Mon. Troch., vol. iv, pl. 234.—ID., Intr. Troch., octavo ed., p. 130 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 198.

Hab. Ecuador.

Male. Forehead and chin brilliant metallic-green. Crown and upper parts deep grass-green, very brilliant when viewed from behind. On the centre of throat a spot of metallic-violet. Breast very dark green. Abdomen and under tail coverts luminous greenish-yellow. Wings purple-brown. Tail feathers blackish-brown. Thighs brown. Bill black; feet black. Total length, 6 in. Wing, 3 in. Tail, $3\frac{1}{2}$ in. Culmen (uncovered), 1 in.

Female. Upper parts grass-green; under parts grayish-white spangled with green. Median rectrices olive, lateral ones dark brown. Under tail coverts grass-green. Tarsi white. Total length, $5\frac{1}{2}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{7}{8}$ in.

Genus XXX.—LAMPRASTER.

Lampraster, TACZANOWSKI, P. Z. S. (1874), p. 140.

TYPE.

L. branicki.

Fig. 30.

*Lampraster branicki*. ♂. (From P. Z. S. 1874.)

Ch. Bill longer than the head, straight. Tail as long as the body, greatly forked. Under tail coverts exceed half the length of the rectrices. Tarsi covered with feathers to the toes.

Range. Peru.

But one species is known.

1. **Lampraster branicki*.

Lampraster branicki, TACZANOW., P. Z. S. (1874), p. 140, pl. 21, fig. 1.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 200.

Hab. Peru.

Male. Centre of the crown occupied by a line of brilliant green, which commences at the base of maxilla, and changes to blue in the centre of the head. Upper parts shining grass-green. Throat metallic-rose, changing to violet in certain lights. Chin brilliant green. Breast shining green; lower part of abdomen, under tail coverts, and tarsi pure white. Greater wing coverts grass-green; secondaries rufous at base, blackish-brown on the remaining part. Median rectrices grass-green, lateral ones black, glossed with violet. Maxilla black; mandible flesh-color. Dimensions as given by M. Taczanowski. Total length, 105 mill. Wing, 68. Tail, 40. Bill at gape, 26.

Female is unknown. The type is unique, and is contained in the Museum at Warsaw.

Genus XXXI.—HELIODOXA.

Heliodoxa, GOULD, P. Z. S. (1849), p. 95.

Leadbeatera, BON., Consp. Gen. Av. (1850), p. 70.

Aspasta, HEIN., Journ. für Ornith. (1863), p. 179.

Hypolia, MULS., Cat. Ois. Mouch. (1875), p. 17.

TYPE.

H. jacula, Gould.*T. leadbeateri*, Bourc.*T. leadbeateri*, Bourc.*T. leadbeateri*, Bourc.

Ch. Bill about as long as head, stout, straight, pointed at tip; feathers of the forehead projecting on to the bill, covering the nostrils; wings long, narrow, and pointed; tail rather long, forked; tarsi clothed to the base of the toes. Sexes dissimilar in plumage.

Range. Costa Rica, Veragua, Venezuela, Columbia, Ecuador, and Peru.

I recognize but three species belonging to this genus.

Key to the species.

A. Under surface shining metallic-green.

a. Spot of metallic-blue on the throat.

a'. Entire crown metallic grass-green.

b'. Centre of crown metallic grass-green, bordered with black.

b. Throat and breast metallic-green, no spot on the throat.

1. *H. jacula.*

2. *H. jamesoni.*

3. *H. leadbeateri.*

This genus, generally supposed to consist of five species, but which I have reduced to three, comprises birds of rather large size, possessing a plumage of extremely luminous colors, confined, as is usually the case, chiefly to the males. The plumage of the sexes is very different, and the species are distinguished by the presence or absence of a luminous spot on the throat, and by the various shades of green which compose the hues of their dress. They terminate the section of the Family to which they belong.

1. *Heliadoxa jacula.*

Heliadoxa jacula, GOULD, P. Z. S. (1849), p. 96.—ID., Mon. Troch., vol. ii, pl. 94.—ID., Intr. Troch., octavo ed., p. 74.—CAB. and HEIN., Mus. Hein. Th., iii, p. 22 (note 4) (1860).—MULS., Hist. Nat. Ois. Mouch., tom ii, p. 202.

Leadbeatera jacula, BON., Consp. Gen. Av., p. 70 (1850).—REICH., Aufz. der Colib., p. 7 (1853).—BON., Rev. and Mag. Zool. (1854), p. 251.

Cæligena jacula, REICH., Troch. Enum., p. 4, t. 688, fig. 4522 (1855).

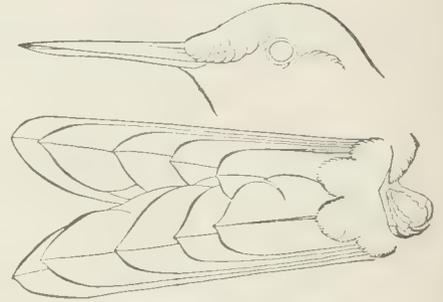
Hab. Costa Rica, Veragua, and Columbia.

Male. Crown of the head and under parts brilliant metallic-green. In the centre of the throat a spot of metallic purplish-blue. Back shining grass-green. Wings purplish-brown. Upper tail coverts bronzy-green. Under tail coverts dark brown with green reflections. Tail blue-black. Bill black. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts dark grass-green. Under parts white with the tips of all the feathers metallic-green, giving to this part of the plumage a spotted appearance. Tail bluish-black, lateral feathers tipped with white.

Some specimens have a line beneath the eye and the lores reddish-buff.

Fig. 31.



Heliadoxa jacula. ♂ ad. Veragua.

2. *Heliodoxa jamesoni*.

- Trochilus jamesoni*, Bourc., Compt. Rend., t. xxxii, p. 187 (1851).—ID., Rev. and Mag. Zool. (1851), p. 97.
Cœligena (Leadbeatera) jamesoni, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4.
Leadbeatera jamesoni, BON., Rev. and Mag. Zool. (1854), p. 251.
Heliodoxa jamesoni, GOULD, Mon. Troch., vol. ii, pl. 95.—ID., Intr. Troch., octavo ed., p. 74.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 204.—CAB. and HEIN., Mus. Hein. Th., iii, p. 22 (note 5).

Hab. Ecuador.

This species is almost precisely like the *H. jacula*, but has only the front and a narrow line on the crown metallic-green; the rest of the crown on the sides appearing greenish-black. It is rather larger than the bird named, and has the bill slightly longer. Total length, $4\frac{3}{8}$ in. Wing, 3 in. Tail, $2\frac{1}{8}$ in. Culmen, 1 in.

The females of the two species resemble each other so closely that I can give no characters by which they may be distinguished.

3. *Heliodoxa leadbeateri*.

- Trochilus leadbeateri*, Bourc., Rev. Zool. (1843), p. 102.
Trochilus otero, TSCHUD., Weigm. Archiv. (1843), p. 390.—ID., Faun. Peruan., p. 249, t. xxiii, fig. 2 (1845-46).
Leadbeatera grata, BON., Consp. Gen. Av., p. 70 (1850).—ID., Rev. and Mag. Zool. (1854), p. 251.—GOULD, Intr. Troch., octavo ed., p. 75 (1861).
Leadbeatera otero, REICH., Aufz. der Colib., p. 7 (1853).—BON., Rev. and Mag. Zool. (1854), p. 251.—GOULD, Intr. Troch., octavo ed., p. 74.
Leadbeatera sagitta, REICH., Aufz. der Colib., p. 7 (1853).
Cœligena sagitta, REICH., Aufz. der Colib., p. 23 (1853).—ID., Troch. Enum., p. 4, t. 689, fig. 4525, and t. 690, figs. 4527-28.
Cœligena otero, REICH., Troch. Enum., p. 3, t. 689, figs. 4523-24 (1855).
Heliodoxa leadbeateri, GOULD, Mon. Troch., vol. ii, pl. 97.—CAB. and HEIN., Mus. Hein. Th., iii, p. 22 (1860).—ELLIOT, Ibis (1876), p. 7.
Heliodoxa otero, GOULD, Mon. Troch., vol. ii, pl. 96.—CAB. and HEIN., Mus. Hein. Th., iii, p. 22 (note 3) (1860).
Heliodoxa sagitta, CAB. and HEIN., Mus. Hein. Th., iii, p. 22 (1860).
Leadbeatera splendens, GOULD, Intr. Troch., octavo ed., p. 74 (1861).
Aspasta leadbeateri, HEIN., Journ. für Ornith. (1863), p. 179.
Aspasta splendens, HEIN., Journ. für Ornith. (1863), p. 180.
Aspasta otero, HEIN., Journ. für Ornith. (1863), p. 180.
Hypolia leadbeateri, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 207.
Hypolia otero, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 209.
Hypolia splendens, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 211 (1876).

Hab. Venezuela, Columbia, Peru, and Bolivia.

Male. Crown of the head metallic-blue or bluish-green. Nape coppery red; black when viewed from the front. Upper parts, abdomen, and flanks dark shining grass-green. Throat and breast extremely brilliant metallic-green. Under tail coverts dark olive margined with buffy-white. Upper tail coverts bronze. Median rectrices bronze, lateral ones black. Bill black. Total length, $5\frac{3}{8}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{3}{4}$ to 1 in.

Female has the upper parts grass-green, reddish on the nape. Under surface white spangled with green, like the female of *H. jacula*. Lower part of abdomen buff. Central rectrices bronze, lateral ones black tipped with white; under tail coverts pale olive-green, margined with buffy-white.

I have shown in the Ibis (1876, p. 7) how impossible it is to separate this species

into three as has been attempted by previous writers, both the geographical distribution and the plumage of the specimens proving very conclusively that there is only one species.

Genus XXXII.—PTEROPHANES.

TYPE.

Pterophanes, GOULD, *Intr. Troch.*, octavo ed., p. 105; *Id.*, *Mon. Troch.*, pt. 1 (1850). *O. temminckii*, BOSS.
Lepidoria, MULS. and VERR., *Class. Troch.* (1865), p. 61. *O. temminckii*, BOSS.

Fig. 32.



Pterophanes temminckii. ♂. Yungas, Bolivia. Buckley.
 (Ridge of Cillulugaza, alt. 12,000 ft.)

Ch. Bill cylindrical, longer than the head, slightly curved upward at the point. Wings very large, falcate. Tail ample, forked. Tarsi clothed. Hind toe shorter than middle one. Sexes unlike.

Range. Columbia, Ecuador, Peru, and Bolivia.

The present genus contains but a single species, remarkable chiefly for its large size, being exceeded in this respect, by only one other in the Family. Although differing greatly from all the other genera, it still has its closest affinity to those species with stout, straight bills, and naturally finds its place here; although we must wait farther discoveries to enable us to supply the species needed to render its connection with the surrounding genera more close and complete.

1. *Pterophanes temminckii*.

Ornismya temminckii, BOISS., *Rev. Zool.* (1839), p. 354.—*Id.*, *Mag. Zool.* (1840), *Ois.*, pl. 14.

Trochilus cyanopterus, "LODD.," *FRAS.*, *P. Z. S.* (1840), p. 17.

Mellisuga temminckii, GRAY, *Gen. Birds.*, vol. i, p. 112, sp. 10.

Pterophanes temminckii, GOULD, *Mon. Troch.*, vol. iii, pl. 178.—*Id.*, *Intr. Troch.*, octavo ed., p. 105.—*BON.*, *Consp. Gen. Av.* (1850), vol. i, p. 70.—*Id.*, *Rev. and Mag. Zool.* (1854), p. 251.—*REICH.*, *Aufz. der Colib.*, p. 14.—*Id.*, *Troch. Enum.*, p. 11.—*CAB. and HEIN.*, *Mus. Hein. Th.*, iii, p. 80.—*MULS.*, *Hist. Nat. Ois. Mouch.*, tom. ii, p. 290.

Lepidoria temminckii, MULS. and VERR., *Class. Troch.* (1865), p. 61.

Hab. Columbia, Ecuador, Peru, and Bolivia.

Male. Plumage of the body dark grass-green, black on the back in some lights. Wings deep shining blue, feathers tipped with black. Tail shining olive-green.

Bill black, feet flesh-color. Total length, $6\frac{1}{2}$ in. Wing, $4\frac{1}{2}$ in. Tail, $3\frac{3}{8}$ in. Culmen, $1\frac{1}{8}$ in.

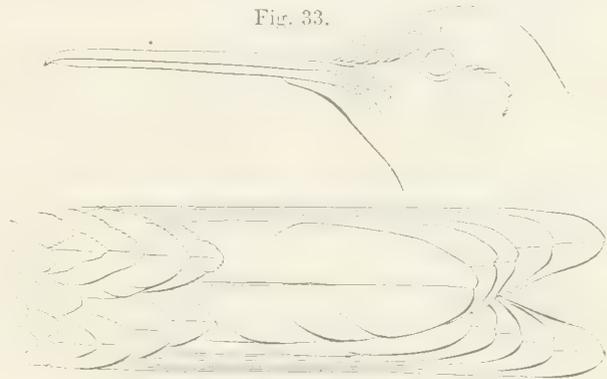
Female. Top of head dark brown, white spot behind the eye. Upper parts bronzy-green, darkest on the rump. Greater wing coverts blue, primaries and secondaries purple-brown. Throat, breast, and abdomen rufous. Under tail coverts dark green. Four central tail feathers bronzy-green, rest black with green reflections, and white tips, the external feathers having the outer webs white. Total length, $6\frac{1}{2}$ in. Wing, 4 in. Tail, 3 in. Culmen, $1\frac{1}{8}$ in.

Genus XXXIII.—PATAGONA.

Cynanthus, LESS. (nec SWAINS., 1827), Tabl. Esp. Ois. Mouch. (1829), p. xii.
Patagona, GRAY, List of Genera of Birds (1840), p. 18.
Hylocharis, GRAY, Gen. Birds, vol. i, p. 114 (1848, nec BORE, 1832).
Hypermetra, CAB. and HEIN., Mus. Hein. Th., iii, p. 80 (1860).

TYPE.
T. gigas, Vieill.
T. gigas, Vieill.
T. gigas, Vieill.
T. gigas, Vieill.

Ch. Size very large. Bill much longer than the head, straight, stout. Feathers of the forehead projecting slightly upon the culmen, hiding the nostrils. Wings very long, reaching nearly to the end of the tail, pointed. Tail long, forked. Feet large, stout; tarsi clothed to the toes. Sexes alike.



Patagona gigas. ♂. Tinta, Peru. Whitely.

Range. Ecuador, Peru, Bolivia, and Chili.

This genus contains the largest species of Humming-birds known, and the remarks already made upon the genus PTEROPHANES, are equally applicable here. In a general arrangement of the Family, it evidently belongs somewhere in this neighborhood, but we must wait for future discoveries to show us its exact position.

1. *Patagona gigas*.

Trochilus gigas, VIEILL., Gal. Ois., tom. i, p. 296, pl. 180 (1834).
Ornismya (*Cynanthus*) *tristris*, LESS., Ois. Mouch., p. 43, t. 3 (1829).
Ornismya gigantea, D'ORB. and LAFRES., Syn. Av., p. 26, sp. 1 (1838).
Patagona gigas, GRAY, List of Gen. Birds (1840), p. 14.—BOX., Consp. Gen. Av., vol. i, p. 75—ID., Rev. and Mag. Zool. (1854), p. 251.—REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 11 (1855).—GOULD, Mon. Troch., vol. iv, pl. 232.—ID., Intr. Troch., octavo ed., p. 127 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 194—ELLIOT, Ibis (1877), p. 134.
Hylocharis gigas, GRAY, Gen. Birds, vol. i, p. 114.
Hypermetra gigas, CAB. and HEIN., Mus. Hein. Th., iii, p. 80 (1860).

Hab. West coast of South America from Ecuador into Chili.

Adult. Upper surface pale greenish-brown, with a patch of white on the rump. Wings purplish-brown. Throat and abdomen rusty-red, the feathers of the former with a blackish-brown spot at the tip. Breast pale brown, feathers edged with buff. Under tail coverts white. Tail dark brownish-green. Shafts of lateral

feathers white except at the tips. External feather grayish-white all but the tip which is brownish-green. Bill and feet black. Total length, $8\frac{1}{2}$ in. Wing, $5\frac{1}{8}$ in. Tail, $3\frac{3}{4}$ in. Bill, $1\frac{7}{16}$ in.

Genus XXXIV.—DOCIMASTES.

Mellisuga, GRAY (nec BRISSON., 1760), Gen. Birds, vol. i, p. 112 (1848).

Docimastes, GOULD, Mon. Troch., pt. i (1850).—ID., Intr. Mon. Troch., octavo ed., p. 129 (1861).

Docimaster, BON., Consp. Gen. Av., vol. i, p. 74 (1850).

TYPE.

O. ensifera, Boiss.

O. ensifera, Boiss.

O. ensifera, Boiss.

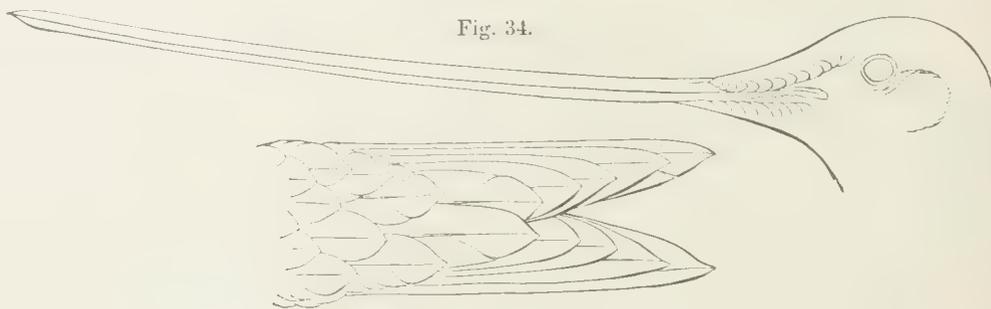


Fig. 34.

Docimastes ensiferus. ♂. Ecuador. Gardener.

Ch. Bill longer than the body and head, and inclining upwards at the tip. Feathers projecting on to the culmen and gonyx. Nostrils hidden. Bill compressed laterally for three-fourths of its length, when it becomes slightly flattened, and graduates rapidly to a point at the tip. Wings long and pointed. Tail forked. Feet rather small, with the hind toe shorter than the middle toe. Tarsi partly clothed. Sexes unlike in plumage.

Range. Columbia, Ecuador, and Peru.

The single species of this genus is remarkable for the extreme length of the bill, which exceeds that of the entire bird. The necessity for this extraordinary development is appreciated when the lengthened tubular flowers are seen, from the bottom of which the species obtains its food, and which could never be reached by a short-billed bird. In size it is a rather large species, the breast being the most luminous portions of the male.

1. *Docimastes ensiferus*.

Ornismya ensifera, BOISS., Rev. Zool. (1839), p. 354.—ID., Mag. Zool. (1840), Ois., pl. 15.

Trochilus derbyanus, FRAS., P. Z. S. (1840), p. 16.

Mellisuga ensifera, GRAY, Gen. Birds, vol. i, p. 112, sp. 1.

Docimastes ensiferus, GOULD, Mon. Troch., vol. iv, pl. 233.—ID., Mon. Troch., octavo ed., p. 129.—REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 11 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 77 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 286.

Docimaster ensiferus, BON., Consp. Gen. Av., vol. i, p. 74 (1850).—ID., Rev. and Mag. Zool. (1854), p. 251.

Docimastes schliephaekei, HEINE, Journ. für Ornith. (1863), p. 215.

Hab. Columbia, Ecuador, and Peru.

Male. Head coppery-green; throat black, the feathers edged with buff. Upper surface bronzy-green. On either side of the neck and upper part of breast a broad metallic emerald-green band. Flanks bronzy-green. Middle of abdomen pale brown. Wings purplish-brown. Tail bronze. Behind the eye a spot of white.

Bill and feet black. Total length, from $7\frac{1}{2}$ – $8\frac{2}{3}$ in. Wing, $3\frac{1}{8}$ in. Tail, $2\frac{3}{8}$ – $2\frac{5}{8}$ in. Bill on culmen, from 3–4 in.

Female differs in having the throat white, each feather with a dark brown central streak. Under surface bronzy-green, each feather margined with white; and also having the metallic-green bands around the throat. Total length, $7\frac{1}{2}$ – $8\frac{3}{4}$ in. Wing, 3 in. Tail, 2 – $2\frac{1}{4}$ in. Culmen, $3\frac{1}{4}$ – $4\frac{1}{4}$ in.

Some of my specimens of females have the bills longer than any of the males, even of those from the same localities.

Genus XXXV.—DIPHLOGÆNA.

Diphlogæna, GOULD, Intr. Mon. Troch., octavo ed., p. 133 (1861), descr.

TYPE.
D. iris.

Ch. Bill straight, slender, very long. Wings very long, pointed. Tail long, deeply forked. Tarsi partially clothed. Sexes very dissimilar.

Range. Ecuador, Bolivia.
Two species are known.

Fig. 35.



Diphlogana hesperus. ♂. Bolivia. Verreaux.

Key to the species.

- A. Centre of crown metallic-blue, forehead and sides of crown metallic orange-scarlet.
- a. Back chestnut-red. 1. *D. iris*.
 - b. Back green. 2. *D. hesperus*.

Still continuing with the straight long-billed birds, we come now to some of the most gorgeously plumaged species in the family. The present genus contains some that are remarkable for the diverse metallic hues of blue and scarlet observed on the head. The females are entirely different, having a metallic-green and chestnut plumage, and for a long time were deemed to represent a different species.

1. **Diphlogæna iris*.

- Helianthea iris*, GOULD, P. Z. S. (1853), p. 61, pl. fig. 1 ♂.—BON., Rev. and Mag. Zool. (1854), p. 251.
Diphlogana iris, GOULD, Mon. Troch., vol. iv, pl. 247.—ID., Intr. Troch., octavo ed., p. 133 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 302.
Helianthea aurora, GOULD, P. Z. S. (1853), p. 61, pl. fig. 2 ♀.—BON., Rev. and Mag. Zool. (1854), p. 251.—CAB. and HEIN., Mus. Hein. Th., iii, p. 80 (note 6) (1860).
Hypochrysis aurora, REICH., Aufz. der Colib., p. 9.—ID., Troch. Enum., p. 6 (1855) ♀.
Hypochrysis iris, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, t. 735, figs. 4685–86 (1855).
Hypochrysis aurora, REICH., Aufz. der Colib., p. 9, ♀, (1853).
Leadbeatera warszewiczii, REICH., Aufz. der Colib., ♀, p. 9.—ID., Troch. Enum., p. 6, t. 690, fig. 4526 (1855).
Cœligena warszewiczii, REICH., Aufz. der Colib. (1853), p. 23. ♀.
Diphlogæna aurora, GOULD, Mon. Troch., vol. iv, pl. 248.—ID., Intr. Troch., octavo ed., p. 134, ♀.
La Diphlogène aurore, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 303, ♀.

Hab. Bolivia.

Male. Forehead metallic golden-green, changing to metallic orange-scarlet on the sides of the crown. Centre of crown deep metallic-blue. Occiput and nape velvety-black. Wing coverts bronzy-brown. Wings purplish-brown. Throat and breast glittering grass-green, with a small spot of purplish-blue in the centre. Lower part of back, abdomen, upper and under tail coverts, and tail chestnut-red. Bill black. Total length, $5\frac{1}{2}$ in. Wing, $3\frac{3}{16}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $1\frac{1}{16}$ in.

Female. Crown, throat, and breast metallic-green, brightest on the crown, rest of plumage chestnut-red.

2. *Diphlogæna hesperus*.

Diphlogæna hesperus, GOULD, Ann. Mag. Nat. Hist. (1865), p. 129.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 304.

Hab. Ecuador.

Male. Almost precisely like the *D. iris*, but differs in having the back and abdomen green. The tail with its coverts are deep chestnut-red, and the throat is metallic golden-green, with a very small spot of purple in the centre. The dimensions of the two species are the same.

Female. Like that of *D. iris*.

Genus XXXVI.—HELIANTHEA.

Helianthea, GOULD, P. Z. S. (1848), p. 11.

Phemone, REICH., Aufz. der Colib. (1853), p. 9.

Hypochrysis, REICH., Aufz. der Colib. (1853), p. 9.

Diphlogæna, MULS. and VERR., Class. Troch. (1865), p. 61 (partim).

Saturia, MULS., Catal. Ois. Mouch. (1875), p. 21.

Calligenia, MULS., Catal. Ois. Mouch. (1875), p. 20.

TYPE.

O. typica, Less.

O. isaacsoni, Parzud.

O. bonaparti, Boiss.

O. isaacsoni, Parzud.

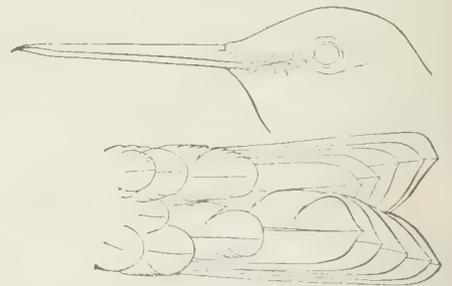
T. lutilice, Delatt. and Bourc.

Ch. Bill very long, straight, cylindrical. Wings long. Tail moderately long, slightly forked. Tarsi feathered. Sexes unlike in plumage.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

Eight species are recognized as belonging to this genus. M. Mulsant has divided the members into various genera, not altogether happily, as he has grouped species together not particularly similar, and separated others that were: viz., *H. eos* and *H. lutilice* in *Calligenia*, leaving *H. bonaparti* in *HELIANTHEA*, whereas in every respect this last is closely allied to *H. eos*, which has a luminous rump, contrary to the species of *Calligenia* as restricted by M. Mulsant.

Fig. 36.



Helianthea typica. ♂ ad. Bogota. Whitely.

Key to the species.

- A. Rump and under parts exceedingly luminous.
- a. Tail steel-black, rump metallic-green. 1. *H. isaacsoni*.
 - b. Tail brownish-black, rump metallic-blue. 2. *H. typica*.
 - c. Tail green, rump metallic golden-yellow. 3. *H. bonapartii*.
 - d. Tail cinnamon tipped with green. 4. *H. eos*.
- B. Rump not luminous, under parts slightly metallic.
- a. Tail greenish-brown, yellow patch on secondaries. 5. *H. lutetiæ*.
- C. Under parts buff.
- a. Tail rufous, white band across breast. 6. *H. violifera*.
 - b. Tail bright buff tipped with green, breast green. 7. *H. osculans*.
 - c. Tail with a broad terminal band of green. 8. *H. dichroua*.

The Helianthiæ are large fine birds, with luminous foreheads in the majority of the species, and all possess brilliant throats and breasts.

1. Helianthea isaacsoni.

Ornismya isaacsoni, PARZ., Rev. Zool. (1845), p. 95.

Hylocharis isaacsoni, GRAY, Gen. Birds, vol. i, p. 114 (1844-49).

Eriopus isaacsoni, BON., Consp. Gen. Av., p. 80, sp. 9 (1850).

Eriocnemis isaacsoni, BON., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. iv, pl. 272.—ID., Intr. Troch., octavo ed., p. 144 (1861).

Pheemonoe isaacsoni, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, t. 741, fig. 4700 (1855).

Helianthea isaacsoni, ELLIOT, Ibis (1874), p. 331.

Saturia isaacsoni, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 299.

Hab. Unknown.

Upper part of head dark metallic-green, a small spot of very luminous light grass-green upon the forehead. Back grass-green inclined to bronze in certain lights. Wings like the back; primaries purplish-brown. Rump and upper tail coverts brilliant metallic grass-green. Entire throat brilliant metallic grass-green. Breast metallic-green, lighter than the throat; rest of under parts metallic coppery-bronze changing in certain lights to red upon the abdomen. Under tail coverts brilliant grass-green. Tail brownish-black with a purple shade. Bill black. Tarsi partly covered with short white feathers. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, 2 in. Culmen, 1 in.

But two specimens are known. One is in my collection, and one in the Liverpool Museum.

2. Helianthea typica.

Ornismya typica, LESS., Rev. Zool. (1838), p. 314.

Mellisuga helianthea, GRAY, Gen. Birds, vol. i, p. 112, sp. 6.

Helianthea typica, GOULD, Mon. Troch., vol. iv, pl. 235.—ID., Intr. Troch., octavo ed., p. 130.—ELLIOT, Ibis (1874), p. 332.—et auct.

Helianthea porphyrogaster, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 293.

Hab. Columbia.

Male. Forehead metallic grass-green. Top of head and loreal space velvety-black. Back, wing coverts, chin, and breast very dark green, appearing black in some lights. Centre of throat metallic purplish-blue. Wings purplish-brown. Abdomen

metallic-lilac, very brilliant. Under tail coverts dark maroon. Tail dark olive-green. Upper tail coverts brilliant metallic light green. Bill black. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $1\frac{1}{4}$ in.

Female. Above grass-green. Rump metallic purplish-green. Beneath deep buff, feathers of breast tipped with green; those of the abdomen with metallic-crimson. Under tail coverts green tipped with buff. Tail and wings like the male.

Young. Throat buff, rest of under parts blackish-brown, streaked with white. Rest of plumage like the female.

3. *Helianthea bonapartii*.

Ornismya bonapartii, BOISS., Rev. Zool. (1840), p. 6.

Trochilus aurogaster, FRAS., P. Z. S. (1840), p. 16.

Mellisuga bonapartii, GRAY, Gen. Birds, vol. i, p. 112, sp. 8.

Hypochrysis bonapartii, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, t. 734, figs. 4683-84.

Helianthea bonapartii, GOULD, Mon. Troch., vol. iv, pl. 236.—ID., Intr. Troch., octavo ed., p. 130.—BON.,

Consp. Gen. Av., vol. i, p. 74.—ID., Rev. and Mag. Zool. (1854), p. 251.—CAB. and HEIN., Mus. Hein. Th., iii, p. 80 (1860).—ELLIOT, Ibis (1874), p. 332.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 295.

Hab. Columbia.

Male. Forehead metallic dark green. Rest of head, back, throat, and breast deep shining green. Rump and upper tail coverts metallic coppery-red. Middle of throat metallic purplish-blue. Abdomen brilliant metallic coppery-red. Under tail coverts and tail bronze, the former sometimes edged with buff. Wings purple. Bill black. Total length, $4\frac{7}{8}$ in. Wing, 3 in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{1}{16}$ in.

Female. Above green, becoming metallic coppery-bronze on upper tail coverts. Breast green; throat and abdomen buff, the feathers of the latter tipped with bronzy-red. Under tail coverts bronze margined with buff. Tail bronze. Bill black.

4. *Helianthea eos*.

Helianthea eos, GOULD, P. Z. S. (1848), p. 11.—ID., Mon. Troch., vol. iv, pl. 237.—ID., Intr. Troch., octavo ed., p. 131.—ELLIOT, Ibis (1874), p. 333.—BON., Consp. Gen. Av., p. 75.—ID., Rev. and Mag. Zool. (1854), p. 251.—CAB. and HEIN., Mus. Hein. Th., iii, p. 79 (note 4) (1860).

Mellisuga eos, GRAY, Gen. Birds, vol. iii, app., p. 5.

Hypochrysis eos, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, t. 733, figs. 4680-82.

Calligenia eos, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 311.

Hab. Merida, Venezuela.

Male. Similar to the *H. bonapartii*, but differs in having the breast metallic golden-yellow instead of green. The frontal and gular spots are much larger. Abdomen and flanks metallic flame-color. Tail cinnamon tipped with bronzy-green. Wings purple, secondaries rufous. Total length, $5\frac{1}{4}$ in. Wing, 3 in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{1}{8}$ in.

Female. Similar to the male, but the colors much less brilliant, and is without the frontal and gular spots. The under parts resemble that of the females of the *H. bonapartii*.

5. Helianthea lutitiæ.

Trochilus lutitiæ, DELATT. and BOURC., Rev. Zool. (1846), p. 307, sp. 6.

Mellisuga lutitiæ, GRAY, Gen. Birds, vol. i, p. 112, sp. 7.

Helianthea lutitiæ, GOULD, Mon. Troch., vol. iv, pl. 238.—ID., Intr. Troch., octavo ed., p. 131 (1861).—ELLIOT, Ibis (1874), p. 333.—BON., Consp. Gen. Av., vol. i, p. 74 (1850).—ID., Rev. and Mag. Zool. (1854), p. 251.—REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, t. 736, figs. 4687-88 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 79 (note 3) (1860).

Calligenia lutitiæ, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 306.

Hab. Ecuador, volcano of Puracé, near Popayan.

Male. Forehead glittering grass-green. Crown and nape velvety-black. Back black glossed with dark green. Wing coverts dark green. Under surface shining dark grass-green. Wings purplish-brown, secondaries buff. Tail very dark bronzy-brown. Bill black. Total length, 5 in. Wing, 3 in. Tail, 2 in. Culmen, $1\frac{1}{4}$ in.

Female. Wings and tail like the male. Upper and under surface shining grass-green. Throat deep buff. Under tail coverts light buff, tipped with bronzy-green. Bill black. Dimensions similar to those of the male.

6. Helianthea violifera.

Trochilus violifera, GOULD, P. Z. S. (1846), p. 87.

Mellisuga violifera, GRAY, Gen. Birds, vol. i, p. 112, sp. 9.

Helianthea violifer, BON., Consp. Gen. Av., p. 75 (1850).

Helianthea violifera, GOULD, Mon. Troch., vol. iv, pl. 239.—ID., Intr. Troch., octavo ed., p. 131 (1861).—BON., Rev. and Mag. Zool. (1854), p. 251.—REICH., Aufz. der Colib., p. 9.—ID., Troch. Enum., p. 6.—CAB. and HEIN., Mus. Hein. Th., iii, p. 80 (note 5) (1860).—ELLIOT, Ibis (1874), p. 333.

Calligenia violifera, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 313.

Hab. Bolivia.

Male. Top of head dark green, almost black. A small indistinct spot of shining green on the forehead. Back and rump bronzy-green. Throat and breast dark green. A metallic spot on the throat violet-blue. A narrow white band across the breast. Abdomen, upper and under tail coverts light rufous. Tail light rufous, tipped with bronzy-green. Wings purple, outer edge of first primary rufous. Bill black. Total length, $5\frac{3}{8}$ in. Wing, $3\frac{1}{8}$ in. Tail, $2\frac{3}{16}$ in. Culmen, $1\frac{1}{4}$ in.

Female. Resembles the male, but has the throat rufous mottled with green.

7. Helianthea osculans.

Helianthea osculans, GOULD, P. Z. S. (1871), p. 503.—ELLIOT, Ibis (1874), p. 334.

Calligenia osculans, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 300.

Hab. Peru, Cachupata, 11,000 feet (Whitely).

Male. Very similar to the *H. violifera*, but is destitute of the white band across the breast. The green of the breast extends on to the abdomen; the median rectrices have their apical half bronzy-green, and the tips of the lateral feathers have a considerable band of bronze-green. Total length, $5\frac{3}{8}$ in. Wing, 3 in. Tail, $2\frac{3}{8}$ in. Culmen, $1\frac{1}{4}$ in.

Female has no frontal nor gular spot. Throat buff spotted with green, rest like the male.

8. *Helianthea dichroua*.

Helianthea dichroua, TACZANOW., P. Z. S. (1874), p. 138.—ELLIOT, Ibis (1874), p. 334.
Calligenia dichroua, MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 309.

Hab. Maraynioc, Peru.

Male. Closely resembling the *H. osculans*. The under surface, with the exception of the lower portion of abdomen and tail coverts, dark green. The principal difference is in the tail, which has the terminal third part bronze-green, forming a conspicuous apical band. Maxilla black, mandible flesh-color, tip black. Total length, $5\frac{1}{4}$ in. Wing, $3\frac{1}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $1\frac{1}{4}$ in. (Type, Taczanowski.)

Female. Unknown.

The members of the next genus *BOURCIERIA* are of about the same size as those of the previous one, and present a variety of coloration, from black and white to metallic-greens and other hues. They possess the same long straight bills as are seen among the species of *HELIANTHEA*. I have retained in this genus the species usually separated in the term *LAMPROPYGGIA*, as I perceive no generic characters to distinguish them. The only one advanced by any author is that of color, which in my opinion should never be regarded as alone sufficient to establish a genus; and of those who think otherwise, it might be asked how such species as *B. conradi* and *inca* could be placed in the same genus or left with *torquata* and *fulgidigula*, with which, as regards *color*, they have hardly any relationship whatever.—It is in fact drawing the line very fine, when we separate generically the species of *HELIANTHEA* and those contained in *BOURCIERIA*, and I am not at all assured in my own mind but that every useful purpose would be equally well served by restricting all these species to the same genus. If color must be a generic character, they require many genera; if structural characters are necessary, it is very difficult to find them.

Genus XXXVII.—*BOURCIERIA*.

Bourcieria, BON., Compt. Rend. (1850), p. 380.
Celigena, BON. (nec LESS., 1832), Compt. Rend., p. 382 (1850).
Homophania, REICH., Aufz. der Colib. (1853), p. 10.
Conradinia, REICH., Aufz. der Colib. (1853), p. 10.
Lampropygia, REICH., Aufz. der Colib. (1853), p. 10.
Polyæna, HEINE, Journ. für Ornith. (1863), p. 215.
Eudosia, MULS., Cat. Ois. Mouch. (1875), p. 20.
Pilonia, MULS., Hist. Nat. Ois. Mouch. (1876), vol. iii, p. 4.

TYPE.

T. prunelli, Bourc.
O. celigena, Less.
T. prunelli, Bourc.
T. conradi, Bourc.
T. wilsoni, Bourc.
O. torquata, Boiss.
D. traviesi, Muls. and Verr.
T. prunelli, Bourc.

Ch. Bill very long, straight, pointed at tip. Tail long, broad, slightly forked. Tarsi bare. Sexes similar in plumage.

Range. Venezuela, Columbia, Ecuador, and Peru.

Thirteen species are here recorded.



Bourcieria fulgidigula. ♂. 32057. Quito.

Key to the species.

- A. Breast deep buff.
 - a. Head black, luminous green spot on forehead. 1. *B. inca*.
- B. Breast pure white.
 - a. Head metallic grass-green. 2. *B. conradi*.
 - b. Forehead, sides of head, and nape black.
 - a'. Throat green. 3. *B. insectivora*.
 - a''. Crown metallic grass-green. 4. *B. fulgidigula*.
 - b''. Crown bluish-green. 5. *B. torquata*.
 - b'. Throat black. Crown purple. 6. *B. traviesi*.
 - c. Forehead and crown metallic-blue, tail bronze. 7. *B. wilsoni*.
- C. White crescent-shaped mark on either side of the neck.
 - a. General plumage purplish-brown. 8. *B. purpurea*.
 - a'. Throat bright metallic-purple. 9. *B. assimilis*.
 - b'. Throat dark gray, without metallic lustre. 10. *B. prunelli*.
 - b. General plumage black. 11. *B. caeligena*.
 - a'. Gular spot dark metallic-purple. 12. *B. columbiana*.
 - b'. Gular spot metallic-green, sometimes with blue reflections. 13. *B. boliviana*.
- D. Without white marks on the sides of the neck; throat without metallic coloring.

1. Bourcieria inca.

Bourcieria inca, GOULD, Jard. Contr. Ornith. (1852), p. 136.—ID., Mon. Troch., vol. iv, pl. 254.—ID., Intr. Troch., octavo ed., p. 136 (1851).—BON., Rev. and Mag. Zool. (1854), p. 252.—REICH., Troch. Enum., p. 7, t. 752, figs. 4725-26 (1855).

Homophania inca, REICH., Aufz. der Colib., p. 10 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 79 (note) (1860).—MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 322.

Hab. Peru and Bolivia.

Male. Head jet-black, excepting a luminous metallic emerald-green spot on the forehead, and tips of the throat feathers which are green. A broad band of deep buff crosses the breast, and covers the sides of the neck; all the rest of the upper and under surface glittering metallic grass-green. Upper tail coverts glittering bronzy-green, as are also the median rectrices, lateral ones white tipped with bronzy-green. Wings purplish-brown. Bill black. Total length, $5\frac{1}{2}$ in. Wing, $3\frac{1}{5}$ in. Tail, $2\frac{5}{16}$ in. Culmen, $1\frac{1}{4}$ in.

Female. Feathers of the crown and nape black tipped with green. Throat reddish-buff spotted with brown; breast deep buff; rest of plumage like the male, but not so brilliant.

2. *Bourcieria conradi.*

Trochilus conradi, BOIRE., P. Z. S. (1847), p. 45.

Mellisuga conradi, GRAY, Gen. Birds, vol. i, p. 112, sp. 14.

Bourcieria conradi, GOULD, Mon. Troch., vol. iv, pl. 253.—ID., Intr. Troch., octavo ed., p. 136.—BOY., Rev. and Mag. Zool. (1854), p. 252.—ID., Consp. Gen. Av., p. 73 (1850).

* *Conradinia conradi*, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, pl. 747, figs. 4714-15 (1855).

Homophania conradi, CAB. and HEIN., Mus. Hein. Th., iii, p. 73 (note) (1860).—MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 320.

Hab. Venezuela.

Male. Top of head shining golden-green. Breast white; rest of upper and under surface shining grass-green. Median rectrices bronzy-green, remainder white with their terminal third bronzy-green. Bill black. Total length, $5\frac{3}{8}$ in. Wing, 3 in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{1}{4}$ in.

Female has the throat buffy-white, rest like the male, but less brilliant, and rectrices tipped with brownish-black.

3. *Bourcieria insectivora.*

Trochilus (Lampornis) insectivorus, TSCHUD., Faun. Per., p. 248, fig. 1 (1844).

Bourcieria insectivora, GOULD, Intr. Troch., octavo ed., p. 135 (1861).—ELLIOT, Ibis (1876), p. 5.

Homophania insectivora, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 1, ad.

Hab. Peru.

Male. Head and back of neck jet-black, with the centre of the crown metallic grass-green. Throat metallic-green. Back, upper tail coverts, abdomen, and under tail coverts shining grass-green. Breast pure white. Wings purplish-brown, their coverts like the back. Median rectrices shining grass-green, remainder pure white tipped with green, most extensive on the outermost feather. Bill black. Total length, $5\frac{1}{8}$ in. Wing, $3\frac{1}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{1}{4}$ in. (Type of adult in my collection.)

Female. Entire upper parts and throat shining green. Median rectrices green; rest white, tipped with black, glossed with green. Rest like the male.

4. *Bourcieria fulgidigula.*

Bourcieria fulgidigula, GOULD, Mon. Troch., vol. iv, pl. 252.—ID., Intr. Troch., octavo ed., p. 135 (1861)—REICH., Troch. Enum., p. 7, pl. 749, figs. 4718-20 (1855).

Homophania fulgidigula, CAB. and HEIN., Mus. Hein. Th., iii, p. 73 (note).—MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 318.

Hab. Ecuador.

Male. Crown bluish-green, rest of head black with green reflections. Chin and throat green. A broad band of white on the breast. Back, abdomen, and tail coverts dark grass-green, the two former black in certain lights. Wings purplish-brown. Median rectrices dark olive-green, rest white tipped with dark olive-green,

most extensive on outermost feather. Bill black. Total length, $5\frac{1}{4}$ in. Wing, 3 in. Tail, 2 in. Culmen, $1\frac{1}{4}$ in.

Female. Above dark green, brownish on the crown. Throat white spotted with brown. Breast white, rest of under parts brownish-black spotted with green. Wings purplish-brown. Tail like that of the male, but tipped with purplish-black.

5. *Bourcieria torquata.*

Ornismya torquata, BOISSON, Rev. Zool. (1840), p. 6.

Mellisuga torquata, GRAY, Gen. Birds, vol. i, p. 112, sp. 12.

Bourcieria torquata, GOULD, Mon. Troch., vol. iv, pl. 251.—ID., Intr. Troch., octavo ed., p. 135.—BON., Consp. Gen. Av., vol. i, p. 73.—ID., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 10.—ID., Troch. Enum., p. 7, t. 748, figs. 4716-17.

Homophania torquata, CAB. and HEIN., Mus. Hein. Th., iii, p. 79 (1860).—MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 317.

Hab. Columbia.

Male. Differs from *B. fulgidigula* by having a metallic-blue crown with violet reflections, and a black throat, with but a slight trace of green. In all other respects the two birds are alike. Total length, $5\frac{1}{4}$ in. Wing, 3 in. Tail, 2 in. Culmen, $1\frac{1}{8}$ in.

Female like that of the previous species.

6. *Bourcieria traviesi.*

Diphlogena (Helianthea) traviesi, MULS. and VERR., Ann. Soc. Linn., Lyon (1866), p. 199.

Eudosia traviesi, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 2.

Hab. Columbia.

Male. Forehead and centre of crown blue graduating into greenish-blue near the occiput; remainder of the upper part of head very dark grass-green, black in some lights. Throat green with a small metallic-violet spot in the centre. A broad white band across the breast. Abdomen, flanks, and under tail coverts glittering grass-green. Upper tail coverts metallic violet-red. Tail dark greenish-bronze. Bill black. Total length, 5 in. Wing, $2\frac{1}{16}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{3}{8}$ in.

Two specimens are known, one in my collection, and one in Count Turati's at Milan.

Female. Unknown.

7. *Bourcieria wilsoni.*

Trochilus wilsoni, DELATT. and BOURC., Rev. Zool. (1846), p. 305.

Mellisuga wilsoni, GRAY, Gen. Birds, vol. i, p. 112 (1844-49).

Celigena wilsoni, BON., Consp. Gen. Av., p. 73 (1850).

Bourcieria wilsoni, BON., Consp. Gen. Av., p. 73 (1850).—ID., Rev. and Mag. Zool. (1854), p. 252.

Celigena wilsoni, GOULD, Mon. Troch., vol. iv, pl. 258.

Lampropygia wilsoni, REICH., Troch. Enum., p. 7, pl. 751, figs. 4723, 4724.—ID., Aufz. der Colib., p. 10.—GOULD, Intr. Troch., octavo ed., p. 137 (1861).—ELLIOT, Ibis (1876), p. 59.—CAB. and HEIN., Mus. Hein.

Th., iii, p. 78 (note) (1860).

Pilonia wilsoni, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 7.

Hab. Columbia, Ecuador.

Adult. Upper parts dark bronze-brown; feathers of the rump margined with metallic grass-green. Wings purplish-brown. Throat metallic-purple. On either side of the neck a patch of white. Under surface rufous-brown. Upper tail coverts bronze-brown; under coverts reddish-brown. Tail bronze. Bill black. Total length, $4\frac{2}{3}$ in. Wing, $2\frac{7}{8}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $1\frac{1}{8}$ in.

8. **Bourcieria purpurea*.

Caligena purpurea, GOULD, Mon. Troch., pt. viii, vol. iv, pl. 256.—ID., Intr. Troch., octavo ed., p. 137 (1861).

REICH., Troch. Enum., p. 3, pl. 753, figs. 4727-28 (1855).

Lampropygia purpurea, CAB. and HEIN., Mus. Hein. Th., iii, p. 78 (note 2) (1860).—ELLIOT, Ibis (1876), p. 59.

Hab. Popayan.

"The shoulders bluish-purple; head, neck, back, and wing coverts very dark purple, becoming of a bronzy hue on the lower part of the back and rump, where also the feathers are fringed with metallic grass-green, most conspicuous when the bird is viewed from behind; tail very dark bronzy-purple; wings purplish-brown; on each side of the chest a lunate mark of white; the remainder of the under surface very dark purplish-brown; the feathers of the throat edged with gray, under tail coverts buff." (Gould, l. c.)

This is most probably only a dark variety of *B. wilsoni*. See my remarks in the Ibis (l. c.).

9. *Bourcieria assimilis*.

Lampropygia — ♀, ELLIOT, Ibis (1876), p. 58.

Hab. Ecuador?

Top of head blackish-brown; nape black with a bluish gloss. Back black, but viewed from behind iridescent, being metallic-red graduating into golden on the rump. Chin brownish-black; *throat metallic-purple*. On either side of the chest a large patch of white. Under parts black with a purple gloss. Under tail coverts black fringed with white; upper tail coverts dark purple. Tail purplish-black. Bill black. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{7}{8}$ in. Tail, 2 in. Culmen, $1\frac{1}{6}$ in.

This bird was referred to by me in the Ibis for 1876, but no name was given to it. I now describe it more particularly. Although in its general plumage it is like the *B. prunelli*, the coloring of the throat is very different, approaching that of the *B. wilsoni*.

10. *Bourcieria prunelli*.

Trochilus prunelli, BOURC. and MULS., Ann. Sc. d'Agric., Lyon (1843), p. 36.

Mellisuga prunelli, GRAY, Gen. Birds, vol. i, p. 112.

Homophania prunelli, REICH., Aufz. der Colib., p. 10 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 79 (1860).

Bourcieria prunelli, BON., Consp. Gen. Av., vol. i, p. 73.—ID., Rev. and Mag. Zool. (1854), p. 252.—REICH., Troch. Enum., p. 7, pl. 750, figs. 4721, 4722.

Cæligena prunelli, GOULD, Mon. Troch., vol. iv, pl. 257.

Lampropygia prunelli, GOULD, Intr. Troch., octavo ed., p. 137 (1861).—ELLIOT, Ibis (1876), p. 58.

Pilonia prunelli, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 4.

Hab. Columbia.

Adult. Head black with a bronzy gloss. Back and upper tail coverts, when viewed from behind, metallic-red changing to golden on the rump. A patch of metallic bluish-green on the throat. A white patch on either side of the breast; under parts purplish-black. Under tail coverts black fringed with white, upper tail coverts purple. Tail purplish-black. Total length, $4\frac{7}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{1}{8}$ in.

11. *Bourcieria cæligena.*

Ornismya cæligena, LESS., Troch., p. 141, pl. 53 (1832).

Mellisuga cæligena, GRAY, Gen. Birds, vol. i. p. 112.

Cæligena typica, BON., Consp. Gen. Av., p. 73 (1850).—ID., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. iv, pl. 255.—REICH., Aufz. der Colib., p. 7.—ID., Troch. Enum., p. 3, t. 686, fig. 4515 (1855).

Lampropygia cæligena, CAB. and HEIN., Mus. Hein. Th., iii, p. 78.—GOULD, Intr. Troch., p. 136.—ELLIOT, Ibis (1876), p. 55.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 10.

Hab. Venezuela.

Adult. Upper part of head, back, and shoulders dark coppery-red, metallic in certain lights. Rump viewed from behind very brilliant metallic-green. Throat white, central portion of feathers blackish-brown. Breast dark gray. Abdomen smoke-color; flanks reddish-bronze. Wings bright purple. Tail dark olive with coppery reflections. Bill black. Total length, 6 in. Wing, $3\frac{1}{8}$ in. Tail, $2\frac{1}{4}$ in. Bill, $1\frac{1}{4}$ in.

12. *Bourcieria columbiana.*

Lampropygia cæligena, ex Columbia, Auct.

Lampropygia columbiana, ELLIOT, Ibis (1876), p. 57.

Hab. Columbia.

Adult. Top and sides of head and nape olive-brown, with rufous reflections; back same as head, slightly darker. Rump viewed from behind brilliant metallic-green. Wings purple; shoulder olive-brown. Throat white, centre of feathers blackish-brown; upper part of breast smoky-white, darker towards the abdomen, which together with the flanks is very dark rufous-brown. Under tail coverts reddish-brown, central portion of the feathers blackish-brown. Tail olive-brown. Bill black. Feet black. Total length, $5\frac{1}{2}$ in. Wing, 3 in. Tail, 2 in. Culmen, $1\frac{1}{8}$ in. Type in my collection.

13. *Bourcieria boliviana.*

Lampropygia boliviana, GOULD, Intr. Troch., p. 137.—ELLIOT, Ibis (1876), p. 57.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 13.

Hab. Bolivia.

Adult. Head and upper parts brownish-black, but when viewed from behind the rump and back are brilliant metallic grass-green. Wings purple. Throat dark brown, feathers margined with white; abdomen and flanks very dark olive-brown, feathers tipped with rufous. Under tail coverts blackish-brown margined with reddish-buff. Tail very dark olive-brown; central feathers glossed with purple. Bill black. Total length, $5\frac{1}{2}$ in. Wing, $3\frac{1}{4}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $1\frac{1}{4}$ in.

Genus XXXVIII.—HEMISTEPHANIA.

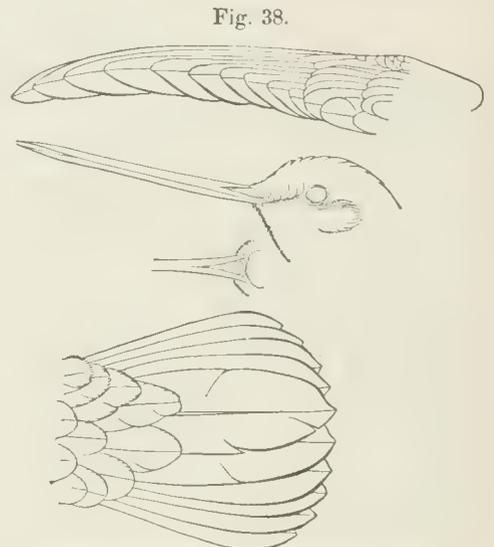
Doryfera, GOULD (lege *Doryphora*, nec ILLIG., 1807, Coleopt.), P. Z. S. (1847), p. 95.
Dorifera, BON., Consp. Gen. Av. (1849), vol. i, p. 68.
Hemistephania, REICH., Aufz. der Colib. (1853), p. 9.
Doryphora, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 77.

TYPE.
T. ludovicæ, Bourc.
T. ludovicæ, Bourc.
T. ludovicæ, Bourc.
T. ludovicæ, Bourc.

Ch. Bill very long, straight, slender, sharp pointed. Wings long, outer web of first primary nearly obsolete. Tail much rounded, rectrices broad. Sexes alike in plumage.

Range. Veragua, through Columbia into Ecuador.

Five species have been described, one of which is, however, only a large race of another, and is hardly worthy of specific rank.



Hemistephania ludovicæ. ♂. New Granada. Salle.

Key to the species.

- | | |
|--|-----------------------------|
| A. Under parts blackish. Forehead metallic-violet. | 1. <i>H. johannæ</i> . |
| B. Under parts bronze-green tinged with gray. | |
| a. Forehead metallic grass-green. | 2. <i>H. ludovicæ</i> . |
| b. Large race of above. | 3. <i>H. rectirostris</i> . |
| c. Forehead metallic bluish-green. | 4. <i>H. euphrosinæ</i> . |
| C. Under parts very dark green. Forehead metallic-green. | 5. <i>H. veraguensis</i> . |

The term *Doryfera* (lege DORYPHORA), which Gould gave to this group of Humming-birds, having been many years previously employed in Entomology by Illiger, cannot properly be again used, and the next proposed is that of HEMISTEPHANIA, Reich., which is the one to be adopted. The species are small in size, with a rather dull green plumage, and a metallic spot on their foreheads. The bills are long and straight, and the group follows naturally the species of BOURCIERIA.

1. *Hemistephania johannæ*.

Trochilus johannæ, BOURC., P. Z. S. (1847), p. 45.—ID., Rev. Zool. (1847), p. 257.

Trochilus violifrons, GOULD, P. Z. S. (1847), p. 95.

Mellisuga johannæ, GRAY, Gen. Birds, vol. i, p. 112.

Dorifera johannæ, GOULD, Mon. Troch., vol. ii, pl. 87.—ID., Intr. Troch., octavo ed., p. 71.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 196.

Dorifera johannæ, BON., Consp. Gen. Av., vol. i, p. 68.—ID., Rev. and Mag. Zool. (1854), p. 251.

Doryphora johannæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 78 (note).

Hemistephania johannæ, REICH., Troch. Enum., p. 6, pl. 731, figs. 4675-76.—ID., Aufz. der Colib., p. 9.

Hab. Columbia.

Male. Forehead metallic-violet; dark blue in certain lights. Nape and upper surface bronze-green. Rump and upper tail coverts grayish-blue, but in some specimens the latter are a darker blue than the rump. Under parts black with green reflections. Under tail coverts dark violet-blue. Tail black, glossed slightly with green. Wings purplish-brown. Bill black, feet brown. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $1\frac{1}{8}$ in.

Female? differs by having no metallic spot on forehead, which is a dull green. Entire under parts light bronzy-green. Tail black, tipped with gray on the lateral feathers. Under tail coverts bluish-green. Slightly smaller in size than the male. This may be possibly a young male.

2. *Hemistephania ludovicæ.*

Trochilus ludovicæ, BOYRE. and MÜLLS., Ann. Soc. d'Agr., Lyon (1847), p. 136.

Mellisuga ludovicæ, GRAY, Gen. Birds, vol. i, p. 112.

Dorifera ludovicæ, BON., Consp. Gen. Av., vol. i, p. 68.—ID., Rev. and Mag. Zool. (1854), p. 251.

Hemistephania ludovicæ, REICH., Aufz. der Colib., p. 9.—ID., Troch. Enum., p. 6, t. 731, figs. 4673-74.

Doryfera ludovicæ, GOULD, Mon. Troch., vol. ii, pl. 88.—ID., Intr. Troch., octavo ed., p. 71.—MÜLLS., Hist. Nat. Ois. Mouch., tom. i, p. 200.

Doryphora ludovicæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 69 (1860).

Hab. Columbia.

Adult. Forehead metallic grass-green. Crown and nape coppery-bronze. Back dark green, passing into bluish-green on upper tail coverts. Under parts dark brownish-gray, with green reflections. Under tail coverts dark gray with blue reflections. Tail black, tipped with gray, most extensive on the lateral feathers. Wings purple. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $1\frac{1}{4}$ in.

3. *Hemistephania rectirostris.*

Doryfera rectirostris, GOULD, Intr. Mon. Troch., octavo ed., p. 71.—MÜLLS., Hist. Nat. Ois. Mouch., tom. i, p. 202.

Doryphora rectirostris, SCLAT. and SALV., Nomencl. Av., p. 82.

Hab. Ecuador.

This is a somewhat larger-sized bird than the *D. ludovicæ*, with a slightly longer bill. There is no difference in the color of the plumage, and I doubt very much, should the locality be unknown, whether the two birds could always be distinguished. It may be regarded as a race, but hardly as a distinct species. Total length, 5 in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $1\frac{9}{16}$ in.

4. *Hemistephania euphrosinæ.*

Dorifera euphrosinæ, MÜLLS. and VERR., Ann. Soc. Linn., Lyon, t. xviii (1870-71), p. 319.—MÜLLS., Hist. Nat. Ois. Mouch., vol. i, pl. 198, pl.

Doryphora euphrosinæ, SCLAT. and SALV., Nomencl. Av., p. 82.

Hab. Ecuador?.

This is a small representative of *ludovicæ* with a bluish-green forehead. In all other respects it resembles that species, but the small size and peculiar coloration

of the metallic spot induce me to regard it as probably a distinct species. Total length, $3\frac{5}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $1\frac{1}{16}$ in.

5. *Hemistephania veraguensis*.

Dorifera veraguensis, SALV., P. Z. S. (1867), p. 154.

Doryfera veraguensis, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 199.

Hab. Veragua.

Adult. Forehead metallic-green, darker than that of *ludovicæ*; nape coppery-red; back shining grass-green, upper tail coverts pale blue. Under parts very dark green, almost black. Under tail coverts dark gray with blue reflections. Tail black tipped with gray. Wings purplish-brown. Bill and feet black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $1\frac{1}{4}$ in.

This bird, which appears to represent a distinct species, can be recognized from *ludovicæ* by the darker green of the forehead, and the general dark, almost greenish-black hue of the plumage of the body.

The genus HELIOMASTER, in which the next group of birds has generally been placed, was instituted by Bonaparte solely for the *T. furcifer*, Shaw. As that species possesses generic character of quite sufficient importance to entitle it to a separate rank, it has been found necessary to seek another term for the four following species, as the only other one besides HELIOMASTER, which has been given them—*Selaspherus*, Reich.—is almost identical with SELASPHORUS, Swain., already employed for a genus of this Family. I, therefore, propose the generic name of FLORICOLA. These birds are of moderate size, the bills straight, plumage bronzy-green above, with a luminous throat-mark, more or less extensive, and a metallic crown on some of the species. By means of the two succeeding genera, a pretty well connected line is formed to the genus HELIOTRYPHA.

Genus XXXIX.—FLORICOLA.

Trochilus, SWAINS. (nec LINN., 1766), Zool. Journ. (1827), p. 357.

Trochilus, BOIE (nec LINN., 1766), Isis (1831), p. 547.

Heliomastes (*l*), BON., Rev. and Mag. Zool. (1854), p. 251.

Selaspherus, REICH., Troch. Enum. (1855), p. 11.

TYPE.

T. longirostris, Vieill.

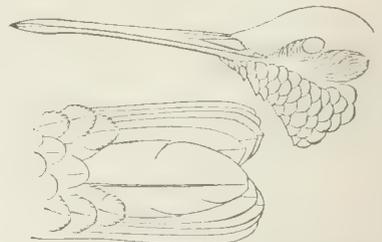
T. longirostris, Vieill.

T. longirostris, Vieill.

Ch. Bill longer than half the body, straight, mandible hooked at the tip; maxilla denuded of feathers at base, which is broad; nostrils exposed. Wings rather long. Tail slightly rounded. Sexes dissimilar.

Range. Mexico, Central America, Guiana, Venezuela, Columbia, and Ecuador.

Fig. 39.



Floricola longirostris. ♂. Trinidad. Gould.

Key to the species.

- | | |
|--|-----------------------------|
| A. Top of head metallic-green. Under tail coverts olive-brown margined with white. | 1. <i>F. longirostris</i> . |
| B. Top of head pale metallic-green. Under tail coverts grayish-white. | 2. <i>F. albicrissa</i> . |
| C. Top of head not metallic. | |
| a. Throat metallic-scarlet, chin black. | 3. <i>F. constanti</i> . |
| b. Lower part of throat metallic-crimson, upper part and chin dark brown, all the feathers tipped with gray. | 4. <i>F. leocadiæ</i> . |

1. *Floricola longirostris*.

Trochilus longirostris, VIEILL., Ois. Dor., t. i. p. 107, pl. 50 (1802).

Trochilus superbus, SHAW., Nat. Misc., vol. xiii. pl. 517.

Ornismya superba, LESS., Ois. Mouch., p. 40, pl. 2 (1829).

Ornismya longirostris, D'ORB. and LAFRES., Syn. Av., ii, p. 29, sp. 15 (1838).

Mellisuga longirostris, GRAY, Gen. Birds, vol. i. p. 112, sp. 4.

Heliomaster longirostris, BON., Consp. Gen. Av., p. 70.—REICH., Troch. Enum. (1855), p. 11.—GOULD, Mon. Troch., vol. iv, pl. 259.—ID., Intr. Troch., octavo ed. (1861), p. 138.—SALV., P. Z. S. (1867), p. 155.—ELLIOT, Ibis (1877), p. 138.

Selaspherus longirostris, REICH., Aufz. der Colib. (1853), p. 13.

Heliomastes longirostris, BON., Rev. and Mag. Zool. (1854), p. 251.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 271.

Heliomaster stuartæ, LAW., Ann. Lyc. Nat. Hist., N. Y. (1860), p. 291.—GOULD, Intr. Troch., octavo ed., p. 138 (1861).

Heliomaster sclateri, CAB. and HEIN., Mus. Hein. Th., iii, p. 54 (1860).—GOULD, Intr. Troch., octavo ed., p. 139 (1861).

Heliomaster pallidiceps, GOULD, Intr. Troch., octavo ed., p. 139 (1861).

Hub. Mexico and Central America, Trinidad, Guiana, Venezuela, the valley of the Amazon and Columbia.

Forehead and crown metallic-green, sometimes tinged with blue; chin black. Throat metallic-crimson. Nape and upper surface bronzy-green. Under surface dark gray, whitish in the middle of the abdomen, washed with green on the flanks, and a large white spot on the thighs. Under tail coverts blackish-brown tipped with white. Wings very dark purple-brown. Upper tail coverts light bronze. Median rectrices bronze-green; the lateral ones bronze-green at base, with the remaining portion black, and a spot of white on the tip, largest on the outermost feathers. Along the side of the throat a conspicuous white stripe. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$. Culmen, $1\frac{1}{4}$ in.

Young. Upper parts light bronze. Throat black with a few metallic feathers on the lower part. Under surface light gray.

Supposed Female, like the male, but has the entire throat dull black.

I can perceive no differences sufficient to distinguish the specimens called *stuartæ*, *sclateri*, and *pallidiceps* as distinct from *longirostris*, the characters given by their describers disappearing and blending together in a large series of specimens.

2. *Floricola albicrissa*.

Heliomaster albicrissa, GOULD, P. Z. S. (1871), p. 504.—SCLAT. and SALV., Nomencl., p. 90.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 274.

Hub. Ecuador.

Only to be distinguished from *H. longirostris* by the under tail coverts, which are grayish-white.

3. *Floricola constanti*.

Trochilus constanti. DELATT., Echo du Mond. Savant. (1843), p. 1069.

Heliomaster constanti, GOULD, Mon. Troch., vol. iv, p. 259.—ID., Intr. Troch., octavo ed., p. 140 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 54.

Selaspherus constanti. REICH., Aufz. der Colib. (1853), p. 13.—ID., Troch. Enum., p. 11.

Heliomastes constanti, BON., Rev. and Mag. Zool. (1854), p. 251.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 269.

Hab. Guatemala and Costa Rica.

Adult. Entire upper surface pale bronzy-green. Wings light purplish-brown. Chin black, throat metallic-scarlet. Along the side of the throat is a white stripe commencing at the bill. Under surface gray, washed with green on the flanks. A tuft of white feathers on the sides of the rump. Middle of abdomen white. Under tail coverts olive-brown margined with white. Median rectrices bronzy-green, lateral ones green at base, then black with a white spot on the inner webs at tips. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{5}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $1\frac{1}{4}$ in.

Description of type in my collection.

4. *Floricola leocadiæ*.

Trochilus leocadiæ. BORR., Ann. Sc. Nat., Lyon, tom. iv (1852), p. 141.

Heliomaster pinicola, GOULD, Mon. Troch., vol. iv, pl. 261.

Selaspherus longirostris, REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).

Heliomastes leocadiæ. BON., Rev. and Mag. Zool. (1854), p. 251.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 276.

Heliomaster leocadiæ, GOULD, Intr. Troch., octavo ed., p. 140 (1861).

Hab. Mexico.

Adult. Exactly like the *H. constanti* in its general plumage. The only difference is in the coloration of the throat, which has the upper part and chin blackish-brown, and the lower part metallic-crimson, all the feathers tipped with gray. Total length, 5 in. Wing, $2\frac{5}{8}$ in. Tail, $1\frac{9}{16}$ in. Culmen, $1\frac{1}{4}$ in.

Mr. Gould states (l. c.) that his *H. pinicola* was described in the P. Z. S. for 1853. I have not been able to find it in that volume.

Genus XL.—LEPIDOLARYNX.

Lepidolarynx, REICH., Aufz. der Colib., p. 13 (1853).

Ornithomyia, BON., Rev. and Mag. Zool. (1854), p. 251.

TYPE.

T. mesoleucus, Temm.

T. mesoleucus, Temm.

Fig. 40.

Ch. Bill straight, twice as long as head. Feathers of the forehead advancing to a point on to the maxilla. Tail slightly forked, rectrices narrow. Sexes different.

Range. Brazil.

One species only is known.



Lepidolarynx mesoleucus. ♂ ad. Brazil. Whitely.

1. Lepidolarynx mesoleucus.

Trochilus mesoleucus, TEMM., Plan. Col., pl. 317, fig. 1. ♂.

Trochilus squamosus, TEMM., Plan. Col., pl. 203, fig. 1, juv.

Trochilus mystacinus, VIEILL., Os. Dor., t. iii, pl. 21, ♂ (inedit.).

Mellisuga squamosus, STREPT., Gen. Zool., vol. xiv, p. 245.

Ornismya Temmincki, LESS., Ois. Mouch., p. 88, pl. 20 (1829), juv.

Ornismya mesoleuca, LESS., Ois. Mouch., p. 110, pl. 29 (1829), ad. ♂.

Mellisuga melanoleuca, GRAY, Gen. Birds, vol. i, p. 112, sp. 15.

Heliomaster mesoleucus, GOULD, Mon. Troch., vol. iv, pl. 262.—BON., Consp. Gen. Av., p. 70.

Lepidolarynx mesoleucus, REICH., Aufz. der Colib., p. 13.—GOULD, Intr. Troch., octavo ed., p. 140.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 283.—REICH., Troch. Enum., p. 11.

Ornithomyia mesoleucus, BON., Rev. and Mag. Zool. (1854), p. 251.

Calothorax mesoleucus, BURM., Th. Bras., vol. ii, p. 339, sp. 1 (1856).

Heliomaster squamosus, CAB. and HEIN., Mus. Hein. Th., iii, p. 53 (1860).

Hab. Brazil.

Male. Top of head metallic pale green; rest of upper parts bronzy-green. Throat frill, much extended on the sides, metallic-crimson. Under surface very dark green, down the centre an irregular line of white. A tuft of white feathers on the flanks, and a white line beneath the eye. Under tail coverts blackish-purple margined with white. Median rectrices dark bronze-green, remainder purplish-black. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $1\frac{1}{8}$ in.

Female. Upper surface bronzy-green. Feathers on the throat dark olive margined with white; under surface bronze-green, with a median white stripe. Middle rectrices bronze-green, rest bronze-green at base, with the remaining portions black tipped with white. Bill black.

Young. Specimen from Bahia has the crown greenish-brown, each feather margined with white. Throat pure white, rest as in the female.

The next genus, HELIOMASTER, was proposed by Bonaparte in the Compt. Rendus for 1850, and the *T. furcifer*, Shaw, cited as the type, no other species being mentioned. In the Consp. Av., HELIOMASTER is made to contain various species, which cannot possibly be grouped together in the same genus; but *furcifer* (called *angelæ*) is placed first. If, as the date would seem to imply, this portion of the Conspectus Avium was published in 1849 (of which I can find no proof), the subsequent article in the Compt. Rendus disposes of the arrangement given, and leaves *furcifer* to represent the genus; but if the Consp. Av. came afterwards, the fact that *furcifer* is placed first in the list indicates that it is still deemed the *type* of HELIOMASTER, to which the species that follow were added. In either case the present species is the only one that can be placed in the genus, there being no other as yet known possessing the same characters. The genus HELIOMASTES!, BON., Rev. and Mag. Zool. (1854), p. 251, is probably a misprint, but as it contains such species as that included in FLORICOLA, Elliot, and CAMPYLOPTERUS!!, Swain., there is nothing left to represent it as a type; and if it is not a misprint, it is too close to HELIOMASTER to be employed without creating confusion. The single species is a very beautiful one, remarkable for the crimson throat surrounded by deep metallic-blue.

Genus XLI.—HELIOMASTER.

Heliomaster, BON., Compt. Rend. (1850), p. 382.
Calliperidia, REICH., Aufz. der Colib. (1853), p. 12.
Callopietria, "REICH.", BON., Ann. Sc. Nat. (1854), p. 137.

TYPE.
T. furcifer, Shaw.
T. furcifer, Shaw.
T. furcifer, Shaw.?

Ch. Bill very long, slender, slightly curved; rectrices rather narrow, pointed; tail deeply forked. Sexes dissimilar.

Range. Southern Brazil and Paraguay.

Fig. 41.

*Heliomaster furcifer*. ♂ ad. Buenos Ayres.1. *Heliomaster furcifer*.

Trochilus furcifer, SHAW, Gen. Zool., vol. viii, p. 280.
Trochilus caudacutus, VIEILL., Nouv. Dict. Hist. Nat. (1817), p. 347.
Heliomaster regis, SCHREIB., Naturfors. Wien. (1832), Sept.—ID., Isis (1833), p. 533.—PELZ., Ornith. Bras., p. 301.
Ornismya angelæ, LESS., Illust. Zool. (1833), pls. 45, ♂; 46, ♀.—D'ORB. and LAFRES., Syn. Av., ii, p. 28, sp. 11 (1838).
Heliomaster angelæ, BON., Compt. Rend. (1850), p. 382.—ID., Consp. Gen. Av., p. 70, vol. i (1850).—GOULD, Mon. Troch., vol. iv, pl. 263.—BURMEIST., Proc. Zool. Soc. (1865), p. 466.
Calliperidia angelæ, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10.—GOULD, Intr. Troch., octavo ed., p. 141.—ELLIOT, Ibis (1877), p. 137.
Ornithomyia angelæ, BON., Rev. and Mag. Zool. (1854), p. 251.
Campylopterus inornatus, BURMEIST., Reise durch die la Plata Staat, Band. ii, p. 447 (1861), juv.
Calliperidia furcifer, SCLAT. and SALV., Nomencl., p. 90 (1873).
Calliperidia regis, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 278.

Hab. Brazil and Paraguay.

Male. Top of head pale metallic-green. Upper surface golden-green. Wings purplish-brown. A spot of white behind the eye. Centre of throat metallic-crimson, surrounded by deep metallic-blue. Under surface deep blue. A patch of white on the flanks. Under tail coverts dark green. Tail glossy dark green. Bill black. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{3}{4}$ in. Culmen, 1 in.

Female. Top of head bronzy-brown. Upper surface golden-bronze. Under surface white. Tail green, terminal portion black, tip of three outer feathers white. Bill black.

Genus XLII.—HELIOTRYPHA.

Heliotrypha, GOULD, Intr. Mon. Troch., octavo ed., p. 131; Mon., pt. (1853).
Parzudakia, REICH., Aufz. der Colib., p. 12 (1853).
Heliotryphon, CAB. and HEIN., Mus. Hein. Th., iii, p. 74 (1860).
Nodalia, MULSANT., Catal. Ois. Mouch. (1875), p. 23.
Helymus, MULSANT., Catal. Ois. Mouch. (1875), p. 23.

TYPE.
T. exortis, Fras.
T. exortis, Fras.
T. exortis, Fras.
H. barrali, Muls. and Verr.
H. micrastur, Gould.

Ch. Bill long as the head, straight, slender. Wings long. Tail long and forked; tarsi partially clothed. Hind toe shorter than the middle one. Sexes unlike.

Range. Columbia and Ecuador.

Four species are here recognized as belonging to this genus.

Fig. 42.



Heliotrypha exortis. ♂ ad. Ecuador. Buckley.

Key to the species.

- | | |
|---|--------------------------|
| A. Breast and under parts metallic-green; no white band across the chest. | |
| a. Throat metallic purplish-violet; chin with light blue reflections. | 1. <i>H. viola</i> . |
| b. Throat metallic pinkish-lilac; chin deep blue, black in some lights. | 2. <i>H. exortis</i> . |
| c. Throat metallic flame-color; chin black. | 3. <i>H. micrastur</i> . |
| d. Throat and chin pale metallic olive-green. | 4. <i>H. barrali</i> . |

The members of this genus are rather large birds, with straight bills, short in comparison to those of the genera immediately preceding, with ample forked tails, a general green plumage more or less luminous, and bright metallic throats.

1. *Heliotrypha viola*.

Heliangelus viola, GOULD, P. Z. S. (1853), p. 61.

Rhamphomicron (Parzudakia) viola, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Heliotrypha viola, GOULD, Mon. Troch., vol. iv, pl. 241.—ID., Intr. Troch., octavo ed., p. 131.—ELLIOT, Ibis (1876), p. 317.—BON., Rev. and Mag. Zool. (1854), p. 252.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 97.

Heliotryphon viola, CAB. and HEIN., Mus. Hein. Th., iii, p. 74 (1860).

Hab. Ecuador.

Male. Forepart of head metallic dark green. Upper surface, breast, abdomen, and flanks shining dark grass-green. Throat metallic purplish-violet, margined with black, under tail coverts buff, with dark green centres. Four middle tail feathers green; remainder dark purplish-brown. Bill and feet black. Total length, $4\frac{2}{3}$ in. Wing, $2\frac{2}{3}$ in. Tail to end of lateral feathers, $2\frac{1}{2}$ in. Culmen, $\frac{1}{2}$ in.

Female. General plumage like the male; but has the throat black, spotted with buffy-white.

2. *Heliotrypha exortis*.

Trochilus exortis, FRAS., P. Z. S. (1840), p. 14.

Ornismya parzudaki, DELONG and PARZ. (nec LESS.), Rev. Zool. (1840), p. 72.

Mellisuga parzudaki, GRAY, Gen. Birds, vol. i, p. 112, sp. 18.

Heliangelus parzudaki, BON., Consp. Gen. Av., vol. i, p. 76 (1850).

Eriopus exortis, BON., Consp. Gen. Av., p. 80 (1850).

Parzudakia dispar, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Heliotrypha parzudaki, BON., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. iv, pl. 240.—ID., Intr. Troch., octavo ed., p. 131.—ELLIOT, Ibis (1876), p. 318.

Heliotryphon parzudaki, CAB. and HEIN., Mus. Hein. Th., iii, p. 74 (1860).

Heliotrypha exortis, ELLIOT, Ibis (1876), p. 318.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 95.

Hab. Columbia and Ecuador.

Male. A small luminous green spot on the forehead. Chin deep blue; centre

of throat metallic pinkish-violet bounded with black. Entire rest of the plumage of the body shining dark green, most brilliant on the breast. Wings purplish-brown. Under tail coverts white. Median rectrices bronzy-green; lateral ones purplish-black. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female. Differs from the male by having the forehead metallic-green, and the throat dark brown with a patch of white in the centre.

3. *Heliotrypha micrastur.*

Helianthus micrastur. GOULD, Ann. and Mag. Nat. Hist. (1872), p. 195.

Helymus micrastur. MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 93.

Hab. Ecuador.

Male. A luminous dark green spot on forehead. Chin black. Throat intensely brilliant, metallic flame-color, margined on the sides with black. Rest of plumage of the body shining dark green, most brilliant on the breast. Wings purplish-brown. Median rectrices bronzy-green, rest purplish-black. Under tail coverts white. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail 2 in. Culmen, $\frac{9}{16}$ in.

Female. Unknown.

This species, by not having any white band across the breast, and by having the tail much forked, cannot remain in the genus *HELIANGELUS*, where it was placed by Mr. Gould, but properly belongs to the present one, finding its natural position between *H. exortis* and *H. barrali*. The term *Helymus*, proposed for it by M. Mulsant, is entirely unnecessary, as the species possesses no characters that differ generically from the other members of *HELIOTRYPHA*.

4. *Heliotrypha barrali.*

Heliotrypha barrali. MULS. and VERR., Ann. Soc. Linnéen., Lyon, vol. xvii, p. 106 (1868).

Helianthus squamigularis. GOULD, P. Z. S. (1871), p. 503.

Nodalina barrali. MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 100 (1877).

Hab. Columbia, Province of Antioquia.

Male. Top of head very dark green, almost black in certain lights. Throat pale metallic olive-green, silvery in some lights, margined with a line of black. Rest of plumage of body shining grass-green, most brilliant on the breast. Wings purplish-brown. Median rectrices bronzy-green; lateral ones, blue-black. Under tail coverts green in the centre, remaining parts grayish-white. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female. Unknown.

Possessing no generic characters differing from those which characterize the species of *HELIOTRYPHA*, the term *Nodalina* of Mulsant is placed among the synonyms as unnecessary. Description taken from the type in my collection.

Genus XLIII.—HELIANGELUS.

Heliangelus, GOULD, Intr. Mon. Troch., octavo ed., p. 132 (1848) (*desc.*).
Anactoria, REICH., Aufz. der Colib., p. 12 (1853).
Diotimia, REICH., Aufz. der Colib., p. 12 (1853).
Peratus, MULS., Catal. Ois. Mouch. (1875), p. 23.

TYPE.
O. clarissæ, De Long.
O. amethysticollis, D'Orb.
T. spencei, Boarc.
O. amethysticollis, D'Orb.

Ch. Bill as long as the head, straight. Tail ample, slightly rounded. Wings long. Hind toe and nail as long as middle toe and nail. Sexes different.

Range. Venezuela, Columbia, Ecuador, and Peru. Five species are known of this genus.



Heliangelus clarissæ. ♂. Bogota, Gould.

Key to the species.

- | | |
|--|--------------------------------|
| A. Band of white across the breast. | |
| a. Luminous spot on forehead, grass-green. | |
| a'. Median rectrices green, lateral ones black. | 1. <i>H. clarissæ</i> . |
| b'. All the rectrices blue-black. | 2. <i>H. strophianus</i> . |
| b. Luminous spot on forehead, pale glaucous green, lateral rectrices bronzy-brown. | 3. <i>H. spencei</i> . |
| B. Band across the breast and abdomen buff. | |
| a. Throat metallic-violet. | 4. <i>H. amethysticollis</i> . |
| b. Throat fiery orange-red. | 5. <i>H. mavors</i> . |

These birds are closely allied to those of the genus HELIOTRYPIA; they are about the same size, and have a similar plumage, but possess rounded tails, and a conspicuous broad white, or buff band across the breast, beneath the metallic throat.

1. *Heliangelus clarissæ*.

Ornismya clarissæ, DE LONG, Rev. Zool. (1841), p. 306.
Mellisuga clarissæ, GRAY, Gen. Birds, vol. i, p. 112, sp. 17.
Anactoria clarissæ, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).
Anactoria libussa, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).
Heliangelus clarissæ, BON., Consp. Gen. Av., p. 76 (1850).—ID., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. iv, pl. 242.—ID., Intr. Troch., octavo ed., p. 132.—BON., Consp. Gen. Av., p. 76.—CAB. and HEIN., Mus. Hein. Th., iii, p. 75 (1860).—MULS., Hist. Nat. Ois. Mouch., vol. iii (1876), p. 84.
Heliangelus taczanowski, PELZ., Ibis (1877) p. 338, juv. ♂.

Hab. Columbia.

Male. Luminous dark green spot on the forehead. Chin, lores, and sides of head black. Upper surface and flanks bronzy-green. Throat metallic-violet, beneath which is a narrow band of white, succeeded by one of brilliant grass-green. Abdomen buff, mottled with green. Under tail coverts white. Median rectrices bronzy-green, lateral ones black. Bill black. Total length, 4 in. Wing, 2½ in. Tail, 1½ in. Culmen, ½ in.

Female differs chiefly in having the throat black mottled with brown. The feathers of the body less brilliant than those of the male.

Herr von Pelzeln having kindly forwarded to me the type of his *Heliangelus*

taczanowski, I ascertained, by comparing it with specimens in my collection, that it was a young male of the present species.

2. *Heliangelus strophianus*.

Trochilus (—?) *strophianus*, GOULD, P. Z. S. (1846), p. 45.

Mellisuga strophianus, GRAY, Gen. Birds, vol. i, p. 112, sp. 39.

Heliangelus strophianus, BON., Consp. Gen. Av., vol. i (1850), p. 76.—ID., Rev. and Mag. Zool. (1854), p. 252.

—GOULD, Mon. Troch., vol. iv, pl. 243.—ID., Intr. Troch., octavo ed., p. 132.—MULS., Hist. Nat. Ois.

Mouch., vol. iii, p. 86 (1876).

Anactoria strophiana, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Hab. Ecuador.

Male. Distinguished from the *H. clarissæ*, by having the entire tail steel- or bluish-black, and a slightly shorter bill. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{7}{8}$ in. Tail, 2 in. Culmen, $\frac{1}{2}$ in.

Female similar to that of *H. clarissæ*.

3. *Heliangelus spencei*.

Trochilus spencei, BOURC., P. Z. S. (1847), p. 46.

Mellisuga spencei, GRAY, Gen. Birds, vol. i, p. 112, sp. 41.

Heliangelus spencei, BON., Consp. Gen. Av., vol. i (1850), p. 88.—ID., Rev. and Mag. Zool. (1854), p. 252.—

GOULD, Mon. Troch., vol. iv, pl. 243.—ID., Intr. Troch., octavo ed., p. 132.—MULS., Hist. Nat. Ois.

Mouch., tom. iii, p. 88.

Diotima spencei, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Hab. Venezuela.

Male. Forehead metallic silvery-green. Upper surface, breast, and flanks golden-green. Throat metallic-violet. A band of white across the breast. Middle of abdomen buff. Median rectrices bronzy-green; lateral ones bronzy-brown. Under tail coverts bronze-green in the centre, margined with grayish-white. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{9}{16}$ in.

Female. Like the male, but with the throat mottled with brown and black.

4. *Heliangelus amethysticollis*.

Orthorhynchus amethysticollis, D'ORB. and LAFRES., Syn. Av., p. 31 (1838).

Lampornis amethysticollis, TSCHUD., Faun. Per., p. 246 (1844).

Mellisuga amethysticollis, GRAY, Gen. Birds, vol. i, p. 112, sp. 40.

Anactoria amethysticollis, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Heliangelus amethysticollis, BON., Consp. Gen. Av., vol. i (1850), p. 76.—ID., Rev. and Mag. Zool. (1854), p.

252.—GOULD, Mon. Troch., vol. iv, pl. 245.—ID., Intr. Troch., octavo ed., p. 133.—CAB. and HEIN., Mus.

Hein. Th., iii, p. 75 (1860).—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 90 (1876).—ELLIOT, Ibis (1877), p. 141.

Hab. Peru.—Bolivia (Bridges).

Male. Forehead metallic dark green. Head, wing coverts, and upper surface dark bronzy-green. Chin black. Throat metallic-violet, beneath which is a band of buff. Flanks and sides of breast bronze-green. Abdomen buff mottled with green. Under tail coverts grayish-white. Median rectrices bronze-green; lateral ones black. Wings purple. Bill black. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{5}{8}$ in. Tail, 2 in. Culmen, $\frac{5}{8}$ in.

Female. Without the luminous spot on the forehead, and the throat deep buff mottled with brownish-black. Otherwise like the male, but less brilliant.

5. *Heliangelus mavors.*

Heliangelus mavors, GOULD, P. Z. S. (1848), p. 12.—ID., Mon. Troch., vol. iv. pl. 246.—ID., Intr. Troch., octavo ed., p. 133.—BOX., Consp. Gen. Av., p. 76 (1850).—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 92.—BOX., Rev. and Mag. Zool. (1854), p. 252.

Mellisuga mavors, GRAY, Gen. Birds, vol. iii, app., p. 5.

Trochilus mavors, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Hab. Columbia, Venezuela.

Male. Forehead metallic fiery-red; rest of upper surface bronzy-green. A spot of white behind the eye. Lores and sides of neck black. Throat metallic fiery orange-red, beneath which is a broad band of buff. Flanks green. Middle of abdomen deep buff. Under tail coverts grayish-buff. Wings purplish-brown. Median rectrices bronzy-green, rest bronzy-brown, the two outermost ones tipped with white. Bill black. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Bill, $\frac{3}{4}$ in.

Female. Similar to the male, but with the throat mottled with brown and black.

Genus XLIV.—UROSTICTE.

Urosticte, GOULD, Intr. Troch., octavo ed., p. 110; ex Mon. Troch., pt. vi (1853).

TYPE.

T. benjamini, Bourc.

Fig. 44.

Ch. Bill longer than the head and straight. Nostrils exposed. Wings moderate and pointed. Tail slightly forked. Hind toe shorter than the middle. Sexes unlike.



Urosticte benjamini ♂. Ecuador. Whately.

Range. Ecuador.

Two species only are known.

Key to the species.

- | | |
|--|---------------------------|
| A. Median rectrices bronzy tipped with white. | |
| a. Throat entirely luminous-green, crissum rufous. | 1. <i>U. ruficrissa</i> . |
| b. Throat luminous-green, beneath which is a dark violet spot. | 2. <i>U. benjamini</i> . |

These are small birds, with straight bills like *HELIANGELUS*, but more slender: a green plumage and brilliant throats.

1. *Urosticte ruficrissa.*

Urosticte ruficrissa, LAWR., Ann. Lyc. Nat. Hist., N. Y. (1864), vol. viii, p. 44.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 103.

Hab. Ecuador.

Male. General plumage dark shining green. Throat luminous grass-green. Wings purplish-brown. Under tail coverts rufous. Tail pale bronze-green, with

the four median feathers tipped with white. Bill black, feet brown. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{7}{8}$ in.

Female. Exactly like the female of *U. benjamini*, but slightly larger and with a longer bill.

2. *Urostitte benjamini*.

Trochilus benjamini, BOIRC., Compt. Rend. (1851), tom. xxxii, p. 187.

Urostitte benjamini, GOULD, Mon. Troch. (pt. vi), vol. iii, pl. 190.—ID., Intr. Troch., octavo ed., p. 110.—BON., Rev. and Mag. Zool. (1854), p. 253.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 101.

Urostitta benjamini, REICH., Aufz. der Colib., p. 13 (1853).

Basilinna benjamini, REICH., Troch. Enum., p. 11 (1855).

Hab. Ecuador.

Male. General plumage of body grass-green. Throat luminous green, beneath which is a conspicuous spot of dark violet. Behind the eye a small white spot. Wings purplish-brown. Tail bronzy-purple. Four middle rectrices extensively tipped with white. Bill black; feet brownish. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Young male differs only in having the throat rufous.

Female. Head and upper surface green. White spot behind the eye. Under parts white spangled with green. Tail bronze, all the feathers but the median pair tipped with white. Bill black.

Between UROSTICTE and EUSTEPHANUS, the one we now reach, there is a considerable gap, and there are no species yet known by which we can bridge it over. The three recognized species of EUSTEPHANUS are large birds, the metallic hues of their plumage being confined to the top of the head. In two species the females possess an entirely different dress, and from the fact that their crowns were also metallic they were for a long time supposed to represent a distinct species, which is now known not to be the fact.—These two species are island forms.

Genus XLV.—EUSTEPHANUS.

Les Séphaniodes, LESS., Ind. Gen. et Syn. du Genr. Troch. (1832), p. xxix.

Eustephanus, REICH., Syst. Av. Nat., pl. 40 (1849).

Sephaniodes, BON., Consp. Gen. Av. (1850), p. 82.

Thaumaste, REICH., Aufz. der Colibri., p. 14 (1853).

Stokosiella. "REICH.", BON., Ann. Sc. Nat. (1854), p. 138.

TYPE.

T. galeritus, Molin.

T. galeritus, Molin.

T. galeritus, Molin.

T. fernandensis, King.

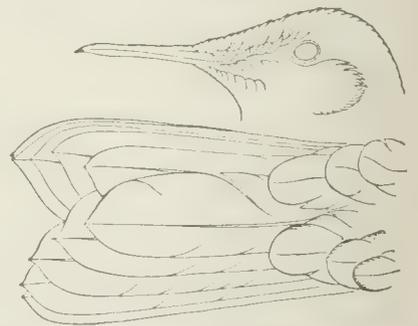
T. fernandensis, King.?

Ch. Bill short, straight, rather stout, sub-cylindrical, pointed. Nostrils covered with feathers. Wings ample long. Tail rather rounded. Tarsi clothed. Sexes unlike in plumage.

Range. Chili, and the islands of Juan Fernandez and Masafuera.

Three species are known.

Fig. 45.



Eustephanus fernandensis. ♂. Juan Fernandez. Bridges.

Key to the species.

- | | |
|--|-----------------------------|
| A. Under parts brownish-gray spotted with green in both sexes. | 1. <i>E. galeritus</i> . |
| B. Under parts cinnamon. | |
| a. Top of head metallic fiery-red. | 2. <i>E. fernandensis</i> . |
| b. Top of head and occiput metallic fiery-red. | 3. <i>E. leyboldi</i> . |

1. Eustephanus galeritus.

- Trochilus galeritus*, MOL., Hist. Chili, p. 219.—GMEL., Syst. Nat., vol. i, p. 484, sp. 23.—LATH., Ind. Orn., vol. i, p. 304.—VIEILL., Ency. Méth. p. 532.
- Mellisuga kingii*, VIG., Zool. Journ., vol. iii, p. 432.
- Mellisuga galerita*, GRAY, Gen. Birds, vol. i, p. 113, sp. 93.
- Orthorhynchus sephaniodes*, LESS. and GARN., Voy. Coquille, pl. 31, fig. 2.
- Ornismya sephanioides*, D'ORB. and LAFRES., Syn. Av., ii, p. 29, sp. 16.
- Trochilus forficatus*, GOULD (nec LINN.), Voy. Beagle (Birds), pt. iii, p. 110 (1841).
- Sephanoides kingii*, GRAY, List Gen. Birds, p. 19.
- Sephanoides galeritus*, BON., Consp. Gen. Av., vol. i, p. 82 (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.
- Eustephanus galeritus*, REICH., Aufz. der Colib. (1853), p. 14.—ID., Troch. Enum., p. 11 (1855).—GOULD, Mon. Troch., vol. iv, pl. 265.—ID., Intr. Troch., octavo ed., pl. 141.—MULLS., Hist. Nat. Ois. Mouch., vol. ii, p. 246.—ELLIOT, Ibis (1877), p. 138.

Hab. Chili, Island of Juan Fernandez.

Male. Entire top of head metallic orange-red. Upper surface and tail bronzy-green. Wings purple. Throat white, spotted with dark brown. Under surface grayish-brown, spotted with green. Under tail coverts pale bronze-green edged with buffy-white. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in.

Female. Top of head bronze-green instead of metallic orange-red. In all other respects, exactly like the male.

2. Eustephanus fernandensis.

- Trochilus fernandensis*, KING, Proc. Com. and Corr. Zool. Soc., pt. i, p. 30, ♂.
- Ornismya cinnamomea*, GERV., Mag. Zool. (1835), pl. 43.
- Ornismya fernandensis*, D'ORB. and LAFRES., Syn. Av., ii, p. 29., sp. 13 (1838).
- Ornismya robinson*, DELATT. and LESS., Rev. Zool. (1839), p. 18.
- Trochilus stokesii*, KING, Proc. Comm. and Corr. Zool. Soc., pt. i, p. 30, ♀ (1830).—LESS., Trochil., p. 135, pl. 50.
- Mellisuga fernandensis*, GRAY, Gen. Birds, vol. i, p. 113, sp. 94.
- Mellisuga stokesii*, GRAY, Gen. Birds, vol. i, p. 113, sp. 95.
- Sephanoides fernandensis*, BON., Consp. Gen. Av., p. 82, vol. i (1850).—MULLS., Hist. Nat. Ois. Mouch., tom. ii, p. 248.—BON., Rev. and Mag. Zool. (1854), p. 256.
- Eustephanus fernandensis*, REICH., Aufz. der Colib., p. 14.—ID., Troch. Enum., p. 11 (1855).—GOULD, Mon. Troch., vol. iv, pl. 267.—ID., Intr. Troch., octavo ed., p. 142.—CAB. and HEIN., Mus. Hein. Th., iii, p. 76. ELLIOT, Ibis (1877), p. 137, ♂.
- Thaumaste stokesii*, REICH., Aufz. der Colib., p. 14 (1853).—ID., Troch. Enum., p. 12 (1855).
- Sephanoides stokesii*, BON., Consp. Gen. Av., p. 82, vol. i.—ID., Rev. and Mag. Zool. (1854), p. 256.
- Eustephanus stokesii*, CAB. and HEIN., Mus. Hein. Th., iii, p. 75 (1860).—GOULD, Mon. Troch., vol. iv, pl. 266.—ID., Intr. Troch., octavo ed., p. 142, ♀.

Hab. Island of Juan Fernandez.

Male. Top of head metallic fiery-red. Wings purplish-brown. Vent buffy-white. Entire rest of plumage of body, and the tail dark cinnamon-red. Bill black. Total length, $5\frac{1}{4}$ in. Wing, $3\frac{2}{16}$ in. Tail, $3\frac{5}{16}$ in. Culmen, $\frac{11}{16}$ in.

Female. Top of head metallic bluish-green. Upper surface and wing coverts dark bronze-green. Wings purplish-brown. Under surface white, spangled with metallic bluish-green on the throat and flanks. Under tail coverts white with green centres. Median reectrices and outer webs of lateral ones dark grass-green. Inner webs white. Total length, $4\frac{5}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

3. *Eustephanus leyboldi*.

Eustephanus leyboldi, GOULD, Ann. Mag. Nat. Hist. (1870), p. 406.—MULS., Hist. Nat. Ois. Mouch., vol. ii, p. 251.

Hab. Island of Mas-a-fuera.

Male. Precisely like the *E. fernandensis*, with the exception that the metallic-red of the crown extends over the occiput. Total length, $5\frac{1}{4}$ in. Wing, $3\frac{3}{16}$ in. Tail, $2\frac{2}{3}$ in. Culmen, $\frac{5}{8}$ in.

Female. Similar to the female of *E. fernandensis*, but differs chiefly in the tail feathers, which have the basal portion of the inner webs and all the outer webs green, leaving only the apical part of the inner ones white. The spots on the throat are bronzy and disposed in lines, and not generally dispersed as in the female of *E. fernandensis*.

Genus XLVI.—TOPAZA.

Polytmus, BOIE (nec BRISS., 1760), Isis, p. 545 (1831).

Topaza, GRAY, List of Genera of Birds (1840), p. 13.

Lampornis, REICH. (nec SWAINS., 1827), Syst. Av. Nat. (1849), t. 39.

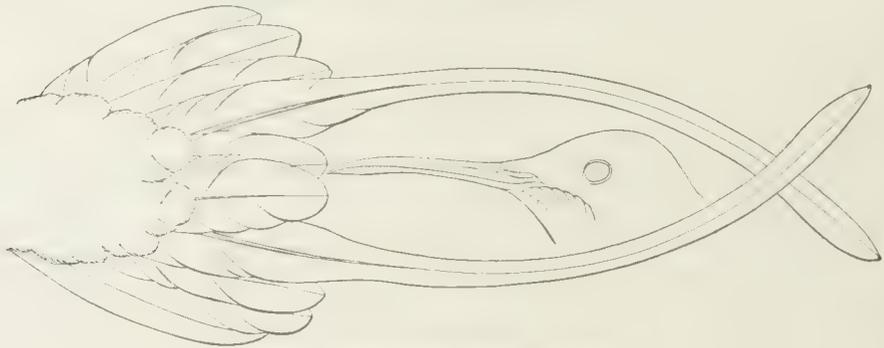
TYPE.

T. pella, Linn.

T. pella, Linn.

T. pella, Linn.

Fig. 46.



Topaza pella. ♂ ad. Cayenne. Bourcier.

Ch. Bill stout, curved, longer than the head. Wings long. Tail rounded, feathers on either side of central pair, narrow and elongated far beyond the rest, crossing each other at the tips of the other reectrices. Tarsi bare, feet rather large.

Range. Trinidad, Cayenne, and head waters of the Amazon, Rio Negro.

Two species are known.

Key to the species.

- A. Throat metallic-green, body metallic-red.
- | | |
|--|----------------------|
| a. Tail. Lateral feathers deep buff. | 1. <i>T. pella</i> . |
| b. Tail. Lateral feathers deep purple. | 2. <i>T. pyra</i> . |

Between this genus and the last there is also a gap, which we are not yet able to fill. The two species of the present one are among the most brilliantly plumaged of the Family, and are also remarkable for their peculiarly formed tails. The sexes are very unlike, but the female also exhibits metallic hues in her dress.

1. *Topaza pella*.

Trochilus pella, LINN., Syst. Nat., vol. i, p. 189 (1766), et Auct.

Trochilus paradiseus, LINN., Syst. Nat., vol. i, p. 189 (1766).

Lampornis pella, JARD., Nat. Lib. Humming-birds, vol. ii, p. 155.

Topaza pella, GRAY, List Gen. Birds, p. 13 (1840).—ID., Gen. Birds, vol. i, p. 109.—GOULD, Mon. Troch., vol. ii, pl. 66.—ID., Intr. Troch., octavo ed., p. 61.—REICH., Aufz. der Colib., p. 11.—ID., Troch. Enum., p. 9, t. 797, figs. 4853-55.—BOX., Rev. and Mag. Zool. (1854), p. 250.—ID., Consp. Gen. Av., p. 73 (1850).—CAB. and HEIN., Mus. Hein. Th., iii, p. 16 (1860).

Hab. Cayenne, Trinidad, Brazil, river Amazon.

Male. Head, lores, and a line encircling the throat black. Back shining dark red changing to orange-red on the rump. Throat metallic greenish-yellow, with a topaz hue in the centre. Rest of lower parts shining crimson. Upper tail coverts light bronze-green. Under coverts golden-green. Median rectrices dark bronze-green; next two on either side dark purple, those next the median greatly elongated, and very narrow beyond the tips of the other feathers; remaining lateral rectrices reddish-buff. Bill black, feet white. Length, $5\frac{1}{2}$ in. Wing, $3\frac{1}{8}$ in. Tail, 2 in. Culmen, 1 in. Lateral rectrices stretch beyond the others 3 in., making total length, $8\frac{1}{2}$ in.

Female. Entirely green, with metallic-red throat. Median rectrices grass-green tipped with black, two next dark purple, remainder, blackish at base tipped with buff. Middle rectrices rather pointed. Tail rounded. Total length, $5\frac{1}{2}$ in. Wing, 3 in. Tail 2 in. Bill on culmen, $\frac{7}{8}$ in.

2. *Topaza pyra*.

Trochilus (Topaza) pyra, GOULD, P. Z. S. (1846), p. 85.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 128.

Topaza pyra, GRAY, Gen. Birds, vol. i, p. 110.—GOULD, Mon. Troch., vol. ii, pl. 67.—ID., Intr. Troch., octavo ed., p. 62.—REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9, t. 798, figs. 4856-57 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 16 (note) (1860).—BOX., Consp. Gen. Av., vol. i, p. 73 (1850).—ID., Rev. and Mag. Zool. (1854), p. 250.

Hab. Rio Negro.

Male. Differs from *T. pella* by having the entire head, cheeks, and a broad band across upper part of throat velvety-black. Throat pale luminous green, bright orange-yellow in the centre. Median rectrices shining green; remainder deep purple. In size the two species are about the same.

In different specimens the colors of the body vary, some being shining crimson-

red like *pella*, while others are a brilliant orange-red. I do not consider that this difference has any specific value.

Female similar to that of *T. pella*, but has the lateral rectrices dark violet, the inner webs of the external feather rufous, and the median pair are greenish-bronze at the base, passing into a violet-black at the tip.

Genus XLVII.—AITHURUS.

Phæthornis, LESS. (nec SWAINS., 1827), Tab. Esp. Ois. Mouch., p. xviii (1829).

Polythmus, LESS. (nec BRISS., 1760), Ind. Gen. Synop. Genr. Troch., p. xvi (1832).

Trochilus, GRAY (nec LINN., 1748), List of Gen. Birds, p. 14 (1840).

Polytmus, REICH. (nec BRISS., 1760), Syst. Av. Nat., pl. 39 (1849).

Aithurus, CAB. and HEIN., Mus. Hein. Th., iii, p. 50 (1860).

TYPE.

O. cephalatra, Less.

Fig. 47.



Aithurus polytmus. ♂. Jamaica. Dresser.

Ch. Bill curved, wide at base, longer than head. Lateral rectrices next the outermost one on either side, lengthened nearly three times that of the other feathers. Tail deeply forked. Head crested. Sexes unlike.

Range. Island of Jamaica.

The species of this genus, by its singularly shaped tail, is apparently allied to those of the genus *TOPAZA*, and naturally finds its place here. It is a bird of moderate size, though from the length of the rectrices it appears larger than it really is.

1. *Aithurus polytmus*.

Trochilus polytmus, LINN., Syst. Nat. (1766), vol. i, p. 189.—GMEL., Syst. Nat. (1788), vol. i, p. 486.—LATH.,

Ind. Orn., vol. i, p. 302.—GOSSE, B. Jamaica, p. 97.—GOULD, Mon. Troch., vol. ii, pl. 98.

Black-capped Humming-bird, LATH., Gen. Syn., vol. ii, p. 748 (1790).—SHAW., Gen. Zool., vol. viii, p. 281.

Ornismya cephalatra, LESS., Ois. Mouch., p. 78, pl. 17 (1829).

Trochilus maria, HILL., Ann. Mag. Nat. Hist. (1849), vol. iii, p. 258.—GOSSE, Ill. B. of Jam., pl. 22.

Polytmus cephalatra, BON., Consp. Gen. Av., p. 72 (1850).

Polytmus cephalater, BON., Rev. and Mag. Zool. (1854), p. 254.

Aithurus polytmus, CAB. and HEIN., Mus. Hein. Th., iii, p. 50 (1860).—GOULD, Intr. Troch., octavo ed., p. 75.

Hab. Island of Jamaica.

Male. Crown of head and nape velvety-black. Upper surface dark green. Wings purplish-brown. Entire under parts lustrous emerald-green. Under tail

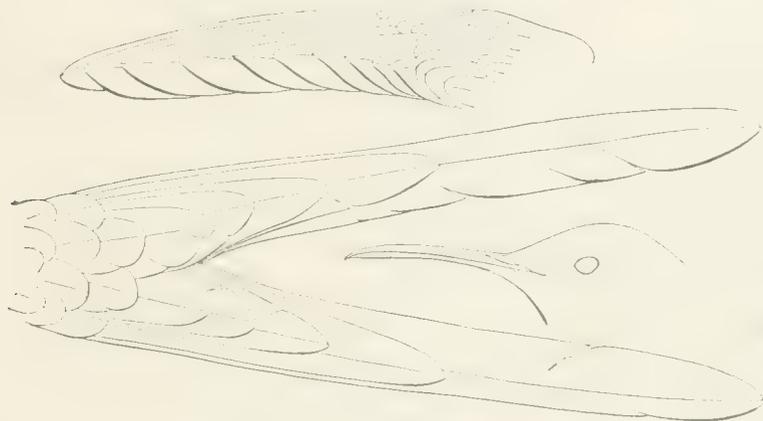
coverts blue-black. Tail deep black. Bill red. Total length, 9 in. Wing, $2\frac{2}{3}$ in. Tail, $6\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

Female. Top of head brown. Upper parts grass-green. Under surface white, flanks green. Tail, middle feathers bronze-green, next one black, bronze-green on outer web, remainder black tipped with white.

Genus XLVIII.—HYLONYMPHA.

Hylonympha, GOULD, Ann. and Mag. Nat. Hist., 4th ser., vol. xii (1873), p. 429. TYPE.
H. macrocerca, Gould.

Fig. 48.



Hylonympha macrocerca. ♂. Northern Brazil. Whitely.

Ch. Bill longer than the head, stout, slightly curved; feathers of forehead projecting forwards and covering the nostrils; wings long, narrow, reaching to the fork of the tail. Tail very long, deeply forked, the external rectrix twice the length of the one next to it, very broad, narrowing to a point, the edges of the webs curving slightly downwards. Feet small, tarsi partly clothed.

Range. Northern Brazil.

One species is known.

The curious bird comprised in this genus, apparently connects the last one with THALURANIA. It is a large species, with a coloring similar to that of *T. glaucopsis*.

1. *Hylonympha macrocerca*.

Hylonympha macrocerca. GOULD, Ann. and Mag. Nat. Hist. (1873), vol. xii, p. 429.—Muls., Hist. Nat. Ois. Mouch., tom. iii, p. 75.

Hab. Northern Brazil.

Male. Forehead and crown, metallic violet-blue, nape black, dark green when viewed from behind. Upper parts very dark green, appearing velvety-black in certain lights on the centre of the back, lightest on the rump and upper tail coverts. Throat and breast metallic emerald-green; flanks dark green; abdomen black washed with green; thighs and under tail coverts brownish-black. Tail steel-blue.

Bill black. Total length, $7\frac{3}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, external feather, 5 in. Culmen, $\frac{7}{8}$ in. Outer tail-feather at the widest part $\frac{7}{16}$ in.

Another specimen not quite so mature, has the chin white, caused by the base of the feathers showing conspicuously, and those of the upper part of the breast are just turning into the luminous green of the throat. The tail is shorter, and the rectrices are narrower than those of the example described above, having a total length of $4\frac{3}{16}$ in., and a width at the broadest part of the external feather of $\frac{6}{16}$ in. In other respects the dimensions are the same.

Female. Unknown.

Genus XLIX.—THALURANIA.

Mellisuga, BOIE (1831), Isis, p. 545 (nec BRISS., 1760).

Thalurania, GOULD, P. Z. S. (1848), p. 13.

Glaucopis, BURM. (nec HUBN., 1816), Th. Bras. (1856), p. 333, 2d pt.

Ch. Bill longer than the head, curved. Wings short; tail large, more or less forked. Tarsi clothed with feathers. Sexes dissimilar.

Range. Tres Marias Islands, Costa Rica, Veragua, to and including Ecuador on the west coast; the islands of Dominica and Trinidad; also Guiana, Venezuela, and northern Brazil on the east.

Eleven species are here recognized as belonging to this genus. They are a strongly marked group, moderate in size, and graceful in form, with a plumage of green, or green and blue in the males, with metallic hues on the crown or throat, sometimes on both. Females have a plain plumage.

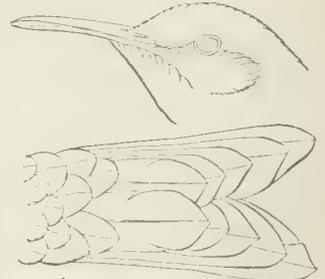
TYPE.

T. furcatus, Gmel.

T. nigro-fasciata, Gould.

T. glaucopis, Gmel.

Fig. 49.



Thalurania glaucopis, ♂. Brazil. Gould.

Key to the species.

- | | |
|--|------------------------------|
| A. Top of the head purplish-blue. | |
| a. Entire under parts green. | 1. <i>T. glaucopis</i> . |
| b. Abdomen prussian-blue. | 2. <i>T. columbica</i> . |
| B. Top of the head dull green. | |
| a. Under parts rich purple. Tail much forked. | 3. <i>T. furcata</i> . |
| b. Under parts purplish-blue. Tail slightly forked. | 4. <i>T. furcatoides</i> . |
| c. Under parts prussian-blue. | 5. <i>T. nigrofasciata</i> . |
| d. Diminutive of species c. | 6. <i>T. jelski</i> . |
| e. Back blue. Tail very long, deeply forked. | 7. <i>T. watertoni</i> . |
| C. Top of the head and back jet-black. | |
| Size large. Tail deeply forked; under parts prussian-blue. | 8. <i>T. refulgens</i> . |
| D. Top of the head brilliant metallic-green. | |
| Back green, under parts prussian-blue. | 9. <i>T. eriphile</i> . |
| Under parts green. | 10. <i>T. hypochlora</i> . |
| E. Head and neck deep rich cobalt-blue. | |
| Body brilliant metallic-green. Tail forked. | 11. <i>T. bicolor</i> . |

1. *Thalurania glaucopsis*.

Trochilus glaucopsis, GMEL., Syst. Nat., vol. i, p. 497 (1788).

Trochilus frontalis, LATH., Ind. Orn., vol. i, p. 318 (1790).

Ornismya glaucopsis, LESS., Ois. Mouch., p. 175, pls. 58, 59 (1829).

Polytmus glaucopsis, GRAY, Gen. Birds, vol. i, p. 108, sp. 58.

Caligena glaucopsis, REICH., Troch. Enum., p. 3, t. 685, figs. 4509-10 (1855).

Thalurania glaucopsis, GOULD, Mon. Troch., vol. ii, pl. 99.—ID., Intr. Troch., octavo ed., p. 76.—BON., Consp. Gen. Av., p. 77.—ID., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 7.—CAB. and HEIN., Mus. Hein. Th., iii, p. 23.—SALV. and ELLIOT, Ibis (1873), p. 355.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 59.

Glaucopsis frontalis, BURMEIST., Th. Bras., 2d pt., p. 333, sp. 1 (1856).

Thalurania luciae, LAW., Ann. Lyc. Nat. Hist. N. Y. (1862), vol. vii, p. 2.—SALV. and ELLIOT, Ibis (1873), p. 355.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 62.

Hab. Brazil, Tres Marias Islands.

Male. Centre of the crown metallic purplish-blue. Upper surface dark grass-green, brightest on the upper tail coverts. Entire under surface shining yellowish-green. Tail steel-blue. Wings purple. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{3}{16}$ in. Tail, 2 in. Culmen, $\frac{5}{8}$ in.

Female. Head and nape bronzy-green, rest of upper surface bright green. Under parts gray, washed with green on the flanks. Median rectrices and base of lateral ones shining green, the remaining portions of lateral ones black tipped with white.

2. *Thalurania columbica*.

Ornismya columbica, BOUCE. and MULS., Rev. Zool. (1843), p. 2.

Polytmus columbicus, GRAY, Gen. Birds, vol. i, p. 108, sp. 60.

Thalurania venusta, GOULD, P. Z. S. (1850), p. 163.—ID., Mon. Troch., vol. ii, pl. 105.—ID., Intr. Troch., octavo ed., p. 78.—BON., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 7.—ID., Troch. Enum., p. 3, pl. 683, figs. 4504-5.—CAB. and HEIN., Mus. Hein. Th., iii, p. 24.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 63.

Thalurania columbiana, GOULD, P. Z. S. (1852), p. 8.

Caligena columbica, REICH., Troch. Enum., p. 3, t. 685, figs. 4511-12 (1855).

Thalurania columbica, GOULD, Mon. Troch., vol. ii, pl. 106.—ID., Intr. Troch., octavo ed., p. 78.—REICH., Aufz. der Colib., p. 7.—SALV. and ELLIOT, P. Z. S. (1873), p. 355.

Thalurania puella, BON., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 7.—ID., Troch. Enum., p. 3 (1855).

Hab. Costa Rica, Veragua, Panama, Columbia.

Male. Crown of head and a band across the back, wing coverts, abdomen, and under tail coverts dark ultramarine blue. Nape and upper part of back, black in some lights, deep green in others. Lower part of back green. Upper tail coverts and tail black glossed with steel-blue. Throat and breast shining emerald-green. Bill black. Total length, $3\frac{5}{8}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female. Above golden-green; beneath gray. Tail green at base, rest steel-blue, lateral feathers tipped with white.

3. *Thalurania furcata*.

Trochilus furcatus, GMEL., Syst. Nat. (1788), vol. i, p. 486.—LATH., Ind. Ornith., vol. i, p. 304 (1790).

Ornismya furcata, LESS., Hist. Nat. Ois. Mouch., p. 82, pl. 18 (1829).

Polytmus furcatus, GRAY, Gen. Birds, vol. i, p. 108, sp. 61.

Cœligena (Thalurania) gyrrinno, REICH., Enum., p. 3, pl. 682, figs. 4500-1.

Thalurania furcata, GOULD, Mon. Troch., vol. ii, pl. 101.—ID., Intr. Troch., octavo ed., p. 77.—BON., Consp. Gen. Av., vol. i, p. 76.—ID., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 7.—CAB. and HEIN., Mus. Hein. Th., iii, p. 24.—SALV. and ELLIOT, Ibis (1873), p. 356.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 71.

Thalurania subfurcata, HEIN., Journ. für Ornith. (1863), p. 181.

Hab. Guiana.

Male. Head dull green, black in certain lights; upper parts of back brilliant purple; rest of back and upper tail coverts grass-green. Throat and upper part of breast luminous grass-green. Under parts brilliant purple like the back. Upper and under tail coverts dark green. Tail blue-black. Maxilla black. Mandible brownish-black. Total length, $3\frac{3}{4}$ in. Wing, $1\frac{7}{8}$ in. Tail $1\frac{5}{8}$ in. Culmen $\frac{5}{8}$ in.

Female. Upper parts grass-green; beneath gray. Median rectrices green, lateral ones bluish-black tipped with white.

4. *Thalurania furcatoides*.

Thalurania furcatoides, GOULD, Mon. Troch., pt. xvi (text to *T. furcata*).—ID., Intr. Troch., octavo ed., p. 357 (1861).—SALV. and ELLIOT, Ibis (1873), p. 357.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 73.

Thalurania forcifata, CAB. and HEIN., Mus. Hein. Th., iii, p. 24 (1860).

Hab. Para.

This species only differs from the *T. furcata* in having a shorter and less forked tail. It is the lower Amazonian form of the species just named.

5. *Thalurania nigrofasciata*.

Ornismya furcata, D'ORB. and LAFRES. (nec GMEL.), Syn. Av., ii, p. 27, sp. 6 (1838).

Trochilus (—?), *nigrofasciatus*, GOULD, P. Z. S. (1846), p. 89.

Thalurania viridipectus, GOULD, P. Z. S. (1848), p. 13.—BON., Consp. Gen. Av., p. 76.—ID., Rev. and Mag. Zool. (1854), p. 254.

Polytmus nigrofasciatus, GRAY, Gen. Birds, vol. i, p. 108, sp. 62.

Saucerottia viridipectus, REICH., Aufz. der Colib., p. 7 (1853).

Cœligena nigrofasciata, REICH., Troch. Enum., p. 3, t. 684, fig. 4506 (1855).

Cœligena viridipectus, REICH., Troch. Enum., p. 3 (1855).

Thalurania nigrofasciata, BON., Consp. Gen. Av. (1850), vol. i, p. 76.—REICH., Aufz. der Colib. (1853), p. 7.—BON., Rev. and Mag. Zool. (1854), p. 254.—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 23.—GOULD, Mon. Troch., vol. ii, pl. 104.—ID., Intr. Troch., octavo ed., p. 78 (1861).—SALV. and ELLIOT, Ibis (1873), p. 357.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 75.—ELLIOT, Ibis (1877), p. 135.

Thalurania tshudi, GOULD, P. Z. S. (1860), p. 312.—ID., Intr. Troch., octavo ed. (1861), p. 78, et Auct.

Hab. Ecuador and Peru.

Male. Head and nape bronze, back shining green. Throat metallic emerald-green, truncated or extending on to the breast, and sometimes bordered with black. Rest of under parts and shoulders prussian-blue. Under tail coverts blue-black. Tail steel-blue. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts shining grass-green; under surface gray. Tail green at base, remaining part steel-blue, with the lateral feathers tipped with white. Dimensions as in the male.

6. *Thalurania jelskii.

Thalurania jelskii, TACZANOW., P. Z. S. (1874), p. 138, sp. 19.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 70.

Hab. Perú.

This is a diminutive of the *T. nigrofasciata*; and there is absolutely no difference between the two except in size. The rectrices of *T. jelskii* are narrow, but not more so than accords with its dimensions. I compared the type with specimens of *nigrofasciata*, and could distinguish no difference, save that the *T. jelskii* was a little smaller. The type is in the Museum at Warsaw.

7. *Thalurania watertoni.

Trochilus watertoni, BOURC., P. Z. S. (1847), p. 44.—ID., Rev. Zool. (1847), p. 256.

Polytmus watertoni, GRAY, Gen. Birds, vol. i, p. 108.

Thalurania watertoni, BON., Consp. Gen. Av., vol. i, p. 76 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.—

GOULD, Mon. Troch., vol. ii, pl. 100.—ID., Intr. Troch., octavo ed., p. 76 (1861).—SALV. and ELLIOT, Ibis (1873), p. 358.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 78.

Thalurania whatertoni, REICH., Aufz. der Colib., p. 7 (1853).

Calligena whatertoni, REICH., Troch. Enum., p. 3 (1855).

Hab. British Guiana.

Male. Crown and nape greenish-bronze; middle of back and flanks metallic-blue; rest of back green; upper tail coverts purple. Throat, breast, and centre of abdomen metallic grass-green. Wings dark purple. Tail and its under coverts steel-blue. Bill black. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $2\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts dark green; under parts gray. A specimen of a female was in the collection of the late Ed. Verreaux, and is now I suppose in the possession of Count H. Turati at Milan.

8. Thalurania refulgens.

Thalurania refulgens, GOULD, P. Z. S. (1852), p. 9.—ID., Mon. Troch., vol. ii, pl. 102.—ID., Intr. Troch., octavo ed., p. 77.—REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 3.—BON., Rev. and Mag. Zool. (1854), p. 254.—SALV. and ELLIOT, Ibis (1873), p. 358.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 79.

Hab. Trinidad.

Male. Top of head velvety-black, bronze when viewed from behind. Middle of back, abdomen, and flanks shining purplish-blue. Lower part of back and rump dark green. Tail and under coverts steel-black. Entire throat metallic emerald-green. Wings purplish-brown. Bill black. Tail much forked. Total length, $4\frac{5}{8}$ in. Wing, $2\frac{1}{2}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female unknown to me.

9. Thalurania eriphile.

Ornismya eriphile, LESS., Hist. Colib., p. 148, pl. 25.—ID., Ois. Mouch. Supp., p. 148, t. 25.

Trochilus fannyi, BOURC. and DELATT., Rev. Zool. (1846), p. 310.

Polytmus eriphile, GRAY, Gen. Birds, vol. i, p. 108, sp. 64.

Hylocharis fannyi, GRAY, Gen. Birds, vol. i, p. 114, sp. 20.

Thalurania verticeps, GOULD, Jard. Contr. Ornith. (1851), pl. 107.

- Thalurania eriphila*, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.
Thalurania lydia, REICH., Aufz. der Colib., p. 7 (1853).
Riccordia verticeps, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 4, t. 705, fig. 4590.
Caligena fannyi, REICH., Troch. Enum., p. 3, t. 683, figs. 4502-3 (1855).
Chloristes verticeps, REICH., Troch. Enum., p. 4, t. 705, fig. 4590 (1855).
Caligena (Thalurania) eriphyle, REICH., Troch. Enum., p. 3, t. 684, figs. 4507-8 (1855).
Thalurania eriphile, GOULD, Mon. Troch., vol. ii, pl. 108.—ID., Intr. Troch., octavo ed., p. 79.—REICH., Aufz. der Colib., p. 7 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 23 (1860).—SALV. and ELLIOT, Ibis (1873), p. 359.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 67.
Thalurania verticeps, GOULD, Mon. Troch., vol. ii, pl. 107.—ID., Intr. Troch., octavo ed., p. 78.
Glaucopsis eriphile, BURM., Th. Bras., vol. ii, p. 334, sp. 2 (1856).
Thalurania fanny, CAB. and HEIN., Mus. Hein. Th., iii, p. 23 (1860).
Thalurania fannice, GOULD, Intr. Troch., octavo ed., p. 78 (1861).

Hab. Brazil, Ecuador, and Columbia.

Male. Anterior part of head and throat, metallic emerald-green. Back of head and upper parts bronzy-green. Shoulders, abdomen, and flanks dark blue, glossed with violet in some lights. Under tail coverts greenish-blue. Wings purplish-brown. Tail steel-blue. Bill black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts shining green; under parts gray. Median rectrices grass-green, rest deep blue tipped with white. Bill black.

10. *Thalurania hypochlora*.

- Thalurania hypochlora*, GOULD, P. Z. S. (1870), p. 104.—SALV. and ELLIOT, Ibis (1873), p. 360.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 66.

Hab. Citado in Ecuador.

Male. Top of head and entire under parts metallic emerald-green. Upper parts shining grass-green, becoming bluish-green on the upper tail coverts. Under tail coverts blue-black. Tail steel-black. Wings purplish-brown. Bill black. Total length, 4 in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper parts shining bronzy-green. Under parts gray. Median rectrices shining grass-green, lateral ones green at base, then deep blue, and tipped with white. The blue color increases in extent as it goes towards the outermost feathers. Total length, $3\frac{1}{4}$ in. Wing $1\frac{3}{4}$ in. Tail, $1\frac{1}{16}$ in. Culmen, $\frac{5}{8}$ in.

11. *Thalurania bicolor*.

- Trochilus bicolor*, GMEL., Syst. Nat., vol. i (1788), p. 496, sp. 51.—VIEILL., Ois. Dor., p. 75, t. 36 (1802).—ID., Ency. Méth., p. 571, sp. 81.

Ornismya wagleri, LESS., Hist. Ois. Mouch., p. 203, pl. 73 (1829).

Hylocharis wagleri, GRAY, Gen. Birds, vol. i, p. 114.

Caligena wagleri, REICH., Troch. Enum., p. 3, t. 702, fig. 4576-77 (1855).

Thalurania wagleri, GOULD, Mon. Troch., vol. ii, pl. 109.—ID., Intr. Troch., octavo ed., p. 79.—REICH., Aufz. der Colib., p. 7.—BON., Consp. Gen. Av., vol. i, p. 77.—ID., Rev. and Mag. Zool. (1854), p. 254.—CAB. and HEIN., Mus. Hein. Th., iii, p. 24.—SALV. and ELLIOT, Ibis (1873), p. 360.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 81.—LAWR., Ann. N. Y. Acad. Sc. (1877), vol. i, p. 46.

Hab. Brazil; Dominica (Ober.).

Male. Top of head, face, and throat deep cobalt-blue. Upper surface shining dark green; under surface metallic grass-green, lighter than the back. Tail with

its upper and under coverts steel-blue. Wings dark purplish-brown. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female. Upper parts bronzy-green, darkest on crown of the head. Upper tail coverts bluish-green. Entire under parts grayish-white, spangled with green on the flanks. Tail, two outermost rectrices dark-gray at base, remaining part steel-blue tipped with white, rest of feathers shining green with the terminal third steel-blue. Maxilla dark brown; mandible flesh-color.

It matters little which group or division we place next, as a gap occurs here, and there is no form known that will connect the last genus with any of those that remain. There is no arrangement of this Family possible that will not exhibit great gaps, although they are much fewer than they were a few years since. The species of the next genus is the smallest known among the Humming-birds, plain in plumage, and without any metallic hues.

Genus L.—MELLISUGA.

Mellisuga, BRISS., Ornith., tom. iii. p. 695 (1760).

Dyrinia, MULS. and VERR., Class. Troch. (1865), p. 88.

TYPE.

T. minimus, Linn.

T. minimus, Linn.

Fig. 59.



Mellisuga minima. ♂. Jamaica. Sallé.

Ch. Bill straight, shorter than the head, rather wide at base, graduating to a point. Wings long, and primaries narrow. Tail very slightly forked, short. Sexes alike. Size minute.

Range. Jamaica, St. Domingo.

But one species of this genus is known.

1. *Mellisuga minima*.

Trochilus minimus, LINN., Syst. Nat. (1766), vol. i. p. 193.—GMEL., Syst. Nat. (1788), tom. i. p. 500.—LATH., Ind. Orn., vol. i. p. 320 (1790).

Le plus petit oiseau-mouche, BUFF., Plan. Enlum., 276, fig. 1.

Trochilus minutulus, VIEILL., Ois. Am. Sept., tom. ii. p. 73 (1807).

Trochilus vieillotii, SHAW, Gen. Zool., vol. viii. p. 347.

Ornismya minima, LESS., Ois. Mouch., pl. 79, ♀ (1829).

Mellisuga humilis, GOSSE., B. Jamaica, p. 127 (1847).

Trochilus catherinae, SALLÉ., Rev. Zool. (1849), p. 498.

Hylocharis nigra, GRAY, Gen. Birds, vol. i. p. 114, sp. 16.

Hylocharis niger, BON., Consp. Gen. Av., vol. i. p. 81 (1850).

Mellisuga minima, BON., Consp. Gen. Av. (1850), vol. i. p. 81.—ID., Rev. and Mag. Zool. (1854), p. 257.—

GOULD, Mon. Troch., vol. iii. pl. 133.—ID., Intr. Troch., octavo ed., p. 87.—REICH., Aufz. der Colib., p. 6.

—ID., Troch. Enum., p. 3, t. 680, figs. 4490-93.—ELLIOT, Ibis (1872), p. 354.—MULS., Hist. Nat. Ois.

Mouch., tom. iv, p. 82 (1877).

Dyrinia minima, MULS. and VERR., Class. Troch. (1865), p. 88.

Hab. Jamaica, St. Domingo.

Male. Upper surface and flanks shining green. Under parts white; throat spotted with brown, abdomen and under tail coverts tipped with green. Tail black; bill black. Total length, $2\frac{3}{8}$ in. Wing, $1\frac{3}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Like the male. Throat without spots. Tail green at base, rest black, the lateral feathers tipped with white.

Genus LI.—MICROCHERA.

Microchera, GOULD, Intr. Mon. Troch., octavo ed., p. 82 (1861) (descr.).

Ch. Size minute. Bill long as the head, slender, straight. Feathers of forehead project on to the culmen. Nostrils covered. Wings long, primaries rather broad. Tail short, square. Tarsi clothed. Sexes dissimilar.

The species of this genus are remarkable for their pure white crowns, a character entirely unknown among the other members of the Family.

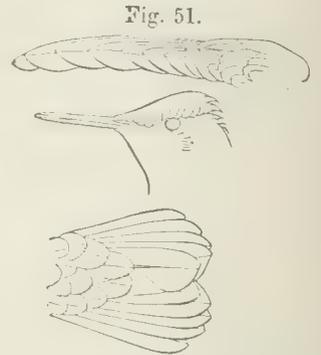
Range. Costa Rica, Nicaragua, and Veragua in Central America.

Two species only are known belonging to this genus.

TYPE.

M. albocoronata.

Fig. 51.



Microchera albocoronata, ♂,
Veragua. Verreaux.

Key to the species.

A. Top of head pure white.

- a. General plumage bluish-black with coppery reflections.
- b. General plumage shining purple.

- 1. *M. albocoronata*.
- 2. *M. parvirostris*.

1. *Microchera albocoronata*.

Mellisuga albocoronata, LAWRENCE, Ann. N. Y. Lyc. Nat. Hist., vol. vi (1855), p. 137, pl. 4.

Microchera albocoronata, GOULD, Mon. Troch. (1858), vol. ii, pl. 116.—*Id.*, Intr. Troch., octavo ed., p. 82.—FRANTZ, Journ. für Ornith. (1869), p. 315.—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 134 (1876).

Hab. Veragua.

Male. Front and crown silky-white. Chin dull greenish. General plumage bluish-black, with coppery reflections. Wings purple. Median rectrices bronzy-green, lateral ones white at base, then a band of blue-black and tips white. Under tail coverts white. Maxilla black, mandible brownish. Total length, $2\frac{1}{2}$ in. Wing, $1\frac{5}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Upper surface bronzy-green. Under surface white. Tail like that of the male, except the blue-black on the lateral feathers is much narrower and the white on the tips more extensive.

2. *Microchera parvirostris*.

Microchera parvirostris, LAWRENCE, Ann. N. Y. Lyc. Nat. Hist. (1870), p. 122, ♀.—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 137.—SALV., P. Z. S. (1867), p. 171.

Hab. Costa Rica, Nicaragua.

Male. Top of head white, throat dull green. General plumage shining reddish-purple. Median rectrices light bronze; lateral ones white at base, rest brownish-black, edged with white. Bill black. Wings purple. Total length, $2\frac{1}{2}$ in. Wing, $1\frac{5}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{1}{2}$ in.

Female. Like that of *M. albocoronata*. Above bronzy-green, beneath white. Middle rectrices bronze-green, rest white with a subterminal black bar. Bill black.

Genus LII.—TROCHILUS.

Trochilus, LINN., Syst. Nat. (1766), vol. i, p. 189.

Cyanthus, BOIE, Isis (1831) (nec SWAINS., 1837), p. 547.

Colubris, REICH., Syst. Av. Nat., pl. 40 (1849).

Archilochus, REICH., Troch. Enum., p. 10 (1855).

Ornismya, MULS. and VERR., Class. Troch. (1865), p. 91.

Ch. Bill straight, slender, long as the head. Wings short. Tail forked, rectrices pointed. Nostrils hidden by frontal feathers. Sexes unlike in plumage.

Range. North America from the Saskatchewan River, to Veragua in Central America, islands of Cuba, Bermuda, and the Bahamas.

This genus, as established by Linnæus, was a composite one, comprising species of various forms, all of which have been included in distinct genera, with the exception of *T. colubris*, which remains as the type. The species are small in size, with luminous throats, but otherwise the plumage is not brilliant.

Only two species are retained in the genus.

Key to the species.

A. Throat metallic ruby-red.

B. Throat black, bounded beneath by a band of metallic-purple.

1. *T. colubris*.

2. *T. alexandri*.

1. *Trochilus colubris*.

Trochilus colubris, LINN., Syst. Nat., tom. i, p. 191 (1766).—WILS., Am. Orn., vol. ii, p. 26, pl. 10, figs. 3, 4.—VIEILL., Ency. Méth. Orn., vol. ii, p. 569.—AUD., B. Amer., vol. i, pl. 47.—SWAIN., Faun. Bor. Amer., vol. ii, p. 323 (1832).—GOULD, Mon. Troch., vol. iii, pl. 131.—ID., Intr. Troch., octavo ed., p. 86.—BOX., Consp. Gen. Av., p. 81.—ID., Rev. and Mag. Zool. (1854), p. 252.—REICH., Aufz. der Colib., p. 12.—ID., Troch. Enum., p. 10.—CAB. and HEIN., Mus. Hein. Th., iii, p. 57 (1860).—ELLIOT, Ibis (1872), p. 354.

Mellisuga colubris, STEPH., Shaw. Gen. Zool., vol. xiv, p. 247.

Mellisuga colubris, GRAY, Gen. Birds, vol. i, p. 113.

Ornismya colubris, LESS., Ois. Mouch., pp. xvi, 151, pl. 48 (1829).—ID., Trochil., p. 1, pl. (1831).—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 52 (1877).

Cyanthus colubris, JARD., Nat. Libr. Humming-Birds, vol. ii, p. 143.

Hab. Eastern North America, Mexico, Central America to Veragua; Cuba, Bahamas, and Bermudas of the West Indies.

TYPE.

T. colubris, Linn.

T. colubris, Linn.

T. colubris, Linn.

T. alexandri, Bourc.

T. alexandri, Bourc.

Fig. 52.



Trochilus colubris. ♂. Washington, D.C.
J. K. Townsend.

Male. Entire upper parts and flanks bronzy-green. Chin black; throat metallic ruby-red. Breast and under parts white, the latter tinged with green. Median rectrices golden-green, lateral ones purplish-brown. Bill black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $1\frac{1}{2}$ in.

Female. Above golden-green; beneath white. Tail—median rectrices green, lateral ones green at base, then black with white tips.

Fig. 53.



2. *Trochilus alexandri*.

Trochilus alexandri, BOURC. and MULS., Ann. Soc. Scien., Lyon (1846), tom. ix, p. 330.—CASS., Ill. B. Calif., p. 141, pl. 22.—BON., Consp. Gen. Av., p. 81, vol. i.—ID., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. iii, pl. 132.—ID., Intr. Troch., octavo ed., p. 87.—CAB. and HEIN., Mus. Hein. Th., iii, p. 57 (1860).

Mellisuga alexandri, GRAY, Gen. Birds, vol. i, p. 113.

Selasphorus alexandri, REICH., Troch. Enum., p. 10 (1855).

Archilochus alexandri, REICH., Troch. Enum., p. 10 (1855).

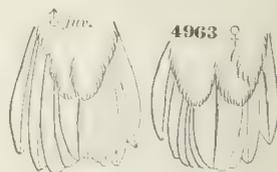
Ornismya alexandri, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 61 (1877).

Hab. California and Mexico.

Male. Top of head dark brown. Upper parts bronzy-green. Wings purplish-brown. Throat black bounded beneath by a brilliant band of metallic-purple. Breast white, rest of under parts bronzy-gray. Median rectrices bronzy-green, lateral ones black glossed with green. Total length, $3\frac{1}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{11}{16}$ in. Description taken from a specimen collected at Sacramento, California, by Dr. A. L. Heermann, now in my collection.

Female. Top of head brown. Upper surface bronzy-green; under surface grayish-white. Central tail feathers bronze-green, lateral ones greenish-gray at base, then black with white tips. Bill black.

Fig. 54.

*Trochilus alexandri*.

Genus LIII.—CALYPTE.

Calypte, GOULD, Intr. Troch., octavo ed., p. 87 (1861), descr.

Leucaria, MULS., Cat. Ois. Mouch. (1875), p. 31.

TYPE.

O. costæ, BOURC.

O. costæ, BOURC.

Ch. "Bill longer than the head; straight or slightly arched; tail rather short, the three outer feathers stiff, narrow, and slightly incurved; tarsi clothed, feet small, hind and fore toes nearly equal in length." (Gould, l. c.)

Range. Mexico and the island of Cuba.

The species of this genus have the head and face of the males brilliantly metallic, and the feathers of the throat are elongated at the sides. They are small in size.

Fig. 55.

*Calypte annæ*. ♂. California. Verreaux.

Key to the species.

- A. Head and throat luminous.
- a. Head and throat metallic-lilac. 1. *C. costæ*.
 - b. Head and throat metallic-crimson.
 - a'. Upper surface golden-green. 2. *C. annæ*.
 - b'. Upper surface greenish-blue. 3. *C. helenæ*.

1. *Calypte costæ*.

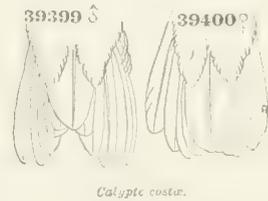
Ornismya costæ, BOURC., Rev. Zool. (1839), p. 294.—ID., Ann. Soc. Sci., Lyon (1840), p. 225, pl. 2.
Mellisuga costæ, GRAY, Gen. Birds, vol. i, p. 113.
Selasphorus costæ, BON., Consp. Gen. Av., p. 82 (1850).—ID., Rev. and Mag. Zool. (1854), p. 257.
Atthis costæ, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).
Calypte costæ, GOULD, Mon. Troch., vol. iii, pl. 134.—ID., Intr. Troch., octavo ed., p. 88 (1861).
Leucaria costæ, MULS., Cat. Ois. Mouch. (1875), p. 31.—ID., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 69.

Hab. Mexico, California.

Male. Head, throat, and elongated neck feathers metallic-lilac. Upper surface golden-green. Under surface white, washed with green on the flanks. Tail green, two outer rectrices brownish-gray with dark tips. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{3}{4}$ in. Tail, 1 in. Culmen, $\frac{5}{8}$ in.

Female. Above golden-green, beneath white, throat with a few brown spots. Median rectrices green, lateral ones gray at base, then black with white tips. Bill black.

Fig. 56.

2. *Calypte annæ*.

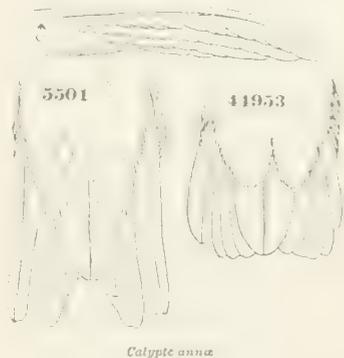
Ornismya annæ, LESS., Ois. Mouch., p. 205, pl. 74 (1829).
Trochilus anna, AUD., B. Amer., vol. iv, pl. 425.—ID., Orn. Biog., vol. v, p. 238.—REICH., Troch. Enum., p. 10.
Trochilus icterocephalus, NUTT., Man. Ornith., vol. i, p. 712.
Mellisuga anna, GRAY, Gen. Birds, vol. i, p. 113.
Selasphorus anna, BON., Consp. Gen. Av., p. 82 (1850).—ID., Rev. and Mag. Zool. (1854), p. 257.
Atthis anna, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).
Calypte annæ, GOULD, Mon. Troch., vol. iii, pl. 135.—ID., Intr. Troch., octavo ed., p. 88.—CAB. and HEIN., Mus. Hein. Th., iii, p. 55 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 73 (1877).

Hab. Mexico and California.

Male. Head, throat, and elongated feathers of the neck, metallic-crimson. Upper surface golden-green. Under surface gray washed with green. Under tail coverts green edged with gray. Median rectrices golden-green, lateral ones dark brown, with pale margins. Bill black. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Head grayish-brown. Upper parts golden-green; beneath gray washed with green. Middle tail feathers golden-green; lateral ones gray at base, then golden-green and then black, the two outer feathers tipped with white. Bill black.

Fig. 57.



3. **Calypte helenæ*.

Orthorhynchus helenæ. LAMBEYE, Aves Isle de Cuba, p. 70, pl. x, fig. 2 (1850).

Orthorhynchus boothi. GUNDEL., Journ. für Ornith. (1856), p. 99.

Calypte helenæ. GOULD, Mon. Troch., vol. iii, pl. 136.—ID., Intr. Troch., octavo ed., p. 88 (1861).—ELLIOT, Ibis (1872), p. 354.—GUNDEL., Journ. für Ornith. (1874), p. 144.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 77 (1877).

Hab. Cuba.

Male. Head, throat, and feathers of the neck metallic-crimson. Upper parts and flanks greenish-blue. Under surface white. Tail deep greenish-blue. Wings purplish-brown. Total length, $2\frac{5}{8}$ in. Wing, $1\frac{3}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{1}{2}$ in.

Female. Head brown. Upper parts dark green, changing into bluish-green on the lower part of the back. Under surface grayish-white. Median rectrices dark bluish-green; lateral ones bluish-green at base, rest black tipped with white. Bill black.

Genus LIV.—SELASPHORUS.

Selasphorus, SWAIN., Faun. Bor. Amer., vol. ii, p. 496 (1831).

TYPE.

T. rufus, Gmel.

Ch. "Stature small Bill subulate and very straight. Feathers of the neck elongated. Wings short, feeble, the quills narrowed and sometimes pointed. Tail moderate graduated, the feathers attenuated towards the end, their tips mucronate." (Swains, l. c.)

Range. Western North America from Nootka Sound to Mexico and into Veragua, Central America.

Eight species are recognized belonging to this genus. They are of small size, with very brilliant throats, and cuneate shaped tails, the rectrices in the majority of the species being rather narrow and pointed. One species has a silvery throat



Fig. 58.

Selasphorus rufus, ♂. California. Mr. Woods.

Key to the species.

- | | |
|--|----------------------------|
| A. Head and throat metallic-scarlet. | 1. <i>S. floresii</i> . |
| B. Throat metallic amethystine-red. | |
| a. Size large. Under parts gray. | 2. <i>S. platycercus</i> . |
| b. Size small. Flanks and abdomen dark green. | 3. <i>S. ardens</i> . |
| C. Throat metallic rose-red. | 4. <i>S. flammula</i> . |
| D. Throat metallic fiery-red. Rectrices narrow, pointed. | |
| a. Sides of head and neck, and rump, rufous, back bronzy-green. | 5. <i>S. rufus</i> . |
| b. Sides of head and neck bronzy-green like the back. Diminutive of a. | 6. <i>S. scintilla</i> . |
| E. Throat glittering orange. Rectrices broad, lateral ones next to median pair with a well-developed notch on inner web. | 7. <i>S. henshawi</i> . |
| F. Throat pale lilac-red, in some lights silvery-gray. | 8. <i>S. torridus</i> . |

1. **Selasphorus floresii*.

Selasphorus floresii, GOULD, Mon. Troch., vol. iii, pl. 139.—ID., Intr. Troch., octavo ed., p. 89.—MULS., Hist. Nat. Ois. Mouch., tom. iv. p. 98 (1877).

Hab. Bolanos, Mexico (Floresi).

Male. Crown and throat metallic-scarlet with violet reflections. Upper surface and flanks bronzy-green; under surface grayish-white. Wings purplish-brown. Median rectrices green with purple reflections; lateral feathers have the outer webs purple, inner webs deep reddish-buff. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{3}{4}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Unknown.

This bird is remarkable for having the top of the head, as well as the throat, metallic, and in this respect is allied to the members of the genus *Calypte*, but the coloring of the tail is more that of *Selasphorus*. It appears to be intermediate between the two genera. The type in Mr. Loddige's collection still remains unique.

2. *Selasphorus platycercus*.

Trochilus platycercus, SWAIN., Ann. Phil. (1827), p. 441.

Ornismya tricolor, LESS., Ois. Mouch. (1829), p. 125, pl. 14.—ID., Trochil., p. 156, pl. 60 (1831).

Ornismya montana, LESS., Trochil., pp. 161, 163, pls. 63, 64 (1831).

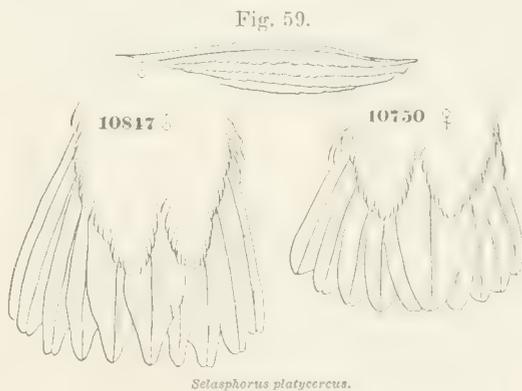
Mellisuga platycerca, GRAY, Gen. Birds, vol. i, p. 113, sp. 78.

Selasphorus platycercus, BON., Consp. Gen. Av., p. 82 (1850).—ID., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 140.—ID., Intr. Troch., octavo ed., p. 89.—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 10 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 56 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 94 (1877).

Hab. Guatemala, Mexico, Rocky Mountains to Utah in North America.

Male. Upper surface and flanks bronzy-green. Spot of white behind the eye. Throat metallic amethystine-red. Breast white, rest of under parts gray, with the centres of under tail coverts brownish. Median rectrices bronzy-green; lateral ones blackish-brown, margined with rufous, most conspicuous on the inner webs. Bill black. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Above bronzy-green; beneath white, throat spotted with brown. Middle tail feathers bronzy-green, lateral ones deep buff at base, remaining portions black with white tips. Bill black. Flanks and under tail coverts sometimes tinged with buff.



Selasphorus platycercus.

3. *Selasphorus ardens*.

Selasphorus ardens, SALV., P. Z. S. (1870), p. 209.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 103 (1877).

Hab. Veragua.

Male. Upper parts dark bronzy-green. Loes and ear coverts rufous, the latter mixed with black. Throat metallic amethystine-red. Breast, middle of abdomen, and under tail coverts white. Flanks dark green, which color almost meets on the upper part of breast. Tail purplish-black, both webs of middle feathers and inner webs of lateral ones margined with rufous. Wings purplish-brown. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

Female. Upper parts bronzy-green, margined with rufous on the sides of lower part of back and rump. Throat buffy-white, spotted with brown. Breast white. Under parts buff. Middle tail feathers bronzy-green, lateral ones buff with a black bar across their central part. Bill black.

4. *Selasphorus flammula*.

Selasphorus flammula, SALV., P. Z. S. (1864), p. 586, sp. 16.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 99 (1877).

Hab. Costa Rica and Veragua.

Male. Upper parts shining grass-green. Throat metallic rose-red. Breast and middle of abdomen white. Flanks buff mixed with green. Wings purplish-brown. Under tail coverts white. Tail purplish-black margined with rufous, the central pair slightly washed with green on outer webs. Maxilla black, mandible flesh-color, tip black. Total length, $2\frac{7}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

Female. Upper parts bronzy-green, brownish upon the head. Flanks buff. Throat, breast, and abdomen white; the throat spotted with dark brown. Under tail coverts buff edged with white. Wings purplish-brown. Four central rectrices grass-green, edged on outer webs with rufous; remainder black tipped with buffy-white. Bill and feet black. In size same as the male.

5. *Selasphorus rufus*.

Trochilus ruber, LINN., Syst. Nat. (1766), vol. i, p. 193, sp. 21.—LATH., Ind. Orn., vol. i, p. 315, sp. 48.—VIEILL. Ency. Méth., p. 573, sp. 74.

Trochilus rufus, GMEL., Syst. Nat., vol. i, p. 497 (1788).

Ruff-necked Humming-Bird, LATH., Gen. Syn. (1781), vol. ii, p. 785, pl. 35.

Trochilus collaris, LATH., Ind. Orn., vol. i, p. 318, sp. 59 (1790).

Ornismya saisin, LESS., Hist. Nat. Ois. Mouch., p. 190, pls. 66, 67 (1829).

Trochilus (Selasphorus) rufus, SWAINS., Faun. Bor. Amer., vol. ii, p. 324 (1832).

Mollisuga rubra, GRAY, Gen. Birds, vol. i, p. 113, sp. 60.

Selasphorus rufus, AUD., B. Amer., octavo ed., vol. iv, p. 200.—BAIRD, B. N. Amer. (1860), p. 134.—GOULD, Mon. Troch., vol. iii, pl. 137 (partim).—ID., Intr. Troch., octavo ed., p. 88.—CAB. and HEIN., Mus. Hein. Th., iii, p. 56 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 106 (1877), partim.

Selasphorus ruber, BON., Consp. Gen. Av., p. 82, vol. i (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 10 (1855).

Selasphorus alleni, HENSHAW, Bull. Nutt. Ornith. Club (1877), vol. ii, p. 54.

Hab. Pacific coast of North America from California to Nootka Sound.

Male. Top of head and back bronzy-green, dullest on the forehead. Sides of the head, rump, flanks, abdomen, and under tail coverts rufous. A gorget of metallic

feathers, covering all the throat and extending on to the sides of the neck, brilliant coppery-red with brassy-reflections in certain lights. Upper part of breast white. Wings purplish-brown. Tail short, cuneate, all the feathers acutely pointed. Median rectrices rather broad, lateral ones narrowing rapidly to the outermost which is extremely attenuated. Bill straight, black. Total length, $3\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Above green. Throat white spotted with metallic-red. Under parts white, washed with rufous on the flanks and abdomen. Under tail coverts buffy-white. Median rectrices green, lateral ones rufous at base, then green and then black tipped with white. Bill black.

Fig. 60.



6. *Selasphorus scintilla*.

Trochilus (Selasphorus) scintilla, GOULD, P. Z. S. (1850), p. 162.

Selasphorus scintilla, GOULD, Mon. Troch., vol. iii, pl. 138.—ID., Intr. Troch., octavo ed., p. 89.—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 10 (1855).—BON., Rev. and Mag. Zool. (1854), p. 257.—CAB. and HEIN., Mus. Hein. Th., iii, p. 56 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 104 (1877).

Hab. Costa Rica and Veragua.

Male. This species is a diminutive of *S. rufus*. The upper parts are a darker green, and there is no rufous on the sides of the back. Throat and under parts like *S. rufus*. Tail rufous with a median line of purplish-black on the central feathers, external ones rufous on inner web, purplish-black on the outer. Maxilla black, mandible flesh-color at base, rest black. Total length, $2\frac{2}{3}$ in. Wing, $1\frac{1}{4}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Head blackish-brown; upper parts golden-green. Throat white spotted with buff, rest of under parts like the male. Median rectrices bronze-green margined with rufous, lateral ones rufous, with a subterminal black bar. Bill black.

7. *Selasphorus henshawi*.

Trochilus rufus, HENSEL, Bull. Nutt. Ornith. Club (1877), vol. ii, p. 54.

Selasphorus henshawi, ELLIOT, Bull. Nutt. Ornith. Club (1877), vol. ii, p. —

Hab. Mexico, northwards along the Pacific coast to Sitka.

Male. Top of head metallic-green; upper parts cinnamon, but some specimens have green feathers intermixed with the rufous ones on the back. Throat metallic-orange, not brilliant as in the other species. Breast and centre of abdomen white; flanks and under tail coverts rufous. Tail rufous tipped with dark brown; feathers pointed at tip, median pair broad, lateral ones growing narrower to the outermost which is the most attenuated.

On the inner web near the tip of the rectrices next the median pair is a well-

Fig. 61.



developed notch. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in. (Type of *S. henshawi* in my collection.)

Female. Entire upper parts shining grass-green, dullest on the crown. Throat white spotted with brown. Under parts white, washed with rufous on the breast and flanks. Under tail coverts buff. Median rectrices green; lateral ones rufous at base, then a band of metallic-green, succeeded by a subterminal broad black bar, and tips white. Bill black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in. Young males are similar to the females, with a few metallic spots on the throat.

8. *Selasphorus torridus.*

Selasphorus torridus. SALV., P. Z. S. (1870), p. 208.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 101 (1877).

Hab. Veragua, Volcano of Chiriqui.

Male. Upper parts dark shining grass-green. Throat shining lilac-red, silvery in certain lights. Feathers on the sides of the neck elongated, same color as the throat. Breast and middle of abdomen white. Flanks green. Under tail coverts buffy-white. Median rectrices bronze-green; lateral ones purplish-black, all except the two outer ones margined with rufous. Wings purplish-brown. Maxilla black, mandible flesh-color, tip black. Total length, $2\frac{3}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

Female. Head brownish, upper parts green. Under parts whitish, feathers of the throat spotted with brown. Flanks rufous. Tail black, base of three outer feathers rufous and tips white, next two margined with rufous; middle feathers green.

Genus LV.—CATHARMA.

Catharma. ELLIOT, Ibis (1876), p. 400.

TYPE.
O. orthura, LESS.

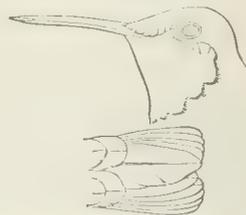
Ch. Bill longer than the head, broad at base, pointed at tip. Wings long, reaching beyond the centre of the tail, which is extremely short and almost square.

Range. Guiana, Merida, in Venezuela (Berlepsch in Litt.).

But one species is known, with the form of that of the next genus, and the plumage of a CALLIPHLOX.

It is a small bird, and until very lately was confounded with another species. See my remarks on the genus in the Ibis, 1876, p. 400.

Fig. 62.



Catharma orthura. ♂. Cayenne: Parzudaki.

1. *Catharma orthura.*

Ornismya orthura. LESS., Hist. Nat. Trochil., pp. 85, 88, pls. 28, 29 (1831).

Trochilus orthurus. REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).

Tryphæna orthura. BON., Rev. and Mag. Zool. (1854), p. 257.

Catharma orthura. ELLIOT, Ibis (1876), p. 400.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 66 (1877).

Hab. Guiana, Venezuela.

Male. Entire upper parts dark shining grass-green. Behind the eye a small white spot. Throat metallic amethystine-red, rather dull, beneath which is a band of grayish-white extending up the sides of the neck; rest of under parts gray tinged with green, lightest in the centre of abdomen. Median rectrices bronze-green, lateral ones green at base, rest black, with a faint indication of white at the tip. Wings purplish-brown. Bill black. Total length, $2\frac{2}{3}$ in. Wing, $1\frac{3}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{5}{8}$ in. (Type in my collection.)

Young male. Above golden green. Throat white spotted with metallic-red, and bounded beneath with a band of green, followed by another of white. Under parts deep buff, washed with green on lower part of breast. Middle rectrices bronze-green, lateral ones green at base, rest black tipped with white. (Type in my collection.)

Female. Above dark green. Ear coverts, cheeks, and a line around lower part of the throat blackish-brown. Throat white spotted with brown. A band of white across the breast, beneath which is another of dark brown. Rest of under parts rufous. Central rectrices bronze-green, lateral ones bronze-green with an apical black band. Under tail coverts pale bronze-green, margined with gray. Wings purple. Bill and feet black. Dimensions as in the male.

Genus LVI.—ATTHIS.

Atthis, REICHENB., Aufz. der Colib. (1853), p. 12

TYPE.

O. heloisæ, Less. and Delatt.

Ch. Bill about as long as the head, straight, rather flat on culmen. Wings nearly as long as the tail, which is much rounded and short. Feathers on the side of the throat much elongated.

Fig. 63.



Range. Mexico and Guatemala. *Atthis heloisæ*, Z. Jalapa. Dr. Heermann.

Two species only are known, closely allied in structure to the preceding one, but very different in the coloring of their plumage.

Key to the species.

- A. Gorget elongated; metallic purplish-red or reddish-violet.
- a. First primary of male very narrow, end abruptly attenuated. 1. *A. heloisæ*, Less. and Del.
 - b. First primary of male uniform, end not attenuated. 2. *A. elliotti*, Ridg.

1. *Atthis heloisæ*.

Ornismya heloisæ, LESS. and DELATT., Rev. Zool. (1839), p. 15.

Mellisuga heloisæ, GRAY, Gen. Birds, vol. i. p. 113. sp. 62.

Tryphæna heloisæ, BON., Rev. and Mag. Zool. (1854), p. 257.

Selasphorus heloisæ, GOULD, Mon. Troch., vol. iii, pl. 141.

Atthis heloisæ, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).—GOULD, Intr. Troch. octavo ed., p. 89 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 91 (1877).

Hab. Mexico.

Male. Upper parts golden-green. Throat metallic reddish-violet, the feathers on the side elongated. Beneath the throat a band of grayish-white. Flanks buff spotted with green. Centre of abdomen white. Under tail coverts buffy-white. Median rectrices shining grass-green; lateral ones buff at base, succeeded by a bar of black, tipped with white. Wings purplish-brown, outer primary abruptly attenuated. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, 1 in. Culmen, $\frac{1}{2}$ in.

Female resembles the male, but has the throat white spotted with brown.

2. *Atthis ellioti*.

Atthis heloisæ, ex Guatemala, Auct.

Atthis ellioti, Ridgw., Proc. U. S. Nat. Mus. (1878), p. 9.

Hab. Guatemala.

Male. Upper parts shining green, less golden than in the preceding species. Throat metallic reddish-purple, with slight violet reflections. Beneath the throat a band of white. Flanks rufous glossed with green. Middle of abdomen, crissum, and under tail coverts white, the last two tinged with rufous. Tail rufous-cinnamon at base, succeeded on the lateral feathers by a broad black band, and the tips white. The median pair of rectrices, black above the cinnamon, glossed with metallic grass-green, this hue strongest on the central portion along the shaft. Wings purplish; the outer primary uniform, not attenuated. Bill and feet black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, 1 in. Culmen, $\frac{3}{8}$ in.

Female like that of *A. heloisæ*.

Though closely resembling each other in their general appearance, the ADULT MALES of the two species of this genus can easily be distinguished by the shape of the first primary.

Fig. 64.



Atthis ellioti, ♂. Guatemala. Bourcier.

Genus LVII.—STELLULA.

Stellula, GOULD, Intr. Troch., octavo ed., p. 90 (1861).

Stellura, MULS. and VERR., Class. Troch. (1865), p. 88.

Ch. "Bill longer than the head, straight and pointed; wings moderately long and sickle-shaped; first primary rigid; tail short and truncate; feet small, claws diminutive and curved."

Range. Mexico.

One species only is known, small in size, with a bright throat, but not luminous.

TYPE.

T. calliope, Gould.

T. calliope, Gould.

Fig. 65.



Stellula calliope, ♂. Mexico. Bourcier.

1. *Stellula calliope*.

Trochilus (Calothorax) calliope, GOULD, P. Z. S. (1847), p. 11.

Calothorax calliope, GRAY, Gen. Birds, vol. i, p. 113.—BON., Consp. Gen. Av. (1850), vol. i, p. 85.—ID., Rev. and Mag. Zool. (1854), p. 257.—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 10 (1855).
GOULD, Mon. Troch., vol. iii, pl. 143.

Stellula calliope, GOULD, Intr. Troch., octavo ed., p. 90 (1861).

Stellura calliope, MULS. and VERR., Class. Troch. (1865), p. 88.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 87 (1877).

Hab. Mexico.

Male. Upper parts dull bronzy-green. Wings and tail pale purplish-brown. Feathers of the throat elongated, metallic-pink with white bases; flanks bronzy-green; rest of under parts white. Bill black, base of mandible flesh-color. Total length, $2\frac{2}{3}$ in. Wing, $1\frac{1}{2}$ in. Tail, 1 in. Culmen, $\frac{1}{2}$ in.

Female. Above golden-green; below buffy-white, throat speckled with brown. Tail greenish-gray at base, rest black, two outermost feathers tipped with white.

Genus LVIII.—RHODOPIS.

Rhodopis, REICH., Aufz. der Colib., p. 13 (1853).

TYPE.

O. vesper, LESS.

Ch. Bill nearly twice as long as the head, curved for its entire length, and wide at base. Frontal feathers projecting on to the culmen hiding the nostrils. Wings long, reaching beyond the middle of tail. Tail very deeply forked, feathers graduated to their tips, which are pointed. Tarsi clothed. Sexes similar.

Range. Peru and Chili.

The species of this genus are of large size comparatively, with deeply forked tails, and narrow rectrices. Throat of brilliant hues.

Key to the species.

- | | |
|--|----------------------------|
| A. Size large. Throat metallic-amethyst in centre, purplish-blue on sides. | 1. <i>R. vesper</i> . |
| B. Size small. Throat of a paler hue than that of <i>R. vesper</i> . | 2. <i>R. atacamensis</i> . |

1. *Rhodopis vesper*.

Ornismya vesper, LESS., Ois. Mouch., p. 85, pl. 19 (1829).—ID., Trochil., p. 33, pl. 6 (1831).—ID., Rev. Zool. (1838), p. 14.—D'ORB. and LAFRES., Syn. Av., ii, p. 28, sp. 10 (1838).

Calothorax vesper, GRAY, Gen. Birds, vol. i, p. 110, sp. 13.

Thaumastura vesper, BON., Compt. Rend., p. 383 (1850).—ID., Consp. Gen. Av. (1850), vol. i, p. 85.

Lucifer vesper, BON., Rev. and Mag. Zool. (1854), p. 257.

Rhodopis vesper, GOULD, Mon. Troch., vol. iii, pl. 154.—ID., Intr. Troch., octavo ed., p. 94 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 55 (note) (1860).—ELLIOT, Ibis (1877), p. 137.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 23 (1877).

Rhodopis vespera, REICH., Aufz. der Colib., p. 13 (1853).

Calliphlox vespera, REICH., Troch. Enum., p. 10 (1855).

Fig. 66.



Rhodopis vesper. ♂. Arequipa, Peru. Whitely.

Hab. Peru.

Male. Upper surface bronzy-green with a brownish shade. Rump rufous. Throat metallic amethystine-red changing to a purple-blue in certain lights. Under surface grayish-white, washed with green on the flanks. Median rectrices olive-green, lateral ones purplish-brown. Wings purplish-brown. Bill black. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $1\frac{3}{8}$ in.

Female. Upper parts like the male, but paler. Central tail feathers and bases of the lateral ones bronzy-green; those next the central ones tipped with black, rest with white tips and subterminal black bar. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{9}{16}$ in. Culmen, $1\frac{5}{16}$ in.

2. **Rhodopis atacamensis.*

Rhodopis atacamensis. LEYB., Ann. Univer. Santiago de Chili (1869), p.—MARTENS, Journ. für Ornith. (1875), p. 442.

Hab. Chili.

This bird is a small form of the *R. vesper*, with a paler colored throat. As the type is the only specimen I have seen, and is the only one that has been procured, so far as I know, it is difficult for me to say if it should really be considered as a distinct species.

Genus LIX.—HELIACTIN.

Heliactin. BOIE, Isis (1831), p. 546.

Heliactinia. REICH., Aufz. der Colib., p. 12 (1853).

Heliactinus. BURMEIST., Th. Bras., tom. ii, p. 356 (1854-56).

TYPE.

T. cornuta, Pr. Max.

T. cornuta, Pr. Max.

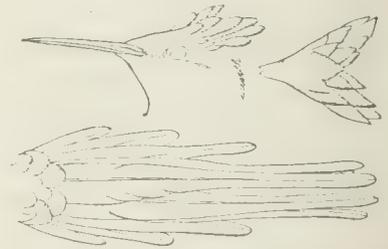
T. cornuta, Pr. Max.

Ch. Bill longer than the head, slender, terminating in a sharp point. On either side of head a tuft of feathers forming a short elevated crest. Wings long, pointed. Four median rectrices longest, broad at base, and graduating to a point. Tarsi bare. Sexes unlike.

Range. Brazil.

This is one of those aberrant forms that unfortunately are so frequently met with among the Trochilidæ. It is not in fact particularly related to any other genus, and the single species possesses characters not found elsewhere. I however place it here, which is probably not far from its rightful position.—The species is peculiar for the brilliant tufts on each side of the head.

Fig. 67.



Heliactin cornuta. ♂. Minas Gaeras, Brazil. Verdey.

1. *Heliactin cornuta.*

Trochilus cornutus. PR. MAX., Beit. zur Naturg. von Bras., p. 99.

Trochilus dilophus. VIEILL., Ency. Méth., vol. ii, p. 573.

Trochilus bilophus. TEMM., Plin. Col., pl. 18, fig. 3.—LESS., Man. Ornith., tom. ii, p. 76.

Mellisuga cornuta. GRAY, Gen. Birds, vol. i, p. 113, sp. 67.

Mellisuga bilopha, СТЕРН., Gen. Zool., vol. xiv, p. 251, pl. 30.

Ornismya chrysolopha, LESS., Ois. Mouch., p. 55, t. 7-8 (1829); Suppl., p. 162, t. 32 (1831).

Heliactin cornuta, BOIE, Isis (1831), p. 546.—GOULD, Mon. Troch., vol. iv, pl. 212.—ID., Intr. Troch., octavo ed., p. 120.—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 64.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 4 (1877).

Heliactin cornutus, BON., Consp. Gen. Av., p. 85 (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.

Heliactinia chrysolopha, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).

Heliactinus cornutus, BURM., Th. Bras., vol. ii, p. 356.

Hab. Brazil.

Male. Forehead and crown shining greenish-blue. Above the eyes a tuft of lengthened feathers, fiery-crimson at base changing to greenish-yellow at tip. Upper parts bronzy-green. Throat velvety-black. Flanks and abdomen bronzy-green. Rest of under parts pure white. Median rectrices olive-green, lateral ones white edged with olive-brown. Bill and feet black. Length, $4\frac{1}{4}$ in. Wing, 2 in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{1}{2}$ in.

Female. Upper surface and flanks bronzy-green. Throat and abdomen buffy-white. Median rectrices bronzy-green, lateral ones bronzy-green at base changing to black, apical half white. Bill black, feet brown.

We now come to various genera, whose species are peculiar for their strangely shaped tails, the feathers of which are generally narrow and pointed. In the next genus, CALOTHORAX, the members of which are small in size, the outer rectrix is shorter than the one next to it, and the four central rectrices are almost hidden beneath the upper tail coverts. The metallic hues are confined to the throat, and are very brilliant.

Genus LX.—CALOTHORAX.

Calothorax, GRAY, Gen. Birds (1840), p. 13.

Lucifer, REICH., Syn. Av. Natur., pl. 39 (1849).

Manilia, MULS. and VERR., Class. Troch. (1865), p. 86.

Cyanopogon, "REICH.," BON., Ann. Soc. Nat. (1854), p. 138.

TYPE.

C. lucifer, Swains.

C. lucifer, Swains.

C. pulchra, Gould.

C. lucifer, Swains.

Ch. Bill long, slender, curved throughout its length, broad at base; nostrils hidden by frontal plumes. Wings moderate, pointed. Tail forked, outermost rectrix on either side shortest, sometimes consisting of but little more than the shaft, the webs being extremely narrow. Tarsi short and partially clothed. Feet small. Sexes unlike.

Range. Mexico; abundant in the vicinity of Jalapa, Cordova, and Oaxaca.



Calothorax lucifer, ♂. Mexico. Whitely.

Key to the species.

A. Throat metallic lilaceous-purple.

- a. Outermost tail feather of uniform breadth like the other rectrices. 1. *C. pulchra*, Gould.
- b. Outermost tail feather filiform, almost bare of web, ending in a point. 2. *C. lucifer*, Swains.

1. *Calothorax pulchra*.

Calothorax pulchra, GOULD, Ann. Mag. Nat. Hist., 3d ser., vol. iv, p. 97.—ID., Mon. Troch., vol. iii, pl. 144.—ID., Intr. Troch., octavo ed., p. 91 (1861).

Manilia pulchra, MELS., Cat. Ois. Mouch. (1875), p. 30.—ID., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 30.

Hab. Oaxaca, Mexico.

Male. Upper surface bronzy-green. Wings purplish-black. Throat metallic lilaceous-purple, feathers elongated on the sides. Flanks bronzy-green. Breast, centre of abdomen, and under tail coverts white. Tail dark purplish-brown, feathers of uniform width. Bill black. Total length, $3\frac{1}{8}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female. Top of head dull brown; rest of upper surface bronzy-green. Lores black. Under surface deep buff. Median rectrices bronze-green; next on either side green tipped with black; remainder buff at base, then crossed by a black bar, and the tips white. Bill black. Wings purplish-brown. Total length, 3 in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

2. *Calothorax lucifer*.

Cyanthus lucifer, SWAINS., Phil. Mag. (1827), p. 442.

Ornismya cyanopogon, LESS., Ois. Mouch., p. 50, pl. 5 (1829).—ID., Supp., pp. 117, 119, pls. 9, 10.

Trochilus simplex, LESS., Trait. Orn., p. 291 (1831).—ID., Hist. Nat. Colib., p. 86, pl. 23, ♀.

Calothorax lucifer, GRAY, Gen. Birds, vol. i, p. 110.—BON., Consp. Gen. Av. (1850), vol. i, p. 85.—CAB. and HEIN., Mus. Hein. Th., iii, p. 55 (1860).—MELS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 26.

Calothorax cyanopogon, GRAY, Gen. Birds (1840), p. 13.—GOULD, Mon. Troch., vol. iii, pl. 143.—ID., Intr. Troch., octavo ed., p. 90 (1861).

Lucifer cyanopogon, REICH., Anz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 10 (1855).—BON., Rev. and Mag. Zool. (1854), p. 257.

Hab. Jalapa and Cordova, Mexico.

Male. A little larger in size than the *C. pulchra*, but in the color of its plumage almost precisely like that species. It can always be distinguished by the outermost rectrices, which are filiform in shape, almost denuded of webs and pointed. Total length, $3\frac{1}{4}$ in. Wing, $\frac{1}{2}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female like that of *C. pulchra*, except the tail, which has the lateral feathers greenish at base instead of buff, then black and tipped with white. Bill black. Total length, 3 in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

The members of the next genus *ACESTRURA* are even smaller than those of the last, and the males have equally brilliant throats. Their tails are very singular, the two outermost rectrices being filamentous, the shafts having hardly any webs attached; the one next to these is the longest, rather broad at base and pointed at tip; and the two middle ones are very short, projecting but a short distance beyond the coverts. The tail of the female is entirely different, being rounded and the feathers rather broad and even.

Genus LXI.—ACESTRURA.

Acestrura, GOULD, Intr. Troch., octavo ed., p. 91 (1861).
Polymnia, MULS. and VERR., Class. Troch. (1865), p. 91.
Myrmia, MULS., Cat. Ois. Mouch. (1875), p. 32.

TYPE.
O. mulsanti, Bourc.
O. mulsanti, Bourc.
C. micrurus, Gould.

Ch. Bill longer than the head, slightly arched. Median rectrices very short; the two outer ones filamentous and shorter than the third. Wings small; tarsi clothed; feet small. Sexes unlike.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

Fig. 69.

*Acestrura mulsanti*, ♂. Rio Napo. Whitely.*Key to the species.*

- | | |
|--|---------------------------------|
| A. Throat luminous, violet-red. | |
| a. Feathers of the neck not prolonged. | |
| a'. Breast and abdomen white. | 1. <i>O. mulsanti</i> , Bourc. |
| b'. Breast gray, abdomen green. | 2. <i>C. decoratus</i> , Gould. |
| b. Feathers of the neck elongated, abdomen and flanks green. | 3. <i>O. heliodori</i> , Bourc. |
| B. Throat metallic-amethyst; under surface buff. | 4. <i>C. micrura</i> , Gould. |

1. *Acestrura mulsanti*.

Ornismya mulsanti, BOURC., Ann. Sci. Phys., Lyon (1842), tom. v, p. 342, pl. xx.
Ornismya cyanopogon, D'ORB. and LAFRES. (nec LESS., 1829), Syn. Av., ii, p. 28, sp. 9 (1838).
Mellisuga mulsanti, GRAY, Gen. Birds, vol. i, p. 113, sp. 63.
Calothorax mulsanti, BON., Consp. Gen. Av. (1850), vol. i, p. 85.—ID., Rev. and Mag. Zool. (1854), p. 257.—REICH., Aufz. der Colib., p. 13 (1853).—GOULD, Mon. Troch., vol. iii, pl. 145
Lucifer mulsanti, REICH., Troch. Enum., p. 10 (1855).
Acestrura mulsanti, GOULD, Intr. Troch., octavo ed., p. 91.—ELLIOT, Ibis (1877), p. 136.
Chætocercus mulsanti, CAB. and HEIN., Mus. Hein. Th., iii, p. 60 (1860).
Acestrura mulsanti, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 118 (1877).

Hab. Columbia, Ecuador, and Peru.

Male. Upper surface and flanks shining dark grass-green. Wings dark purple. Throat metallic violet-red. Line behind the eye, chin, breast, abdomen, under tail coverts, and a tuft behind the thigh pure white. Tail purplish-black. Bill black. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Above bronzy-green. Throat white; a patch of dark green on the sides of the neck. Flanks dark green. Rest of under parts reddish-buff. Tail reddish-buff with a subterminal black bar. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{11}{16}$ in.

2. **Acestrura decorata*.

Calothorax decoratus, GOULD, P. Z. S. (1860), p. 309.—ID., Mon. Troch., vol. iii, pl. 146.
Acestrura decorata, GOULD, Intr. Troch., octavo ed., p. 91.

Hab. Columbia?

Precisely like the following species (*A. heliodori*); but the feathers of the throat are not prolonged at the sides as in that bird. The present is at best but very questionably distinct, being most probably a specimen of the *A. heliodori* with the throat feathers not fully developed, examples of which are not infrequently met with, both in this and other genera having species with elongated gorgets.

3. *Acestrura heliodori*.

Ornismya heliodori, BOURC., Rev. Zool. (1840), p. 275.—ID., Ann. Sci. Phys., Lyon, tom. v (1842), p. 308, pl. xv, ♂; pl. xvi, ♀.

Mellisuga heliodori, GRAY, Gen. Birds, vol. i, p. 113, sp. 66.

Calothorax heliodori, BON., Consp. Gen. Av. (1850), vol. i, p. 85.—REICH., Aufz. der Colib., p. 13 (1853).—GOULD, Mon. Troch., vol. iii, pl. 147.

Calothorax heliodorus, BON., Rev. and Mag. Zool. (1854), p. 257.

Lucifer heliodori, REICH., Troch. Enum., p. 10 (1855).

Chætocercus heliodori, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 60.

Acestrura heliodori, GOULD, Intr. Troch., octavo ed., p. 92 (1861).

Acestura heliodori, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 120 (1877).

Hab. Venezuela and Columbia.

Male. Upper surface, abdomen, and under tail coverts dark grass-green. Throat metallic violet-red, feathers elongated on the sides. Breast grayish-white. A patch of white on the flanks near the thighs. Vent white. Tail brownish-black. Bill black. Total length, $2\frac{2}{3}$ in. Wing, $1\frac{1}{3}$ in. Tail, 1 in. Culmen, $\frac{1}{2}$ in.

Female. Above bronzy-green. Lores and ear coverts dark brown. Under surface deep buff. Tail deep buff, with a subterminal black bar. Bill black. Total length, $2\frac{1}{4}$ in. Wing, $1\frac{1}{4}$ in. Tail, $\frac{3}{4}$ in. Culmen, $\frac{1}{2}$ in.

4. **Acestrura micrura*.

Calothorax micrura, GOULD, P. Z. S. (1853), p. 109.—ID., Mon. Troch., vol. iii, pl. 148.

Acestrura micrura, GOULD, Intr. Troch., octavo ed., p. 92 (1861).

Myrmia micrura, MULS., Cat. Ois. Mouch. (1875), p. 32.—ID., Hist. Nat. Ois. Mouch., tom. iv, p. 113 (1877).

Hab. Bolivia.

Male. Upper surface bronze-green. Chin, sides of the throat, and under surface buff. Throat metallic-amethyst. Under tail coverts white. Tail black. Bill black. Total length, $2\frac{3}{8}$ in. Wing, $1\frac{5}{16}$ in. Tail, $\frac{3}{8}$ in. Culmen, $1\frac{9}{16}$ in.

Female. Above bronze-green. Beneath buff. Tail black. Lateral rectrices tipped with white.

Genus LXII.—CHÆTOCERCUS.

Chætocercus, GRAY, Gen. Birds (1853), p. 22.

Osalia, MULS. and VERR., Class. Troch. (1865), p. 92.

Polyæmus, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 123 (1877).

TYPE.

O. jourdani, Bourc.

O. jourdani, Bourc.

C. bombus, Gould.

Ch. Bill long as the head, straight, slender; nostrils hidden in frontal plumes. Median rectrices extremely short; two next the outermost ones lengthened, equal, and uniform; outermost one, about half the length of the one next, filiform, graduating to a point, stiff. Sexes dissimilar in plumage.

Range. Island of Trinidad, Venezuela, Ecuador.

Three species are known, remarkable for their peculiarly shaped tails, a description of which is given above.



Key to the species.

- A. Throat metallic-lilac.
 B. Throat metallic-erimson.
 a. Breast white.
 b. Breast dark buff.

1. *O. jourdani*, Bourc.
 2. *T. rosæ*, Bourc.
 3. *C. bombus*, Gould.

1. *Chætocercus jourdani*.

Ornismya jourdani, Bourc., Rev. Zool. (1839), p. 295.—ID., Ann. Soc. Sci., Phys., etc., Lyon (1840), p. 227, pls. 5, 6.

Mellisuga jourdani, GRAY, Gen. Birds, vol. i, p. 113, sp. 65.

Calothorax jourdani, BON., Consp. Gen. Av. (1850), vol. i, p. 85.—REICH., Aufz. der Colib., p. 13.—BON., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 150.

Lucifer jourdani, REICH., Troch. Enum., p. 10 (1855).

Chætocercus jourdani, GRAY, Gen. and Subgen. Birds (1855), p. 22, no. 349.—GOULD, Intr. Troch., octavo ed., p. 92.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 125 (1877).

Osalia jourdani, MULS. and VERR., Class. Troch. (1865), p. 92.

Hub. Island of Trinidad.

Male. Upper parts and median rectrices, flanks and abdomen bronzy-green. Throat metallic-violet, beneath which is a band of white. Lateral rectrices purplish-brown, the lengthened ones with a buff central stripe at their base. Bill black. Total length, 2 $\frac{3}{8}$ in. Wing, 1 $\frac{3}{8}$ in. Tail, 1 in. Culmen, $\frac{3}{8}$ in.

Female. Upper parts and flanks golden-green. Median rectrices green, lateral ones buff, with a subterminal black bar. Under parts buffy-white. Description from the types in my collection.

2. *Chætocercus rosæ*.

Trochilus rosæ, Bourc. and MULS., Ann. Soc. Sci., Lyons, tom. ix (1846), p. 316.

Mellisuga rosæ, GRAY, Gen. Birds, vol. i, p. 113, sp. 64.

Calothorax rosæ, REICH., Aufz. der Colib., p. 13 (1853).—BON., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 149.

Lucifer rosæ, REICH., Troch. Enum., p. 10 (1855).

Chætocercus rosæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 60 (1860).—GOULD, Intr. Troch., octavo ed., p. 92.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 127 (1877).

Hub. Venezuela.

Male. In the general plumage of the body and tail, this species is exactly like the *C. jourdani*, but the throat is differently colored, being in the present bird rich metallic-erimson instead of lilac. Total length, 3 in. Wing, 1 $\frac{1}{2}$ in. Tail, 1 $\frac{1}{2}$ in. Culmen, $\frac{3}{16}$ in.

Female. Precisely like that of *C. jourdani*. Total length, $2\frac{1}{2}$ in. Wing, $1\frac{3}{16}$ in. Tail, $\frac{1}{6}$ in. Culmen, $\frac{7}{16}$ in. The above descriptions are taken from the types in my collection.

3. *Chaetocercus bombus*.

Chaetocercus bombus, GOULD, P. Z. S. (1870), p. 804.

Polyxenus bombus, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 123 (1877).

Hab. Citado in Ecuador.

Male. Upper parts and abdomen dark bronze-green. Throat metallic-crimson, beneath which is a broad buff band, that extends on to the sides of the neck. Tail purplish-black, inner web of third rectrices margined with buff at the base. Bill black. Total length, $2\frac{1}{2}$ in. Wing, 1 in. Tail, $\frac{3}{4}$ in. Culmen, $\frac{9}{16}$ in.

Female. Above green, beneath deep buff. Tail deep buff with a subterminal black bar. Bill black. Total length, $2\frac{3}{8}$ in. Wing, $1\frac{3}{16}$ in. Tail, $\frac{1}{6}$ in. Culmen, $\frac{1}{2}$ in. (Typical examples.)

Genus LXIII.—THAUMASTURA.

Phaetornis, TSCHUD. (nec SWAINS., 1827), Consp., p. 37 (1844).

Thaumastura, BON., Consp. Gen. Av. (1850), vol. i, p. 85 (nec Compt. Rend., p. 383, 1850).

Cora, "REICH.", BON., Ann. Sc. Nat. (1854), p. 138.

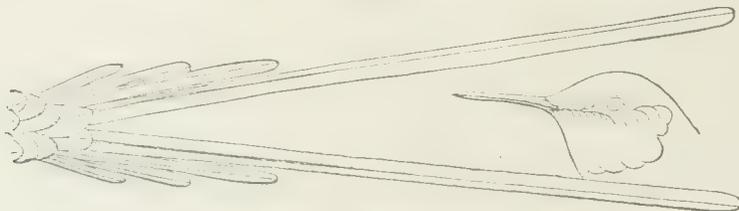
TYPE.

O. cora, Less.

O. cora, Less.

O. cora, Less.?

Fig. 71.



Thaumastura cora. ♂. Islay, Peru. Whitely.

Ch. Bill short, straight, wide at base. Wings long. Tarsi partially clothed. Middle pair of rectrices almost hidden in coverts, next on either side greatly elongated and longest, remainder much shorter and decreasing in length to the outermost one. All are very narrow, but of uniform width for their entire length.

Range. Peru.

One species only is known, small in size, with a strangely shaped tail as described above; a brilliant throat, and green and white plumage. The male, as is the case in all these genera, is the only sex adorned with metallic colors, the female being plainly dressed, and with a short tail of moderately broad feathers.

This genus was established by Bonaparte in the Comptes Rendus for 1850, giving as his types the *O. vesper*, Less., and the *O. fanny*, Less.; the *O. cora*, Less., not being mentioned. In the Conspectus Avium of the same year, however, he places the latter species, together with those given in the Comptes Rendus, in his genus

THAUMASTURA. As both *O. vesper* and *O. funny* became subsequently the types of other genera, the *O. cora* is left to represent THAUMASTURA, BON., although it was not originally intended as the type.

1. *Thaumastura cora*.

Ornismya cora, LESS. and GARN., Voy. de la Coq., pl. 13, fig. 4.—LESS., Ois. Mouch., p. 52, pl. 6 (1829).—ID., Trochil., pp. 109, 111, pls. 39, 40 (1831).—D'ORB. and LAFRES., Syn. Av., ii, p. 31, sp. 25 (1838).

Trochilus (Phætornis) cora, TSCHUD., Consp., p. 37.—ID., Faun. Per., p. 245 (1844).

Calothorax cora, GRAY, Gen. Birds, vol. i, p. 110, sp. 6.

Thaumastura cora, BON., Consp. Gen. Av. (1850), vol. i, p. 85.—ID., Rev. and Mag. Zool. (1854), p. 257.—REICH., Aufz. der Colib., p. 13 (1853).—GOULD, Mon. Troch., vol. iii, pl. 153.—ID., Intr. Troch., octavo ed., p. 93 (1861).—CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 58.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 8 (1877).

Lucifer coræ, REICH., Troch. Enum., p. 10 (1855).

Hab. Peru.

Male. Upper surface golden-green. Throat metallic-crimson with blue reflections. Flanks washed with green. Rest of under parts white. Tail black on outer web, white on inner nearly to the tip. Bill black. Total length, $5\frac{7}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $3\frac{7}{8}$ in. Culmen, $\frac{7}{16}$ in.

Female. Head gray-green. Upper parts bronzy-green. Under parts buffy-white. Middle tail feathers green on inner web, white on outer and tipped with black; lateral ones white, with a broad subterminal black band. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{3}{16}$ in. Culmen, $\frac{1}{2}$ in.

As now constituted, the next genus DORICHA, comprises species of very different forms so far as their tails are concerned. The one I have placed first, the *D. enicura*, has similarly shaped rectrices to those of THAUMASTURA CORA; the *D. elizæ* has moderately long, broad tail feathers, while the remaining species have narrow rectrices, all of which are about equal in length, while those of the first two mentioned are of different lengths. Although many genera of this Family have been made on far less important difference than these, yet I believe it is the proper course to keep them all in one genus, for in every other respect they are closely related. They are all small birds, and the males have luminous throats.

Genus LXIV.—DORICHA.

Doricha, REICH., Aufz. der Colib. (1853), p. 12.

Elisa, "REICH.," BON., Ann. Sc. Nat. (1854), p. 138.

Myrtis, CAB. and HEIN. (nec REICH., 1853), Mus. Hein. Th., iii, p. 59 (1860).

Dolicha, HEINE, Journ. für Ornith. (1863), p. 208.

Amathusia, MULS. and VERR., Class. Troch. (1865), p. 85.

Egolia, MULS. and VERR., Class. Troch. (1865), p. 86.

Amalasia, MULS., Cat. Ois. Mouch. (1875), p. 29.

Amalusia, MULS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 15.

TYPE.

T. enicurus, Vieill.

T. elizæ, Less.?

T. enicura, Vieill.

T. elizæ, Less.?

T. enicura, Vieill.

T. evelynæ, Bourc.

T. enicura, Vieill.

T. enicura, Vieill.

Ch. Bill longer than the head, slender, curved for its whole length. Wings moderate. Tail long, median feathers nearly hidden in their coverts, two outer ones generally nearly equal and longest. Feet small. Sexes dissimilar.

Range. Bahamas, Mexico, Guatemala, Costa Rica, and Veragua.

Five species are known.

Key to the species.

- | | |
|---|-----------------------|
| A. Throat metallic-purple. Two outer rectrices lengthened, purplish-black. | 1. <i>D. enicura.</i> |
| B. Throat metallic violaceous-crimson. Three outer rectrices lengthened purplish-black, margined with buff on inner webs. | 2. <i>D. elizæ.</i> |
| C. Throat metallic-crimson. Inner webs of rectrices margined with buff. | 3. <i>D. bryanlæ.</i> |
| D. Throat metallic purplish-violet. Inner webs of rectrices bright buff. | 4. <i>D. evelynæ.</i> |
| E. Throat and forehead metallic purplish-violet. Tail slightly forked, external feathers curving outwards. | 5. <i>D. lyruræ.</i> |

1. *Doricha enicura.*

Trochilus enicurus, VIEILL., Nouv. Dict. Hist. Nat. (1817), tom. 23, p. 429.—ID., Ency. Méth., tom. ii, p. 560.—TEMM., Plin. Col., no. 66, fig. 3.

Ornismya heteropygia, LESS., Ois. Mouch., p. 72, pl. 15 (1829).

Trochilus swainsoni, LESS., Trochil., p. 167, pl. 66, ♀ (1831).

Calothorax enicura, GRAY, Gen. Birds, vol. i, p. 110.—BON., Consp. Gen. Av. (1850), vol. i, p. 85.

Doricha henicura, REICH., Aufz. der Colib., p. 12 (1853).

Lucifer enicurus, BON., Rev. and Mag. Zool. (1854), p. 257.

Calliphlox henicura, REICH., Trochil. Enum., p. 10 (1855).

Thaumastura enicura, GOULD, Mon. Troch., vol. iii, pl. 157.

Myrtis enicura, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 59.

Doricha enicura, GOULD, Intr. Troch., octavo ed., p. 95 (1861).

Amalasia enicura, MULS., Cat. Ois. Mouch. (1875), p. 29.

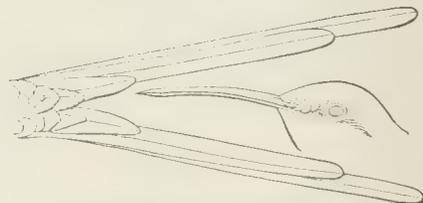
Amalusia enicura, MULS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 16.

Hab. Guatemala.

Male. Upper parts and flanks dark grass-green. Chin black. Throat metallic dark purple. Breast deep buff. Centre of abdomen dark gray. Lateral rectrices purplish-black, inner webs of two outer feathers narrowly margined with buff. Median rectrices shining grass-green. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $1\frac{3}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{3}{16}$ in.

Female. Upper surface and four central tail feathers bronzy-green. Lores and ear coverts blackish-brown. Under surface deep buff. Tail feather next the middle ones rufous at base, then green with a black tip, two outer ones rufous at base, then black with white tips. Bill black. Total length, 3 in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{16}$ in.

Fig. 72.



Doricha enicura. ♂. Guatemala. Verdey.

2. Doricha elizæ.

Trochilus eliza, LESS. et DELATRE., Rev. Zool. (1839), p. 20.

Myrtis eliza, REICH., Aufz. der Colib., p. 13 (1853).

Lucifer eliza, BON., Rev. and Mag. Zool. (1854), p. 257.—REICH., Troch. Enum., p. 10 (1855).

Calothorax eliza, GRAY, Gen. Birds, vol. i, p. 110.

Thaumastura elizæ, GOULD, Mon. Troch., vol. iii, pl. 155.

Doricha elizæ, GOULD, Intr. Troch., octavo ed., p. 94 (1861).

Amalasia elizæ, MULS., Cat. Ois. Mouch. (1875), p. 29.

Amalasia elizæ, MULS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 20.

Hab. Mexico, vicinity of Jalapa and Cordova.

Male. Upper parts and flanks bronzy yellowish-green. Throat metallic violaceous-crimson. Breast, centre of abdomen, and under tail coverts white. Upper tail coverts shining green. Middle tail feathers green on inner webs, buff on outer. Lateral feathers which are lengthened purplish-black, two next the outermost, margined with buff on the inner webs. Bill black. Total length, $3\frac{2}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Head brown, upper surface golden-green. Wings purplish-brown. Under parts white tinged with buff. Median rectrices green; next green edged with buff and tipped with black, remainder buff at base then black and tipped with white. Bill black.

3. Doricha bryantæ.

Doricha bryantæ, LAWR., Ann. N. Y. Lyc. Nat. Hist. (1867), vol. viii, p. 483.—MULS., Hist. Nat. Ois. Mouch., tom. iv (1877), p. 42.

Hab. Costa Rica.

Male. Upper surface dark grass-green. Throat metallic-crimson. Breast grayish-white, flanks and lower portion of breast dull green; abdomen rufous. Under tail feathers green margined with rufous. Tail purplish-black, the rectrices margined on their inner webs with rufous. Bill black. Iris dark brown. Total length, 4 in. Wing, $1\frac{11}{16}$ in. Tail, $1\frac{1}{2}$ in. Bill, $\frac{7}{8}$ in.

Female. Above dull dark green. Sides of neck and upper parts of flanks dark green. Throat and breast pale buff. Abdomen and crissum rufous. Middle tail feathers grass-green, next rufous at base, with the terminal half purplish-black; remaining rectrices rufous with a broad purplish-black band across the central portion. Bill black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{5}{8}$ in. Tail 1 in. Culmen, $\frac{7}{8}$ in.

4. Doricha evelynæ.

Trochilus evelynæ, BOURC., P. Z. S. (1847), p. 44.

Calothorax evelynæ, GRAY, Gen. Birds, vol. i, p. 110.—REICH., Aufz. der Colib., p. 13 (1853).—GOULD, Mon. Troch., vol. iii, pl. 156.

Lucifer evelinæ, REICH., Troch. Enum., p. 10.

Calothorax evillina, BON., Rev. and Mag. Zool. (1854), p. 257.

Trochilus bahamensis, BRYANT, Proc. Nat. Hist. Soc. Bost. (1859), vol. vii, p. 106.

Doricha evelynæ, GOULD, Intr. Troch., octavo ed., p. 95 (1861).—ELLIOT, Ibis (1872), p. 353.—MULS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 38.

Hab. Islands of Nassau and New Providence of the Bahamas.

Male. Above golden-green. Throat metallic purplish-violet. Breast white. Abdomen green mingled with rufous. Under tail coverts buffy-white. Median rectrices purple, the inner web of all but that of the external feather cinnamon. Bill black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female. Above greenish-gray. Throat buffy-white. Abdomen and under tail coverts rufous. Middle tail feathers bronzy-green, lateral feathers rufous with a subterminal black band, beneath which there is a green gloss on the outer webs. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, 1 in. Culmen, $\frac{5}{8}$ in.

5. *Doricha lyrura*.

Doricha lyrura, GOULD, Ann. Mag. Nat. Hist., 4th ser. (1869), vol. iv, pp. 111, 112.—ELLIOT, Ibis (1872), p. 354.—MULS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 41.

Hab. Islands of Inagua, and Long Island of the Bahamas.

Male. Forehead and throat metallic purplish-violet. Upper surface dull grass-green. A band of white across the breast, rest of under parts rufous, except vent which is white. Tail lyre-shaped, feathers turning outward at the tips, purplish-black, all the feathers except middle and outermost ones having their inner web rufous. Bill black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{1}{2}$ in.

Female. Upper parts pale brownish, glossed with metallic-green. Throat and breast white; rest of under parts pale rufous. Tail rounded. Median pair of rectrices shining grass-green; remainder buff with a broad black central band. The feather next the central pair on either side has a shining grass-green gloss on the outer web beneath the black. Wings purple. Bill and feet black. Total length, $3\frac{1}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Genus LXV.—MYRTIS.

Myrtis, REICH., Aufz. der Colib., p. 13 (1853).

Zephyritis, MULS. and VERR., Class. Troch. (1865), p. 87.

Eudosia, MULS., Cat. Ois. Mouch. (1875), p. 32 (*nee* p. 20).

Eulidia, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 114 (1877).

TYPE.

O. fanny, LESS.

O. fanny, LESS.

T. yarrelli, BOURC.

T. yarrelli, BOURC.

Ch. Bill longer than the head, curved for its entire length. Wings rather long, reaching half the length of the tail. Median rectrices extremely short, almost hidden in the coverts; the four lateral ones long.

Range. Ecuador, Peru, and Bolivia.

Two species are known, of small size, with peculiarly shaped tails in the males, and brilliant throat marks.

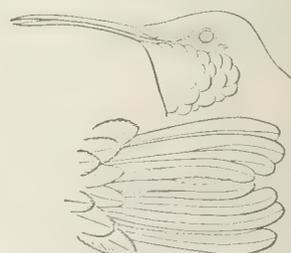


Fig. 73.

Myrtis fanniæ. ♂. Tiuta, Peru. Whately.

Key to the species.

- | | |
|---|-------------------------|
| A. Throat metallic-green bordered by violet; four lateral rectrices uniform in width. | 1. <i>M. fanniæ</i> . |
| B. Throat metallic-lilac with blue reflections. Three lateral rectrices narrow and pointed. | 2. <i>M. yarrelli</i> . |

1. *Myrtis fanny*.

- Ornismya fanny*, LESS., Ann. Sci. Nat. (1838), tom. ix, p. 170.—ID., Rev. Zool. (1838), p. 314.
Trochilus labrador, BOURC., Ann. Soc. Sci., Lyon (1839), p. 389, pl. viii.—DELATTE., Rev. Zool. (1846), p. 311.
Calothorax fanny, GRAY, Gen. Birds, vol. i, p. 110, sp. 14.—GOULD, Mon. Troch., vol. iii, pl. 151.
Thaumastura fanny, BON., Compt. Rend., p. 383 (1850).—ID., Consp. Gen. Av. (1850), vol. i, p. 85.
Myrtis fanny, REICH., Aufz. der Colibri., p. 13 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 59 (1860).—
 GOULD, Intr. Troch., octavo ed., p. 93 (1861).—MULS., Hist. Nat. Ois. Mouch. (1877), tom. iv, p. 33.
Lucifer labrador, BON., Rev. and Mag. Zool. (1854), p. 257.—REICH., Troch. Enum., p. 10 (1855).

Hab. Ecuador and Peru.

Male. Upper parts light bronze-green; brownish on top of the head. Throat metallic bluish-green, bounded beneath by a narrow line of luminous violet. A white band across the breast; flanks bronzy, washed with buff on lower half, rest of under parts white. Tail brownish-black with a bronze gloss. Wings brown. Bill black. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{2}{3}$ in. Type of *T. labrador*, Bourc.

Female. Above like the male. Throat white, rest of under parts deep buff. Median rectrices green; next green tipped with black. Lateral ones, buff at base, rest black tipped with white. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, 1 in. Culmen, $\frac{3}{4}$ in. Type of *T. labrador*, Bourc., in my collection.

2. *Myrtis yarrelli*.

- Trochilus yarrelli*, BOURC., P. Z. S. (1846), p. 45.
Calothorax yarrelli, REICH., Aufz. der Colib., p. 13 (1853).—GOULD, Mon. Troch., vol. iii, pl. 152.
Calothorax yarrelli, BON., Rev. and Mag. Zool. (1854), p. 257.
Lucifer yarrelli, REICH., Troch. Enum., p. 10 (1855).
Myrtis yarrelli, GOULD, Intr. Troch., octavo ed., p. 93 (1861).
Eudisia yarrelli, MULS., Cat. Ois. Mouch. (1875), p. 32.
Eulidia yarrelli, MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 115 (1877).

Hab. Bolivia.

Male. Upper parts and four central tail feathers light yellowish-green. Throat metallic-lilac with blue reflections. Under parts white, washed with green on the flanks. Lateral tail feathers, which are stiff and narrow, and graduate to a point, dark brown. Bill black. Total length, $2\frac{7}{8}$ in. Wing, $1\frac{3}{16}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Above like the male, beneath buffy-white. Middle tail feathers green, next green with black tips, remainder buff at the base, then black and tipped with white. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, 1 in. Culmen, $\frac{7}{16}$ in.

Descriptions taken from Bourcier's specimens, now in my collection, which were the types of Mr. Gould's plate in his Monograph.

Genus LXVI.—TILMATURA.

Tilmatura, REICH., Aufz. der Colib., p. 8 (1853).
Tryphæna, GOULD, Intr. Troch., octavo ed., p. 96 (1861).

TYPE.
O. duponti, Less.
O. duponti, Less.

Ch. Bill as long as the head, straight. Wings rather short. Tail deeply forked, outermost feather tapering rapidly at the tip, and curved inwards. Feet small. Sexes dissimilar.

Range. Restricted to Guatemala.

But one species is known, remarkable for the very unusual style of coloration exhibited on the tail feathers of the male. In this respect it is totally unlike all other members of the Trochilidæ.

Fig. 74.

*Tilmatura duponti*, ♂. Guatemala. Gould.1. *Tilmatura duponti*.

Ornismya duponti, LESS., Ois. Mouch. Supp., p. 100, pl. 1 (1829).

Ornismya cælestis, LESS., Trait. Ornith. (1831), p. 276.

Ornismya zemès, LESS., Rev. Zool. (1838), p. 315.

Mellisuga duponti, GRAY, Gen. Birds, vol. i, p. 113, sp. 71.

Tryphæna duponti, BON., Consp. Gen. Av., p. 84 (1850).—GOULD, Mon. Troch., vol. iii, pl. 158.—ID., Intr. Troch., octavo ed., p. 97.

Tilmatura lepida, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 711, figs. 4610-14.

Thaumastura duponti, BON., Rev. and Mag. Zool. (1854), p. 257.

Trochilus duponti, JARD., Nat. Lib. Humming-birds, vol. i, p. 131, pl. 26.

Tilmatura duponti, CAB. and HEIN., Mus. Hein. Th., iii, p. 59 (note) (1860).—MULS., Cat. Ois. Mouch. (1875), p. 28.—ID., Hist. Nat. Ois. Mouch., tom. iv, p. 11 (1877).

Hab. Guatemala.

Male. Upper parts dark green, with a white spot on each side of the rump. Throat deep blue. Across the breast a band of white; rest of under surface and crissum green. Median rectrices short, shining green, next one dark brown, the next dark brown with a white spot on inner web, and white tip. Remainder dark brown at base, then a band of rufous, then one of white succeeded by another of dark brown, and tip white. Bill black. Total length, 4 in. Wing, 1½ in. Tail, 2 in. Culmen, ⅝ in.

Female. Upper surface bronzy-green with two buffy-white patches on each side of the rump. Under surface deep buff, with an indistinct band of white across the breast, and vent white. Middle tail feathers green, rest green at base, remaining part black tipped with white. Bill black. Total length, 2¾ in. Tail, ⅞ in. Wing, 1⅓ in. Culmen ⅝ in.

Genus LXVII.—SMARAGDOCHRYSIS.

Smaragdochrysis, GOULD, Intr. Troch., octavo ed., p. 180 (1861).

TYPE.

C. iridescens, Gould.

Ch. “Bill longer than the head, straight and slender; wings small, primaries narrow and rigid; tail of moderate size and deeply forked; tarsi clothed; feet small; hind toe and nail nearly as long as the middle toe and nail.” (Gould, loc. cit.)

Range. Brazil.

One species only is known, and together with that of the succeeding genus, with which it is closely allied, leads on naturally to CALLIPHLOX.

Fig. 75.



Smaragdochrysis iridescens. ♂. Type. Brazil. Gould.

1. *Smaragdochrysis iridescens*.

Calliphlox? *iridescens*. GOULD, P. Z. S. (1860), p. 310.

Smaragdochrysis iridescens, GOULD, Mon. Troch., vol. v, pl. 359.—ID., Intr. Troch., octavo ed., p. 181.

Hab. Brazil.

“The whole of the body including the upper and under tail coverts iridescent pale green and light coppery-red, most brilliant on the throat; the deeply forked tail steely dark brown, each feather tipped with a more bronzy or purplish hue, which is seen only in certain lights; upper mandible and the tip of the lower one black, the remainder of the latter apparently reddish flesh-color. Total length, $3\frac{1}{4}$ in. Bill $\frac{3}{4}$ in. Wing, $1\frac{9}{16}$ in. Tail $1\frac{1}{4}$ in.” (Gould, l. c.)

Genus LXVIII.—PTOCHOPTERA.

Ptochoptera, ELLIOT, Ibis (1874), p. 261.

TYPE.

T. iolama. Pelz.

Ch. Bill moderately long, straight, sharply pointed. Wings extremely short, a little over one-third the entire length of the bird. Tail long, deeply forked, feathers narrow, outer ones curving slightly inwards. Tail coverts very long, reaching to the fork of the tail.

Range. Brazil.

The single known species, like that of SMARAGDOCHRYSIS, is a small bird, of rather plain plumage, but with a brilliant throat. The females of both genera are entirely unknown.

Fig. 76.



Ptochoptera iolama. ♂. Type. Brazil. Natterer.

1. **Ptochoptera iolæma*.

Riccordia iolæma, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum. p. 4, pl. 705, figs. 4588–89.
Thalurania iolæma, VON PELZ., Ornith. Bras., p. 57.—SALV. and ELLIOT, Ibis (1873), p. 361.
Ptochoptera iolæma, ELLIOT, Ibis (1874), p. 261.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 89.

Hab. Brazil.

Male. Top of head and nape dull dark green, entire upper parts grass-green, only slightly metallic. The tail coverts are a lighter green than the back, and reach to the fork of the tail. Throat pale metallic grass-green. Rest of under parts pale smoky-brown, with some of the flank feathers tipped with grass-green. Under tail coverts long, same color as the abdomen, with a slight metallic-greenish lustre on the centre of the feathers. Tail long, deeply forked, dark purplish-brown, feathers very narrow. Wings purplish-brown. Bill and feet black. Total length, $4\frac{3}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, 2 in. Bill along gape, $\frac{3}{4}$ in. From type of species in the Vienna Zoological Museum.

Genus LXIX.—CALLIPHLOX.

Calliphlox, BOIE, Isis (1831), p. 544.
Philodice, MULS. and VERR., Class. Troch. (1865), p. 86.

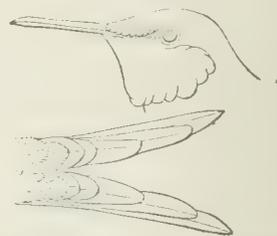
TYPE.
T. amethystinus, Gmel.
T. mitchelli, Bourc.

Ch. Bill shorter than the head, straight, slightly curved at extreme tip. Wings moderate. Tail rather long, deeply forked, feathers narrow. Sexes unlike.

Range. Venezuela, island of Trinidad, Brazil, and Ecuador.

Two species are known; similar in form to those of the preceding genera, with rather dull metallic throats, not luminous in any light.

Fig. 77.

*Calliphlox amethystina*. ♂. Brazil. Whitely.*Key to the species.*

- A. Tail long and deeply forked.
 a. Throat metallic-amethyst.
 b. Throat metallic dark violet.

1. *C. amethystina*.
 2. *C. mitchelli*.

1. *Calliphlox amethystina*.

Trochilus amethystinus, GMEL., Syst. Nat. (1788), vol. i, p. 496.—LATH., Ind. Orn., vol. i, p. 319 (1790).—SHAW, Gen. Zool., vol. iii, p. 328.—PR. MAX., Beitr. Natur. Bras., p. 90.
Mellisuga amethystina, STEPH., Gen. Zool., vol. xiv, p. 243.—GRAY, Gen. Birds, vol. i, p. 113, sp. 72.
Trochilus brevicauda, SPIX., Av. Bras., vol. i, p. 79, t. 80, fig. 2 (1825).
Ornismya amethystina, LESS., Ois. Mouch., p. 150, pl. 47 (1829).—ID., Suppl., pls. 20, 21, 22.
Ornismya amethystoides, LESS., Troch., p. 79, pl. 25, 26, 27 (1831).
Mellisuga amethystoides, GRAY, Gen. Birds, vol. i, p. 113, sp. 72.
Trochilus campestris, PR. MAX., Beit. Naturg. Bras., p. 73.
Tryphæna amethystina, BON., Consp. Gen. Av. (1850), vol. i, p. 84.—ID., Rev. and Mag. Zool. (1854), p. 257.
Tryphæna amethystoides, BON., Consp. Gen. Av. (1850), vol. i, p. 84.

Calliphlox amethystina, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum. (1855), p. 10.—GOULD, Mon. Troch., vol. iii, pl. 159.—ID., Intr. Troch., octavo ed., p. 97.—CAB. and HEIN., Mus. Hein. Th., iii, p. 58 (1860).—ELLIOT, Ibis (1876), p. 398.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 45 (1877).

Calliphlox amethystoides, REICH., Aufz. der Colib. (1853), p. 12.—ID., Troch. Enum., p. 10 (1855).—BON., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Intr. Troch., octavo ed., p. 98.

Hab. Island of Trinidad, Venezuela, Brazil.

Male. Upper parts dark bronzy-green. Throat metallic-amethyst, beneath which is a band of white, flanks green, abdomen gray changing to buff on the lower part of the flanks and under tail coverts. Central tail feathers green, lateral ones purplish-brown. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{16}$ in.

Female. Upper parts golden-green, brownish on the head. Under parts pale gray, throat spotted with brown. Wings purplish-brown. Median rectrices bright metallic-green, lateral ones have basal half light purplish-gray, washed with green, remaining part black tipped with white. Bill black, feet brown. Total length, 3 in. Wing $1\frac{3}{4}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{1}{2}$ in.

2. *Calliphlox mitchelli*.

Trochilus mitchelli, BOURC., P. Z. S. (1847), p. 47.

Mellisuga mitchelli, GRAY, Gen. Birds, vol. i, p. 113, sp. 74.

Calothorax mitchelli, REICH., Aufz. der Colib., p. 13 (1853).

Lucifer mitchelli, REICH., Troch. Enum., p. 10 (1855).

Tryphana mitchelli, BON., Rev. and Mag. Zool. (1854), p. 257.

Calliphlox mitchelli, GOULD, Mon. Troch., vol. iii, pl. 160.—ID., Intr. Troch., octavo ed., p. 98 (1861).—ELLIOT, Ibis (1876), p. 399.—MULS., Hist. Nat. Ois. Mouch., tom. iv, p. 49 (1877).

Hab. Ecuador.

Male. Upper surface, abdomen, flanks, and under tail coverts dark grass-green. Throat dark metallic-violet. Breast grayish-white. A patch of buff on each side of the rump. Tail dark purple. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

Female. Upper parts dark green. Under parts buff, changing to rufous on the abdomen and under tail coverts. Lores and sides of neck blackish-brown. Middle tail feathers bronze-green, lateral ones rufous with a subterminal black bar. Bill black. Total length, $2\frac{5}{8}$ in. Wing, $1\frac{1}{2}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{1}{2}$ in.

Genus LXX.—LOPHORNIS.

Lophornis, LESS., Tab. Esp. Ois. Mouch., p. xxxvii (1829).

Bellatrix, BOIE, Isis, p. 545 (1831).

Lophorinus, BON., Rev. and Mag. Zool. (1854), p. 257.

Polemistria, CAB. and HEIN., Mus. Hein. Th., iii, p. 63 (note) (1860).

Telamon, MULS. and VERR., Class. Troch. (1865), p. 75.

Paphosia, MULS. and VERR., Class. Troch. (1865), p. 75.

Dialia, MULS., Catal. Ois. Mouch. (1875), p. 27.

Idas, MULS., Catal. Ois. Mouch., p. 27 (1875).

Aurinia, MULS., Catal. Ois. Mouch., p. 27 (1875).

TYPE.

T. ornatus, Bodd.

T. ornatus, Bodd.

O. delatirii, Less.

T. verreauxi, Bourc.

O. delatirii, Less.

O. helenæ, Delatt.

L. adorabilis, Salv.

T. magnificus, Vieill.

T. verreauxi, Bourc.

Ch. Head usually crested. Feathers of the sides of the throat more or less lengthened into ruffs, and projecting outwards. Tail rounded. Bill straight, short, weak. Sexes unlike in plumage.

Range. Central America, island of Trinidad, Guiana, Venezuela, Brazil, Columbia, and Ecuador.

This genus, as instituted by Lesson (l. c.), was a composite one. It contained as the first of its species, his *Ornismya nattereri* (= *T. superbus*, Vieill.), followed by *O. petasophora* (= *T. serrirostris*, Vieill.), *O. delalandi*, *O. cristata*, *O. ornata*, Linn., *O. strumaria* (= *T. magnificus*, Vieill.), and *O. vieillotii* (= *T. chalybeus*, Vieill.).

Of these, the first is the type of Mr. Gould's genus AUGASTES, the second is the type of PETASOPHORA, Gray, the third is the type of CEPHALLEPIS (CEPHALOLEPIS), Lodd., and the fourth is the type of BELLONA, Muls., leaving the two remaining species in Lesson's genus LOPHORNIS, of which his *Ornismya ornata* (*Trochilus ornatus*, Bodd.) may be considered as the type. The birds comprised in this genus seem best placed here, as from them through GOULDIA and DISCURA we arrive naturally at STEGANURA, LODDEGESIA, and the long-tail species commonly known as the blue-, and fire-tail Hummers.—Although the tails of the species of LOPHORNIS and GOULDIA are very different, yet there are points of resemblance between them in plumage, among which could be cited the conspicuous bar that crosses the rump. The *Coquettes*, as they are called, are small birds possessing a highly ornamented plumage, having elongated feathers springing from the sides of the neck with metallic tips. Some species are also adorned with crests, and all have metallic throats, with but two exceptions. Of course this is understood to imply only as regards the males. The females are differently attired.

Ten species are recognized as belonging to this genus; two very closely allied, viz., *L. delatirii* and *L. regulus*, and it may be well doubted if they really are distinct.

Key to the species.

A. Throat metallic-green.

a. No metallic colors on upper parts of the head.

a'. Crest spotted throughout its length.

b'. Crest unspotted.

a''. Crest tipped minutely with black.

b''. Crest conspicuously tipped with greenish-black.

b. Front covered with metallic-green feathers.

a'. Feathers of neck elongated, buff tipped with green.

b'. Feathers of neck elongated, white.

a''. Elongated feathers with round apical metallic-green spots.

b''. Elongated neck feathers with apical metallic-green bars.

c'. Feathers of neck elongated, buff streaked with black, or all black.

c. Front covered with metallic-red feathers; crown white.

Fig. 78.



Lophornis ornatus. ♂. Trinidad. Whately.

1. *L. stictolophus*.

2. *L. delatirii*.

3. *L. regulus*.

4. *L. ornatus*.

5. *L. gouldi*.

6. *L. magnificus*.

7. *L. helenæ*.

8. *L. adorabilis*.

B. Throat not metallic.

a. Elongated neck feathers green spotted with white.

a'. Under parts deep oil-green. Tail bronzy-brown.

9. *L. chalybea*.

b'. Under parts dark brown with bronzy-brown reflections. Tail purplish-bronze.

10. *L. verreauxi*.

1. *Lophornis stictolophus*.^o

Lophornis reginae, GOULD (nec SCHREIB.), P. Z. S. (1847), p. 97.—ID., Mon. Troch., vol. iii, pl. 122.—ID., Intr. Troch., octavo ed., p. 84 (1861).—BON., Consp. Gen. Av., vol. i, p. 84 (1850).—ID., Rev. and Mag. Zool. (1854), p. 257.

Bellatrix reginae, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).

Lophornis stictolophus, SALV. and ELLIOT, Ibis (1873), p. 280.

Telamon stictolophus, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 201 (1876).

Hab. Venezuela, Columbia, and Ecuador.

Male. Distinguished from all others of the genus by its crest, which is broad, rust-red in color, each feather tipped with a green spot; the spots commencing in the centre of the crown. Back shining green. Rump and upper tail coverts bronzy-brown; a white band across the rump. Throat metallic-green, beneath which is a spot of white. Under parts light shining green. Under tail coverts buff. Tail brownish-chestnut, external feathers margined and tipped with bronzy-green. Bill flesh-color, brown at tip. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Head not crested. Front and crown deep buff, occiput dark green. Rump bronzy-brown, crossed by a band of buff. Upper part of throat white spotted with blackish-brown, lower portion black with bronze reflections. Tail buff, with a broad subterminal blackish-brown band with bronzy-green reflections. Remaining plumage as in the male. Types in my collection.

2. *Lophornis delatirii*.

Ornismya (Lophornis) delatirii, LESS., Rev. Zool. (1839), p. 19.

Lophornis delatirii, GOULD, Mon. Troch., vol. iii, pl. 121.—ID., Intr. Troch., octavo ed., p. 84 (1861).—REICH., Aufz. der Colib., p. 12.—ID., Troch. Enum., p. —, (1855).—BON., Rev. and Mag. Zool. (1854), p. 257.—ID., Consp. Gen. Av., p. 83 (1850).

Mellisuga delatirii, GRAY, Gen. Birds, vol. i, p. 113.

Telamon delatirii, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 199 (1876).

Hab. Veragua, Panama, Columbia, Ecuador, Peru, and Bolivia.?

Male. Differs from the *L. stictolophus* simply in the form of its crest, which is rufous, lengthened, central feathers the longest, and tipped with minute green spots. Rest of plumage like *L. stictolophus*. Total length, $2\frac{1}{2}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{5}{16}$ in.

Female like that of *L. stictolophus*.

Young male has the forehead and throat rufous, rest like the female.

3. *Lophornis regulus*.

Trochilus (Lophornis) regulus, GOULD, P. Z. S. (1847), p. 89.—ID., Mon. Troch., vol. iii, pl. 120.—BON., Consp. Gen. Av., p. 84 (1850).

Mellisuga regulus, GRAY, Gen. Birds, vol. i, p. 113.

Lophornis lophotes, GOULD, Intr. Mon. Troch., octavo ed., p. 83 (1861).

Hab. Bolivia.

Male. Only differs from *L. delatirii* by having the crest conspicuously tipped with dark green spots, and a slightly longer bill. Total length, $2\frac{1}{2}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{16}$ in.

Female. Exactly like that of the *L. delatirii*.

The *L. lophotes*, Gould, is the same as *regulus* with still larger spangles on the tips of the crest feathers. It is most probable that all these three constitute but one species, which should be called *L. delatirii*.

4. *Lophornis ornatus*.

Trochilus ornatus, BODD., Plan. Enlum. d'Aubent, pl. 640, fig. 3 (1783).—GMEL., Syst. Nat. (1788), vol. i, p. 497.—LATH., Ind. Orn., vol. i (1790), p. 318.—SHAW., Gen. Zool. vol. viii., p. 345.—VIEILL., Ency. Méth., p. 565, sp. 64.

Ornismya ornata, LESS., Ois. Mouch., p. 139, pl. 41 (1829).—ID., Troch., p. 77, pl. 24, juv. (1831).

Mellisuga ornata, GRAY, Gen. Birds, vol. i, p. 13, sp. 84.—LÉOT., Ois. Trinid., p. 148.

Lophornis auratus, BON., Consp. Gen. Av., vol. i, p. 83 (1850).

Lophornis ornata, REICH., Aufz. der Colib., p. 12 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 62 (1860).

Lophornis ornatus, GOULD, Mon. Troch., vol. iii, pl. 117.—ID., Intr. Troch., octavo ed., p. 82 (1861).—BON., Rev. and Mag. Zool. (1854), p. 257.—ID., Consp. Gen. Av., p. 83, vol. i.—REICH., Aufz. der Colib., p. 12.—ID., Troch. Enum., p. 9.—LESS., Trait. Ornith., p. 285 (1831).—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 215.

Hab. Trinidad, Venezuela, and Guiana.

Male. Head and crest deep chestnut, unspotted. Forehead and throat metallic-green. On either side of neck, a series of lengthened graduated feathers, each one tipped with metallic-green. Under surface bronzy-green. Rest of plumage like *L. stictolophus*. Total length, $2\frac{9}{16}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Top of head, upper and under surface bronzy-green. Across the rump a band of buffy-white. Throat and upper part of breast buff. Rest of plumage like the female of *L. stictolophus*.

5. *Lophornis gouldi*.

Ornismya gouldi, LESS., Trochil., p. 103, pl. 36 (1831-33).

Lophornis reginæ, SCHREIB., Collect. Faun. Bras. (1833), pl. 1.

Bellatrix gouldi, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).

Lophornis gouldi, GOULD, Mon. Troch., vol. iii, pl. 118.—ID., Intr. Troch., octavo ed., p. 83 (1861).—BON., Consp. Gen. Av., vol. i, p. 83 (1850).—ID., Rev. and Mag. Zool. (1854), p. 257.—SALV. and ELLIOT, Ibis (1873), p. 279.—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 218 (1876).

Hab. Brazil, Amazonian valley—vicinity of Para.

Male. Head and crest chestnut-red. Forehead and throat metallic-green. Upper and under surface, and wing coverts bronzy-green. Rump chestnut-brown, crossed by a band of white. On either side of neck are lengthened graduated white feathers, each one with a round metallic-green spot at tip. Tail chestnut-red, feathers margined and tipped with bronzy-green. Bill flesh-color, tip brown. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{7}{16}$ in.

Female. Head and upper surface golden-green. Loes and throat buff. Median rectrices bronzy-green, lateral ones buff, with bronzy-green subterminal bar. Rest of plumage like the male, no elongated feathers on sides of the neck.

6. *Lophornis magnificus*.

- Trochilus magnificus*, VIEILL., Nouv. Dict. Hist. Nat. (1817), t. vii, p. 367, et t. xxiii, p. 428, pl. G, 36, fig. 3.
 —ID., Ois. Dor., tom. iii, pl. 8.—TEMM., Plan. Col., 229, fig. 2.—PR. MAX., Beit. Nat. Bras., p. 79.
Colibri helios, SPIX., Av. Bras., tom. i, p. 81, tab. 82, fig. 2 (1824).
Trochilus decorus, LICHT., Doubl., p. 14, no. 120.
Ornismya magnifica, LESS., Man. Ornith., tom. ii, p. 80.
Ornismya strumaria, LESS., Ois. Mouch., p. 143, pl. 42, ♂ (1829); pl. 43, fig. 1, ♀; fig. 2, ♂, juv.
Lophornis strumaria, LESS., Trait. Ornith., p. 285 (1831).
Mellisuga magnifica, GRAY, Gen. Birds, vol. i, p. 113, sp. 88.
Bellatrix magnifica, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).
Lophornis magnificus, GOULD, Mon. Troch., vol. iii, pl. 119.—ID., Intr. Troch., octavo ed., p. 83 (1861).—BON.,
 Consp. Gen. Av., vol. i, p. 83 (1850).—ID., Rev. and Mag. Zool. (1854), p. 257.
Lophornis magnifica, CAB. and HEIN., Mus. Hein. Th., iii, p. 62 (1860).
Telamon magnificus, GRAY, Handl.-B., p. 147, vol. i.
Idus magnificus, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 211 (1876).

Hab. Brazil.

Male. Precisely like the *L. gouldi*, except that the elongated neck feathers have the tip crossed by a bar of metallic-green, instead of a round spot. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{8}$ in.

Female like that of *L. gouldi*.

7. *Lophornis helenæ*.

- Ornismya helenæ*, DELATTR., Echo du Monde Savant. (1843), p. 1068.—ID., Rev. Zool. (1843), p. 133.
Mellisuga helenæ, GRAY, Gen. Birds, vol. i, p. 133.
Lophornis helenæ, REICH., Aufz. der Colib., p. 12.—ID., Troch. Enum., p. 9 (1855).—BON., Consp. Gen. Av. (1850), vol. i, p. 83.—ID., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 123.—ID., Intr. Troch., octavo ed., p. 84.
Paphosia helenæ, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 205 (1876).

Hab. Mexico, Guatemala, and Costa Rica.

Male. Top of head and crest dark shining green. From either side of the occiput spring three long, slender, greenish-black feathers. Back and wing coverts bronzy-green. Rump bronzy-brown, crossed by a narrow line of white. Throat metallic light green, surrounded by black, the feathers on the sides of the neck elongated and streaked with buff. Under surface white, each feather with a golden spot at the tip. Under tail coverts dark rufous. Median rectrices green, lateral ones deep rufous margined with dark brown. Bill flesh-color. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail $1\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

Female. Upper surface and abdomen bronzy-green. Throat white spotted with green. Tail deep buff, with a subterminal band of black. Middle rectrices dark green tipped with black.

8. *Lophornis adorabilis*.

- Lophornis adorabilis*, SALV., P. Z. S. (1870), p. 207.
Dialia adorabilis, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 208 (1876).

Hab. Chiriqui.

Male. Forehead metallic ruby-red. Crown pure white, narrowing to a point on the occiput. From each side of the occiput spring a few narrow, lengthened dark

green feathers. Sides of the head bordering the white, dark brown. Back and wing coverts bronzy-green. Rump dark purple crossed by a narrow white band. Throat metallic dark green. Upper part of breast white. Flanks bronzy-green. Abdomen and under tail coverts dark rufous. Tail deep rufous, with the tips of the median feathers, and edges of the others, greenish-brown. Bill flesh-color, tip brown. Wings purple. Total length, $2\frac{7}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. Top and sides of head dark brown. Upper parts bronzy-green. Throat and breast white spotted with dark brown. Tail deep buff with a subterminal black bar. Flanks bronzy-green. Abdomen and under tail coverts deep rufous. Rump as in the male. Maxilla black, mandible flesh-color at base, tip black.

9. *Lophornis verreauxi*.

Trochilus verreauxi, BOURC., Rev. Zool. (1853), p. 193.

Lophornis verreauxi, REICH., Aufz. der Colib., p. 12.—ID., Troch. Enum., p. 9 (1855).—GOULD, Mon. Troch., vol. iii, pl. 125.

Bellatrix verreauxi, BON., Rev. and Mag. Zool. (1854), p. 257.

Polemistria verreauxi, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 63 (note).—GOULD, Intr. Troch., octavo ed., p. 85.—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 221.

Hab. Upper Amazon and Columbia, Peru.

Male. Forehead and patch beneath the eye metallic grass-green. Crest deep chestnut, each feather tipped and margined with dark green. Back and flanks dark bronzy-green. Across the rump a line of white. Throat and sides of neck dull pale green, the feathers of the neck tipped with white. Centre of breast and abdomen dark green—almost black. Upper tail coverts bronzy-purple. Tail purplish-bronze. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{16}$ in.

Female. Top of head dark brown, without crest. Back bronzy-green. A line of white on sides of throat. Flanks washed with green. Throat and abdomen black spotted with buff. Line across the rump buff. Upper tail coverts dark crimson. Tail bronze-green at base, changing to blackish-brown, all the lateral feathers tipped with pearly-white. Under tail coverts blackish-brown. Description taken from a female procured by Chesterton in Columbia.

10. *Lophornis chalybea*.

Trochilus chalybeus, VIEILL., Ency. Méth., vol. ii, p. 574.—TEM., Pl. Col., no. 66, fig. 2.

Trochilus festivus, LICHT., Doubl., p. 14.

Colibri mystax, SPIX., Av. Bras., tom. i, p. 82, tab. 82, fig. 3 (1824).

Ornismya vieilloti, LESS., Hist. Nat. Ois. Mouch., p. 186, pl. 64 (1829).—ID., Trochil., p. 37, pl. 8; p. 41, pl. 9; p. 44, pl. 10; p. 46, pl. 11 (1831).

Ornismya audeniti, LESS., Ois. Mouch. Supp., p. 102, pl. 2 (1831).

Mellisuga chalybea, GRAY, Gen. Birds, vol. i, p. 113 (1844-49).

Mellisuga audeniti, GRAY, Gen. Birds, vol. i, p. 113.

Lophornis audeniti, BON., Consp. Gen. Av., vol. i (1850), p. 84.

Lophornis chalybeus, BON., Consp. Gen. Av., vol. i (1850), p. 84.—REICH., Troch. Enum., p. 9 (1855).—GOULD, Mon. Troch., vol. iii, pl. 124.—BERLEPSCH., Journ. für Ornith. (1873), p. 275.

Lophornis chalybea, REICH., Aufz. der Colib., p. 12 (1853).

Bellatrix chalybeus, BON., Rev. and Mag. Zool. (1854), p. 297.

Lophornis festivus, BURM., Th. Bras., vol. ii, p. 354, sp. 2 (1856).

Polemistria chalybea, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 63.—GOULD, Intr. Troch., octavo ed., p. 85 (1861).

Polemistria vieilloti, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 231 (1876).

Hab. Brazil.

Male. Forehead, line beneath the eye, and ear coverts metallic grass-green. Back, wing coverts, and back of head bronzy-green. Rump dark purple, crossed by a narrow white band. Throat and lengthened feathers on the sides dark glossy green, not metallic, the latter tipped with white. Breast grayish-white; abdomen and flanks dark brown with bronze reflections. A line of white across the vent. Upper tail coverts pale gray tipped and margined with bronzy-green. Tail bronzy-brown tipped with white. Wings dark purplish-brown. Bill black. Total length, $3\frac{1}{8}$ in. Wing, $1\frac{3}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{16}$ in.

Female. Top of head brown, upper surface of body greenish-bronze; beneath grayish-white. Throat streaked with brown. Tail bronzy-green at base, changing into dark bronzy-brown, and tipped with buff. Rump, bill, and wings like the male.

We now reach a group of birds allied in many ways to those of the genus LOPHORNIS, yet differing greatly in their singular tails, which are composed of lengthened attenuated feathers, the three outermost ones on either side being the longest, although very unequal, and the four median ones so short as to be hardly visible. The species first given is perhaps possessed of the most spine-like rectrices, closely followed, however, by the next; but when the *G. latitiæ* is reached we find it to be almost the counterpart of *Discura longicauda*, the only species of the following genus, but without the *spatules* at the end of the external rectrices. All the species of GOULDIA are small but of a graceful shape. I have kept the *G. popelairi* in the same genus as the rest, not considering that the possession of a crest is of sufficient importance to give the species a distinct generic rank.

Genus LXXI.—GOULDIA.

Gouldia, BON., Compt. Rend., p. 381 (1850).

Popelairia, REICH., Aufz. der Colib., p. 12 (1853).

Gouldomyia, BON., Rev. and Mag. Zool. (1854), p. 257.

Prymnacantha, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 64.

Tricholopha, HEINE, Journ. für Ornith. (1863), p. 209.

Mytinia, MULS., Catal. Ois. Mouch. (1875), p. 28.

Mythinia, MULS., Hist. Nat. Ois. Mouch., vol. iii (1876), pp. 235, 245.

TYPE.

T. langsdorffi, Vieill.

T. popelairi, DuBus.

T. langsdorffi, Vieill.

T. popelairi, DuBus.

T. popelairi?, DuBus.

T. latitiæ, Bourc.

T. latitiæ, Bourc.

Ch. Bill about as long as the head. Rectrices lengthened, stiff, graduating to a fine point. Outermost one bare of outer web for nearly three-fourths its length. Tarsi covered by a tuft of feathers.

Range. Veragua and Costa Rica in Central America, Brazil, the upper Amazon, Columbia, Ecuador, Peru, and Bolivia.

Four species are here included in this genus.

Key to the species.

- | | |
|---|----------------------------|
| A. Head crested, breast black, not metallic. | 1. <i>G. popelairii</i> . |
| B. Head not crested, breast metallic. | |
| a. Breast luminous green bordered with red. | 2. <i>G. langsdorffi</i> . |
| b. Breast shining green, abdomen dull green. | 3. <i>G. conversi</i> . |
| c. Breast metallic-green, a patch of white on its lower border. | 4. <i>G. laticitæ</i> . |

1. *Gouldia popelairii*.

Trochilus popelairii, DU BUS, Esquiss. Ornith., pl. 6 (1845).

Mellisuga popelairii, GRAY, Gen. Birds, vol. i, p. 113.

Gouldia popelairi, BON., Consp. Gen. Av. (1850), vol. i, p. 86.—GOULD, Mon. Troch., vol. iii, pl. 127.—BON., Rev. and Mag. Zool. (1854), p. 257.

Popelairia trichotopha, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).—MULS., Hist. Nat. Ois. Mouch. (1876), vol. iii, p. 235.

Prymnacantha popelairi, CAB. and HEIN., Mus. Hein. Th., iii, p. 64 (1860).—GOULD, Intr. Troch., octavo ed., p. 87.

Tricolopha popelairi, HEINE, Journ. für Ornith. (1863), p. 209.

Hab. Columbia, Ecuador, and Peru.

Male. Top of head and throat metallic grass-green. Lengthened hair-like feathers, extending beyond the short crest, black. Back and upper tail coverts grass-green. A white band across the rump, between this band and the tail coverts the rump is greenish-black. Breast and abdomen black; flanks light brownish-gray. Under tail coverts white. Tail steel-blue, shafts white in the middle feathers, brownish in the lateral ones. Thighs red. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $1\frac{3}{8}$ in. Tail, $2\frac{5}{8}$ in. Culmen, $\frac{7}{16}$ in.

Female. Upper parts, flanks, and tail coverts bronzy-green, white band across the rump. Chin and a line on side of the neck grayish-white. Centre of throat and abdomen bluish-black. Tail short, steel-blue with gray base and white tips. Thighs red.

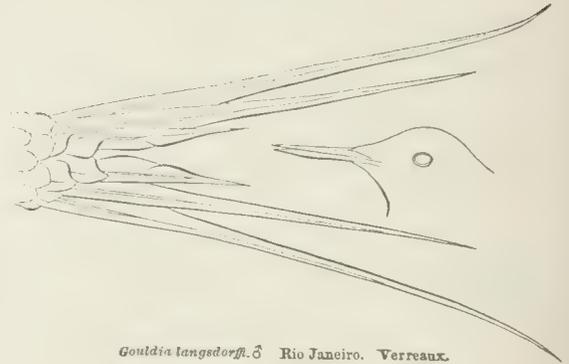
2. *Gouldia langsdorffi*.

Trochilus langsdorffi, BONNAT. and VIEILL., Ency. Méth., vol. ii, p. 574 (1794).—TEMM., Plan. Col., no. 66, fig. 1.

Orthorhynchus langsdorffi, LESS., Man. Ornith., tom. ii, p. 77 (1828).

Ornismya langsdorffi, LESS., Ois. Mouch., p. 102, pl. 26 (1829).—ID., Supp., p. 129, pl. 16.—ID., Trochil., p. 101, pl. 35 (1831).

Fig. 79.



Gouldia langsdorffi, ♂ Rio Janeiro. Verreaux.

Colibri hirundinaceus, SPIX., Av. Bras., vol. i (1824), p. 80, pl. 81, fig. 2.

Mellisuga langsdorffi, GRAY, Gen. Birds, vol. i, p. 113.

Gouldia langsdorffi, BON., Consp. Gen. Av. (1850), vol. i, p. 86.—ID., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 128.—DES MURS, Voy. Castel. (Oiseaux.), p. 41.—REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).

Prymnacantha langsdorffi, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 64.—MULS., Hist. Nat. Ois. Mouch., vol. iii (1876), p. 238.

Gouldia melanosternum, GOULD, Ann. and Mag. Nat. Hist. (1868), 4th ser., vol. i, p. 323.

Hab. Brazil, upper Amazon, Peru.

Male. Crown, throat, and breast glittering metallic grass-green, bounded beneath by a line of fiery-red. Upper surface bronzy-green, with a white band across the rump. Lower portion of breast black, rest of under parts grayish-white. Median rectrices steel-blue with white shafts, lateral ones steel-blue at base, then brownish-white with brown shafts. Wings purple-brown. Bill black. Total length, $4\frac{7}{8}$ in. Wing, $1\frac{3}{8}$ in. Tail, $3\frac{3}{8}$ in. Culmen, $\frac{7}{16}$ in.

Female. Upper surface bronzy-green with a white band across the rump. Chin black; a white line from the angle of bill. Throat spotted with green. Tail short. Median rectrices steel-blue tipped with white; lateral ones grayish-white, with a subterminal steel-blue bar.

3. *Gouldia conversi*.

Trochilus conversi, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), p. 313.—ID., Rev. Zool. (1846), p. 314, pl. 3.

Mellisuga conversi, GRAY, Gen. Birds, vol. i, p. 113 (1844-49).

Gouldia conversi, BON., Consp. Gen. Av. (1850), vol. i, p. 86.—ID., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 129.—REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).—GOULD, Intr. Troch., octavo ed., p. 86 (1861).

Prymnacantha conversi, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 65.—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 242.

Hab. Columbia.

Male. Head and throat shining dark grass-green. A white band across the rump below which is a broad one of deep chestnut. Entire rest of body dark bronze-green. Wings purplish-brown. Rectrices steel-blue, with a central line and tips pale brown. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $1\frac{3}{4}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{3}{8}$ in.

Female. General plumage dark green, with a white band across the rump. Throat black, with a white line on either side from the angle of the mouth. Tail feathers, dark gray at base, with a greenish gloss on the central pair, succeeded by steel-blue and tipped with white. Tail short and rounded. Total length, $2\frac{7}{8}$ in. Wing, $1\frac{9}{16}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

4. *Gouldia lætitiaë*.

Trochilus lætitiaë, BOURC., Ann. Soc. Agr., Lyon (1852), p. 143.

Gouldia lætitiaë, BON., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 130.—REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9 (1855).—GOULD, Intr. Troch., octavo ed., p. 86 (1861).

Prymnacantha lætitiaë, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 64.

Mythimna lætitiaë, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 245 (1876).

Hab. Bolivia?.

Male. Head and throat glittering pale grass-green. Upper surface coppery-brown; band across the rump white. A white patch beneath the green of the throat. Upper part of abdomen and flanks bronzy-green. Lower portion of belly gray. Upper tail coverts red, changing to golden-green. Tail black, shafts rufous. Under tail coverts golden-green bordered with black. Bill: Maxilla black, mandible flesh-color at base, rest black. Total length, $3\frac{5}{8}$ in. Wing, $1\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{8}$ in.

Female. Unknown.

Only two examples of this species have been obtained; one in my collection, and one in that of Mr. Gould.

Genus LXXII.—DISCURA.

Platurus, LESS., Ois. Mouch. (1829), p. xxii (nec Latr. Rept.).
Ocreatus, GOULD, P. Z. S. (1846), p. 86 (partim).
Discosura, BON., Comp. Rend., p. 383 (1850), vol. i, p. 84.
Discura, REICH., Aufz. der Colib., p. 8 (1853).

TYPE.

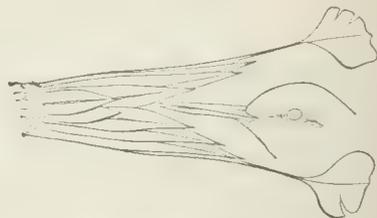
T. longicaudus, Gmel.
T. longicaudus, Gmel.
T. longicaudus, Gmel.
T. longicaudus, Gmel.

Ch. Bill short, straight, cylindrical, converging rapidly near the tip to a slender point. Tail deeply forked, the rectrices pointed, the outermost ones bare of webs near their tips, and terminating in a spatula. Sexes unlike in plumage.

Range. Guiana, Brazil.

But one species of this genus is known, very closely resembling the *Gouldia laticia* in plumage, but possessing spatules on the external rectrices, and thus leading directly to STEGANURA.

Fig. 80.



Discura longicauda. ♂. Cayenne. Sallé.

1. *Discura longicauda*.

Trochilus longicaudus, GMEL., Syst. Nat., vol. i, p. 498 (1788).
Trochilus platurus, LATH., Ind. Ornith., vol. i, p. 317 (1790).—SHAW, Gen. Zool., vol. viii, p. 316.—VIEILL., Nouv. Dict. Hist. Nat. (1817), tom. vii, p. 370.—ID., Ency. Méth., tom. ii, p. 569.—PR. MAX., Beit. Naturg., t. iv, p. 96.—TSCHEID., Faun. Peruan., p. 245 (1840-46).
Mellisuga platura, STEPH., Gen. Zool., vol. xiv, p. 242.
Trochilus bilophus, TEMM., Pl. Col., no. 18, fig. 3.
Ornismya platura, LESS., Ois. Mouch., p. 136, pl. 40 (1829).—ID., Supp., p. 159, pl. 31 (1831).
Trochilus (Ocreatus) ligonicaudus, GOULD, P. Z. S. (1846), p. 86.
Mellisuga ligonicauda, GRAY, Gen. Birds, vol. i, p. 113, sp. 57.
Discosura longicauda, BON., Consp. Gen. Av., vol. i (1850), p. 84.
Discosura ligonicauda, BON., Consp. Gen. Av., vol. i (1850), p. 84.
Discura platura, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 706, figs. 4591-95 (1855).
Discura longicauda, REICH., Aufz. der Colib., p. 8.—ID., Troch. Enum., p. 5, pl. 706, figs. 4591-95.—BON., Rev. and Mag. Zool. (1854), p. 257.—GOULD, Mon. Troch., vol. iii, pl. 126.—ID., Intr. Troch., octavo ed., p. 85.—CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 65.

Hab. Guiana, Brazil.

Male. Face, throat, neck, and upper part of breast shining grass-green. A small black spot on the chin. Back and upper tail coverts bronzy-green. A band of

buffy-white crosses the lower part of back. Flanks golden-green. A few green feathers on the centre of the breast edged with white. Middle of abdomen golden-brown; lower part and under tail coverts buff. Tail purplish-brown, each feather having a central stripe of buff. Shaft of outermost ones elongated beyond the rest and terminating in a purplish-black spatula. Wings purplish-brown. Bill black. Total length, $3\frac{7}{8}$ in. Wing, $1\frac{3}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

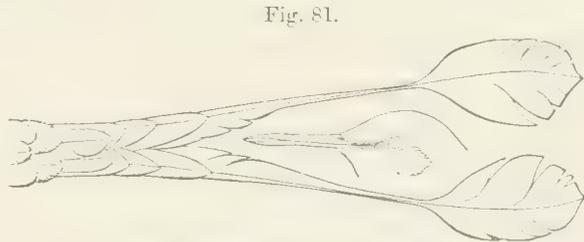
Female. Head greenish-brown. Upper surface and flanks bronzy-green. A broad buff band across the lower part of back. Centre of throat black, bordered on either side with white. Centre of abdomen blackish-brown. Upper tail coverts black. Tail dark gray, largely tipped with purplish-black, the black on the outermost feathers edged with white. Bill black. At the base of bill is a small spot of buff. Total length, $2\frac{7}{8}$ in. Wing, $1\frac{1}{8}$ in. Tail 1 in. Culmen, $\frac{3}{8}$ in.

Genus LXXIII.—STEGANURA.

Ocreatus, GOULD, P. Z. S. (1846), p. 86 (partim).
Steganurus, REICH., Syst. Av. Nat., pl. 40 (1849).
Steganura, REICH., Aufz. der Colib., p. 8 (1853).
Spathura, GOULD, Intr. Troch., octavo ed., p. 99.
Uralia, MILLS and VERR., Class. Troch. (1865), p. 81.

TYPE.
T. addæ, Bourc.
O. underwoodi, Less.
O. underwoodi, Less.
O. underwoodi, Less.
S. cissiura, Gould.

Ch. Bill straight, about as long as the head; wings moderately long. Tail deeply forked, the outer rectrix on each side, with one exception, having the shaft bare of webs for a portion of its length and terminating in a spatula. Tarsi hidden in a tuft of downy feathers; hind toe and nail shorter than the middle toe and nail. Sexes unlike in plumage.



Steganura underwoodi. ♂. New Granada. Whitely.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.
 Six species are known belonging to this genus. They are strongly characterized birds, with luminous throats and breasts, tarsi completely hidden in downy puffs, and elongated external rectrices, bare of webs near the tips and terminating in a spatula. They are of various sizes, but generally rather small.

Key to the species.

- A. Tarsal tufts white.
 - a. Chin bronzy-green in ♂, breast and abdomen in ♀ white spangled with green.
 - 1. *S. underwoodi*.
 - 2. *S. melananthera*.
 - b. Chin black in ♂, breast and abdomen in ♀ pure white.
- B. Tarsal tufts rufous.
 - a. Outer rectrices very long, spatules oval.
 - 3. *S. solstitialis*.
 - 4. *S. peruana*.
 - b. Outer rectrices moderately long, spatules wide as long.
 - 5. *S. addæ*.
 - c. Outer rectrices shorter than those of *b*; spatules wider than long.
 - 6. *S. cissiura*.
 - d. Outer rectrices webbed throughout their entire length. Spatules small.

1. *Steganura underwoodi*.

Ornismya underwoodi, LESS., Troch., p. 105, pl. 37 (1831).

Ornismya kieneri, LESS., Troch., p. 165, pl. 65. ♀ (1831).

Mellisuga underwoodi, GRAY, Gen. Birds, vol. i, p. 113, sp. 56.

Steganura underwoodi, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5 (1855).—MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 254.

Steganura spatuligera, REICH., Aufz. der Colib., pp. 8, 24 (1853).—ID., Troch. Enum. p. 5 pl. 707, figs. 4596-9 (1855).

Steganura remigera, REICH., Aufz. der Colib., pp. 8, 24 (1853).—ID., Trochil. Enum., p. 5, pl. 708, figs. 4601-2.

Steganurus remigera, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 67.

Steganurus underwoodi, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 66.

Spathura underwoodi, GOULD, Mon. Troch., vol. iii, pl. 162.—BON., Consp. Gen. Av., p. 80 (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Intr. Troch., octavo ed., p. 100 (1861).

Hab. Columbia and Venezuela.

Male. Upper surface, abdomen, flanks, and under tail coverts bronzy-green. Throat and breast luminous grass-green. Tail, outer rectrices, and inner webs of rest brown; outer webs and middle pair grass-green; spatules large, black. External rectrices vary considerably in length among individuals. Tarsal tufts white, bill black. Total length, $5\frac{1}{2}$ in. Wing, $1\frac{3}{4}$ in. Tail, $3\frac{3}{8}$ in. Culmen, $\frac{1}{2}$ in.

Female. Upper surface and median rectrices grass-green. Beneath white spangled with green. Under tail coverts buff, lateral rectrices light brown, outer ones tipped with white, rest washed with green on outer webs. Wings purple. Bill black. Tarsal tufts white. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{1}{2}$ in.

2. *Steganura melananthera*.

Trochilus (Spathura) melananthera, JARD., Contr. Ornith. (1851), p. 111, pl. 20.

Discura melananthera, BON., Consp. Gen. Av. (1850), vol. i, p. 70.—ID., Rev. and Mag. Zool. (1854), p. 256.

Steganura melananthera, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 710, figs. 4608-9 (1855).

Spathura melananthera, GOULD, Mon. Troch., vol. iii, pl. 163.—ID., Intr. Troch., octavo ed., p. 100 (1861).

Steganurus melanantherus, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 66 (note 3).

Hab. Ecuador.

Male. Differs from the *S. underwoodi* by having the chin jet-black, and the spatules somewhat smaller. Otherwise the two are almost precisely alike. Total length, $4\frac{3}{8}$ in. Wing, $1\frac{1}{2}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{9}{16}$ in.

Female. Differs from the female of *S. underwoodi* by having the under surface pure white, without any spangles of green on the breast. Total length, $2\frac{7}{8}$ in. Wing, $1\frac{1}{2}$ in. Tail, 1 in. Culmen, $\frac{9}{16}$ in.

3. *Steganura solstitialis*.

Spathura (Steganurus) solstitialis, GOULD, Ann. Mag. Nat. Hist. (1871), 4th ser., vol. viii, p. 62.

Steganura solstitialis, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 260 (1876).

Hab. Ecuador.

Male. Upper surface, abdomen, flanks, and under tail coverts dark grass-green. Throat and breast luminous grass-green. Wings purplish-brown. Tarsal tufts very deep buff. Tail dark brown; outer webs of all but the outermost rectrices washed

with green. Spatules black. Specimen before me (a typical one) has no gray on the edges. Bill black. Total length, $5\frac{1}{4}$ in. Wing, $1\frac{7}{8}$ in. Tail, 3 in. Culmen, $\frac{5}{8}$ in.

Female. Upper parts bronzy-green. Entire under parts white spotted with green. Under tail coverts buff. Middle rectrices bronzy-green, outermost one on either side brown tipped with white, remainder brown on inner web, bronzy-green on outer. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{3}{4}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

4. *Steganura peruana*.

Spathura peruana, GOULD, Mon. Troch., vol. iii. pl. 164.—ID., Intr. Troch., octavo ed., p. 100 (1861).—BOX., Consp. Gen. Av. (1850), vol. i. p. 80.—ID., Rev. and Mag. Zool. (1854), p. 256.

Steganura peruana, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 709, figs. 4606-7 (1855). Muls., Hist. Nat. Ois. Mouch., vol. iii, p. 261 (1876).

Steganurus peruanus, CAB. and HEIN., Mus. Hein. Th., iii. p. 66 (note 5) (1860).—WHITELEY, P. Z. S. (1873), p. 784.

Hab. Peru.

Male. Throat and breast metallic grass-green; rest of plumage of body bronzy-green. Wings and tail brown; the outer webs of all the lateral rectrices except the outermost bronzy-green. Bill black. Tarsal tufts buff. Total length, 5 in. Wing, $1\frac{3}{4}$ in. Tail, $3\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in.

Female. Upper surface and median rectrices bronzy-green. Under surface white spangled with green. Tarsal tufts and under tail coverts buff. Outermost rectrices brown tipped with white, rest brown on inner web, green on outer. Bill black. Wings brown. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen $\frac{5}{8}$ in.

Obs. Although Mr. Gould cites the P. Z. S., for 1849, as the place where this species was described, and he has been followed in this citation by others, yet I cannot find that the species was published in the volume for that year, but was evidently first described in the Monograph of the Trochilidæ.

5. *Steganura addæ*.

Trochilus addæ, BOURC., Rev. Zool. (1846), p. 312, Sept.

Trochilus (Ocreatus) rufocaligatus, GOULD, P. Z. S. (1846), p. 86, Oct.

Mellisuga rufocaligata, GRAY, Gen. Birds, vol. i, p. 113, sp. 59.

Spathura addæ, BOX., Consp. Gen. Av. (1850), vol. i, p. 80.—ID., Rev. and Mag. Zool. (1854), p. 256.

Steganura addæ, REICH., Aufz. der Colib., p. 8 (1853).—ID., Trochil. Enum., p. 5, pl. 709, figs. 4603-5.—Muls., Hist. Nat. Ois. Mouch., vol. iii, p. 263 (1876).

Spathura rufocaligata, GOULD, Mon. Troch., vol. iii. pl. 165.—ID., Intr. Troch., octavo ed., p. 100 (1861).

Steganurus addæ, CAB. and HEIN., Mus. Hein. (1861) Th., iii, p. 66 (note 6).

Hab. Bolivia.

Male. Throat and breast brilliant green; rest of body and middle rectrices bronze-green. Under tail covers bronze-green, margined with buff. Tarsal tufts rufous. Tail brown, spatules black. Bill black. Total length, $4\frac{3}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $2\frac{3}{8}$ in. Culmen, $\frac{9}{16}$ in. From Bourcier's type in my collection.

Female. Upper parts and median rectrices bronze-green. Under surface white spotted with green. Tarsal tufts and under tail coverts rufous. Outermost rectrices brown tipped with white, rest brown on inner web, green on outer. Bill black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{5}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

6. **Steganura cissiura*.

Spathura cissiura, GOULD, P. Z. S. (1853), p. 109.—ID., Mon. Troch., vol. iii, pl. 166.—ID., Intr. Troch., octavo ed., p. 100 (1861).

Steganurus cissiurus, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 66 (note 4).

Uralia cissiura, MULS., Hist. Nat. Ois. Mouch., vol. iii, p. 265 (1876).

Hab. Peru.

Male. "General plumage bronzy-green; wings purplish-brown; four outer tail feathers purplish steel-black; under surface green, paler on the throat; thighs thickly plumed and of a reddish-buff. Total length, $4\frac{1}{4}$ in. Bill, $\frac{5}{8}$ in. Wing, $1\frac{5}{8}$ in. Tail, $2\frac{3}{8}$ in." (Gould, l. c.)

Female. Unknown.

This species is easily recognized from having the outermost rectrix webbed for its entire length. Two specimens only are known, brought by Warszewicz from Peru.

Genus LXXIV.—LODDIGESIA.

Loddigesia, GOULD, Mon. Troch., vol. iii.—ID., Intr. Troch., octavo ed., p. 99 (1861).

Loddigiornis, BON., Compt. Rend., p. 381 (1850).

Mulsantia, REICH., Aufz. der Colib., p. 12 (1853).

Thaumatoëssa, HEIN., Journ. für Ornith. (1863), p. 209.

TYPE.

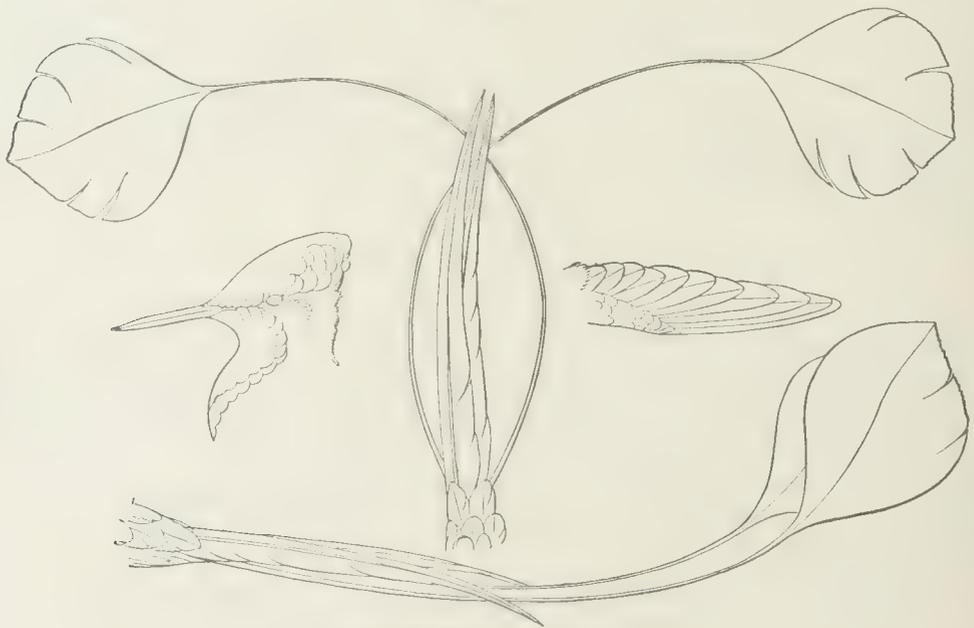
T. mirabilis, Bourc.

T. mirabilis, Bourc.

T. mirabilis, Bourc.

T. mirabilis, Bourc.

Fig. 82.



Loddigesia mirabilis. ♂. (From Gould.)

Ch. "Bill straight, longer than the head; wings diminutive; primaries rounded at the tip; outer tail feathers on each side very much prolonged, and terminating in a large spatule."

Range. Peru.

Only one species is known, the extraordinary *L. mirabilis*. This species is remarkable for the enormous spatules at the end of the external rectrices. We know very little about it, the type still remains unique, and even the precise locality the species inhabits has never been ascertained.

1. **Loddigesia mirabilis*.

Trochilus mirabilis, Bourc., P. Z. S. (1847), p. 42.—ID., Rev. Zool. (1847), p. 253.

Loddigesia mirabilis, GOULD, Mon. Troch., vol. iii, pl. 161.—ID., Intr. Troch., octavo ed., p. 99 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 252 (1876).

Mulsantia mirabilis, BON., Consp. Gen. Av., p. 80 (1850), vol. i.—REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 9, pl. 830, fig. 4888 (1855).

Loddigiornis mirabilis, BON., Rev. and Mag. Zool. (1854), p. 256.

Thaumatoëssa mirabilis, HEIN., Journ. für Ornith. (1863), p. 210.

Hub. Chachapoyas, Peru. One specimen procured, now in Mr. Loddige's collection.

Male. "Crown of the head brilliant blue, neck, scapularies, back, wing, and tail coverts golden-green; on the throat a gorget of very brilliant green, tinged with blue in the centre, and bounded on each side by a narrow band of coppery-red; sides of the breast and flanks dull white; the greatly prolonged shaft of the outer feather on each side and the large spatule at its tip violaceous-black; centre tail feathers shining glaucous-green, passing into brown at their tips; bill and feet black" (Gould, l. c.). Length of bill, 20 mm.; wings, 40 mm. Outer rectrices, about 160 mm. Spatules, 20 mm. Middle rectrices, 60 mm. (Bourc., l. c.).

Female. Unknown.

The Genus LESBIA, which succeeds, is composed of various species, possessing lengthened rectrices of nearly even width for their entire length, and having generally a luminous tip. All the species have metallic-green throats, and differ from each other, in size, and the length and coloration of their tails. The females are very differently clothed, having white breasts spangled with green, and comparatively short tails.

Genus LXXV.—LESBIA.¹

Lesbia, LESS., Ind. Gen. et. Syn. des Ois. du Genre Trochilus (1832), p. xvii.

Cynanthus, BON. (nec SWAINS., 1827), Consp. Gen. Av., p. 81 (1850).

Aguclyta, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 70.

Psalidoprymna, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 52 (note).

TYPE.

O. nuna, Less.

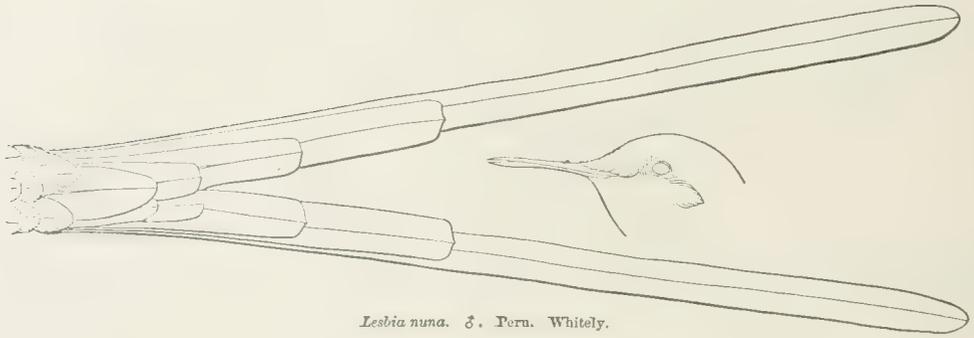
T. amaryllis, Bourc.

T. gouldi, Lodd.

T. amaryllis, Bourc.

¹ Lesson instituted this genus, including in it species not closely related, such as *L. sappho*, *L. nuna*, and *L. kingii*. The first of these is the SAPPHO SPARGANURA, Auct., and the last (the *T. forficatus*, Linn.) is the type of Swainson's genus CYNANTHUS, thus leaving the *O. nuna*, Less., as the type of his genus LESBIA.

Fig. 83.

*Lesbia nuna*. ♂. Peru. Whitely.

Ch. Bill short, straight. Tail very deeply forked, rectrices narrow, outermost ones greatly exceeding the others in length. Feet rather large. Sexes different.

Range. Columbia, Ecuador, and Peru.

I recognize four species only belonging to this genus.

Key to the species.

- | | |
|---|--------------------------|
| A. Outermost rectrices on either side black glossed and tipped with green, the rest brownish-black at base, remaining portion metallic-green. | 1. <i>L. gouldi</i> . |
| B. Rectrices black at base, apical half of all but the two outermost metallic-green, the outermost pair all black with luminous green tips. | 2. <i>L. nuna</i> . |
| C. Rectrices brownish-black, largely tipped with grass-green, except the outermost which has a bronze tip. | 3. <i>L. eucharis</i> . |
| D. Rectrices black, their tips greenish-bronze. | 4. <i>L. amaryllis</i> . |

1. *Lesbia gouldi*.

Trochilus gouldi, LODD., P. Z. S. (1832), p. 7.

Ornismya sylphia, LESS., Rev. Zool. (1840), p. 73.

Trochilus (Lesbia) gracilis, GOULD, P. Z. S. (1846), p. 86.

Mellisuga gouldi, GRAY, Gen. Birds, vol. i, p. 113, sp. 51 (1844-49).

Mellisuga gracilis, GRAY, Gen. Birds, vol. i, p. 113, sp. 53.

Cynanthus gracilis, BON., Consp. Gen. Av. (1850), vol. i, p. 81.

Cynanthus gouldi, BON., Consp. Gen. Av. (1850), vol. i, p. 81.—ID., Rev. and Mag. Zool. (1854), p. 252.

Lesbia gouldi, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 712, figs. 4615-17.—GOULD, Mon. Troch., vol. iii, pl. 167.—ID., Intr. Troch., octavo ed., p. 101 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 293 (1876).

Agalyta gouldi, CAB. and HEIN., Mus. Hein. (1860) Th., iii, pp. 70, 71 (note).

Lesbia gracilis, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., pl. 713, figs. 4618-19 (1855).—GOULD, Mon. Troch., vol. iii, pl. 168.—ID., Intr. Troch., octavo ed., p. 101 (1861).—MULS., Ois. Mouch., tom. iii, p. 295.

Lesbia chlorura, GOULD, P. Z. S. (1871), p. 504.

Hab. Columbia and Ecuador. Peru.?

Male. Upper parts, breast, upper part of abdomen, and flanks golden-green; abdomen sometimes mottled with buff; throat metallic grass-green. Lower part of abdomen buff, under tail coverts green margined with buff. Rectrices brownish-black at base, remaining part metallic-green. Outermost one black, with a shining green tip, the outer web buff for three-fourths its basal length. Wings purplish-

brown. Bill black. Total length, $5\frac{5}{8}$ in. Wing, $2\frac{1}{16}$ in. Tail, $3\frac{7}{8}$ in. Culmen, $\frac{5}{16}$ in.

Female. Upper surface golden-green. Outer rectrices, much shorter than those of the male, brown, the basal two-thirds of the outer web, shaft, and tip buff. Under surface white speckled with bronzy-green. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $2\frac{2}{3}$ in. Culmen, $\frac{5}{16}$ in.

Obs. I have placed the *L. gracilis*, Gould, as a synonym of the present species, for with ample materials before me to judge, I cannot find any difference sufficient in my opinion to separate them. The rectrices vary in width, and this character is evidently not to be relied upon, any more than is the extent of their green or buff coloring.—I also consider the *L. chlorura*, Gould, to be the same as this species, an examination of the type having failed to convince me of its claims to a distinct specific rank.

2. *Lesbia nuna.*

Ornismya nuna, LESS., Supp. Ois. Mouch., p. 169, pl. 35? juv. ♂.

Ornismya gouldi, D'ORB. and LAFRES., Syn. Av., ii. p. 27, sp. 5 (1838).

Ornismya nuna-kouli, DELATTR. and LESS., Rev. Zool. (1839), p. 19.

Lesbia nuna, GOULD, Mon. Troch., vol. iii, pl. 169.—ID., Intr. Troch., octavo ed., p. 101 (1861).—MULLS., Hist. Nat. Ois. Mouch., tom. iii, p. 291 (1876).—ELLIOT, Ibis (1877), p. 135.

Cyananthus bifurcatus, BON., Consp. Gen. Av. (1850), p. 81.—ID., Rev. and Mag. Zool. (1854), p. 252.

Lesbia bifurcata, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 716, figs. 4624–25? (1855).

Psalidoprymna bifurcata, CAB. and HEIN., Mus. Hein. Th., iii, p. 53 (1860) (partim).

Hab. Peru.

Male. Upper surface, breast, and under parts dark bronzy-green. Throat covered by a rounded gorget of metallic grass-green. Wings purplish-brown. Rectrices black at base, all but the outermost ones with their apical half metallic grass-green; the outermost one black for its entire length with luminous green tips, and the basal half of outer web buffy-white. Under tail coverts green margined with buff. Thighs white. Bill black. Total length, $7\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $5\frac{1}{4}$ in. Culmen, $\frac{9}{16}$ in.

Female. Upper parts bronzy-green. Under surface white spangled with green, and a few metallic-golden spots on the throat. Under tail coverts buffy-white. Tail colored like that of the male but much shorter, the outer web of outermost feather being buffy-white nearly to the tip. Bill black. Total length, $4\frac{1}{2}$ in. Wing, 2 in. Tail, $2\frac{2}{3}$ in. Culmen, $\frac{9}{16}$ in.

3. *Lesbia eucharis.*

Trochilus eucharis, BOURC., Rev. Zool. (1848), p. 274.

Lesbia eucharis, REICH., Aufz. der Colib., p. 8.—ID., Troch. Enum., p. 5.—GOULD, Mon. Troch., vol. iii, pl. 171.

—ID., Intr. Troch., octavo ed., p. 102 (1861).—MULLS., Hist. Nat. Ois. Mouch., tom. iii, p. 289 (1876).

Cyananthus eucharis, BON., Rev. and Mag. Zool. (1854), p. 252.

Hab. Columbia.

Male. Entire upper surface, breast, abdomen, and flanks bronzy-green. Throat metallic grass-green. Vent and under tail coverts buff, the latter with green centres. Wings purplish-brown. Rectrices brownish-black, largely tipped with grass-

green, except the outermost one which has a bronze tip. Bill black. Total length, $7\frac{3}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $5\frac{3}{8}$ in. Culmen, $\frac{7}{16}$ in. From Bourcier's type in my collection.

Female. Above golden-green; beneath buff spangled with green. Tail like the male but shorter, and with the outer web of outermost feather grayish-white for three-fourths its length.

Though similar to the *L. nana*, besides the differences already mentioned, the present is a larger bird, and is I believe a very distinct species.

4. *Lesbia amaryllis.*

Trochilus victoriae, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), tom. ix, p. 312.—ID., Rev. Zool. (1846), p. 315, pl. 4 (discolored specimen).

Mellisuga victoriae, GRAY, Gen. Birds, vol. i, p. 113, sp. 54.—REICH., Troch. Enum., pl. 715, figs. 4622-23 (1855).

Trochilus amaryllis, BOURC., Rev. Zool. (1848), p. 273.—GRAY, Gen. Birds, vol. iii; Supp., App. 30 a, p. 103.

Lesbia victoriae, REICH., Troch. Enum., p. 5, pl. 714, figs. 4620-21.—ID., Aufz. der Colib., p. 8 (1853).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 286 (1876).

Cynanthus amaryllis, BON., Rev. and Mag. Zool. (1854), p. 252.

Cynanthus victoriae, BON., Consp. Gen. Av. (1850), vol. i, p. 81.

Lesbia amaryllis, REICH., Aufz. der Colib., p. 8 (1853).—GOULD, Mon. Troch., vol. iii, pl. 170.—ID., Intr. Troch., octavo ed., p. 101 (1861).

Psalidoprymna victoriae, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 52.

Psalidoprymna amaryllis, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 53 (note).

Hab. Columbia and Ecuador.

Male. Upper surface, breast, and flanks golden-green. Elongated patch on the throat metallic yellowish-green. Lower part of abdomen and under tail coverts deep buff. Tail purplish-black, each feather tipped with greenish-bronze. Bill black. Wings purplish-brown. Total length, $8\frac{1}{2}$ in. Wing, $2\frac{5}{8}$ in. Tail, $6\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

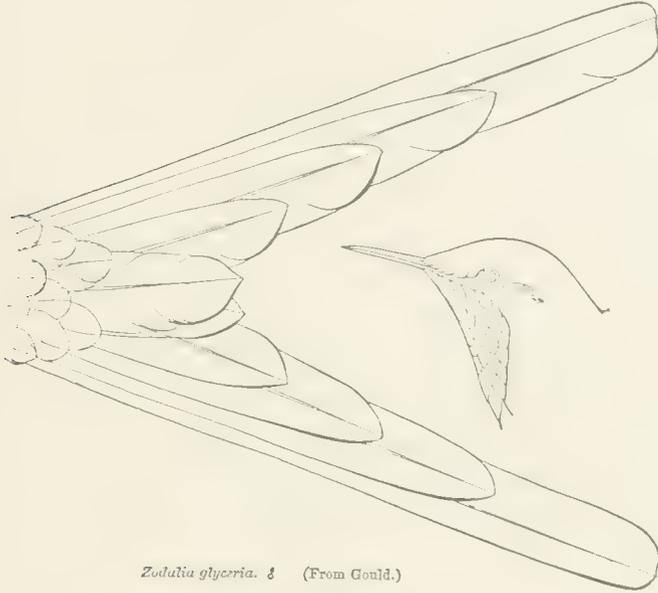
Female. Upper surface golden-green. On the centre of the throat a small lengthened patch of metallic golden-green. Rest of under surface white spotted with green. Under tail coverts light buff. Wings purplish-brown. Tail purplish-black, each feather tipped with bronzy-green; outer web of outermost feather buff to within an inch of the tip. Bill black. Total length, $5\frac{3}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $3\frac{1}{8}$ in. Culmen, $\frac{9}{16}$ in.

M. Mulsant (l. c.) has called this species *L. victoriae*. As this name was bestowed on a discolored specimen it cannot be continued, although published prior to *amaryllis*, as the description gives an entirely erroneous idea of the species, and would certainly mislead.

Genus LXXVI.—ZODALIA.

Zodalia, MULSANT, Hist. Nat. Ois. Mouch., tom. iii, p. 281 (1876).TYPE.
Lesbia ortonii, Lawr.

Fig. 84.

*Zodalium glyceria*. ♂ (From Gould.)

Ch. Bill straight, shorter than the head. Tail long, deeply forked, feathers broad and even throughout their length.

Range. Columbia and Ecuador.

Two species only are known.

Key to the species.

- A. Throat metallic pale green.
- a. Upper parts purple. Median rectrices green, external ones brownish-black. 1. *Z. ortonii*.
 - b. Upper parts shining green. Rectrices reddish-purple. 2. *Z. glyceria*.

I have adopted the term ZODALIA for these birds, as proposed by M. Mulsant, for in many ways they appear to differ from the species of all other allied genera. They are rather large in size, with short feeble bills, rectrices broad for their length, and a general style of coloration that, were it not for their metallic throats, would be suggestive of the female sex. The types of the two known species are unique.

1. *Zodalium ortonii.

Lesbia ortonii, LAWRENCE, Ann. N. Y. Lyc. Nat. Hist. (1869), vol. ix, p. 269.

Zodalium ortonii, MULSANT, Hist. Nat. Ois. Mouch., tom. iii, p. 282.

Hab. Quito, Ecuador.

Male. "Entire upper plumage and wing coverts of a rich glossy purple; the concealed bases of the feathers are green; upper tail coverts similar in color to the back, but marked centrally between the purple and green with crimson; the tail

feathers are brownish-black, except the two central which are green; the ends of the eight middle tail feathers are largely marked with a deep vinous bronzy-crimson, most in extent on the short central feathers; the long outer feather on each side ends with obscure bronzy-green; the outer edge of the lateral feather is buff for three-quarters its length from the base—this color occupying only about one-third the width of the web; the under surface of the tail is steel-blue, bronzy at the ends of the feathers; the shafts of the two long lateral feathers are whitish at base for about half their length; wings brownish-purple; the throat gorget is of a brilliant metallic pale green; the sides of the neck, breast, upper part of abdomen, and sides are a shining green; lower part of abdomen ashy-buff. Bill and feet black. Length, $5\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, lateral feathers, $3\frac{7}{16}$ in., short central ones $1\frac{1}{16}$ in. Bill, $\frac{1}{2}$ in." (Lawr., l. c.)

Female. Unknown.

2. **Zodalia glyceria.*

Lesbia glyceria, BON., Rev. and Mag. Zool. (1854), p. 252.

Cometes mossai, GOULD, Athen. (1853).—ID., Rep. Brit. Ass. (1853), p. 68.

Cometes! glyceria, GOULD, Mon. Troch., vol. iii, pl. 176.—ID., Intr. Troch., octavo ed., p. 104 (1861).

Sparganura mossai, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 52 (note).

Sparganura glyceria, SCLAT. and SALV., Nomencl., p. 86 (1873).

Hab. Columbia.

Male. "Head, back of neck, wing coverts, back, and tail coverts deep shining-green; wings purplish-brown; chin and throat metallic light olive-green; sides of neck and under surface buff with a spot of deep shining green on the tip of each feather; tail dark reddish-purple, passing into deep bluish-green at the tip except on the outer feathers, where the hue is so faint as to be scarcely perceptible; the outer feathers also have the basal three-fourths of the shaft and the outer webs buffy-white, the base of the shaft paler than the web; basal three-fourths of the shaft of the next feather also buffy-white; under tail coverts buff, with a brown mark in the centre near the tip." (Gould, Mon. Troch.)—Total length, 6 in. Wing, $2\frac{1}{2}$ in. Tail, $3\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

Female. Unknown.

Genus LXXVII.¹—CYNANTHUS.

TYPE.

Cynanthus, SWAINS., Classif. Birds, vol. ii, p. 330 (1837) (nec 1827).

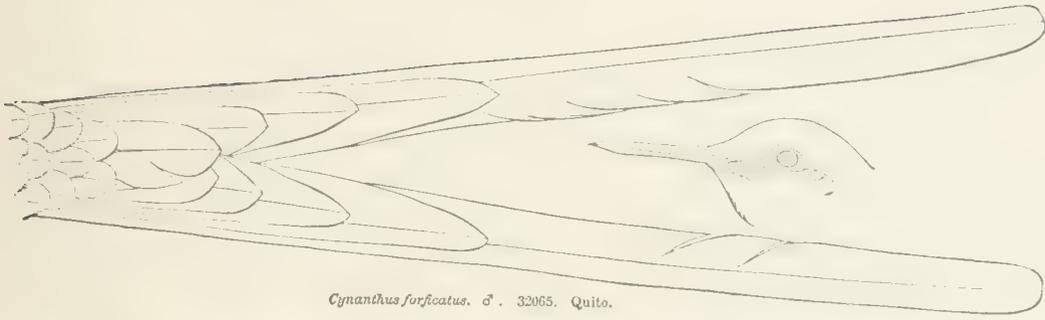
T. forficatus, Linn.

Lesbia, CAB. and HEIN. (nec LESS., 1832), Mus. Hein. Th., iii, p. 71 (1860).

T. mocoa, Delatt. and Bourc.

¹ This genus was first established by Swainson in 1827, Zool. Journ., p. 357, and contained species belonging to various genera, all of which he called types. In 1837 (l. c.), he ejected the species from CYNANTHUS, which he had previously placed in it, and inserted *T. forficatus*, Linn., only, which now stands as the type of the genus.

Fig. 85.



Cynanthus forficatus. ♂. 32065. Quito.

Ch. Bill shorter than the head, straight, graduating rapidly at the tip to a sharp point. Wings long, first primary slightly falcate. Tail extremely long and deeply forked. Tarsi bare. Sexes different.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

Two species only are known, but they are among the most beautiful of the Family, and are remarkable for their lengthened and brilliantly colored tails.

Key to the species.

- A. General plumage shining green. Top of head metallic grass-green.
- a. Tail entirely shining blue, or shining green with outermost feather blue. 1. *C. forficatus*.
 - b. Tail metallic grass-green. 2. *C. mocoa*.

1. *Cynanthus forficatus*.

- Trochilus forficatus*, LINN., Syst. Nat. (1766), p. 190, sp. 5.
Trochilus cyanurus, STEPH., Shaw Gen. Zool., vol. xiv, p. 239.
Ornismya (Lesbia) kingii, LESS., Trochil., p. 107, pl. 38 (1829); Ind., p. xvii.—BOISS., Rev. Zool. (1840), p. 7.
Cynanthus forficatus, SWAIN., Class. Birds, vol. ii, p. 330 (1836)
Mellisuga forficata, GRAY, Gen. Birds, vol. i, p. 113, sp. 49 (1844-49).
Mellisuga cyanura, GRAY, Gen. Birds, vol. i (1849), p. 113, sp. 50.
Cynanthus forficatus, BON., Consp. Gen. Av. (1850), vol. i, p. 8.
Lesbia forficata, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 718, figs. 4628-29.—BON., Rev. and Mag. Zool. (1854), p. 252.—CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 71.
Lesbia gorgo, REICH., Aufz. der Colib., pp. 8, 24 (1853).—ID., Troch. Enum., p. 5 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 71 (1860).
Cynanthus cyanurus, GOULD, Mon. Troch., vol. iii, pl. 172.—ID., Intr. Troch., octavo ed., p. 102 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 268 (1876).—ELLIOT, Ibis (1876), p. 10.
Mellisuga salvadori, BENVENUT. Ann. Zool. Mus. Flor. (1865), p. 204.
Cynanthus celestis, GOULD, Mon. Troch. Intr., octavo ed., p. 102 (1861).
Lesbia margarethæ, HEIN., Journ. für Ornith. (1863), p. 213, ex Venezuela.
Cynanthus —?, VON PELZ, Verh. Zool. bot. Gesellsch., Wien (1876), xxv., p. 768.

Hab. Venezuela, Columbia, and Ecuador.

Male. Crown metallic grass-green, bordered on the sides with a greenish-black line. Throat metallic-purple. Plumage of the body bronzy-green, darkest on the back, and sometimes with a brownish hue on the under parts. Wing coverts green like the back. Primaries and secondaries brown. Rectrices—in some specimens the feathers of the tail are black, with the portions that project beyond the tip of the rest shining purple—in others the central rectrices are metallic-green; the three next are black with metallic-green tips, inclining to blue on the inner web, and on

the edge of the outer web. Outermost rectrices black on their basal half, remaining part deep metallic-blue. Under tail coverts shining green. A few white feathers near the vent, and a minute white spot behind the eye. Bill and feet black. Total length, $7\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $5\frac{5}{8}$ in. Culmen, $\frac{9}{16}$ in.

Female. Crown dark shining green, not so brilliant as in the male. Upper parts bright bronze-green. Throat grayish-white, each feather tipped with green. Under surface rufous, washed with green on the flanks. Central rectrices shining green. Lateral ones black glossed with dark blue, the outermost one tipped with white. A white spot behind the eye. Bill and feet black. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{2}$ in.

There are two styles among individuals of this species, observable in the coloration of their rectrices; some have these a uniform purplish-blue on their apical half, while others have all but the outermost feather margined and tipped with metallic-green. These styles do not seem to be peculiar to any particular locality, as both are found in Columbia and elsewhere. Mr. Gould has separated the Ecuador bird from the others, as *C. caelestis* (l. c.), on account of its size (!) and a coppery-brown hue of the under parts. I cannot perceive that this is in any wise a peculiar character of Ecuadorian specimens, and consider Mr. Gould's species to have been established upon too slight grounds to be maintained. The Venezuelan birds are of a lighter green generally than those from the western part of South America, and, as stated by Mr. Gould, are nearly destitute of the black line, bordering the brilliant green of the crown; but, in my opinion, these characters are not worthy of being considered as indicating a separate species. The different styles can only be regarded as phases of plumage belonging to one widely distributed, variable species.

2. *Cyananthus mocoa*.

Trochilus mocoa, DELATT. and BOURC., Rev. Zool. (1846), p. 311.

Trochilus (Lesbia) smaragdinus, GOULD, P. Z. S. (1846), p. 85.

Mellisuga smaragdinus, GRAY, Gen. Birds, vol. i, p. 113, sp. 52 (1844-49).

Cyananthus smaragdicaudus, GOULD, Mon. Troch., vol. iii, pl. 173.

Cyananthus mocoa, BON., Consp. Gen. Av. (1850), vol. i, p. 81.—GOULD, Intr. Troch., octavo ed., p. 103 (1861).

—TACZANOW., P. Z. S. (1874), p. 544.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 271 (1876).

Lesbia mocoa, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum. p. 5, pl. 717, figs. 4626-27.—BON., Rev. and Mag. Zool. (1854), p. 252.—CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 71.

Hab. Ecuador, Peru, and Bolivia.

Male. Crown brilliant metallic-green. Plumage of the body bronze-green, inclining to a brownish hue on the lower surface. A metallic-blue spot on the centre of the throat. Wings purplish-brown. Basal half of rectrices black, remaining portion brilliant metallic-green. Behind the eye a minute white spot. Under tail coverts grass-green. Bill and feet black. Total length, $7\frac{1}{8}$ in. Wing, $2\frac{3}{4}$ in. Tail, 5 in. Culmen, $\frac{9}{16}$ in.

Female. Crown shining green, not so luminous as the males. Upper surface golden-bronze. Throat grayish-white, each feather tipped with white. Under surface rufous, washed with green on the flanks. Central rectrices metallic-green; lateral ones black tipped with white. Wings purplish-brown. Bill black. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{1}{2}$ in.

The next genus, which naturally succeeds *CYNANTHUS*, is composed of probably the most wonderfully plumaged birds, certainly so as regards the brilliancy of their hues, that are to be found among the known species of the Trochilidæ. The tails of the males blaze with the radiance of flashes of flame, while their ruby backs, luminous green throats, and under surface present altogether a tout ensemble that is perfectly unique, and unapproached by anything yet known in the whole range of Ornithology. They are of rather large size, and the sexes are very unlike, although if the male was unknown, the female would probably be considered very beautiful. Three species are retained in the genus, but it is doubtful if one of them, the *S. caroli*, has really its proper place with the others; but at present we know so little about it, and the specimens that have been obtained are so few, that it will be necessary to wait for farther information to enable the doubt to be satisfactorily removed.

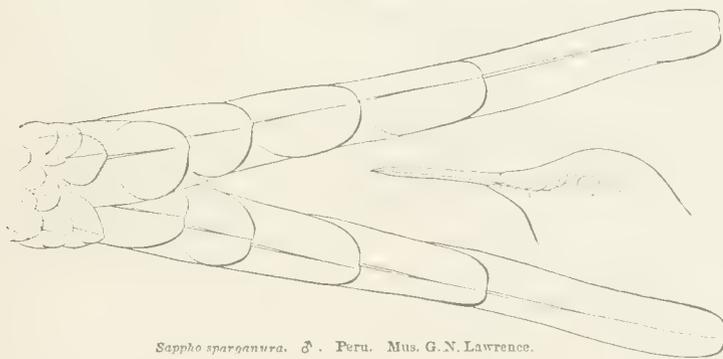
Genus LXXVIII.—SAPPHO.

Cynanthus, TSCHUD., Consp., p. 36 (1844) (nec SWAINS., 1837).
Cometes, GOULD, P. Z. S. (1847), p. 31 (nec HODG., 1841).
Sappho, REICH., Syst. Av. Natur., pl. 40 (1849).
Lesbia, BON. (nec LESS., 1832), Rev. and Mag. Zool. (1854), p. 252.
Sparganura, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 52.
Polyonymus, HEINE, Journ. für Ornith. (1863), p. 206.
Leobia, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 297 (1876).

TYPE.

T. sparganurus, Shaw.
T. caroli, Bourc.
T. caroli, Bourc.

Fig. 86.

*Sappho sparganura*. ♂. Peru. Mus. G.N. Lawrence.

Ch. Bill arched, longer than the head. Tail long and deeply forked. Tarsi naked, hind toe and nail nearly as long as middle toe. Sexes different.

Range. Columbia, Peru, Bolivia, and Argentine Republic.

I place three species in this genus as follows:—

Key to the species.

- | | |
|--|---------------------------|
| A. Throat metallic-green, tail luminous. | |
| a. Rectrices fiery orange-red, tips black. | 1. <i>S. sparganura</i> . |
| b. Rectrices dark luminous crimson. | 2. <i>S. phaon</i> . |
| B. Throat scarlet; central rectrices bronze-green, lateral ones black. | 3. <i>S. caroli</i> . |

1. *Sappho sparganura*.

- Trochilus sparganurus*, SHAW, Gen. Zool., vol. viii. p. 291, pl. 39.
Trochilus chrysurus, CUV. RÉGN., Anim. (1829), t. i, p. 486 (note).
Ornismya sappho, LESS., Ois. Mouch., p. 105. t. 27-28 (1829).—ID., Troch., p. 131, pl. 49 (1831).
Ornismya chrysurus, D'ORB. and LAFRES., Syn. Av., ii, p. 26, sp. 3 (1838).
Orthorhynchus chrysurus, D'ORB. and LAFRES., Syst. Av. (1838), p. 36.
Trochilus (Cyanthus) chrysurus, TSCHUD., Consp., p. 36 (1844).
Mellisuga sparganura, GRAY, Gen. Birds, vol. i, p. 113, sp. 46 (1844).
Cometes sappho, GOULD, P. Z. S. (1847), p. 31.
Cometes sparganurus, BON., Consp. Gen. Av., vol. i (1850), p. 81.—ID., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. iii, pl. 174.—ID., Intr. Troch., octavo ed., p. 103 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 274.—ELLIOT, Ibis (1877), p. 134.
Sappho sparganura, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5, pl. 724, figs. 4651-52 (1855).
Lesbia sparganura, BON., Rev. Zool. (1854), p. 252.
Sparganura sappho, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 52.

Hab. Bolivia, Argentine Republic.

Male. Head, upper part of back, wing coverts, and under surface shining bronze-green. Back and upper tail coverts shining crimson. Rectrices dark brown at base, remaining part metallic fiery-orange tipped with velvety-black. Basal half of outer web of external rectrices pale brown. Wings purplish-brown. Under tail coverts light brown with purplish-red centres. Bill and feet black. Total length, $6\frac{3}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $4\frac{1}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Crown and back greenish-brown. Throat and sides of the face buffy-white spotted with green; rest of under parts whitish, with large spots of green on the flanks. Rump and upper tail coverts shining crimson. Central rectrices crimson; lateral ones, brownish glossed with crimson; the external feather white on its outer web. Bill and feet black. Total length, 5 in. Wing, $2\frac{1}{2}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in.

2. *Sappho phaon*.

- Ornismya chrysura* var., D'ORB. and LAFRES., Syn. Av., ii, p. 27, sp. 4 (1838).
Cometes phaon, GOULD, P. Z. S. (1847), p. 31.—ID., Mon. Troch., vol. iii, pl. 175.—ID., Intr. Troch., octavo ed., p. 104 (1861).—BON., Consp. Gen. Av. (1850), vol. i, p. 81.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 279.—ELLIOT, Ibis (1877), p. 135.
Mellisuga phaon, GRAY, Gen. Birds, vol. i, p. 113, sp. 47.
Sappho phaon, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5, pl. 725, figs. 4633-34.
Lesbia phaon, BON., Rev. Zool. (1854), p. 252.
Sparganura phaon, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 52 (note).

ab. Bolivia, Peru.

Male. Head, neck, and under surface brownish-green, darkest on the head. Back, and upper tail coverts dark crimson. Throat metallic grass-green. Vent white. Under tail coverts buff with a central line of dark brown in some specimens. Tail; basal half blackish-brown, rest metallic crimson, with velvety-black tips. Wings purple-brown. Bill and feet black. Total length, $6\frac{3}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail $4\frac{1}{4}$ in. Culmen, 1 in.

Female. Like that of *S. sparganura*, but the tail is dark crimson as in the male. Total length, $5\frac{3}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail, 3 in. Culmen, $\frac{7}{8}$ in.

3. *Sappho caroli.

- Trochilus caroli*, BOURC., P. Z. S. (1847), p. 48.—ID., Rev. Zool. (1847), p. 260.
Hylocharis caroli, GRAY and MITCH., Gen. Birds, vol. i, p. 115, sp. 44.—BOX., Consp. Gen. Av. (1850), vol. i, p. 74.
Calliphlox caroli, REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).
Avocettinus carolus, BOX., Rev. and Mag. Zool. (1854), p. 256.
Cometes? caroli, GOULD, Mon. Troch., vol. iii, pl. 177.—ID., Intr. Troch., octavo ed., p. 104 (1861).
Polyonymus caroli, HEIN., Journ. für Ornith. (1863), p. 206.
Leobia caroli, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 298 (1876).

Hab. Peru.

Male? “Crown, wing-coverts, and upper surface dull greenish-bronze, becoming of a greener cast on the lower part of the back and upper tail coverts; wings purplish-brown; four middle tail feathers bronzy-green, the remainder black with violet reflections, the outer one with a stripe of dull or buffy-white along the apical portion of the outer web; behind the eye a small spot of white, and a small streak of buff from the angle of the mouth; throat red; under surface pale bronzy-green, each feather slightly fringed with gray; on each flank near the back a tuft of white; vent and under tail coverts buffy-white, with a streak of brown down the centre of each feather. Bill black.” (Gould, Mon. Troch.) Length, $5\frac{1}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, 2 in. Culmen, $\frac{3}{4}$ in.—Although I hardly consider that this species belongs to the genus *Sappho*, I leave it there for the present, additional information being required, for its proper position to be accurately determined.

Between SAPPHO and OXYPOGON, the next genus, a gap occurs. The first named terminates its section, as there is no genus in the Family that has any especial claims to be placed immediately after the “Fire-tails.” OXYPOGON leads on to RHAMPHOMICRON through OREONYMPHA, and these three genera constitute a small section by themselves, without any particular affinities to the other members of the Trochilidæ. The species of the next genus are birds of moderate size, without any brilliant coloration, but possessing high crests and lengthened feathers on the throat, usually designated as “beards.”—They are dwellers of the elevated regions among the Andean range.

Genus LXXIX.—OXYPOGON.

Oxyvogon, GOULD, P. Z. S. (1848), p. 14.

TYPE.

O. guerini, Boiss.

Fig. 87.

Ch. Head crested. Bill shorter than the head, feeble, straight. Face above and below the bill ornamented with lengthened plumes. Tail ample, forked. Feet large. Tarsi naked, hind toe and nail longer than middle toe and nail.

Range. Venezuela and Columbia.

Two species are known of this genus.



Oxyvogon lindeni ♂ Merida. Verreaux.

Key to the species.

- A. Head black; lengthened feathers above and below the bill pure white. Head bounded on sides and front with a white band. Tail coppery-bronze. 1. *O. lindeni*.
- B. Head brownish-black. Feathers in centre of crown buffy-white. Lengthened feathers on the throat buffy-white, with a line of brilliant green in the centre. Lateral rectrices coppery-bronze, with a stripe of white in the centre. 2. *O. guerini*.

1. *Oxygogon lindeni*.

Ornismya lindeni, PARZ., Rev. Zool. (1845), p. 253.

Mellisuga lindeni, GRAY, Gen. Birds, vol. i, p. 113, sp. 31.

Oxygogon lindeni, GOULD, P. Z. S. (1848), p. 14.—ID., Mon. Troch., vol. iii, pl. 183.—ID., Intr. Troch., octavo ed., p. 108 (1861).—BON., Consp. Gen. Av., vol. i, p. 79.—ID., Rev. and Mag. Zool. (1854), p. 253.—REICH., Aufz. der Colib., p. 12 (1853).—ID., Enum., p. 10 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 67 (note) (1860).—SCLAT. and SALV., P. Z. S. (1870), pp. 782, 787.—MULS., Hist. Nat. Ois. Mouch. tom. iii, p. 182 (1876).

Hab. Venezuela.

Male. Head and crest black with a narrow line of white feathers down the centre. A lengthened tuft of white feathers hangs from the centre of the throat. Black of the head is bounded by a band of white. Plumage of the body bronzy-green, with an olive hue on the under surface. Central rectrices bronzy-green; lateral ones coppery-bronze, with the shafts white for three-fourths their length. Wings purplish-brown. Bill and feet black. Total length, $5\frac{1}{4}$ in. Wing, 3 in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{5}{16}$ in.

Female. Head and upper surface coppery-brown. Throat mottled with white and coppery-brown. Flanks coppery-brown with a green lustre. Tail as in the male. In size she is a little smaller.

2. *Oxygogon guerini*.

Ornismya guerini, BOISS., Rev. Zool. (1840), p. 7.—LORD., P. Z. S. (1843), p. 122.

Trochilus parvirostris, FRAS., P. Z. S. (1840), p. 18, juv.

Mellisuga guerini, GRAY, Gen. Birds, vol. i, p. 112, sp. 30 (1844-49).

Oxygogon guerini, GOULD, P. Z. S. (1848), p. 14.—ID., Mon. Troch., vol. iii, pl. 182.—ID., Intr. Troch., octavo ed., p. 108 (1861).—BON., Consp. Gen. Av., vol. i, p. 79 (1850).—ID., Rev. and Mag. Zool. (1854), p. 253.—REICH., Aufz. der Colib., p. 12 (1853).—ID., Troch. Enum., p. 10 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 67, sp. 148 (1860).

Hab. Columbia.

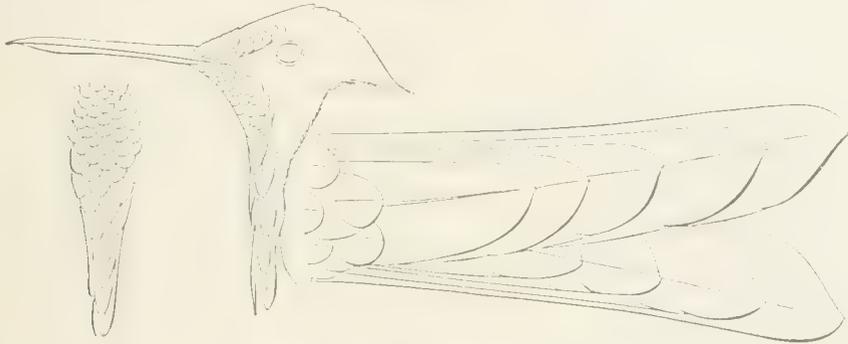
Male. Head and crest brownish-black, with a central line of buffy-white feathers. From the centre of the throat hangs a tuft of buffy-white feathers, in the middle of which is a line of brilliant metallic-green. A band of buffy-white bounds the black of the head. Upper surface, wing coverts, and central rectrices bronzy-green; lateral feathers coppery-bronze with a strip of white down their centres. Shafts of all the rectrices white for nearly their entire length. Wings purplish-brown. Under surface pale brown, bronzy on the flanks. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{3}{8}$ in.

I have not seen an authenticated female, but doubt if she would differ much from the male.

Genus LXXX.—OREONYMPHA.

Oreonympha, GOULD, P. Z. S. (1869), p. 295.TYPE.
O. nobilis, Gould.

Fig. 88.

*Oreonympha nobilis*. ♂. Huatocto, Peru. Whitely.

Ch. "Bill longer than the head, stout, and with a somewhat downward curvature; wings large and sickle-shaped; tail ample and forked; tarsi clothed nearly to the toes, which are of moderate size; the hinder toe and nail rather shorter than the middle toe and nail." (Gould, l. c.).

Range. Peru.

But one species is known, the magnificent—

1. *Oreonympha nobilis*.

Oreonympha nobilis, GOULD, P. Z. S. (1869), p. 295.—WHITELY, P. Z. S. (1874), p. 676.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 175, pl. (1876).

Hab. Huatocto, Paucartambo, and vicinity of Tinta, Peru.

Male. Forehead and centre of crown black; remaining portion of top of head dark blue. Cheeks and sides of throat black. Throat metallic-green, succeeded by a tuft of lengthened metallic reddish-purple feathers. Upper surface bronzy-brown. Sides of neck and under surface grayish-white, mottled faintly with brown on the abdomen and flanks. Under tail coverts bronzy-brown. Central rectrices bronze; lateral feathers white at base, rest bronze; the external one all white excepting a streak of bronze at the tip of the inner web. Bill and feet black. Total length, 7 in. Wing, $3\frac{1}{2}$ in. Tail, $3\frac{1}{2}$ in. Culmen, 1 in. Specimen described is a very fine male from Huatocto, Peru, collected by Mr. Whitely.

Female or young male. Centre of crown deep chestnut, rest greenish-blue. Sides of face and throat black. Centre of throat metallic-green, no pendant tuft. Under part brownish-white. Rest of plumage like that of the male. Bill and feet black. Total length, $5\frac{2}{3}$ in. Wing, 3 in. Tail, $2\frac{3}{4}$ in. Culmen, $\frac{1}{6}$ in. This specimen came from Paucartambo, Peru.

Genus LXXXI.—RHAMPHOMICRON.

Ramphomicron, BON., Compt. Rend., p. 382 (1850).
Chalcostigma, REICH., Aufz. der Colib. (1853), p. 12.
Lampropogon, BON., Rev. and Mag. Zool. (1854), p. 252.
Eupogonus, MULS. and VERR., Class. Troch. (1865), p. 73.

TYPE.

O. microrhyncha, Boiss.
O. heteropogon, Boiss.
O. heteropogon, Boiss.
T. herrani, Delatt. and Bourc.

Ch. Bill shorter than the head, straight, rather stout. Feathers of lower part of throat lengthened, and hanging in a tuft. Wings long, ample. Tail broad, forked, in one species only slightly so when closed.

Range. Columbia, Ecuador, Peru, and Bolivia.

I recognize six species belonging to this genus. They are birds of rather large size, without crests, but having pendant "beards" of metallic feathers of various colors. They constitute a well-marked group of this Family and terminate the section to which they belong.

Key to the species.

- | | |
|---|-----------------------------|
| A. Throat green, terminating in lengthened purplish-red feathers. | |
| a. General plumage dull olive-brown. | 1. <i>R. olivaceus</i> . |
| b. General plumage greenish-bronze. Tail bronzy-brown. | 2. <i>R. heteropogon</i> . |
| c. Upper surface bronzy-green; rump bronzy-rufous. Tail purplish-black, lateral ones tipped with white. | 3. <i>R. herrani</i> . |
| d. Upper surface bluish-violet; beneath sooty-brown. Tail bluish-green. | 4. <i>R. stanleyi</i> . |
| B. Throat and beard-like appendage metallic-green. | |
| a. Top of head rufous-chestnut. Tail bronze. | 5. <i>R. ruficeps</i> . |
| b. Head and upper parts shining purple. Tail velvety-black. | 6. <i>R. microrhyncha</i> . |

1. *Rhamphomicron olivaceus*.

Rhamphomicron olivaceus, LAWRE., Ann. N. Y. Lyc. Nat. Hist. (1867), p. 44.—TACZANOW., P. Z. S. (1874), p. 544.—MULS., Hist. Nat. Ois. Mouch., tom. iii. p. 170 (1876).

Hab. Junin and Maraynioc, Peru (Jelski), Bolivia.

Upper surface and tail dull olive-green. Wings light purplish-brown. Chin and upper part of throat metallic-green, ending in a bunch of elongated feathers, metallic-crimson terminating in violet-purple. Under surface brownish-olive. Vent grayish-white. Under tail coverts olive-green, the feathers margined with pale rufous. Bill and feet black. Total length, $5\frac{1}{4}$ in. Wing, $3\frac{3}{4}$ in. Tail, $2\frac{7}{8}$ in. Culmen, $\frac{7}{16}$ in. There does not seem to be any difference in the plumage of the sexes.

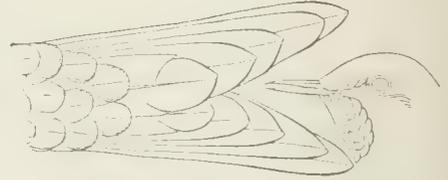
2. *Rhamphomicron heteropogon*.

Ornismya heteropogon, BOISS., Rev. Zool. (1839), p. 355.—*Id.*, Mag. Zool. (1840), pl. 12 (Ois.).

Trochilus coruscus, FRAS., P. Z. S. (1840), p. 15

Mellisuga heteropogon, GRAY, Gen. Birds, vol. i, p. 112, sp. 28.

Fig. 89.

*Rhamphomicron microrhynchum*. ♂. 24630. "Andes."

Rhamphomicron heteropogon, BON., Consp. Gen. Av., vol. i (1850), p. 79.—GOULD, Mon. Troch., vol. iii, pl. 184.—*Id.*, Intr. Troch., octavo ed., p. 109 (1861).—REICH., Troch. Enum., p. 10 (1855).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 167 (1876).

Chalcostigma heteropogon, REICH., Aufz. der Colib., p. 12 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 67 (1860).

Lampropogon heteropogon, BON., Rev. and Mag. Zool. (1854), p. 252.

Hab. Columbia.

Adult. Forehead and crown shining dark green. Upper surface greenish-bronze, becoming reddish-bronze on lower part of rump and upper tail coverts. Throat metallic-green, from which hangs a bunch of lilac feathers. Under surface bronzy-green, becoming rufous-brown on the abdomen. Under tail coverts buff with bronze centres. Wings purplish-brown. Tail shining bronze-brown. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{1}{2}$ in.

Female? or *young* have no beard-like appendage. Throat spotted with green.

3. *Rhamphomicron herrani*.

Trochilus herrani, DELATT. and BOURC., Rev. Zool. (1846), p. 309.

Calothorax herrani, BON., Consp. Gen. Av. (1852), vol. i, p. 85.

Rhamphomicron herrani, GOULD, Mon. Troch., vol. iii, pl. 187.—*Id.*, Intr. Troch., octavo ed., p. 109 (1861).—REICH., Troch. Enum., p. 10 (1855).—MULS., Hist. Nat. Troch., tom. iii, p. 172 (1876).

Chalcostigma herrani, REICH., Aufz. der Colib., p. 12 (1853).

Lampropogon herrani, BON., Rev. and Mag. Zool. (1854), p. 253.

Hab. Ecuador and Columbia.

Male. Forehead and centre of the crown rusty-red margined with black. Rest of head, the upper and under surfaces bronzy-green, becoming brownish on the abdomen. Grayish-white band across the vent. Wings purplish-brown. Rump and upper tail coverts bronzy-rufous. Tail has the middle feathers purplish-blue; lateral ones purplish-black with the two outer ones tipped with white. Chin metallic-green, beneath which are elongated metallic-red feathers bounded on either side with black. Under tail coverts buffy-white. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

Female like the male without the throat mark; this part being dark brown with rufous tinge.

4. *Rhamphomicron stanleyi*.

Trochilus stanleyi, BOURC. and MULS., Ann. Soc. d'Agr., Lyon (1850), p. 199, 3d ser.

Rhamphomicron stanleyi, GOULD, Mon. Trochil., vol. iii, pl. 185.—*Id.*, Intr. Troch., octavo ed., p. 109 (1861).

—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 164 (1876).—TACZAN., P. Z. S. (1874), p. 544.

Rhamphomicron vulcani, GOULD, Jard. Contr. Ornith. (1852), p. 135.—*Id.*, Mon. Troch., vol. iii, pl. 186.—*Id.*,

Intr. Troch., octavo ed., p. 109 (1861).—REICH., Troch. Enum., p. 10 (1855).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 166 (1876).

Chalcostigma stanleyi, REICH., Aufz. der Colib., p. 12 (1853).—*Id.*, Troch. Enum., p. 10 (1855).

Lampropogon stanleyi, BON., Rev. and Mag. Zool. (1854), p. 253.

Chalcostigma vulcani, REICH., Aufz. der Colib., p. 12 (1853).

Lampropogon vulcani, BON., Rev. and Mag. Zool. (1854), p. 253.

Hab. Ecuador, Peru.

Adult. Top of head dark greenish-bronze. Back dark violet-blue. Sides of face and throat black. Centre of throat metallic-green, terminating with some elongated

amethyst feathers. Under surface sooty-brown. Upper tail coverts and tail dark bluish-green. Under tail coverts grayish-white with the central part bluish. Wings brown. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{9}{16}$ in. Culmen, $\frac{7}{16}$ in.

Female or *young* has no brilliant gorget; but the throat is grayish-white, each feather tipped with greenish-brown. I can perceive nothing in the specimens called *rulcani* by Mr. Gould, to separate them from the present species, and I do not consider them distinct.

5. *Rhamphomicron ruficeps*.

Trochilus (—?) *ruficeps*, GOULD, P. Z. S. (1846), p. 89.

Mellisuga ruficeps, GRAY, Gen. Birds, vol. i (1844), p. 112, sp. 29.

Rhamphomicron ruficeps, BON., Consp. Gen. Av., vol. i, p. 79 (1850).—GOULD, Mon. Troch., vol. iii, pl. 188.—

Id., Intr. Troch., octavo ed., p. 109 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 171 (1876).

Chalcostigma ruficeps, REICH., Aufz. der Colib., p. 12 (1853).—Id., Troch. Enum., p. 10 (1855).

Lampropogon ruficeps, BON., Rev. and Mag. Zool. (1854), p. 252.

Hab. Peru (Whitely), Bolivia (Bridges) (Buckley).

Male. Front and crown dark chestnut-red. Upper surface bronzy-green. Throat metallic-green. Under surface dark buff spotted with green. Under tail coverts pale buff. Tail greenish-bronze. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{1}{2}$ in. (Specimen procured in Peru by H. Whitely, 9000 feet elevation.)

Female. Upper surface bronzy-green. Under surface buff; rufous in the centre of the throat, and flanks spotted with green. Wings purplish-brown. Tail greenish-bronze. Bill and feet black. Total length, $3\frac{5}{16}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{16}$ in. (Specimen procured by Buckley in Bolivia.)

6. *Rhamphomicron microrhynchum*.

Ornismya microrhyncha, BOISS., Rev. Zool. (1839), p. 354.—Id., Mag. Zool. (1840), Ois., pl. 16.

Trochilus brachyrhynchus, FRAS., P. Z. S. (1840), p. 16.

Mellisuga microrhyncha, GRAY, Gen. Birds, vol. i, p. 112, sp. 32 (1844-49).

Rhamphomicron microrhyncha, BON., Consp. Gen. Av., vol. i, p. 79 (1850).—GOULD, Mon. Troch., vol. iii, pl.

189.—Id., Intr. Troch., octavo ed., p. 109 (1861).—REICH., Aufz. der Colib., p. 12 (1853).—Id., Troch.

Enum., p. 10 (1855).—WHITELY, P. Z. S. (1873), p. 190.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 162 (1876).

Rhamphomicrus microrhynchus, BON., Rev. and Mag. Zool. (1854), p. 253.—CAB. and HEIN., Mus. Hein. Th., iii, p. 70 (1860).

Hab. Columbia, Ecuador.

Male. Head and upper surface shining purple. Wings purplish-brown. Throat luminous grass-green. Under surface bronzy-green. Band of buff crosses the vent. Tail black with a purplish-gloss. Under tail coverts bronzy-green edged with buff. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, 2 in. Culmen, $\frac{1}{4}$ in.

Female. Upper surface bronzy-green. Throat buffy-white spotted with dull green. Rest of under surface white spotted with green. Tail purplish-black, two outermost feathers tipped with white. Bill and feet black. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{1}{4}$ in.

Genus LXXXII.—AVOCETTINUS.

Avocettinus, BON., Rev. and Mag. Zool. (1854), p. 256 (nec 1850).

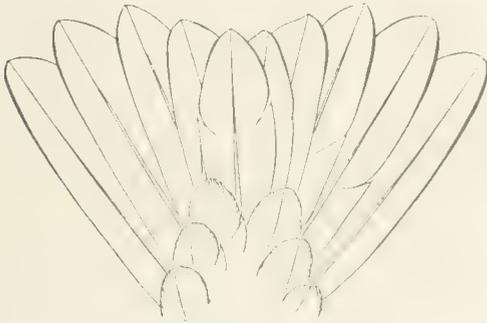
Opisthoprora, CAB. and HEIN., Mus. Hein. Th., iii, p. 76 (note) (1860).

TYPE.

T. eurypyterus, Lodd.

T. eurypyterus, Lodd.

Fig. 90.



Avocettinus eurypyterus. ♂. (From Gould.)



Avocettinus eurypyterus. Bogota.
Mus. G. N. Lawrence.

Ch. Bill shorter than the head; gonys ascending rapidly at their apical termination. Culmen straight until just at the tip, when it turns slightly upwards. Bill broad at its base, narrowing rapidly to a point at the tip. Wings moderate. Tail very slightly forked when closed. Feet strong, hind toe and nail as long as, if not slightly longer than, middle toe and nail.

Range. Columbia.

But one species of this singular genus is known, a plainly colored bird, chiefly remarkable for having the bill turned upwards at the tip.

This genus appears to have been first established by Bon. with the *Avocettula recurvirostris* as type, Consp. Av., p. 75, and the type afterwards changed by him to the *T. eurypyterus* (l. c.).

1. *Avocettinus eurypyterus*.

Trochilus eurypyterus, Lodd., P. Z. S. (1832), p. 7.

Trochilus georginae, BOERC., P. Z. S. (1847), p. 48.

Polytmus eurypyterus, GRAY, Gen. Birds, vol. i, p. 109.

Polytmus georginae, GRAY, Gen. Birds, vol. i, p. 109 (1844-49).

Avocettula eurypyterus, REICH., Aufz. der Colib., p. 6 (1853).—*Id.*, Troch. Enum. (1855), p. 3. pl. 679. figs. 4485-86.

Avocettula georginae, REICH., Aufz. der Colib., p. 6 (1853).

Delatiria georgina, BON., Rev. and Mag. Zool. (1854), p. 256.

Avocettinus eurypyterus, BON., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. iii. pl. 264.—*Id.*,

Intr. Troch., octavo ed., p. 114 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 264 (1876).

Opisthoprora eurypyterus, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 76 (note).

Hab. Columbia.

Adult. Head bronze; rest of upper surface bronze-green, darkest on the rump and upper tail coverts. Wings purplish-brown. Sides of neck and flanks bronzy-green. Throat and breast grayish-white, each feather tipped with green. Lower

part of abdomen and under tail coverts rufous. Median rectrices bronze-green, lateral ones purplish-black with a green gloss, the outermost ones tipped with buffy-white. Bill black, feet brown. Total length, 4 in. Wing, $2\frac{7}{8}$ in. Tail, 2 in. Culmen, $\frac{1}{2}$ in.

Apparently there is no difference between the sexes in the color of their plumage.

Genus LXXXIII.—AVOCETTULA.

Avocettula, REICH., Syst. Av. Nat., pl. 39 (1849).

Avocettinus, BON., Consp. Gen. Av., vol. i, p. 75 (1850, nec 1854).

Streblorhamphus, CAB. and HEIN., Mus. Hein. Th., iii, p. 76 (1860).

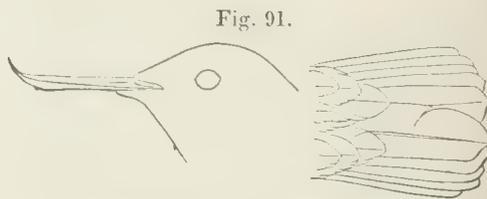
TYPE.

} *T. recurvirostris*, Swains.

H. Bill longer than the head, turned up at the point. Nostrils exposed. Wings long and pointed. Tail slightly rounded. Tarsi partly clothed.

Range. Guiana.

With a bill similar in structure to that of the species in the preceding genus, the single member of the present one possesses also fiery metallic tail feathers, very similar to those of the species contained in the genus immediately succeeding. It seemed, therefore, that here was the proper place for it to occupy. The single species is rather small, of a not ungraceful form, and brilliant plumage.



Avocettula recurvirostra. ♂. Guiana. Parzudaki.

1. *Avocettula recurvirostris*.

Trochilus recurvirostris, SWAINS., Zool. Ill., vol. ii, pl. 105.—JARD., Nat. Libr. Humming-Birds, vol. i, p. 80, pl. 3.

Mellisuga recurvirostris, STEPH., Cont. Shaw. Gen. Zool., vol. xiv, p. 248.

Ornismya recurvirostris, LESS., Ois. Mouch. (1829), p. xxxvi, and Supp., p. 166, pl. 34.

Ornismya avocetta, LESS., Supp. Ois. Mouch., p. 145, pl. 24 (1831).—ID., Trochil., p. 74, pl. 23 (1831).—JARD., Nat. Libr. Humming-birds, vol. i, p. 78, pl. 2.

Campylopterus recurvirostris, SWAINS., Class. B., vol. ii, p. 330 (1836).

Hylocharis avocetta, GRAY, Gen. Birds, vol. i, p. 114, sp. 12.

Hylocharis recurvirostris, GRAY, Gen. Birds, vol. i, p. 114, sp. 11.

Avocettinus recurvirostris, BON., Consp. Gen. Av., vol. i, p. 75 (1850).

Avocettinus lessoni, BON., Consp. Gen. Av., vol. i, p. 75, juv. (1850).

Avocettula recurvirostris, REICH., Aufz. der Colib., p. 6 (1853).—ID., Trochil. Enum. (1855), p. 3, pl. 679, figs.

4487-89.—BON., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon., Troch., vol. iii, pl. 201.—ID., Intr.

Troch., octavo ed., p. 114 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 262 (1876).

Streblorhamphus recurvirostris, CAB. and HEIN., Mus. Hein. Th., iii, p. 76 (1860).

Hab. Guiana.

Male. Upper surface, abdomen, and under tail coverts bronze-green. Throat and breast luminous emerald-green. On the centre of the abdomen is a narrow black stripe. Wings blackish-purple. Median rectrices bronze-green; lateral ones above coppery-brown, margined on the outer webs with green, beneath metallic fiery copper-red. Bill black, feet brownish. Total length, $3\frac{5}{8}$ in. Wing, $3\frac{5}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female? or young. Upper surface and flanks bronze-green. Throat and abdomen white, with a black stripe running the entire length of both. Under tail covers green. Tail above, dark purple glossed with green and the lateral feathers tipped with white; beneath, the lateral feathers are fiery-bronze for three-fourths their length, succeeded by a purplish-black bar glossed with green, and the tips white. Size same as that of the male.

Immature male. Resembles the above, but has the centre of the throat luminous emerald-green bordered with white.

Genus LXXXIV.—METALLURA.

Metallura, GOULD, P. Z. S. (1847), p. 94.

Urolampyra, CAB. and HEIN., MUS. HEIN. Th., iii, p. 68 (1860).

Lavinia, MULS., Catal. Ois. Mouch. (1875), p. 24.

Lavinia, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 106 (1877).

TYPE.

T. opaca, Licht.

T. tyrianthina, Lodd.

T. eupogon, Cab.

T. eupogon, Cab.

Ch. Bill straight, moderately long. Tail ample, rounded when spread. Tarsi bare; feet large; hind toe and nail longer than middle toe and nail. Sexes unlike.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

Nine species are now known, of a comparatively large size, with brilliant throats, and luminous rectrices. These last are of various colors, and in some of the species are extremely brilliant. Contrary to the general law in this Family, the tails of the females are as luminous as those of the males, but the rest of their plumage is different and much more subdued in its coloration.

Fig. 92.



Metallura tyrianthina. ♂. 25740. Quito.

Key to the species.

A. Throat bluish-green; general plumage blackish-purple.

a. Tail luminous copper-color.

b. Tail luminous vinous-purple.

c. Tail luminous purple, crissum white!

B. Centre of throat metallic-red.

C. Throat metallic-green.

a. Tail metallic-bronze, changing to blue above, luminous bronze-green beneath.

b. Tail purplish-blue above, shining grass-green beneath.

c. Tail purplish-green above, beneath deep violet.

d. Tail purple-bronze.

e. Tail deep violet with blue reflections.

1. *M. opaca*.

2. *M. jelski*.

3. *M. chloropogon*.

4. *M. eupogon*.

5. *M. æneicauda*.

6. *M. primolina*.

7. *M. williami*.

8. *M. tyrianthina*.

9. *M. smaragdnicollis*.

1. *Metallura opaca*.

Trochilus (Lampornis) opacus, "Licht." Tsch., Consp., p. 38.—Id., Faun. Per., p. 248 (1844).

Trochilus (—?) *cupreicauda*, GOULD, P. Z. S. (1846), p. 87.

Mellisuga cupreicauda, GRAY, Gen. Birds, vol. i, p. 113. sp. 43.

Metallura cupreicauda, GOULD, P. Z. S. (1847), p. 94.—ID., Mon. Troch., vol. iii, pl. 191.—ID., Intr. Troch., octavo ed., p. 111 (1861).—BON., Consp. Gen. Av., vol. i, p. 75 (1850).—REICH., Troch. Enum., p. 5, pl. 721, figs. 4638–39.—ID., Aufz. der Colib., p. 8 (1853).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 110 (1876).
Agleactis cupreicauda, BON., Rev. and Mag. Zool. (1854), p. 253.
Metallura opaca, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 69.

Hab. Peru and Bolivia.

Male. General plumage lustrous dark purplish-brown. A metallic bluish-green spot on the throat, across the vent a buff line. Tail fiery reddish-bronze. Bill black, feet brown. Total length, $4\frac{1}{2}$ in. Wing, $3\frac{3}{4}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{5}{8}$ in. The female is not certainly known.

2. *Metallura jelski*.

Metallura jelski, CAB., Journ. für Ornith. (1874), p. 99.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 109.
Metallura cupreicauda, TACZAN., P. Z. S. (1874), p. 544.

Hab. Peru (Jelski).

Male. General plumage purplish-black. A bluish-green metallic spot on the lower part of the throat. Wings purplish-brown. A white band crosses the vent. Under tail coverts purplish-black margined narrowly with rufous. Tail luminous vinous-purple. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in. From a typical example.

I have specimens of the *M. opaca* from Peru and Bolivia. The present species, which is very distinct, has as yet only been found in Peru at Maragnoc by M. Jelski.

3. **Metallura chloropogon*.

Urolampra chloropogon, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 68.

Hab. —?

Mas. Purpureo-fuscescens nitore quodam metallico virescenti, vertice humeris uropygioque valde, imprimis autem macula gulari splendidissime virescente-fulgentibus; alis purpureo-fuscis, rectricibus latissimis pulchre purpureo-resplendentibus; crisso albido, tectricibus caudæ inferioribus virescenti-nitentibus margine lutescenti.

Fem. (an mas. juv.). Subtus brunnescenti-ochracea gula lateribusque maculis, parvis fuscis virescentibusque guttatis, rectricibus splendide pupurascentibus, tribus externis apice pallide albescentibus. Long. tot., 3'' 6''; al., 2''; caud., 1'' 6''; rostr. culm., 5''.—(Cab., l. c.)

I do not know this bird.

4. *Metallura eupogon*.

Metallura eupogon, CAB., Journ. für Ornith. (1874), p. 97.

Metallura hedvigæ, TACZAN., P. Z. S. (1874), p. 544, pl. xxi, fig. 2.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 107 (1876).

Hab. Peru (Jelski).

Male. General plumage bronzy-green. Line down the centre of the throat metallic fiery-red. Tuft of white feathers below the thighs. Wings purple-

brown. Tail bronze above with blue reflections; beneath luminous grass-green. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, 2 in. Culmen, $\frac{1}{2}$ in. From typical example in my collection.

Female. Unknown.

5. *Metallura æneicauda.*

Trochilus (—?) *æneicauda*, GOULD, P. Z. S. (1846), p. 87.

Mellisuga æneicauda, GRAY, Gen. Birds, vol. i, p. 113, sp. 44.

Metallura æneicauda, BON., Consp. Gen. Av., vol. i, p. 75 (1850).—GOULD, Mon. Troch., vol. iii, pl. 192.—ID.,

Intr. Troch., octavo ed., p. 111 (1861).—REICH., Troch. Enum., p. 5, pl. 720, figs. 4634–36.—ID., Aufz.

der Colib., p. 8 (1853).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. —WHITELY, P. Z. S. (1873), p. 191.

Aglæactis æneicauda, BON., Rev. and Mag. Zool. (1854), p. 253.

Urolampira æneicauda, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 68.

Hab. Peru and Bolivia.

Male. Upper surface bronzy-green. Throat luminous metallic-green. Under surface bronzy-green on the flanks, centre of breast and abdomen mingled green and brown. Under tail coverts pale bronze-green margined with rufous. Wings purple-brown. Tail, metallic-bronze above changing to blue in certain lights, beneath luminous green. White spot behind the eye. Bill and feet black. Length, $4\frac{3}{8}$ in. Wing, $2\frac{9}{16}$ in. Tail, 2 in. Culmen, $\frac{3}{4}$ in.

Female. Differs in having the under surface brown, each feather tipped with bronzy-green. Centre of abdomen buff. Tail colored like the male, but the lateral feathers are tipped with buff. Bill and feet black.

6. *Metallura primolina.*

Metallura primolina, BOURC., Rev. and Mag. Zool. (1853), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 113.

Metallura primolinus, GOULD, Mon. Troch., vol. iii, pl. 194.—BON., Rev. and Mag. Zool. (1854), p. 253.

Metallura primolina, REICH., Aufz. der Colib., p. 8 (1855).—ID., Troch. Enum., p. 5 (1855).

Urolampira primolina, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 68 (note 5).

Metallura primolii, GOULD, Intr. Troch., octavo ed., p. 112 (1861).

Hab. Ecuador. Vicinity of Laguano, on the banks of the Napo.

Female? Upper surface bronzy-green. Under surface has the base of the feathers rufous-white, darkest on the throat and abdomen, tips bronzy-green. Wings purplish-brown. Tail luminous bronzy-green changing to purple in certain lights, on the upper surface; and metallic luminous grass-green on the under surface; the three outermost feathers tipped with brownish-gray. Bill and feet black. Total length, $3\frac{9}{16}$ in. Wing, $2\frac{5}{16}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{9}{16}$ in. From Bourceir's specimen in my collection.

7. *Metallura williami.*

Trochilus williami, BOURC. and DELATTRE, Rev. Zool. (1846), p. 308.

Mellisuga williami, GRAY, Gen. Birds, vol. i, p. 112, sp. 38.

Metallura williami, BON., Consp. Gen. Av. (1850), vol. i, p. 75.—REICH., Troch. Enum., p. 5 (1855).—ID., Aufz.

der Colib., p. 8 (1853).—BON., Rev. and Mag. Zool. (1854), p. 253.—GOULD, Mon. Troch., vol. iii, pl. 193.

—ID., Intr. Troch., octavo ed., p. 112 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 114 (1876).

Urolampira williami, CAB. and HEIN., Mus. Hein. Th., iii, p. 68 (note 6).

Hab. Columbia.

Male. Upper surface dark bronzy-green. Throat and upper part of breast luminous grass-green. Under surface bronzy-green, the base of the feathers buff. Wings purplish-brown. Tail dark green above, with bright purple reflections in certain lights; beneath luminous violet, with green reflections. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{1}{2}$ in. (From type in my collection.)

Female. Like the male, but the under surface is mottled with green and buff.

8. *Metallura tyrianthina.*

Trochilus tyrianthinus, LODD., Proc. Zool. Soc. (1832), p. 6.

Ornismya allardi, BOURC., Rev. Zool. (1839), p. 294.—ID., Ann. Soc. d'Agr., Lyon (1840), p. 226, pls. 3 and 4.

Ornismya pauline, BOISS., Rev. Zool. (1839), p. 354.—ID., Mag. Zool. (1840), pl. 13.

Mellisuga tyrianthina, GRAY, Gen. Birds, vol. i, p. 112, sp. 36.

Trochilus allardi, JARD., Contr. Ornith. (1850), pp. 81–89, and 151, pl. 55.

Metallura tyrianthina, BON., Consp. Gen. Av., vol. i, p. 75 (1850).—REICH., Troch. Enum., p. 5, pl. 719, figs 4630–31.—ID., Aufz. der Colib., p. 8 (1853).—BON., Rev. and Mag. Zool. (1854), p. 253.—GOULD, Mon. Troch., vol. iii, pl. 195.—ID., Intr. Troch., octavo ed., p. 112 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 117 (1876).

Urolampra tyrianthina, CAB. and HEIN., Mus. Hein. Th., iii, p. 68 (1860).

Metallura quitensis, GOULD, Intr. Troch., octavo ed., p. 112 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 115 (1876).

Hab. Venezeula, Columbia, Ecuador, and Peru.

Male. Upper surface dark bronze-green. A small white spot behind the eye. Throat luminous grass-green. Under surface bronze-green, the base of the feathers buff, which, showing in various parts, gives a mottled appearance to the plumage. Under tail coverts bronzy-green margined with reddish-buff. Wings purplish-brown. Tail brilliant metallic purple-bronze. Bill and feet black. A tuft of white feathers on each side of the vent. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail $1\frac{7}{8}$ in. Culmen, $\frac{7}{16}$ in.

Young male. Like the male, but with the exception, that the throat and under parts are buff- or grayish-white, the feathers tipped with green. No luminous spot on the throat.

Female. Upper parts bronzy-green. Entire under parts rufous, lightest on the abdomen, spotted with green on the throat, and mottled with green on the flanks. Tail bronzy-purple, lighter than the males. In size she is slightly smaller than the male.

The Ecuador bird separated by Mr. Gould as *M. quitensis* (l. c.) does not always possess a greater size to distinguish it, as I have some from Columbia quite equal to it in measurements. I do not consider it a distinct species, and have placed Mr. Gould's term among the synonyms of the *M. tyrianthina*.

9. *Metallura smaragdinicollis.*

Orthorhynchus smaragdinicollis, D'ORB. and LAFRES., Syn. Av., ii, p. 31, no. 23 (1838).—D'ORB., Voy. Amer. Méri., tom. iv, p. 375. Atl. Ois., pl. 59, fig. 2.

Mellisuga smaragdinicollis, GRAY, Gen. Birds, vol. i, p. 112, sp. 42.

Metallura smaragdinicollis, BON., Consp. Gen. Av., vol. i, p. 75 (1850).—REICH., Troch. Enum., p. 5, pl. 719, fig. 4632.—ID., Aufz. der Colib., p. 8 (1853).—BON., Rev. and Mag. Zool. (1854), p. 253.—GOULD, Mon. Troch., vol. iii, pl. 196.—ID., Intr. Troch., octavo ed., p. 112 (1861).—WHITELEY, P. Z. S. (1873), p. 191.—TACZAN., P. Z. S. (1874), p. 544.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 120 (1876).—ELLIOT, Ibis (1877), p. 141.

Urolampira smaragdinicollis, CAB. and HEIN., Mus. Hein. Th., iii, p. 68 (note 4) (1860).

Hab. Peru, Bolivia.

Male. Upper and under surface bronzy-green. Throat luminous dark grass-green. Wings purplish-brown. Tail above dark violet, with green reflections on the edges and tips of the feathers; beneath reddish-violet. Bill and feet black. Length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{1}{2}$ in.

Young male has the throat bronzy-green like the rest of the under parts.

Female. Above bronzy-green. Beneath deep buff, glossed with green on the flanks and spotted with bronzy-green on the throat, breast, and abdomen. Tail purple-violet, lateral feathers tipped with grayish-white.

The next genus, CHRYSURONIA, has generally been placed far from its present position, among such genera as AMAZILIA and EUCEPHALA. I do not perceive that it has any especial relationship with these; but its different species, in the shape and brilliant coloration of their tails, seem to possess an affinity to the members of METALLURA, and properly belong to the small section of these birds with rounded luminous rectrices. The species vary greatly from each other in their style of coloration, and while certain ones have the head and breast highly metallic and luminous, others have the throat and under surface possessed of very little brilliancy.—The sexes differ in their plumage, but, like those of the species of METALLURA, the females also have luminous tails.

Genus LXXXV.—CHRYSURONIA.

Chrysuronina, BON., Consp. Gen. Av., vol. i, p. 75 (1850).

Chrysurus, BON., Compt. Rend., p. 382 (1850).

Chrysurisca, CAB. and HEIN., Mus. Hein. Th., iii, p. 42 (1860).

TYPE.

O. anone, Less.

O. anone, Less.

O. anone, Less.

Ch. Bill a little longer than the head, slightly curved, broad at base and rather flat, graduating rapidly to a sharp point. Feathers of the forehead not advancing on to the culmen, nostrils exposed. Wings long, narrow. Tail very slightly rounded when spread. Feet rather large. Tarsi clothed. Plumage of sexes different.

Range. Central America, Columbia and Ecuador, Peru, Venezuela, Brazil, and Argentine Republic.

Five species are known.

Fig. 93.



Chrysuronina anone. ♂. Ecuador. Buckley.

Key to the species.

- | | |
|---|--------------------------|
| A. Top of head and throat blue; tail bronze-green. | 1. <i>C. humboldti</i> . |
| B. Entire head and throat blue, tail fiery golden-bronze. | 2. <i>C. ænone</i> . |
| C. Crown of head and chin blue, tail golden-bronze. | 3. <i>C. josephina</i> . |
| D. Crown green, throat lazuline-blue, tail shining green-bronze. | 4. <i>C. eliciæ</i> . |
| E. Head golden inclining to brown, throat buff. Tail metallic-golden. | 5. <i>C. chrysura</i> . |

1. *Chrysuronia humboldti*.

Trochilus humboldti, BOURC. and MULS., Ann. Sci. Phys., Lyon (1852), p. 142.

Chrysuronia humboldti, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5 (1855).—GOULD, Mon. Troch., vol. v, pl. 327.—ID., Intr. Troch., octavo ed., p. 165 (1861).—BON., Rev. and Mag. Zool. (1854), p. 254.

Chrysurisca humboldti, CAB. and HEIN., Mus. Hein. Th., iii, p. 42 (note 4) (1860).

Thaumatias viridicaudus, LAWR., Ann. Lyc. Nat. Hist. N. Y. (1866), p. 403, ♀.

Hab. Ecuador.

Male. Top of head and throat dark purple-blue. Upper surface golden-green, bronzy on the rump. Wings purplish-brown. Under surface shining light bronzy-green with a white streak in the centre of the abdomen. Tail dark bronzy-green, with a bluish shade on the central feathers. Under tail coverts white. Bill flesh-colour, or red?, tip black. Feet brown. Total length, 4 in. Wing, $2\frac{2}{3}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

Female. Upper parts coppery-bronze. Under surface dull white, breast spangled with green. Central tail feathers dark green, lateral ones bronzy-green, graduating into dark brown and tipped with white. Total length, 4 in. Wing, $2\frac{2}{3}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

2. *Chrysuronia ænone*.

Ornismya ænone, LESS., Ois. Mouch. Supp., p. 157, pl. 30.—DELATT. and LESS., Rev. Zool. (1839), p. 17.

Polytmus ænone, GRAY, Gen. Birds, vol. i, p. 109, sp. 80.

Chrysuronia ænone, BON., Consp. Gen. Av., vol. i, p. 75 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.—

REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5, t. 722, figs. 4642-43 (1855).—GOULD, Mon.

Troch., vol. v, pl. 325.—ID., Intr. Troch., octavo ed., p. 164 (1861).—MULS., Hist. Nat. Ois. Mouch., tom.

ii, p. 7 (1875).

Chrysurisca ænone, CAB. and HEIN., Mus. Hein. Th., iii, p. 42 (1860).

Hab. Venezuela, Columbia, Ecuador.

Male. Head and throat deep shining blue. Upper parts grass-green. Under parts luminous yellowish-green. Wings purplish-brown. Upper and under tail coverts, and tail fiery golden-bronze. Maxilla black. Mandible flesh-color, tip black. Total length, 4 in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female. Upper surface golden-green. Under surface white, spangled with green. Vent white. Rest like the male. Dimensions the same.

There is a slight difference in the length of bill observable between Columbian and Ecuadorian examples, and the heads of the latter are a greenish-blue; but I believe there is only one species.

3. Chrysuronia josephinae.

Ornismya neera, LESS. and DELATT., Rev. Zool. (1839), p. 18, desc. null.

Ornismya josephinae, BOURC. and MULS., Rev. Zool. (1848), p. 272.

Trochilus josephinae, GRAY, Gen. Birds, vol. iii; Supp., app. 30a.

Chrysuronia josephinae, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5 (1855).—BON., Rev. and Mag. Zool. (1854), p. 254.—GOULD, Mon. Troch., vol. v, pl. 326.—ID., Intr. Troch., octavo ed., p. 164 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 10 (1875).

Chrysurisca josephinae, CAB. and HEIN., Mus. Hein. Th., iii, p. 42 (note 3) (1860).

Chrysuronia neera, GOULD, Intr. Troch., octavo ed., p. 165 (1861).

Chrysuronia caeruleicapilla, GOULD, Intr. Troch., octavo ed., p. 165 (1861).

Hab. Brazil, upper Amazon.

Male. Crown of the head and chin deep blue. Upper parts golden-green. Under parts luminous grass-green. Upper tail coverts and tail golden-bronze, the upper coverts more coppery than the tail. Under tail coverts golden-bronze fringed with gray. Wings purplish-brown. Maxilla black, mandible flesh-color, tip black; feet black. Total length, 4 in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{6}$ in.

Female. Upper parts bronzy-green. Under parts white, washed with green on the flanks. Rest like the male, but the tail not so brilliant. Dimensions the same.

4. Chrysuronia eliciae.

Trochilus eliciae, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), t. ix, p. 314.—ID., Rev. Zool. (1846), p. 316.

Polytmus eliciae, GRAY, Gen. Birds, vol. i, p. 109, sp. 82.

Chrysuronia eliciae, BON., Consp. Gen. Av., vol. i, p. 75 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5, pl. 722, figs. 4644-45.—GOULD, Mon. Troch., vol. v, pl. 328.—ID., Intr. Troch., octavo ed., p. 165 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 13 (1875).

Chrysurisca eliciae, CAB. and HEIN., Mus. Hein. Th., iii, pp. 42, 92 (1860).

Hab. Central America. Guatemala to Chiriqui.

Male. Upper surface and flanks dark green. Throat lazuline-blue. Abdomen buff washed with green; under tail coverts fawn. Upper tail coverts coppery-bronze. Wings purplish-brown. Tail metallic greenish-bronze, in some specimens golden-bronze. Bill flesh-color, tip black. Feet black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female very similar to the male, but less brilliant, and with but an indication of the blue on the throat.

5. Chrysuronia chrysur.

Ornismya chrysur, LESS., Ois. Mouch. Supp., p. 107, pl. 4 (1831).

Ornismya ruficollis, D'ORB. and LAFRES., Syn. Av., ii, p. 30, sp. 22 (1838).

Polytmus chrysurus, GRAY, Gen. Birds, vol. i, p. 100, sp. 81.

Chrysuronia chrysur, BON., Consp. Gen. Av., vol. i, p. 75 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.—REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 5, pl. 721, figs. 4640-41 (1855).—GOULD, Mon. Troch., vol. v, pl. 329.—ID., Intr. Troch., octavo ed., p. 165 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 4 (1875).—ELLIOT, Ibis (1877), p. 140.

Rhamphodon chrysurus, REICH., Aufz. der Colib., p. 15?—ID., Troch. Enum., p. 12? (1855).

Chrysurisca chrysur, CAB. and HEIN., Mus. Hein. Th., iii, p. 42 (note 5) (1860).

Hab. Brazil, Paraguay, and Argentine Republic.

Male. Upper surface golden-bronze, most brilliant upon the tail; and inclining to brown upon the head. Throat buff. Breast and flanks golden-brown. Middle of abdomen buff. Under tail coverts golden with gray edges. Bill flesh-color, tips black. Feet black. Total length, $3\frac{2}{3}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

Some specimens have the two outermost rectrices tipped with gray. These may possibly be females; and occasionally the rectrices of the males are reddish-bronze very brilliant, instead of golden-bronze.

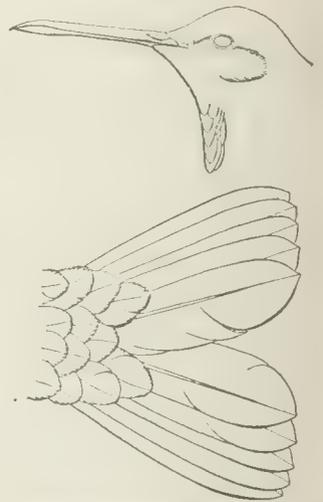
Next to *CHRYSURONIA* I place *AUGASTES*, containing species with highly luminous tails, and a bill similar in shape to the preceding species, yet inclining towards the point to the attenuated form so characteristic of the wedge-like bills of *SCHISTES* and *HELIOTHRIX*. One of the species is a rather large bird, of most beautiful and luminous plumage, and both are distinguished for the metallic color exhibited on their heads and throats.

Genus LXXXVI.—AUGASTES.

Augastes, GOULD, *Intr. Troch.*, octavo ed., p. 123 (1861), desc. *Mou. Troch.*, pt. ii (1850).
Lamprurus, REICH., *Aufz. der Colib.* (1853), p. 12.

TYPE.
T. superbus, Vieill.
O. lumachella, Less.

Fig. 94.



Augastes lumachellus. ♂. Minas Gaoras, Brazil. Verreaux.

Ch. Bill straight, longer than the head, attenuated slightly at the tip; frontal feathers not advancing upon the culmen. Wings long; tail moderately long and square; tarsi clothed; feet small, hind toe diminutive.

Range. Brazil.

Key to the species.

- | | |
|--|----------------------------|
| A. Forehead and throat golden-green, the latter ending in reddish-orange.
Tail metallic bronze-red. | 1. <i>A. lumachellus</i> . |
| B. Forehead and throat emerald-green. Tail shining green with a bluish-gloss. | 2. <i>A. superbus</i> . |

1. *Augastes lumachellus*.

Ornismya lumachella, LESS., *Rev. Zool.* (1838), p. 315, juv.

Trochilus lumachellus, BOURC., *Rev. Zool.* (1846), p. 313.

Hylocharis lumachellus, GRAY, *Gen. Birds*, vol. i, p. 114, sp. 30.

Augastes lumachellus, BON., *Consp. Gen. Av.*, p. 84 (1850).—ID., *Rev. and Mag. Zool.* (1854), p. 253.—GOULD,

Mou. Troch., vol. iv, pl. 222.—ID., *Intr. Troch.*, octavo ed., p. 123.—CAB. and HEIN., *Mus. Hein. Th.*,

iii, p. 46 (1860).—MULS., *Hist. Nat. Ois. Mouch.*, tom. iii, p. 147.

Lamprurus lumachellus, REICH., Aufz. der Colib. (1853), p. 12.

Rhamphomicron (Lamprurus) lumachellus, REICH., Troch. Enum., p. 10 (1855).

Hab. Brazil, Bahia.

Male. Forehead, face, and throat luminous golden-green, bounded beneath by a narrow line of greenish-blue, below which is a tuft of metallic reddish-orange. Top of the head, ear coverts, and a narrow line on side of the throat velvety-black. On either side of the reddish-tuft on breast is a narrow white bar. Rest of plumage of body shining bronze-green. Wings purplish-bronze. Tail metallic bronze-red. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female or young. Differs in having the top of the head green; throat less luminous, and the tail a coppery-bronze, with the outer web of external rectrices grayish-white near the tip.

2. *Augastes superbus*.

Trochilus superbus, VIEILL., Ency. Méth., tom. ii, p. 561.

Trochilus scutatus, NATT., Temm. Plin. Col., no. 299, fig. 3.

Ornismya naterreri, LESS., Ois. Mouch., p. 75, pl. 16 (1829).

Hylocharis superba, GRAY, Gen. Birds, vol. i, p. 114, sp. 29.

Augastes scutatus, GOULD, Mon. Troch., vol. iv, pl. 221.—ID., Intr. Troch., octavo ed., p. 123 (1861).

Augastes superbus, BON., Consp. Gen. Av., vol. i, p. 84 (1850).—REICH., Aufz. der Colib., p. 13 (1853).—ID.,

Troch. Enum., p. 11 (1855).—BON., Rev. and Mag. Zool. (1854), p. 253.—CAB. and HEIN., Mus. Hein. Th.,

iii, p. 45 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 150.

Hab. Brazil.

Male. Forehead, face, and throat glittering emerald-green, these feathers forming a point on the chest. Band across the crown and ear coverts black. A white spot behind the eye. Upper surface bronzy-green. Wings purplish-brown. Under parts indigo-blue, with a crescentic buffy-white mark on the upper part of chest broadest beneath the green throat mark. Tail metallic-green, with a bluish gloss. Under tail coverts whitewashed with green. Bill and feet black. Length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{5}{8}$ in. Culmen, $1\frac{1}{16}$ in.

Female differs in having the crescent mark white instead of buff, the abdomen green instead of blue, under tail coverts pure white, and the outer rectrices tipped with white.

Genus LXXXVII.—PHILOGOPHILUS.

Phlogophilus, GOULD, P. Z. S. (1860), p. 310.

Ch. "Bill straight; wings ample and rather rounded, tarsi long and bare; tail rather large and rounded; hind toe and nail shorter than middle toe and nail." (Gould, loc. cit.)

Range. Ecuador.

One species is attributed to this genus, which if it is adult would seem to belong to the female sex, but if a male is certainly immature.

TYPE.

P. hemileucurus, Gould.

Fig. 95.



Phlogophilus hemileucurus, Ecuador.
Mus. G. N. Lawrence.

1. *Phlogophilus hemileucurus*.

Phlogophilus hemileucurus, GOULD, P. Z. S. (1860), p. 310.—ID., Mon. Troch., vol. v, pl. 360.—ID., Intr. Troch., octavo ed., p. 181 (1861).
Elvira hemileucurus, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 264.

Hab. Ecuador.

Female? or *young?* Upper surface and flanks grass-green. Throat white, feathers tipped with green. Chest, centre of the abdomen, and under tail coverts white. Median rectrices bronze-green; lateral feathers white, with a band of purplish-black in the centre; this band most extensive on the outer feathers and becoming narrower as it goes towards the median ones, where on those next the central pair it is merely a subterminal bar. Bill black. Feet and tarsi yellow. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

All the specimens known of this bird are apparently in the plumage of the female or young. Mr. Gould has made it the type of a new genus, and thinks it is probably allied to *Adelomyia*. It seems to me, however, its proper place is between *Schistes* and *Augustes*, and it would not at all surprise me if it should eventually prove to be the female of one of the species of the latter genus. It is so closely allied to *Augustes*, that I cannot perceive it possesses any generic characters to separate it (unless it may be the bare tarsus); but for the present I leave it in the genus in which Mr. Gould placed it.

Genus LXXXVIII.—SCHISTES.

TYPE.

Schistes, GOULD, Mon. Troch., pt. vi (1853), and Intr. Troch., octavo ed., p. 122 (1861). *T. geoffroyi*, Bourc.

Ch. "Bill longer than the head, straight, wedge-shaped at the tip. Wings moderately long and slightly rounded; tail rounded, the feathers broad; tarsi partially clothed; feet small; hind toe and nail shorter than middle toe and nail." (Gould, loc. cit.)

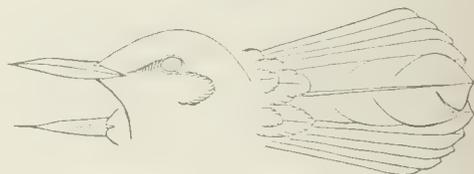
Range. Columbia and Ecuador.

Two species are known, allied to AUGASTES in the shape of their bills; but of small size, and tails not quite so luminous.

Key to the species.

- | | |
|--|---------------------------------|
| <p>A. Forehead and crown bronzy-green, a faint line of luminous green on the first; throat luminous green; on either side of the breast a tuft of lilac-blue
Tail bronze-green, with a subterminal chalybeate bar.</p> | <p>1. <i>S. geoffroyi</i>.</p> |
| <p>B. Forehead, face, and throat glittering pale metallic-green. Tuft of violet-blue feathers on either side of breast. Tail bronze-green with a bluish lustre.</p> | <p>2. <i>S. personatus</i>.</p> |

Fig. 96.



Schistes geoffroyi. ♂. Columbia. Whitely.

1. *Schistes personatus*.

Schistes alboularis, GOULD, Jard. Contr. Ornith. (1851), p. 140. juv.—ID., Mon. Troch., vol. iv. pl. 220. juv.—CAB. and HEIN., Mus. Hein. Th., iii, p. 27 (note) (1860).

Schistes albicularis, REICH., Aufz. der Colib., p. 13 (1853).—BON., Rev. and Mag. Zool. (1854), p. 251.—GOULD, Intr. Troch., octavo ed., p. 123, juv. (1861).

Schistes personatus, GOULD, P. Z. S. (1860), p. 311.—ID., Mon. Troch., vol. iv. pl. 219.—ID., Intr. Troch., octavo ed., p. 122 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 153 (1876).

Schistes geoffroyi, SELAT., P. Z. S. (1860), p. 70.

Hab. Ecuador.

Male. Forehead, face, and throat glittering pale green, behind which is a patch of black. Upper surface bronzy-green. On each side of breast a tuft of violet-blue feathers. Across the upper part of breast is a crescentic-white bar. Abdomen and flanks dark green. Tuft of white behind the thighs. Tail bronze-green with a blue shade. Bill and feet black. Length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{8}$ in.

Young, possibly *female*. Differs in having the throat white, and the violet-blue tufts almost obsolete. Mr. Gould in his descriptions gives the tail as crossed near the tip by a chalybeate band. There is no indication of this band in my specimens, the rectrices being a uniform bronzy-green with a slight bluish shade in one example.

If, as I believe is the case, the *S. alboularis* proves to be the young of *personatus*, the latter name will have to sink into a synonym, having been proposed nine years after *alboularis*.

2. *Schistes geoffroyi*.

Trochilus geoffroyi, BOURC. and MULS., Ann. Soc. d'Agr., Lyon (1843), t. vi, p. 37. pl. 3.—ID., Rev. Zool. (1843), p. 101.

Petasophora? *geoffroyi*, GOULD, P. Z. S. (1847), p. 9.

Polytmus geoffroyi, GRAY, Gen. Birds, vol. i, p. 108, sp. 31.

Colibri geoffroyi, BON., Consp. Gen. Av., vol. i, p. 69 (1850).

Petasophora geoffroyi, REICH., Troch. Enum., p. 11 (1853).

Schistes geoffroyi, GOULD, Mon. Troch., vol. iv, pl. 218.—ID., Intr. Troch., octavo ed., p. 122 (1861).—REICH., Aufz. der Colib., p. 13 (1853).—BON., Rev. and Mag. Zool. (1854), p. 251.—CAB. and HEIN., Mus. Hein. Th., iii, p. 27 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 155 (1860).

Hab. Ecuador.

Male. Crown, upper part of back and wing coverts bronze-green. A faint luminous green line on the forehead. Lower part of back and rump rufous. Wings purplish-bronze. A white spot behind the eye. Throat luminous green. Ear coverts dark brown. On each side of breast a tuft of lilac-blue feathers. Under surface dark green. White tuft behind the thighs. Under tail coverts green edged with gray. Rectrices bronze-green; lateral ones with a subterminal chalybeate bar and tipped with white. Bill black, feet brown. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{1}{2}$ in.

Young? Differs in having the throat buffy-white, this color extending also on each side of the upper part of breast. Middle of abdomen also whitish. Mantle green; rest of upper parts bronze. Rest of plumage like the male, though the under parts not above mentioned are a paler green than the male. This plumage

may possibly be that of the female; though I have not seen an authenticated specimen of that sex.

The members of the next genus, *HELIOTHRIX*, are rather large in size, of a most graceful form, distinguished by their singular wedge-shaped bills, pleasing plumage of green and white, and the metallic-blue tufts on the sides of the neck. There is very little difference in the plumage of the sexes, and when it does exist, consists of the absence of metallic coloring upon the throat of the female. The rectrices of this sex are always much longer than those of the males.

Genus LXXXIX.—*HELIOTHRIX*.

Heliothrix, BOIE, Isis (1831), p. 547.
Heliothrys, GRAY, List Gen. Birds, p. 14 (1840).

TYPE.

T. auritus, Gmel.
T. auritus, Gmel.

Ch. Bill longer than the head, the culmen descending, and the gonys ascending to the tip. Maxilla broad at base, narrowing rapidly towards the middle, the apical half greatly compressed laterally. Tip slender and sharply pointed, nostrils exposed. Wings long, narrow, and pointed. Tail long (longest in the female), much rounded, outermost rectrices two-thirds the length of median ones, upper tail coverts reaching two-thirds the length of the tail. Tarsi clothed to the toes. Sexes similar in color.



Fig. 97.

Heliothrix auritus, ♂. N. Brazil. Whitely.

Range. Central America, Columbia, Ecuador, Peru, Venezuela, Guiana, and Brazil.

Three species are known.

Key to the species.

- A. Head metallic-green.
 - a. Throat white.
 - b. Throat metallic-green.
- B. Head metallic-purple, throat white.

- 1. *H. aurita*.
- 2. *H. auriculatus*.
- 3. *H. barroti*.

1. *Heliothrix auritus*.

- Trochilus auritus*, GMEL., Syst. Nat. (1788), vol. i. p. 493, sp. 47.—LATH., Ind. Ornith. (1790), tom. i, p. 311.—WIED., Beitr., vol. iv, p. 104.—CAB., Schomb. Reis. Guian., vol. iii, p. 707.
Trochilus leucoerotophus, VIEILL., Nouv. Dict. (1817), vol. vii, p. 374.
Ornismya aurita, LESS., Ois. Mouch., p. 63, t. 10-11 (1829).
Ornismya nigrotis, LESS., Ind. Gen. and Syn. Ois. Gen. Troch., p. 20, sp. 48, ♀ (1831).
Heliothrix nigrotis, GRAY, Gen. Birds, vol. i, p. 115, sp. 2.

Heliiothrix auritus, BOIE, Isis (1831), p. 547.—GRAY, Gen. Birds, vol. i. p. 115, sp. 1.—BOX., Consp. Gen. Av., vol. i, p. 69.—ID., Rev. and Mag. Zool. (1854), p. 251.—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 28.—GOULD, Mon. Troch., vol. iv, pl. 213.—ID., Intr. Troch., octavo ed., p. 121 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 238.—ELLIOT, Ibis (1876), p. 395.

Heliiothrix longirostris, GOULD, P. Z. S. (1862), p. 124.

Hab. Northern Brazil, Guiana, Venezuela, Columbia, Ecuador, and Peru.

Male. Entire upper surface and lengthened upper tail coverts shining golden-green, brightest on the head. Wings purplish-black. Lores and a line below the eye black, ending in violet-blue. Below this line is another of luminous green extending from the gape. Entire under surface pure white. Four middle rectrices bluish-black, remainder pure white. Bill and feet black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{5}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female. Wants the green line beneath the black one on the face; and the violet tufts on the checks. It also differs in having a much longer tail, and an oblique black bar across the lateral rectrices near their base. In all other respects she resembles the male. Total length, $5\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Tail, $2\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

2. *Heliiothrix auriculatus*.

Trochilus auriculatus, "LICHT.," Nordm. Erman Reise (1835), p. 5, t. 2, figs. 1 and 2.

Ornismya poucheti, LESS., Rev. Zool. (1840), p. 72.

Heliiothrix auriculatus, GRAY, Gen. Birds, vol. i. p. 115, sp. 3.—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).—GOULD, Mon. Troch., vol. iv, pl. 214.—ID., Intr. Troch., octavo ed., p. 121.—BOX., Rev. and Mag. Zool. (1854), p. 251.—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 28.—ELLIOT, Ibis (1876), p. 396.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 340 (1875).

Heliiothrix poucheti, BON., Consp. Gen. Av., p. 69 (1850).

Heliiothrix aurita, BURM., Th. Bras., vol. ii, p. 336, juv.

Heliiothrix phainolæma, GOULD, P. Z. S. (1855), p. 87.—ID., Mon. Troch., vol. iv, pl. 215.—ID., Intr. Troch., octavo ed., p. 121 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 28 (note 4) (1860).

Heliiothrix phainoleuca, HARTL., Weig. Arch., vol. xxii, 2, p. 23.

Hab. Southern Brazil.

Male. Differs from the *H. auritus* only in having the chin and sides of the neck luminous grass-green. In all other respects they are alike. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{5}{8}$ in. Tail, 2 in. Culmen, $\frac{5}{8}$ in.

Female. Precisely like the female of *H. auritus*, and the dimensions the same.

3. *Heliiothrix barroti*.

Trochilus barroti, BOURC., Rev. Zool. (1843), p. 72.—ID., Ann. Soc. Agr. Lyon (1843), t. vi, p. 48.

Heliiothrix barroti, GRAY, Gen. Birds, vol. i, p. 115, sp. 4.—BOX., Consp. Gen. Av., vol. i, p. 69 (1850).—REICH., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).—BOX., Rev. and Mag. Zool. (1854), p. 271.—GOULD, Mon. Troch., vol. iv, pl. 217.—ID., Intr. Troch., octavo ed., p. 121, sp. 241.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 242.—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 28 (note 3).—ELLIOT, Ibis (1876), p. 397.

Heliiothrix purpureiceps, GOULD, P. Z. S. (1855), p. 87.—ID., Mon. Troch., vol. iv, pl. 216.—CAB. and HEIN., Mus. Hein. Th., iii, p. 28 (note 3) (1860).

Heliiothrix violifrons, GOULD, Intr. Troch., octavo ed., p. 122, sp. 242 (1861).—SALV., P. Z. S. (1870), p. 210.

Hab. Central America, Columbia, Ecuador.

Male. Top of head purplish-blue. Rest of plumage like *H. auritus*. Total length, $4\frac{3}{8}$ in. Wing, $2\frac{5}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female. Like the female of *H. auritus*, except the green of the upper surface is darker on the lower part of the back and upper tail coverts. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail, $2\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

Genus XC.—CHRYSOLAMPIS.

Chrysolampis, BOIE, Isis (1831), p. 546.

TYPE.
T. moschitus, Linn.

Ch. Bill straight, long as the head, nostrils hidden. Feathers of the forehead project on the culmen for nearly one-half the length of the bill. Wings long, tail rounded. Feet small, tarsi bare. Sexes dissimilar.

Range. Brazil (Amazonian region), Venezuela, Trinidad, and Columbia.

There is only one species, the well-known "Ruby Topaz" of the commercial world. It is distinguished by the frontal plumes projecting far over the culmen, and the beauty of coloring exhibited on the head and throat. The female is a very plain little bird, possessing none of the glittering hues of the male.

Fig. 98.



Chrysolampis moschitus. ♂. 24650. "South America."

1. *Chrysolampis moschitus*.

Trochilus moschitus. LINN., Syst. Nat. (1766), vol. i, p. 192.—GMEL., Syst. Nat., tom. i, p. 494 (1788).—LATH., Ind. Ornith., vol. i, p. 316 (1790).—SWAINS., B. Brazil, pl. 30.—CAB., Schomb. Reis. Guian., iii, p. 705.

Trochilus carbunculus. GMEL., Syst. Nat., t. i, p. 498, sp. 51 (1788).

Trochilus pegasus. GMEL., Syst. Nat., t. i, p. 495 (1788).—LATH., Ind. Ornith., vol. i, p. 315, ♀ (1790).

Trochilus guianensis. GMEL., Syst. Nat., t. i, p. 498 (1788).—LATH., Ind. Ornith., vol. i, p. 316, sp. 50 (1790).

Trochilus elatus. GMEL., Syst. Nat., t. i, p. 499 (1788).—LATH., Ind. Ornith., vol. i, p. 317, sp. 54 (1790).

Trochilus hypophæus. SHAW., Gen. Zool., vol. viii., p. 333, juv.

Ornismya moschitus. LESS., Ois. Mouch., p. 166, pls. 52-54 (1829).—ID., Trait. Ornith., p. 280 (1831).

Mellisuga moschita. STEPH., Shaw, Gen. Zool., vol. xiv, p. 253.—GRAY, Gen. Birds, vol. i, p. 113, sp. 96.

Chrysolampis moschitus. BOIE, Isis (1831), p. 546.—BON., Consp. Gen. Av., vol. i, p. 82 (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. iii, pl. 204.—ID., Intr. Troch., octavo ed., p. 115 (1861).—REICH., Aufz. der Colib. (1853), p. 9.—ID., Troch. Enum., pl. 723, figs. 46-46-49.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 254 (1875).

Chrysolampis carbunculus. REICH., Troch. Enum., p. 5, pl. 723, fig. 4650.—ID., Aufz. der Colib., p. 9 (1853).

Chrysolampis moschita. CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 21.

Chrysolampis reichenbachii. CAB. and HEIN., Mus. Hein. Th., iii, p. 21 (1860).

Hub. Island of Trinidad, Venezuela, Guiana, Brazil as far south as Bahia, and through the Amazonian valley into Columbia. Plentiful around Bogota.

Male. Entire upper part of head and nape metallic ruby-red. Rest of upper surface bronze-brown, nearly black on the upper part of back. Chin, throat, and breast glittering topaz-yellow. Abdomen and flanks dark snuff-brown. Tuft of white feathers behind the thighs. Under tail coverts rufous. Tail chestnut-red

tipped with black. Bill and feet black. Total length, $3\frac{5}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{7}{16}$ in.

Female. Upper surface bronzy-green. Under surface grayish-white. Wings purplish-brown. Median rectrices bronzy-green, lateral ones purplish-brown with a green gloss and tipped with white. Bill and feet black.

Young male. Like the female, but with a few brilliant ruby feathers on the head, and a line of glittering topaz on the centre of the throat.

Very young bird. Upper surface rufous; under parts gray. Tail purple-brown, lateral feathers tipped with white.

Variations in the hues of the head and throat are perceptible among individuals of this species from various localities, but there does not seem to be more than one species. Sometimes very curious forms occur; and one before me from Brazil (?), ex Whitely, has the top of the head luminous orange, and the chin, throat, and breast metallic *emerald-green*. I can, however, only consider this specimen as an abnormal one of the present species; as in every other respect it resembles it exactly.

The next genus, *BELLONA*, although possessing species of a very different style of coloration from the previous one, seems well placed here. Its members have the basal portion of the culmen hidden in the frontal feathers, and the general shape of the birds is very like that of the "Ruby Topaz."—They differ, however, in having well-developed crests, and also from the fact, that the metallic hues are confined to the heads, there being none upon any part of the under surface. The term *Orthorhynchus*, which has been applied to the species of *BELLONA*, is stated, by nearly all ornithologists, to have been established by Cuvier. This does not appear to be the fact. The first naturalist who mentions the genus *Orthorhynchus*, as I have been able to ascertain, is Lacépède in the *Memoir de l'Institute*, 1799–1800, tom. 3, p. 510; and Cuvier himself in the *Règne Animal*, 1817, vol. i, p. 413, cites Lacépède as the author of the term. No species were given in the *Mem. de l'Inst.* as especially belonging to the genus, and the definition is simply, "Bec droit et remplé vers le bout."—Now this will apply to at least one hundred species of the Trochilidæ, and it is very clear that Lacépède never intended to restrict his genus to *cristatus* and *exilis*.—The old authors seem to have divided the Humming-birds into two classes, those with straight bills, which they designated "Orthorhynchus," and those with curved bills, called "Ornismya," or "Colibri," and these were not altogether used as genera as understood at the present day. I am unable to find that this term *Orthorhynchus*, although used as a genus by authors, has ever been defined beyond the very unsatisfactory definition quoted. As has been shown, it was first employed in the vaguest possible manner by Lacépède; afterwards restricted by Illiger in his *Prodromus*, 1811, p. 209, to three species (all belonging to different genera), among which *cristatus* and *exilis* were not included, and then of late applied in an entirely different sense from that for which it was established by the author last mentioned. Writers, quoting Cuvier as the creator of the genus *Orthorhynchus*, have usually accredited him also with making the *T. cristatus* its type. The only circumstance I can find to uphold this idea is, that Cuvier in the *Règne Animal*, 1817, p. 414, in a foot-note gives *cristatus* as an example of those

species having *straight bills*, but evidently without any intention of making it the type of Lacépède's genus, because he also includes among the *straight bill birds*, as belonging to *Orthorhynchus*, the *Lophornis ornatus*, *Campylopterus largipennis*, *Florisuga mellirora*, and *Discura longicauda*. Under these circumstances, I do not see how it is possible to retain the term *Orthorhynchus* for any group of humming-birds; it should be rejected entirely as many another term has been, and that of *BELLONA* proposed by M. Mulsant for *cristatus* and *exilis* is the one that should be adopted.

Genus XCI.—BELLONA.

Bellona, MULS. and VERR., Class. Troch. (1865), p. 75.

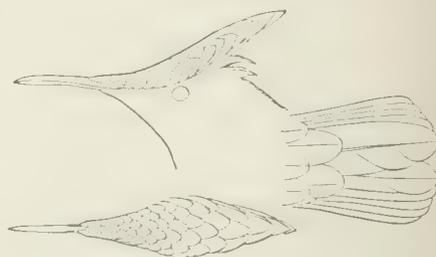
TYPE.
T. cristatus, Linn.

Ch. Bill straight, about as long as the head: feathers of the forehead projecting forward, covering one-half the length of the culmen. Nostrils hidden. Head covered with a broad, pointed crest. Wings rather long. Tail rounded. Feet small, tarsi naked. Sexes dissimilar.

Range. Islands of the West Indies.

Two species are allotted to this genus.

Fig. 99.



Bellona cristata. ♂. Barbadoes. Verreaux.

Key to the species.

- A. Crest with the frontal half golden-green, rest blue.
B. Crest golden-green, tips grass-green.

1. *B. cristata*.
2. *B. exilis*.

1. *Bellona cristata*.

Trochilus cristatus, LINN., Syst. Nat., vol. i, p. 192 (1766).—SCHOMB., Hist. Barb., p. 681.—ID., Gmel. Syst. Nat., vol. i, p. 498 (1788).—LATH., Ind. Orn., tom. i, p. 317 (1790).—SWAINS., B. Braz., pl. 21.

Trochilus puniceus, GMEL., Syst. Nat., tom. i, p. 497 (1788).

Trochilus pileatus, LATH., Ind. Ornith., vol. i, p. 318 (1790).

Mellisuga cristata, GRAY, Gen. Birds, vol. i, p. 113, sp. 98.

L'oiseau mouche huppé, LESS., Ois. Mouch. (1829), p. 113, pls. xxxi, xxxii.

Ornismya cristata, LESS., Troch., p. 20, pl. 4 (1831).—ID., Gen. and Syn. Troch., p. xxx.—ID., Trait. Ornith., p. 285.

Orthorhynchus cristatus, BON., Consp. Gen. Av., vol. i, p. 83 (1850).—REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum. (1855), p. 9.—BON., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. iv, pl. 205.—ID., Intr. Troch., octavo ed., p. 116 (1861).—CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 61.—ELLIOT, Ibis (1872), p. 355.

Orthorhynchus ornatus, GOULD, Mon. Troch., vol. iv, pl. 206.—ID., Intr. Troch., octavo ed., p. 117 (1861).—ELLIOT, Ibis (1872), p. 355.

Bellona cristata, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 193 (1876).

Hab. Islands of St. Vincent, Barbadoes, Martinique, St. Lucia.

Male. Forehead and crown golden-green, changing into deep blue on the lengthened crest feathers. Upper surface dark grass-green, darkest on the back of the neck. Wings purplish-brown. Throat smoky-brown. Under surface purplish-

black. Tail purplish-black. Bill and feet black. Total length, 3 in. Wing, 2 in. Tail, $1\frac{3}{8}$ in. Bill along the gape, $\frac{5}{8}$ in.

Female. Upper surface bronzy-green. Wings purplish-brown. Under surface smoky-gray. Median rectrices bronzy-green; lateral feathers purplish-brown, outermost ones tipped with gray. Bill and feet black.

2. *Bellona exilis*.

Trochilus exilis, GMEL., Syst. Nat., vol. i, p. 484 (1788).—LATH., Ind. Ornith., vol. i, p. 310 (1790).

Trochilus cristatellus, LATH., Ind. Ornith. Supp., p. xxxix (1790).

Mellisuga exilis, GRAY, Gen. Birds, vol. i, p. 113, sp. 98.

Orthorhynchus chlorolophus, BON., Consp. Gen. Av., vol. i, p. 83 (1850).

Orthorhynchus exilis, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 9 (1855).—BON., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. iv, pl. 207.—ID., Intr. Troch., octavo ed., p. 117 (1861).—ELLIOT, Ibis (1872), p. 355.

Bellona exilis, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 196 (1876).

Hab. Islands of Dominica, Nevis, St. Thomas, and St. Croix.

Male. Forehead and crown golden-green, blending into grass-green at the tip of the crest. Upper parts bronze-green. Throat smoke brown; under parts purplish-black, glossed with green on the flanks. Wings purple-brown. Middle rectrices dark bronze-green, rest dark purple. Bill and feet black. Total length, $3\frac{3}{8}$ in. Wing, 2 in. Tail, $1\frac{5}{8}$ in. Bill along gape, $\frac{5}{8}$ in.

Female, exactly like the female of *O. cristatus*.

Although Gmelin's diagnosis of "*crista basi viridi, apice aurea*," is exactly transposed, for the base of the crest is *golden* and the *tip green*, I deem it most probable he intended to describe this species and therefore leave it under his name, by which it has been so long known.

Genus XCII.—CEPHALOLEPIS.

Cephallepis (*lege Cephalolepis*), LODD., P. Z. S. (1830), p. 12.

Smaragdites, REICH. (nec BOIE., 1831), Syst. Av. Nat., pl. 40 (1849).

Cephalolepis, CAB. and HEIN., Mus. Hein., iii, p. 61 (1860).

Orthorhynchus, BURM. (nec LACEP., 1799), Th. Bras. (1856).

TYPE.

T. delalandi, Vieill.

T. delalandi, Vieill.

T. delalandi, Vieill.

T. delalandi, Vieill.

Ch. Bill straight, a little shorter than the head. Nostrils hidden. Head covered with a long rather loose crest, terminating in one, sometimes two, narrow feathers extending far beyond the rest. Wings long. Tail slightly rounded. Tarsi bare. Sexes unlike.

Range. Brazil.

I recognize but two species in this genus; which are remarkable for the single lengthened plume rising from the crest. Sometimes there are two of these, and I have one specimen possessing *three*. They are gracefully formed birds, with a pleasing plumage, though not highly luminous.

Fig. 100.



Cephalolepis delalandi. ♂. Brazil. Sharpe.

Key to the species.

- | | |
|---|---------------------------|
| A. Crown and crest metallic grass-green; lengthened plume black. | 1. <i>C. delalandi</i> . |
| B. Crown and crest luminous lilaceous-blue; lengthened plume black. | 2. <i>C. loddigesii</i> . |

1. *Cephalolepis delalandi*.

- Trochilus delalandi*, VIEILL., Nouv. Dict. Hist. Nat., tom. 22, p. 427, pl. G. 36, fig. 3.—ID., Ency. Méth., vol. ii, p. 558.—TEMM., Pl. Col., pl. 18, figs. 1, 2.—LESS., Ind. Syn. Troch., p. xxx.—SWAINS., B. Braz. pl. 22.
- Trochilus versicolor*, VIEILL., Nouv. Dict. Hist. Nat., tom. 23, p. 430.
- Cephalolepis delalandii*, LODD., P. Z. S. (1830), p. 12.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 187.
- Mellisuga delalandi*, GRAY, Gen. Birds, vol. i, p. 114, sp. 99.
- Cephalolepis lalandii*, BON., Consp. Gen. Av., vol. i., p. 83 (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.
- Cephalolepis delalandi*, REICH., Aufz. der Colib., p. 12 (1853).—GOULD, Mon. Troch., vol. iv, pl. 208.—ID., Intr. Troch., octavo ed., p. 118 (1861).
- Orthorhynchus delalandii*, BURM., Th. Bras., pt. ii, p. 351 (1860).—REICH., Troch. Enum., p. 9 (1855).
- Cephalolepis delalandi*, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 61.—SCLAT. and SALV., Nomen., p. 88 (1873).
- Cephalolepis beskii*, VON PELZ., Orn. Bras. (1868), p. 58.—ELLIOT, Ibis (1874), p. 262.

Hab. Southern Brazil.

Male. Forehead, crown, and short crest feathers glittering grass-green; lengthened plume black. Upper surface bronzy-green. Small white spot behind the eye. Sides of neck and flanks and under tail coverts brownish-gray, rest of under parts shining violet-blue. Median rectrices bronze-green; lateral one green at base, changing to black and tipped with white. Wings purplish-brown. Bill black, feet flesh-color. Total length, $3\frac{3}{8}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{2}$ in.

Female. Above bronzy-green; beneath grayish-brown. Tail like that of the male.

2. *Cephalolepis loddigesii*.

- Trochilus loddigesii*, GOULD, P. Z. S. (1830), p. 12.—LESS., Troch., p. 138, pl. 51.—ID., Gen. Syn. Troch., p. xxx (1831).
- Trochilus opisthocomus*, "LICHT." Nordm. Ermann. Reise. Verz. v. Thier. und pflanz. atlas, t. 2, fig. 3 (1835).
- Mellisuga loddigesii*, GRAY, Gen. Birds, vol. i, p. 114, sp. 100.
- Cephalolepis loddigesii*, BON., Consp. Gen. Av., vol. i, p. 83 (1850).—ID., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. iv, pl. 209.—ID., Intr. Troch., octavo ed., p. 118 (1861).
- Cephalolepis loddigesii*, REICH., Aufz. der Colib., p. 12 (1853).
- Orthorhynchus loddigesii*, REICH., Troch. Enum., p. 9 (1855).
- Cephalolepis loddigesii*, CAB. and HEIN., Mus. Hein. Th., iii, p. 61 (note) (1860).
- Cephalolepis loddigesii*, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 191 (1876).

Hab. Southeastern Brazil.

Male. Crown and short feathers of the crest lilaceous-blue; lengthened plumes black. Upper surface bronze-green. White spot behind the eye. Chin, sides of the neck, flanks, and under tail coverts brownish-gray; rest of under parts dark blue. Tail bronzy-green; lateral feathers black near their extremities and tipped with white. Bill black, feet brown. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{9}{16}$ in.

Female like the male, except that the under surface is entirely dull grayish-brown.

Genus XCIII.—ADELOMYIA.

Adelomyia. BON., Rev. and Mag. Zool. (1854), p. 253.

Adelisca, CAB. and HEIN., Mus. Hein. Th., iii, p. 72 (1860).

Ch. Bill about equal in length to the head, straight. Tail slightly rounded. Wings rather long; primaries slightly curved inward near the tip. Tarsi naked. Sexes alike.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

I recognize four species belonging to this genus. They are birds of small size and plain plumage, only one having any conspicuous metallic hues, and these confined to the throat.

Key to the species.

- | | |
|---|----------------------------|
| A. Under parts buff; rufous on the flanks. Throat spotted with brown. | 1. <i>A. cervina</i> . |
| B. Under parts brown, with bronze reflections on the flanks. | |
| a. Throat spotted with blue. | 2. <i>A. inornata</i> . |
| b. Throat spotted with green. | 3. <i>A. chlorospila</i> . |
| c. Throat spotted with dark brown. | 4. <i>A. melanogenys</i> . |

1. *Adelomyia cervina*.

Adelomyia cervina, GOULD, Ann. Mag. Nat. Hist. (1872), p. 453.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 131.

Hab. Columbia, Antioquia (Salmon).

Adult. Head and upper parts bronzy-green. Under parts dark buff, becoming rufous on the flanks. Throat spotted or streaked with dark brown. Wings purplish-brown. Tail dark bronze, with a purple gloss near the tips in some specimens, all the feathers tipped with buff. Bill black, feet brown. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{5}{8}$ in.

2. *Adelomyia inornata*.

Trochilus (—?) *inornatus*, GOULD, P. Z. S. (1846), p. 89.

Mellisuga inornata, GRAY, Gen. Birds, vol. i, p. 112, sp. 34.

Rhamphomicron inornatus, BON., Consp. Gen. Av., vol. i, p. 79 (1850).

Adelomyia inornata, GOULD, Mon. Troch., vol. iii, pl. 197.—ID., Intr. Troch., octavo ed. p. 113 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 127.—BON., Rev. and Mag. Zool. (1854), p. 253.—WYATT, Ibis (1871), p. 377.—WHITELY, P. Z. S. (1873), p. 189.

Metallura inornata, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5 (1855).

Adelisca inornata, CAB. and HEIN., Mus. Hein. Th., iii, p. 72 (note) (1860).

Hab. Peru and Bolivia.

Male. Upper surface bronzy-green. Lores rufous, and a buff stripe over the eye. Ear coverts brownish-black. Under surface brown inclining to rufous on the flanks.

TYPE.

T. melanogenys, FRAS.

T. melanogenys, FRAS.

Fig. 101.



Adelomyia melanogenys. ♀. 21653.
New Granada.

with bronzy reflections; and the feathers of the throat tipped with blue. Wings purple-brown. Tail bronze, tips buff, and a purple gloss beneath the buff. Bill black. Feet flesh-color. Total length, $3\frac{3}{8}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{9}{16}$ in.

Female differs in having the throat spotted with brown.

3. *Adelomyia chlorospila*.

Adelomyia chlorospila, GOULD, Ann. and Mag. Nat. Hist. (1872), p. 452.—WHITELY, P. Z. S. (1873), p. 189.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 128 (1876).

Hab. Peru.

Adult. Upper parts bronzy-green, darkest on the head; white spot behind the eye, and a buff stripe over it. Ear coverts black. Under parts pale buff, washed with green on the flanks, and the throat spotted with light green. Wings purplish-brown. Tail bronze with a purple gloss, and tipped with buff. Bill black, feet flesh-color. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in.

Only to be distinguished from *A. inornata* by the green spots on the throat, which, however, are very small and indistinct.

4. *Adelomyia melanogenys*.

Trochilus melanogenys, FRAS., P. Z. S. (1840), p. 18.

Trochilus sabinae, BOURC. and MULS., Ann. Soc. Ag., Lyon (1846), p. 323.—ID., Rev. Zool. (1846), p. 316.

Mellisuga sabinae, GRAY, Gen. Birds, vol. i, p. 112, sp. 33 (1844-49).

Mellisuga melanogenys, GRAY, Gen. Birds, vol. i, p. 112, sp. 35.

Rhamphomicron sabinae, BON., Consp. Gen. Av., p. 79 (1850).

Rhamphomicron melanogenys, BON., Consp. Gen. Av., vol. i, p. 79 (1850).

Adelomyia melanogenys, GOULD, Mon. Troch., vol. iii, pl. 198.—ID., Intr. Troch., octavo ed., p. 113.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 131 (1876).

Metallura sabinae, REICH., Anz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 5, pl. 720, figs. 4636-37 (1855).

Adelomyia sabina, BON., Rev. and Mag. Zool. (1854), p. 253.

Adelisca melanogenys, CAB. and HEIN., Mus. Hein. Th., iii, p. 72 (1860).

Adelomyia maculata, GOULD, Mon. Troch., pl. 199.—ID., Intr. Troch., octavo ed., p. 113 (1861).

Hab. Venezuela, Columbia, Ecuador, and Peru.

Adult. Upper surface golden-green. A white line behind the eye. Ear coverts brownish-black. Under surface brownish-white, washed with rufous and spotted with green on the flanks. Throat spotted with brown. Wings purplish-brown. Rectrices bronzy-brown, with the basal half of inner webs, and tips of the lateral ones buffy-white. Bill black. Length, $3\frac{3}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{8}$ in.

Genus XCIV.—ANTHOCEPHALA.

Anthocephala, CAB., Mus. Hein. Th., iii (1860), p. 72 (note).

Ch. Bill straight, pointed, long as the head. Wings long pointed. Tail rounded.

Range. Columbia.

One species is known, and seems to be quite an aberrant form, though, perhaps, nearest allied to ADELOMYIA. It is a small bird, chiefly remarkable for the peculiar coloration of its crown.

TYPE.

T. floriceps, Gould.

Fig. 102.

*Anthocephala floriceps*. ♂. Type. Columbia. Gould.1. **Anthocephala floriceps*.

Trochilus (—?) *floriceps*, GOULD, P. Z. S. (1853), p. 62.

Metallura floriceps, REICH., Aufz. der Colib., p. 8 (1853).—ID., Trochil. Enum., p. 5 (1855).

Adelomyia floriceps, GOULD, Mon. Troch., vol. iii, pl. 202.—BON., Rev. and Mag. Zool. (1854), p. 253.

Anthocephala floriceps, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 72 (note).—GOULD, Intr. Troch., octavo ed., p. 114 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 125 (1876).

Hab. Columbia.

Male. "Forehead buffy-white, passing into a beautiful deep peach-blossom hue on the crown; throat gray, passing into the rufous of the abdomen; wings purplish-brown; middle tail feathers bronzy; lateral tail feathers bronzy at the base, passing into purplish-black, and largely tipped with buff; bill black; feet apparently light brown." (Gould, Mon. Troch.)

Genus XCV.—ABEILLIA.

Abeillia, BON., Consp. Gen. Av., vol. i, p. 79 (1850) (Rhamphomicron, sp. 4).

Baucis, REICH., Aufz. der Colib., p. 13 (1853).

Myiabeillia, BON., Rev. and Mag. Zool. (1854), p. 253.

TYPE.

O. abeillei, Delat. and Less.*O. abeillei*, Delat. and Less.*O. abeillæi*, Delat. and Less.

Fig. 103.

*Abeillia typica*, ♂. 50312. Guatemala City.

Ch. Bill shorter than the head, straight, weak. Wings long pointed, reaching nearly to the end of the tail. The tail is slightly forked when closed. Size small. Sexes dissimilar.

Range. Mexico and Central America to Veragua.

But one species is known, and is the representative of a distinct generic form, having but little relationship with any other. The male is adorned with a luminous throat, but otherwise is plainly colored.

1. *Abeillia typica*.

Ornismya abeillei, DELATTR. and LESS., Rev. Zool. (1839), p. 16.

Mellisuga abeillei, GRAY, Gen. Birds, vol. i, p. 112, sp. 37.

Rhamphomicron abeillei, BON., Consp. Gen. Av., vol. i, p. 79 (*Abeillia typica*) (1850).

Basalinna abeillei, REICH., Aufz. der Colib., p. 13 (1853).

Myiabeillia typica, BON., Rev. and Mag. Zool. (1854), p. 253.—GOULD, Mon. Troch., vol. iv, pl. 211.—ID., Intr. Troch., octavo ed., p. 119.

Baucis abeillei, REICH., Troch. Enum., p. 11 (1855).—CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 72.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 144 (1876).

Hab. Mexico to Veragua into Central America.

Male. Upper surface and flanks shining grass-green. Wings purplish-brown. Throat luminous grass-green. Centre of chest dull black; abdomen ash-gray. Under tail coverts pale green margined with gray. Central rectrices dark grass-green, lateral ones black tipped with gray. Bill black, feet brown. Total length, $3\frac{1}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{7}{16}$ in.

Female. Under surface brownish-gray; rest like the male.

Genus XCVI.—KLAIS.

Klais, REICH., Aufz. der Colib., p. 13 (1853).

Basilinna, CAB. and HEIN. (nec BOIE, 1831), Mus. Hein. Th., iii, p. 44 (1860).

Guimetiia, "REICH.," BON., Ann. Sc. Nat. (1854), p. 137.

TYPE.

T. guimeti, BEURE.

T. guimeti, BOURE.

T. guimeti, BOURE.?

Fig. 104.



Klais guimeti. ♂. Veragua. Doucard.

Ch. Bill straight, little longer than the head, wide at base, graduating to a point. Wings long. Tail rounded. Tarsi clothed. Size small. Sexes different.

Range. Venezuela and Columbia, Costa Rica.

But one species is known, and appears best placed next to ABEILLIA.

1. *Klais guimeti*.

Trochilus guimeti, BOURE and MULS., Ann. Soc. d'Agr., Lyon (1843), p. 88, pl. 2.—ID., Rev. Zool. (1843), p. 72.

Hylocharis guimeti, GRAY, Gen. Birds, vol. i, p. 114, sp. 33.

Klais guimeti, REICH., Aufz. der Colib. (1853), p. 13.—ID., Troch. Enum., p. 11 (1855).—GOULD, Mon. Troch., vol. iv, pl. 210.—ID., Intr. Troch., octavo ed., p. 119 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 139 (1876).

Myiabeillia guimeti, BON., Rev. and Mag. Zool. (1854), p. 253.

Basilinna guimeti, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 44.

Mellisuga merrittii, LAWRE., Ann. Lye. Nat. Hist. N. Y. (1860), vol. vii, p. 110.

Klais guimeti, SCLAT. and SALV., Nomencl., p. 88 (1873).

Hab. Costa Rica, Veragua, Venezuela, and Columbia.

Male. Top of head and throat dark rich blue. Upper surface bronzy-green. Wings purplish-brown. Feathers of the under surface, ashy at base, pale green at tips. A white spot behind the eye. Tail bronze-green like the back, the lateral

feathers blackish near their ends, and tipped with white. Bill black, feet brown. Total length, $3\frac{1}{5}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

Female. Entire under surface gray, glossed with green on the flanks; rest like the male.

The Costa Rica specimens, named *merrittii* by Lawrence, are paler beneath, but cannot be separated specifically.

Between the last genus and AGLÆACTIS there is no relationship. In fact the birds of this genus stand alone. I have placed them here, however, on account of their peculiar coloration, which is distributed similarly to that seen in ERIOCNEMIS. The most brilliant part of each is the rump which is highly luminous, but the manner of exhibiting it is different, for to be able to perceive the full beauty of the AGLÆACTE it is necessary to look at them from behind, towards the head. In their short straight bills they also resemble the species of ERIOCNEMIS. They are rather large birds, with but little difference in the plumage of the sexes; the chief one being that the females have less brilliancy upon their rumps than the males.

Genus XCVII.—AGLÆACTIS.

Aglæactis, GOULD, P. Z. S. (1848), p. 11.

Aglæactis, CAB. and HEIN., Mus. Hein. Th., iii, p. 69 (1860).

TYPE.

T. cupripennis, Bourc.

O. pamelæ, D'Orb. and Lafres.

Fig. 105.



Aglæactis cupripennis. ♂. New Granada. Whitely.

Ch. Bill short, straight. Wings long, primaries falcate. Tail ample, forked when closed. Tarsi partially clothed. Hind toe and nail longer than the middle toe and nail. Sexes similar.

Range. Columbia, Ecuador, Peru, and Bolivia.

Four species are recognized.

Key to the species.

- | | |
|---|----------------------------|
| A. Tuft of feathers on the breast pale buff. | |
| a. Entire under parts rufous. | 1. <i>A. cupripennis</i> . |
| b. Breast dark bronzy-green; abdomen buff. | 2. <i>A. caumatonota</i> . |
| B. Tuft of feathers on the breast pure white. | |
| a. Rump metallic lilaceous-purple. | 3. <i>A. castelnaudi</i> . |
| b. Rump metallic-green. | 4. <i>A. pamela</i> . |

1. *Aglæactis cupripennis*.

Trochilus cupripennis, BOURC. and MULS., Ann. Soc. d'Agr., Lyon (1843), t. vi, p. 46.—ID., Rev. Zool. (1843), p. 71.

Mellisuga cupripennis, GRAY, Gen. Birds, vol. i, p. 112, sp. 25.

Aglæactis cupripennis, BON., Consp. Gen. Av., vol. i, p. 73 (1850).—ID., Rev. and Mag. Zool. (1854), p. 253.
—REICH., Aufz. der Colib., p. 9 (1853).—GOULD, Mon. Troch., vol. iii, pl. 179.—ID., Intr. Troch., octavo ed., p. 106.

Helianthea cupripennis, REICH., Troch. Enum., p. 6, pl. 737, figs. 4689-90 (1855).

Aglaiactis cupripennis, CAB. and HEIN., Mus. Hein. Th., iii, p. 69 (1860).

Aglaiactis æquatorialis, CAB. and HEIN., Mus. Hein. Th., iii, p. 70 (note) (1860).—GOULD, Intr. Troch., octavo ed., p. 106 (1861).

Aglæactis parvula, GOULD, Intr. Troch., octavo ed., p. 106 (1861).

Aglæactis cupripennis, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 24 (1875).

Hab. Columbia, Ecuador, and Peru.

Male. Top of head and back blackish-brown. Viewed against the feathers, the back is luminous purplish-crimson, grass-green on upper tail coverts; wings purplish-brown; shaft of external feather rufous for three-fourths its length. A tuft of pale buff feathers on the breast, rest of under parts rufous. Middle rectrices rufous at their base, remaining portion bronze, lateral ones rufous margined and tipped with bronze. Maxilla black, mandible flesh-color, tip black. Total length, $4\frac{5}{8}$ in. Wing, $3\frac{1}{2}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female like the male, less luminous on the back.

2. *Aglæactis caumatonota*.

Aglæactis caumatonota, GOULD, P. Z. S. (1848), p. 12.

Aglæactis caumatonota, BON., Consp. Gen. Av., vol. i, p. 73 (1850).—REICH., Aufz. der Colib., p. 9 (1853).

Helianthea caumatonota, REICH., Troch. Enum., p. 5 (1855).

Aglæactis olivaceo-cauda, LAWR., Ann. N. Y. Lyc. Nat. Hist. (1867), p. 470.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 26 (1875).

Aglaiactis caumatonota, CAB. and HEIN., Mus. Hein. Th., iii, p. 70 (note 4) (1860).

Aglæactis caumatonota, GOULD, Intr. Troch., octavo ed., p. 106 (1861).—WHITELY, P. Z. S. (1873), p. 190.

Hab. Peru.

Male. Top of head, back, cheeks, and throat brownish-black. Loral space and spot behind the eye rufous. Lower part of back and rump when viewed from behind dark crimson, shading into green on the upper tail coverts. Upper part of breast and sides of neck deep buff. Tuft of buff feathers on the breast. Lower part of breast and flanks dark bronzy-green almost black. Abdomen and under tail coverts reddish-buff. Greater wing coverts olive-green, primaries and secondaries purplish-brown. Shaft of outer primary rufous for three-fourths its length.

Base of central rectrices bright rufous, remaining portion dark olive-green; lateral feathers have two-thirds of the basal portion of the inner webs rufous, rest dark olive-green. Bill and feet black. Total length, $4\frac{5}{8}$ in. Wing, $3\frac{1}{8}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{1}{6}$ in.

Female. Lighter colored than the male. Head, back, throat, and breast pale brown. Lower part of back less brilliant, rest of plumage like the male.

3. *Aglæactis castelnaudi*.

Trochilus castelnaudii, BOURE. and MULS., Rev. Zool. (1848), p. 270.

Trochilus castelnaui, GRAY, Gen. Birds, vol. iii, App., p. 30 a (1849).

Aglæactis castelnaui, GOULD, Mon. Troch., vol. iii, pl. 180.—BON., Rev. and Mag. Zool. (1854), p. 253.

Aglæactis castelnaudi, BON., Consp. Gen. Av., vol. i, p. 73 (1850).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 21.

Aglæactis castelnaudi, REICH., Aufz. der Colib., p. 9 (1853).—GOULD, Intr. Troch., octavo ed., p. 107 (1861).

—WHITELY, P. Z. S. (1873), p. 190.

Helianthea castelnaudi, REICH., Troch. Enum., p. 6, pl. 739, figs. 4693-94 (1855).

Aglæactis castelnaui, CAB. and HEIN., Mus. Hein. Th., iii, p. 69 (note 3) (1860).

Hab. Peru.

Male. Head, upper part of back, throat, breast, and flanks dark bronzy-brown. On lower part of throat is a rufous spot. A tuft of pure white elongated feathers on the breast. Centre of abdomen buff. Under tail coverts rufous. Lower part of back and upper tail covers deep metallic lilaceous-purple. Greater wing coverts olive-green, primaries and secondaries purplish-brown. Shaft of first primary rufous for two-thirds its basal length. Tail rufous, margined with bronzy-green. Bill black, with the exception of a flesh spot at base of mandible. Feet black. Total length, $4\frac{5}{8}$ in. Wing, $3\frac{1}{4}$ in. Tail, $2\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

Female similar to the male, but without any luminous feathers on the rump.

4. *Aglæactis pamela*.

Orthorhynchus pamela, D'ORBIGN. and LAFR., Syn. Av., ii, p. 29, no. 14 (1838).—D'ORB., Voy. dans l'Amer. Mérid. Ois., tom. iv, p. 375, pl. 60, fig. 1.

Hylochavis pamela, GRAY, Gen. Birds, vol. i, p. 114, sp. 13.

Aglæactis pamela, GOULD, Mon. Troch., vol. iii, pl. 181.—ID., Intr. Troch., octavo ed., p. 107 (1861).

Aglæactis pamela, BON., Consp. Gen. Av., vol. i (1850), p. 73.—ID., Rev. and Mag. Zool. (1854), p. 253.—

MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 19.—ELLIOT, Ibis (1877), p. 137.

Helianthea pamela, REICH., Troch. Enum., p. 6, pl. 738, figs. 4691-92 (1855).

Aglæactis pamela, CAB. and HEIN., Mus. Hein. Th., iii, p. 69 (1860).

Hab. Bolivia.

Male. Head, upper part of back, and entire under surface, with the exception of a tuft of pure white feathers on the breast, jet-black. Under tail coverts light chestnut. Lower part of back and upper tail covert glittering metallic grass-green. Wings bronzy-brown. Tail chestnut, the feathers edged and tipped with bronzy-brown. Bill and feet black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female only differs in not having the black of the plumage of such a velvety hue, but more inclined to a brownish shade.

The genus *ERIOCNEMIS* is one of the most strongly characterized of those composing the Trochilidæ. Many of the species possess a very brilliant plumage, the lower part of the back being especially luminous, and moreover they are distinguished by having large downy puffs upon the tarsi, completely concealing them. These downy feathers are black, white, pale buff, or brown and white. The species are moderate in size, but of a rather robust form, with straight strong bills, and long wings. The general hues of the species are various, and consist of dark gray, green, coppery-red, and purplish-black; while the metallic hues are golden-green, blue, bronze, and others of similar brilliancy. Although many genera have been proposed, I do not see that there are any characters to separate the species, and have kept them all in the term first given.

Genus XCVIII.—ERIOCNEMIS.

Eriopus, GOULD, P. Z. S. (1847), p. 16 (nec TREITSCHKE, 1825, Lepid.).
Eriocnemis, REICH., Syst. Av., pl. xl (1849).
Engyete, REICH., Syst. Av., pl. xl (1849).
Threptria, REICH., Syst. Av., pl. xl (1849).
Phemonœc, REICH., Syst. Av., pl. xl (1849).
Eriocnemys!, BON., Rev. and Mag. Zool. (1854), p. 252.
¹*Aline*, "REICH.," BON., Consp. Syst. Ornith., Ann. Sc. Nat., 4th ser. Zool. (1854), tom. i, p. 137.
¹*Mosquera*, "REICH.," BON., Consp. Syst. Ornith., Ann. Sc. Nat., 4th ser. Zool. (1854), tom. i, p. 137.
¹*Luciani*, "REICH.," BON., Consp. Syst. Ornith., Ann. Sc. Nat., 4th ser. Zool. (1854), tom. i, p. 137.
¹*Derbomiya*, "REICH.," BON., Consp. Syst. Ornith., Ann. Sc. Nat., 4th ser. Zool. (1854), tom. i, p. 137.
Erebenna, MULS. and VERR., Class. Troch. (1865), p. 66.
Niche, MULS., Catal. Ois. Mouch., p. 21 (1875).
Pholoe, MULS., Catal. Ois. Mouch. (1875), p. 22.
Nania, MULS., Catal. Ois. Mouch. (1875), p. 21.
Eriona, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 28.

Ch. Bill straight, about as long as the head: nostrils exposed. Wings long pointed. Tail forked. Tarsi thickly clothed with lengthened downy feathers, forming a very conspicuous tuft. Sexes different.

Range. Venezuela, Columbia, Ecuador, Peru, and Bolivia.

Seventeen species are now known belonging to this genus.

TYPE.

O. vestita, Longuem.
O. vestita, Longuem.
O. alinae, Bourc.
T. mosquera, Bourc. and Delatt.
T. luciani, Bourc.

O. alinae, Bourc.?

T. mosquera, Bourc.?

T. luciani, Bourc.?

T. derbyi, Bourc. and Delatt.?
T. derbyi, Bourc. and Delatt.
T. glaucopoides, D'Orb. and Lafr.
E. dyselius, Elliot.
T. cupreiventris, Fras.
T. godini, Bourc.

Fig. 106.



Eriocnemis aureliæ. New Granada. Sharpe.

¹ These four genera are cited by Bonaparte as Reichenbach's. I have not found them in any of Reichenbach's publications that I have seen, and, as no species were given by Bonaparte, there are consequently no types for any of them.

Key to the species.

- | | |
|---|----------------------------------|
| A. Downy puffs on the tarsi, black. | 1. <i>E. derbiana</i> . |
| B. Downy puffs on the tarsi, pale brown. | 2. <i>E. assimilis</i> . |
| C. Downy puffs on the tarsi, pale chestnut and white. | |
| a. Under surface bronzy-green, very dark almost black on the throat. | 3. <i>E. aureliæ</i> . |
| b. Under surface dark gray. | 4. <i>E. squamata</i> . |
| D. Downy puffs on tarsi, white. | |
| a. Under tail coverts dark gray. | 5. <i>E. lugens</i> . |
| b. Under tail coverts metallic-green. | |
| a'. Under surface metallic glittering green. | 6. <i>E. alinæ</i> . |
| b'. Throat and breast golden-bronze. | 7. <i>E. mosquera</i> . |
| c. Under tail coverts shining blue. | |
| a'. Forehead shining bluish-green. | 8. <i>E. glaucopoides</i> . |
| b'. Forehead violet-blue. | 9. <i>E. luciani</i> . |
| c'. Upper surface bronzy-green, abdomen copper-red. | 10. <i>E. cupreiventris</i> . |
| d'. Upper surface green with coppery reflections. Tail dark blue. | 11. <i>E. sapphiropygia</i> . |
| e'. Throat metallic yellowish-green; general plumage copper-color, tail steel-blue. | 12. <i>E. chrySORAMA</i> . |
| f'. Throat metallic-blue. | |
| a''. Under surface metallic glittering yellowish-green. | 13. <i>E. godini</i> |
| b''. Breast dark green, black in certain lights, abdomen and flanks metallic-green. | 14. <i>E. vestita</i> . |
| c''. Breast and under parts golden-green. | 15. <i>E. smaragdinipectus</i> . |
| d''. General plumage black, with faint green reflections. | 16. <i>E. nigrivestis</i> . |
| d. Under tail coverts purplish-black. | 17. <i>E. dysclius</i> . |

1. *Eriocnemis derbiana*.

Trochilus derbyi, DELATT. and BOURC., Rev. Zool. (1846), p. 306.

Eriopus derbyi, GOULD, P. Z. S. (1847), p. 17.—BOX., Consp. Gen. Av., vol. i, p. 80 (1850).

Eriocnemis (Threptia) derbyi, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, pl. 728, figs. 4666-67 (1855).

Eriocnemys derbyanus, BOX., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemis derbianus, GOULD, Mon. Troch., vol. iv, pl. 279.

Eriocnemis derbiana, GOULD, Intr. Troch., octavo ed., p. 145 (1861).—ELLIOT, Ibis (1872), p. 295.

Eriocnemis derbyi, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 40 (1875).

Hab. Ecuador.

Male. Forehead shining golden-green: rest of head and back golden-bronze. Under surface brilliant golden-green. Upper and under tail coverts extremely luminous metallic-green. Wings purplish-brown. Tail brownish-black. Tarsal tufts jet-black. Bill and feet black. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{8}$ in. (Type in my collection.)

Female. Differs in having the feathers of the under surface white at their base, tips golden-green. Tarsal tufts white. In other respects she resembles the male. (Type in my collection.)

2. *Eriocnemis assimilis*.

Eriocnemis assimilis, ELLIOT, Bull. Zool. Soc., France (1876), p. 227.

Hab. Environs of Tilotilo and Apollo, Bolivia.

Adult. Head, neck, and upper tail coverts coppery-red. Back and wing coverts shining green. Wings purple-brown. Under parts shining green with a coppery-lustre, lightest on the throat. Abdomen buff. Under tail coverts shining green, margined with buff. Tarsal tufts pale brown. Tail bronze at the base, passing to black at the tips. Bill black; feet light brown. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

3. *Eriocnemis aureliæ.*

Trochilus aureliæ, BOUCE and MULS., Ann. Soc. Agr., Lyon (1846), p. 315, pl. 10.—ID., Rev. Zool. (1846), p. 316.

Hylocharis aureliæ, GRAY, Gen. Birds, vol. i, p. 114, sp. 8.

Eriopus aureliæ, BON., Consp. Gen. Av., vol. i, p. 80 (1850).

Eriocnemis aureliæ, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, pl. 727, figs. 4660-61.—GOULD, Mon. Troch., vol. iv, pl. 283.—ID., Intr. Troch., octavo ed., p. 146 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 51 (1875).—ELLIOT, Ibis (1872), p. 295.

Eriocnemys aureliæ, BON., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemys russata, GOULD, P. Z. S. (1871), p. 505.

Hab. Columbia and Ecuador.

Adult. Upper surface bronzy-green with a rufous tinge on the head. Upper tail coverts coppery-bronze. Under surface bronzy-green, almost black on the throat; feathers of the vent fringed with white. Tarsal tufts pale chestnut and white. Under tail coverts grass-green. Bill black, feet flesh-color. Tail bluish-black. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.) The bill varies slightly in length among individuals, some reaching an inch in length; this is the *E. russata* of Gould.

4. *Eriocnemis squamata.*

Eriocnemis squamata, GOULD, P. Z. S. (1860), p. 311.—ID., Mon. Troch., vol. iv, pl. 281.—ID., Intr. Troch., octavo ed., p. 146 (1861).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 55 (1875).

Hab. Ecuador.

Adult. Upper surface bronzy-green, inclining to coppery-bronze on the head and upper tail coverts. Under parts dark leaden-gray, washed with green on the flanks, and the feathers of the throat edged with white. Front part of tarsal tufts white, hind portion buff. Tail blue-black. Wings purplish-brown. Bill black, feet brown. Total length, 4 in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{5}{8}$ in.

5. *Eriocnemis lugens.*

Eriopus lugens, GOULD, Jard. Contr. Ornith. (1851), p. 140.

Eriocnemys lugens, BON., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemis (Threpteria) lugens, REICH., Troch. Enum., p. 6, pl. 740, figs. 4695-96.—ID., Aufz. der Colib., p. 9 (1853).

Eriocnemis lugens, GOULD, Mon. Troch., vol. iv, pl. 282.—ID., Intr. Troch., octavo ed., p. 146 (1861).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 53 (1875).

Hab. Ecuador.

Adult. Precisely the same in coloration as the *E. squamata*, except that the tarsal tufts are pure white. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{2}{3}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

6. *Eriocnemis alinæ*.

- Ornismya alinæ*, BOURC., Ann. Soc. Agr., Lyon (1842), p. 343, pl. xx.—ID., Rev. Zool. (1842), p. 373.
Hylocharis alinæ, GRAY, Gen. Birds, vol. i, p. 114, sp. 6.
Eriopus alinæ, BON., Consp. Gen. Av., vol. i, p. 80 (1850).
Eriocnemis (Engyete) alinæ, REICH., Aufz. der Colib., p. 9.—ID., Troch. Enum., p. 5, pl. 726, figs. 4655-56.
Eriocnemys alinæ, BON., Rev. and Mag. Zool. (1854), p. 252.
Eriocnemis alinæ, GOULD, Mon. Troch., vol. iv, pl. 280.—ID., Intr. Troch., octavo ed., p. 145.—CAB. and HEIN., Mus. Hein. Th., iii, p. 73 (1860).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 30 (1875).

Hab. Columbia.

Adult. Upper surface shining grass-green. Forehead and entire under surface, except a white spot on the breast, metallic glittering green. Tarsal tufts very long and thick, pure white. Tail dark shining green. Wings purplish-brown. Bill black, feet brown. Total length, $3\frac{3}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{2}{8}$ in.

7. *Eriocnemis mosquera*.

- Trochilus mosquera*, BOURC. and DELATRE., Rev. Zool. (1846), p. 306.
Hylocharis mosquera, GRAY, Gen. Birds, vol. i, p. 114, sp. 5.
Eriopus mosquera, BON., Consp. Gen. Av., vol. i, p. 80 (1850).
Eriocnemis (Threptia) mosquera, REICH., Troch. Enum., p. 6, pl. 728, figs. 4664-65.—ID., Aufz. der Colib., p. 9 (1853).
Eriocnemis mosquera, GOULD, Mon. Troch., vol. iv, pl. 274.—ID., Intr. Troch., octavo ed., p. 144 (1861).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 49.
Eriocnemys mosquera, BON., Rev. and Mag. Zool. (1854), p. 252.

Hab. Columbia.

Adult. Upper surface bronzy-green, graduating into pure green on the rump, and becoming luminous on the upper tail coverts. Throat and breast golden-bronze, very luminous, this color passing over the sides of the neck on to the back. Flanks and abdomen shining bronzy-green. Tarsal tufts white. Under tail coverts shining green. Median rectrices bright green, lateral ones shining green at base, graduating into dark green at tips. Wings purplish-brown. Bill and feet black. Total length, $4\frac{9}{16}$ in. Wing, $2\frac{7}{8}$ in. Tail, $2\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in.

8. **Eriocnemis glaucopoides*.

- Ornismya glaucopoides*, D'ORB. and LAFR., Syn. Av., ii, p. 27, sp. 7 (1838).
Trochilus d'orbignyï, BOURC. and MULS., Ann. Sc. Phys. Nat., Lyons (1846), p. 320.
Hylocharis d'orbignyï, GRAY, Gen. Birds, vol. i, p. 114, sp. 10.
Thalwanian glaucopoides, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 3 (1855).—BON., Rev. and Mag. Zool. (1854), p. 254.
Eriocnemis (Phemonòe) d'orbignyï, REICH., Troch. Enum., t. 741, fig. 4697.—ID., Aufz. der Colib., p. 9 (1853).
Eriocnemys d'orbignyï, BON., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemis dorbignyi, GOULD, Mon. Troch., vol. iv, pl. 278.—ID., Intr. Troch., octavo ed., p. 145.—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 29 (1875).—SCLAT. and SALV., Nomencl., p. 91.

Eriocnemis glaucopoïdes, ELLIOT, Ibis (1877), p. 136.

Hab. Valle Grande Bolivia.

Male. Forehead violet-blue, a white spot behind the eye. Upper surface bronzy-green. Under surface glittering golden-green, washed with blue on the throat and chest. Tail bluish-black. Bill black. Tarsal tufts pure white. Under tail coverts shining blue. Total length, $4\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in. Unique type in Paris Museum.

9. *Eriocnemis luciani*.

Trochilus luciani, BOURC., Ann. Soc. Agr., Lyon (1847), p. 624.

Hylocharis luciani, GRAY, Gen. Birds, vol. i, p. 114, sp. 4.

Eriopus luciani, BON., Consp. Gen. Av., vol. i, p. 80 (1850).

Eriocnemis (Phemonöe) luciani, REICH., Troch. Enum., p. 6, pl. 730, figs. 4771-72.—ID., Aufz. der Colib., p. 9 (1853).

Eriocnemis luciani, GOULD, Mon. Troch., vol. iv, pl. 273.—ID., Intr. Troch., octavo ed., p. 144 (1861).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 47.

Eriocnemys luciani, BON., Rev. and Mag. Zool. (1854), p. 252.

Hab. Ecuador.

Adult. Forehead shining bluish-green. Upper surface bronzy-green, becoming glittering grass-green on the upper tail coverts. Wings purplish-brown. Under surface glittering golden-green. Under tail coverts rich violet-blue. Tail blue-black. Bill black, feet brown. Total length, $4\frac{7}{8}$ in. Wing, $2\frac{1}{2}$ in. Tail, $2\frac{1}{2}$ in. Culmen, $\frac{1}{6}$ in.

Female like the male but a little smaller.

10. *Eriocnemis cupreiventris*.

Ornismya vestita, ♀, LONGUEM., Rev. Zool. (1838), p. 314.

Trochilus cupreiventris, FRAS., P. Z. S. (1848), p. 15.

Eriopus simplex, GOULD, P. Z. S. (1849), p. 96.

Hylocharis cupreiventris, GRAY, Gen. Birds, vol. i, p. 114, sp. 3.

Eriopus cupreiventris, BON., Consp. Gen. Av., vol. i, p. 80 (1850).

Eriocnemis (Phemonöe) cupreiventris, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, pl. 729, figs. 4668-69.

Eriocnemys cupreiventris, BON., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemys simplex, BON., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemis cupreiventris, GOULD, Mon. Troch., vol. iv, pl. 270.—ID., Intr. Troch., octavo ed., p. 143 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 73.—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 45 (1875).

Eriocnemis simplex, GOULD, Mon. Troch., vol. iv, pl. 271.—REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., pl. 729, fig. 4670 (1855).

Hab. Columbia.

Adult. Upper parts bronzy-green, passing into luminous grass-green on the upper tail coverts. Throat and breast shining grass-green passing into coppery-red on the abdomen. Under tail coverts dark shining blue. Tarsal tufts white. Tail blue-black. Bill and feet black. Wings purplish-brown. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

11. *Eriocnemis sapphiropygia.

Eriocnemis sapphiropygia, TACZAN., P. Z. S. (1874), p. 139.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 37 (1875).

Hab. Peru.

Adult. Upper parts bronzy-green, passing into pure green on the rump and upper tail coverts. Wings purplish-black. Under surface glittering green. Under tail coverts shining sapphire-blue. Tarsal tufts white. Tail dark blue. Bill black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail, 2 in. Bill along the gape, $1\frac{1}{8}$ in.

12. Eriocnemis chrySORAMA.

Eriocnemis chrySORAMA, ELLIOT, Ann. Mag. Nat. Hist. (1874), p. 375.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 44.

Hab. Ecuador.

Adult. Upper and lower surface metallic fiery-copper color. Chin and throat metallic yellowish-green; golden-yellow in some lights. Upper tail coverts luminous yellowish-green. Under tail coverts white on their basal half, rest blue. Wings purplish-brown. Tail much forked, steel-black. Tarsal tufts pure white. Bill black. Total length, $4\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Bill, $\frac{7}{8}$ in. (Type in my collection.)

13. Eriocnemis godini.

Trochilus godini, BOUCC., Compt. Rend., tom. xxxii, p. 186 (1851).

Eriocnemis godini, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6 (1855).—GOULD, Mon. Troch., vol. iv, pl. 277.—ID., Intr. Troch., octavo ed., p. 145 (1861).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 36.

Eriocnemys godini, BON., Rev. and Mag. Zool. (1854), p. 252.

Hab. Ecuador.

Adult. Head and back bronzy-green, rump and upper tail coverts luminous grass-green. Under surface golden-green, with a bright blue spot in the centre of the throat. Tarsal tufts pure white. Under tail coverts bright smalt. Wings purplish-brown. Tail blue-black. Bill and feet black. Total length, 4 in. Wing, $2\frac{3}{8}$. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in. (Type in my collection.)

14. Eriocnemis vestita.

Ornismya vestita, LONGUEM., Rev. Zool. (1838), p. 314.

Trochilus uropygialis, FRAS., P. Z. S. (1840), p. 15

Hylocharis vestita, GRAY, Gen. Birds, vol. i, p. 114, sp. 2.

Ornismya glomata, LESS., Echo du Monde Savant. (1843).

Eriopus vestita, BON., Consp. Gen. Av., vol. i, p. 80 (1850).

Eriocnemis vestita, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6, pl. 726, figs. 4657-59.—GOULD, Mon. Troch., vol. iv, pl. 275.—ID., Intr. Troch., octavo ed., p. 145 (1861).—CAB. and HEIN., Mus. Hein. Th., iii, p. 73 (1860).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 33.—ELLIOT, Ibis (1876), p. 10.

Eriocnemys vestitus, BON., Rev. and Mag. Zool. (1854), p. 252.

Mellisuga ridolfii, BENY., Ann. R. Mus. Flor. (1865), p. 205.

Hab. Venezuela and Columbia.

Male. Upper parts dark shining green. Rump and upper tail coverts metallic yellowish-green, intensely luminous. Throat and under tail coverts violet-blue. Breast dark green, black in certain lights; rest of under parts glittering metallic golden-green. Tarsal tufts pure white. Tail steel-black. Bill and feet black. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Differs in having the throat and upper part of the breast reddish-buff, feathers of the throat tipped with blue, those on the breast spangled with golden-green. Centre of abdomen and vent white. Under tail coverts blue margined with white. In all other respects she resembles the male.

Some male specimens, which may possibly be in partly immature dress, or seasonal state, have the breast more or less mottled with rufous.

15. *Eriocnemis smaragdinipectus*.

Eriocnemis smaragdinipectus, GOULD, Ann. Mag. Nat. Hist. (1868), p. 322.—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 35. —

Hab. Ecuador.

Adult. This species only differs from the *E. vestita* by having the brilliant metallic-green of the breast extend quite to the throat mark, without the dark almost black hue that covers the breast of the common species. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

16. *Eriocnemis nigrivestis*.

Trochilus nigrivestis, BOURC. and MULS., Ann. Soc. Agr., Lyon (1852), p. 144.

Eriocnemis nigriventris, REICH., Anz. der Colib., p. 9 (1853).

Eriocnemys nigrivestis, BON., Rev. and Mag. Zool. (1854), p. 252.

Eriocnemis nigrivestis, REICH., Troch. Enum., p. 6 (1855).—GOULD, Mon. Troch., vol. iv, pl. 276.—ID., Intr. Troch., octavo ed., p. 145 (1861).—ELLIOT, Ibis (1872), p. 295.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 38.

Hab. Ecuador.

Male. General plumage black, with green reflections. Throat metallic-blue. Wings purplish-black. Upper tail coverts indigo-blue; under tail coverts violet-blue. Tarsal tufts white. Tail blue-black. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{5}{8}$ in. (Type in my collection.)

Female. Upper surface bronzy-green, becoming pure green on rump and upper tail coverts, these last luminous. Throat blue, breast golden-bronze. Under parts shining green. Tarsal tufts white. Under tail coverts violet-blue. Tail blue-black. Bill and feet black.

17. *Eriocnemis dyselius*.

Eriocnemis dyselius, ELLIOT, Ibis (1872), p. 294.—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 50.—SCLAT. and SALV., Nomencl., p. 91 (1873).

Hab. Ecuador.

Head and upper parts black with a purple gloss; upper tail coverts with a greenish gloss. Throat and under parts black, with a purple gloss on the abdomen and under tail coverts. Wings purplish-black. Tarsal tufts pure white. Tail deeply forked, steel-blue with purple reflections. Bill black, feet black. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

Genus XCIX.—PANTERPE.

Panterpe, CAB. and HEIN., Mus. Hein. Th., iii, p. 43 (1860).

Ch. Size large. Bill straight, slender, about as long as the head. Nostrils exposed. Wings long, first primary slightly falcate. Tail slightly forked when open. Feet large, tarsi bare. Sexes alike.

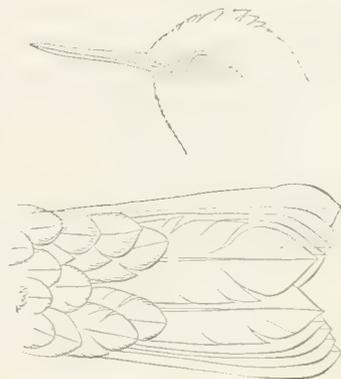
Range. Costa Rica, Chiriqui.

One species only is known, but a very beautiful one with a brilliant metallic throat. It is a large bird, and the sexes are apparently alike richly colored. I think it should be placed near to *ERIOC-NEMIS*.

TYPE.

P. insignis, Cab. an. Hein.

Fig. 107.



Panterpe insignis, ♂. 74025. Costa Rica.

1. *Panterpe insignis*.

Panterpe insignis, CAB. and HEIN., Mus. Hein. Th., iii, p. 43 (note) (1860).—GOULD, Mon. Troch., vol. v, pl. 336.—ID., Intr. Troch., octavo ed., p. 167 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 25.

Hub. Costa Rica, Chiriqui.

Adult. Crown of the head shining dark blue. Upper parts, lower part of abdomen, and under tail coverts bronzy-green. Nape of neck showing black in certain lights. Throat metallic-scarlet, bordered on the side with luminous yellow-green. Centre of breast deep blue. Upper tail coverts cobalt. Wings purplish-brown. Tail steel-blue. Bill black, base of mandible flesh-color. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{7}{8}$ in.

Between *PANTERPE* and *URANOMITRA* there is a gap. The members of the latter genus, which is now reached, are of moderate size, have a green and white plumage, metallic hues appearing chiefly upon the head and upper surface; and some species have bright red bills. There is no difference in the plumage of the sexes the female being as gayly dressed as the male.

Genus C.—URANOMITRA.

Uranomitra, REICH., Aufz. der Colib. (1853), p. 10.
Cyanomyia, BOY., Rev. and Mag. Zool. (1854), p. 254.
Leucolia, MULS., Catal. Ois. Mouch. (1875), p. 8.
Leucolia, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 24.

TYPE.

T. franciæ, Bourc.
T. cyanocephala, Less.
C. viridifrons, Elliot?
T. cyanicollis, Gould.

Ch. Bill longer than the head, straight or slightly curved; broad and flat at base; nostrils exposed. Wings reaching nearly to the end of the tail, and pointed. Tail rather rounded. Tarsi partly clothed. Sexes alike.

Range. Mexico, Central America, Columbia, and Peru.

Seven species are known.

Fig. 108.



Uranomitra cyanocephala. ♀. 28835.
Tres Marias.

Key to the species.

- | | |
|---|--|
| <p>A. Entire under parts pure white.</p> <p>a. Tail olive-green; top of head metallic-blue, sometimes with purple reflections.</p> <p>b. Tail bronzy-red; top of head metallic-purple, sometimes with blue reflections.</p> <p>c. Tail metallic golden, tip bronzy-red; top of head dull metallic dark green.</p> | <p>1. <i>U. quadricolor</i>.</p> <p>2. <i>U. violiceps</i>.</p> <p>3. <i>U. viridifrons</i>.</p> |
| <p>B. Breast and abdomen white; flanks metallic-green or bronze.</p> <p>a. Under tail coverts greenish-gray.</p> <p>b. Under tail coverts bronzy-red.</p> <p>c. Under tail coverts white; top of head blue.</p> <p>d. Under tail coverts white; top of head and nape blue.</p> | <p>4. <i>U. cyanocephala</i>.</p> <p>5. <i>U. microrhyncha</i>.</p> <p>6. <i>U. francixæ</i>.</p> <p>7. <i>U. cyanicollis</i>.</p> |

1. *Uranomitra quadricolor*.

Trochilus quadricolor, VIEILL., Ency. Méth., p. 573, tom. ii.

Polytmus quadricolor, GRAY, Gen. Birds, vol. i, p. 119, sp. 85.

Trochilus verticalis, LICHT., Preis-Verz., Thier. (1830), nos. 27-28.

Uranomitra quadricolor, REICH., Aufz. der Colib., p. 10 (1853).—CAB. and HEIN., Mus. Hein. Th., iii, p. 41 (1860).

Argyrtria (Uranomitra) quadricolor, REICH., Troch. Enum., p. 7, pl. 761, figs. 4758-59 (1855).

Cyanomyia quadricolor, BON., Rev. and Mag. Zool. (1854), p. 254.—GOULD, Mon. Troch., vol. v, pl. 284.—ID., Intr. Troch., octavo ed., p. 147 (1861).—ELLIOT, Ibis (1876), p. 312.

Leucolia quadricolor, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 217.

Hab. Northern Mexico.

Adult. Top of head rich metallic-blue, sometimes with purple reflections. Upper surface pale brown tinged with green. Wings purple-brown. Entire under surface pure white. Tail pale bronzy-brown. Bill coral-red, tip brown. Feet black. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{7}{8}$ in.

2. *Uranomitra violiceps*.

Cyanomyia violiceps, GOULD, Ann. Mag. Nat. Hist. (1859), p. 97.—SCLAT., P. Z. S. (1859), p. 386.—GOULD, Mon. Troch., vol. v, pl. 285.—ID., Intr. Troch., octavo ed., p. 147 (1861).—ELLIOT, Ibis (1876), p. 313.

Uranomitra violiceps, CAB. and HEIN., Mus. Hein. Th., iii, p. 41 (note 5) (1860).

Leucolia violiceps, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 214.

Hab. Mexico.

Adult. Differs from the *U. quadricolor* in having the tail a bronzy-red hue. Dimensions the same.

3. Uranomitra viridifrons.

Cyanomyia viridifrons, ELLIOT, Ann. and Mag. Nat. Hist. (1871), vol. viii, p. 267.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 224.

Hab. Putla, Mexico.

Adult. Forehead dark green, metallic in some lights. Centre of crown dark gray. Upper part of back brilliant light green, lower part of back bronzy-brown. Wings purple. Upper tail coverts and tail rich coppery-bronze. Flanks grass-green. Entire under parts pure white. Bill reddish, black at tip. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in. (Type in my collection.)

4. Uranomitra cyanocephala.

Ornismya cyanocephala, LESS., Supp. Ois. Mouch., p. 134, pl. 18 (1831).

Polytmus verticalis, GRAY, Gen. Birds, vol. i, p. 109, sp. 86.

Uranomitra cyanocephala, REICH., Aufz. der Colib. (1853), p. 10.

Agyrtria (Uranomitra) cyanocephala, REICH., Troch. Enum., p. 7, pl. 760, figs. 4754-55 (1855).

Agyrtria faustine, REICH., Troch. Enum., tom. i, p. 7, pl. 760, figs. 4756-57 (1855).

Cyanomyia verticalis, BON., Rev. and Mag. Zool. (1854), p. 254.

Cyanomyia cyanocephala, BON., Rev. and Mag. Zool. (1854), p. 254.—GOULD, Mon. Troch., vol. v, pl. 286.—

Id., Intr. Troch., octavo ed., p. 147 (1861).—ELLIOT, Ibis (1876), p. 314.

Cyanomyia guatemalensis, GOULD, Intr. Troch., octavo ed., p. 148 (1861).

Uranomitra lessoni, CAB. and HEIN., Mus. Hein. Th., iii, p. 41 (1860).

Leucolia cyanocephala, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 219.

Hab. Mexico, Guatemala, Honduras.

Adult. Top of head shining greenish-blue. Upper surface and flanks bronzy-green. Wings purplish-bronze. Tail pale green-bronze. Throat and middle of abdomen white. Under tail coverts olive fringed with white. Maxilla black, mandible flesh-color, tip black. Feet black. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

5. Uranomitra microrhyncha.

Cyanomyia microrhyncha, ELLIOT, Ibis (1876), p. 316.

Hab. Honduras.?

Adult. "Top of head and occiput dark metallic-blue. Hind neck and mantle shining metallic-green; rest of upper parts bronzy-red. Throat, upper part of breast, and centre of abdomen white, with a few metallic-green feathers scattered among the white ones. Flanks and under tail coverts metallic bronzy-red. Wings deep brown, slightly shaded with purple. Tail brilliant metallic-bronze. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{1}{2}$ in." (Type in my collection.)

6. Uranomitra franciæ.

Trochilus franciæ, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), tom. ix, p. 324.

Polytmus franciæ, GRAY, Gen. Birds, vol. i, p. 109, sp. 87.

Uranomitra franciæ, REICH., Aufz. der Colib., p. 10 (1853)—CAB. and HEIN., Mus. Hein. Th., iii, p. 41 (1860).

Agyrtria franciæ, REICH., Troch. Enum., p. 7, pl. 761, figs. 4760-61 (1855).

- Cyanomyia franciæ*, Box., Rev. and Mag. Zool. (1854), p. 254.—GOULD, Mon. Troch., vol. v, pl. 287.—ID., Intr. Troch., octavo ed., p. 149 (1861).—ELLIOT, Ibis (1876), p. 316.
Leucolia franciæ, Muls., Hist. Nat. Ois. Mouch., tom. i, p. 217.
Trochilus hypoleucus, LICHT., Mus. Berlin.

Hab. Columbia.

Adult. Top of head and occiput shining blue. Sides and nape of neck brilliant metallic pale green. Upper parts bronzy-green, changing to coppery-red on the rump and upper tail coverts. Wings purplish-brown. Flanks bronzy-green. Entire rest of under parts pure white. Tail greenish-bronze. Maxilla and tip of mandible black, base of latter flesh-color. Feet black. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in. (Type in my collection.)

Young have the crown green, and a dark band on the lateral rectrices.

7. **Uranomitra cyanicollis*.

- Trochilus* (—?) *cyanicollis*, GOULD, P. Z. S. (1853), p. 61.
Uranomitra cyanicollis, REICH., Aufz. der Colib. (1853), p. 10.—ID., Troch. Enum., p. 7 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 41 (note 4) (1860).
Cyanomyia cyanicollis, Box., Rev. and Mag. Zool. (1854), p. 254.—GOULD, Mon. Troch., vol. v, pl. 288.—ID., Intr. Troch., octavo ed., p. 149 (1861).—ELLIOT, Ibis (1876), p. 316.
Leucolia cyanicollis, Muls., Hist. Nat. Ois. Mouch., tom. i, p. 212.

Hab. Peru.

“Crown of the head, sides, and nape of the neck greenish-blue; upper surface bronzy-green; throat, centre of the abdomen, and under tail coverts white; flanks bronzy-brown; tail bronzy-green, all but the two middle feathers crossed near the tip with an obscure dusky band; upper mandible and tip of the lower mandible black, the remainder of the latter fleshy-white; feet dark brown.” (Gould, Mon. Troch.) Total length, $3\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{1}{2}$ in. Bill, $\frac{7}{8}$ in.

Genus CI.—LEUCIPPUS.

- ¹*Leucippus*, Box., Compt. Rend., p. 382 (1850).
Talaphorus, Muls., Hist. Nat. Ois. Mouch., tom. i, p. 257.

TYPE.

- T. chionogaster*, Tsch.
T. chlorocercus, Gould.

Fig. 109.

Ch. Bill longer than the head, slightly curved, narrow and rounded at base, nostrils exposed; wings long and pointed. Tail rounded. Tarsi clothed to the toes. Sexes alike.

Range. Brazil, valley of the Amazon; Peru and Bolivia.

Two species are known.



Leucippus chlorocercus. ♂. 55378. Pebas, Peru.

¹ Bonaparte (l. c.) gives the *T. turneri*, Bourc. (= *T. chionogaster*, Tsch.), and *T. fallax*, Bourc., as the types of his genus LEUCIPPUS, but afterwards (1854) made the latter the type of his genus DOLEROMYIA.

Key to the species.

- A. Throat pure white; tail dark bronze-green. 1. *L. chionogaster*.
 B. Throat spotted with brown, tail pale green, tipped with grayish-white. 2. *L. chlorocercus*.

This genus is extremely close to *Uranomitra*, and it may well be questioned if its members are really generically distinct from the species grouped together under the above term. A slight difference in the shape of the bill at its base appears to be the only generic character the two birds named above possess.

1. *Leucippus chionogaster*.

- Trochilus (Lampornis) leucogaster*, Tsch., Consp. Av., p. 37.
Trochilus chionogaster, Tsch., Faun. Per., p. 247, pl. 22, fig. 2 (1844).
Trochilus turneri, Bourc., Rev. Zool. (1846), p. 313.
Trochilus (—?) *hypoleucus*, Gould, P. Z. S. (1857), p. 90.
Polytmus chionogaster, Gray, Gen. Birds, vol. i, p. 108, sp. 49.
Polytmus hypoleucus, Gray, Gen. Birds, vol. i, p. 108, sp. 56.
Thaumatias leucogaster, Bon., Consp. Gen. Av., vol. i, p. 78 (1850).
Leucippus turneri, Bon., Consp. Gen. Av., vol. i, p. 73 (1850).—Reich., Aufz. der Colib. (1853), p. 11.—Id., Troch. Enum., p. 8 (1855).
Thaumatias chionogaster, Bon., Rev. and Mag. Zool. (1854), p. 255.
Leucippus nigrirostris, Reich., Troch. Enum., p. 8, t. 779, fig. 4812? (1855).
Leucippus chionogaster, Gould, Mon. Troch., vol. v, pl. 290.—Id., Intr. Troch., octavo ed., p. 150.—CAB. and HEIN., Mus. Hein. Th., iii, p. 31 (1860).—Muls., Hist. Nat. Ois. Mouch., tom. i, p. 259.
Leucippus pallidus, Taczanow., P. Z. S. (1874), p. 542.
Leucippus leucogaster, Elliot, Ibis (1876), p. 8.

Hab. Peru and Bolivia.

Adult. Upper parts and flanks bronzy-green. Under surface pure white. Under tail coverts pale green edged with white. Wings purplish-brown. Tail feathers dark bronzy-green, with the inner webs and shafts of lateral ones white. Maxilla and tip of mandible black, rest of latter flesh-color. Feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

I have retained Tschudi's second name of *chionogaster* as being more strictly correct than *leucogaster*.

2. *Leucippus chlorocercus*.

- Leucippus chlorocercus*, Gould, P. Z. S. (1866), p. 194.—Muls., Hist. Nat. Ois. Mouch., tom. i, p. 257.

Hab. Banks of the upper Ucayali, eastern Peru.

Adult. This species resembles closely the *L. chionogaster*, but differs in having the throat spotted with brown. Tail pale green, with a faint subterminal bar of darker green, and tipped with grayish-white, this extending as it goes outwards, until it covers the whole outer web of the external feather. Bill black, feet brown. Total length, $3\frac{3}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in.

Genus CII.—LEUCOCHLORIS.

Leucochloris, REICH., Aufz. der Colib., p. 10 (1853).

TYPE.

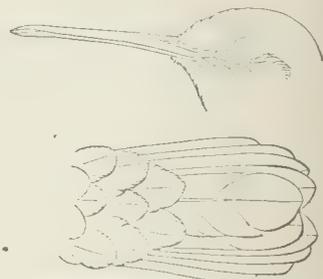
T. albicollis, Vieill.

Fig. 110.

Ch. Bill straight, slightly longer than head, wide at base; feathers of the forehead projecting slightly on the culmen, hiding the nostrils. Tail rounded. Tarsi clothed. Sexes alike.

Range. Brazil.

One species is known, and naturally finds its place here.



Leucochloris albicollis. 24788. Brazil.

1. *Leucochloris albicollis*.

Trochilus albicollis, VIEILL., Nouv. Diet. Hist. Nat. (1818), tom. 23, p. 426.

Ornismya albicollis, LESS., Ois. Mouch., p. 184, pl. 63 (1829).—D'ORB. and LAFRES., Syn. Av., ii, p. 30, sp. 19 (1838).

Colibri albogularis, SPIX., Av. Bras., t. i, p. 81, pl. 82, fig. 1 (1825).

Basilinna albicollis, LESS., Ind. Gen. and Syn. Ois. Genre. Troch., p. xxv (1831).

Polytmus albicollis, GRAY., Gen. Birds, vol. i, p. 108, sp. 43.

Thaumatias albicollis, BON., Consp. Gen. Av., vol. i, p. 78 (1850).

Leucochloris albicollis, REICH., Aufz. der Colib., p. 10 (1853).—GOULD, Mon. Troch., vol. v, pl. 291.—ID., Intr. Troch., octavo ed., p. 151 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 261.—ELLIOT, Ibis (1877), p. 138.

Thaumatias albicollis, BON., Rev. and Mag. Zool. (1854), p. 255.

Leucippus albicollis, REICH., Troch. Enum., p. 8, pl. 782, figs. 4818-19 (1855).

Agyrtia albicollis, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 32.

Hab. Brazil.

Adult. Upper surface, chin, flanks, and abdomen shining grass-green. Throat, breast, abdomen, and under tail coverts white. Wings purplish-brown. Median rectrices dark grass-green; lateral ones black, the three outermost tipped with white. Maxilla and tip of mandible black, rest of latter flesh-color; feet black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{5}{8}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{1}{8}$ in.

The members of the next genus, which in the regular order of succession comes here, are birds of moderate size, and of a pleasing plumage, the chief colors of which are green and white. The genus comprises a large number of species, in fact is one of the most extensive among the Trochilidæ. Subsequent to the publication of Mr. Gould's Monograph of the Family, it has been known as the genus THAUMATIAs, but as this term was applied by Bonaparte to a bird belonging to an entirely different genus (viz., *Trochilus thaumantias*, Linn.), and was, moreover, preoccupied by Eschscholtz for a genus of Acalephs, it of course cannot be continued, and that of AGYRTRIA proposed by Reichenbach is the one that has priority.—There is no difference in the plumage of the sexes, the females having as much metallic coloring as the males.—For the discussion of the synonymy of the various species, and their relative claims to such a rank, I would suggest that my article published in the Ibis for January, 1878, upon the genus THAUMATIAs (Gould) should be consulted.

Genus CIII.—AGYRTRIA.

TYPE.

Thaumatias, BON. (nec Eschsch., Acal., 1829, nec BON., Compt. Rend., 1850), Rev. and Mag. Zool. (1854), p. 255.

Thaumatias, GOULD (nec BON., Compt. Rend., 1850), Mon. Troch. Intr., octavo ed., p. 151 (1861).

Agyrtria, REICH., Troch. Enum., p. 7 (1855).

Leucodora, MCLS., Hist. Nat. Ois. Mouch., tom. i, p. 309 (nec 1875).

T. candidus, Bourc.
O. brevirostris, Less.
T. norrisii, Bourc.

Ch. Bill slightly longer than the head, straight or slightly curved. Feathers of the forehead not extending upon the culmen. Nostrils exposed. Wings long, narrow, pointed; first primary slightly falcate. Tail ample, even, or slightly rounded. Tarsi clothed. Sexes alike.

Range. Mexico, Central America, Islands of Tobago and Trinidad, Brazil, Guiana, Venezuela, Columbia, Ecuador, and Peru.

I recognize twenty species belonging to this genus.

Fig. 111.



Agyrtria niveipectus. ♂. Cayenne. Whitely.

Key to the species.

A. Throat and breast white.

a. Top of head brilliantly metallic.

a'. Bill black.

a''. Tail purplish-bronze.

b'. Bill; maxilla black, mandible flesh-color, tip black.

a''. Tail steel black, median feathers greenish-bronze.

b''. Tail greenish-gray, barred with brown near tip, bill long, stout.

c''. Tail greenish-gray, subterminal bar dark brown; bill short, weak.

1. *A. niveipectus*.

2. *A. leucogaster*

3. *A. viridiceps*.

4. *A. milleri*.

5. *A. candida*.

6. *A. norrisii*.

7. *A. brevirostris*.

8. *A. compsa*.

9. *A. neglecta*.

10. *A. bartletti*.

11. *A. nitidifrons*.

12. *A. caruleiceps*.

b. Top of head slightly metallic.

a'. Entire abdomen white.

a''. Tail greenish-bronze with a subterminal dark brown bar.

b'. Abdomen and flanks pale rufous.

c'. Centre of abdomen white.

a''. Tail pale bronze-green barred with brown, tip dusky.

b''. Tail blue-black.

B. Throat and upper part of breast blue.

a. Tail pale greenish-bronze, with a subterminal blackish bar.

b. Tail steel-blue.

C. Throat and breast metallic-green.

a. Under tail coverts gray, with a central line of bronze-green.

a'. Crown of head and face glittering green.

b'. Crown of head and back of neck shining greenish-blue.

- b. Crown of head dull green.
- a'. Under tail coverts white with central brown or green streak.
- a''. Tail, median feathers except tips, and the basal portions of the others, bright green; central part of lateral ones blackish, tips gray. Throat and breast shining grass-green. 13. *A. tephrocephala*.
- b''. Tail, median feathers bronze-green, remainder black with pale tips. Throat and breast golden-green. 14. *A. tobaci*.
- c''. Tail black. Throat and breast grass-green, with a slight bluish tinge. 15. *A. fluvialtilis*.
- d''. Tail, median feathers green, broadly tipped with blue-black, rest black, tipped with white. Throat and breast golden-green. 16. *A. apicalis*.
- e''. Tail, median feathers green, tipped with black, next one on either side bronze-green for two-thirds their length, rest black; remaining feathers green at base, then black with a metallic-green spot on the tip which graduates into white on its upper edge. 17. *A. maculicauda*.
- f''. Tail bronze-green, lateral feathers with a subterminal purplish-bronze bar, tips ashy-gray. Throat and breast glittering bluish-green. 18. *A. lucixæ*.
- b'. Under tail coverts pure white.
- a''. Tail, all the feathers steel-black, median ones slightly tinged with green in certain lights. 19. *A. nigricauda*.
- b''. Tail, median pair of rectrices golden-green, remaining ones have the inner webs, except tips, black; outer webs metallic golden-green; all the lateral feathers are tipped with bright metallic golden green. 20. *A. nilidicauda*.

1. *Agyrtia niveipectus*.

Thaumatias chionopectus, GOULD, Mon. Troch., pt. xviii (1859), pl. 5; vol. v, pl. 293.—ID., Intr. Troch., octavo ed., p. 152 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 227.—ELLIOT, Ibis (1878), p. 40.

Agyrtia niveipectus, CAB. and HEIN., Mus. Hein. Th., iii, p. 33 (note 10) (1860).

Polytmus chionopectus, LÉON., Ois. Trinid., p. 140, no. 71 (1866).

Hab. Trinidad, Venezuela, Guiana.

Adult. Top of head and sides of neck glittering metallic-green. Upper surface coppery-green. Throat and centre of abdomen white; flanks golden-green. Under tail coverts grayish with whitish margins. Tail purplish-bronze, with a subterminal purplish-brown bar. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

2. *Agyrtia leucogaster*.

Trochilus leucogaster, GMEL., Syst. Nat. (1788), vol. i, p. 495.

Ornismya albirostris, LESS., Ois. Mouch., p. 212, pl. 78 (1829).

Thaumatias leucogaster, BON., Rev. and Mag. Zool. (1854), p. 255.

Thaumatias mellisuga, BON., Consp. Gen. Av., vol. i, p. 78 (1850).

Agyrtia leucogastra, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, pl. 762, figs. 4762-64 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 34 (1860).

Thaumatias leucogaster, GOULD, Mon. Troch., vol. v, pl. 294.—ID., Intr. Troch., octavo ed., p. 152 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 231.—ELLIOT, Ibis (1878), p. 41.

Hub. Guiana and Brazil.

Adult. Upper parts and sides of neck metallic grass-green. Flanks bronzy-green. Throat, centre of the abdomen, and under tail coverts pure white. Median rectrices bronzy-green, lateral ones steel-black. Maxilla and tip of mandible black, rest of latter flesh-color. Feet black. Wings purple-brown. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{16}$ in.

3. *Agyrtria viridiceps.*

Thaumatias viridiceps, GOULD, P. Z. S. (1860), p. 307.—ID., Mon. Troch., vol. v, pl. 295.—ID., Intr. Troch., octavo ed., p. 152 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i. p. 229.—ELLIOT, Ibis (1878), p. 42.

Hub. Ecuador.

Adult. Crown, nape, and sides of the neck metallic light green; upper parts luminous bronzy-green. Throat, abdomen, and under tail coverts pure white. Flanks washed with green. Wings purplish-green. Tail greenish-gray, with a subterminal bar of brown. Maxilla and tip of mandible black, rest of latter flesh-color, feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{1}{8}$ in.

4. *Agyrtria milleri.*

Trochilus milleri, BOURC., P. Z. S. (1847), p. 43.—ID., Rev. Zool. (1847), p. 255.

Polytmus milleri, GRAY, Gen. Birds, vol. i, p. 108, sp. 46.

Thaumatias milleri, BOX., Consp. Gen. Av., vol. i, p. 78 (1850).—GOULD, Mon. Troch., vol. v, pl. 296.—ID., Intr. Troch., octavo ed., p. 152.—ELLIOT, Ibis (1878), p. 42.

Agyrtria milleri, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, pl. 759, figs. 4752-53.—CAB. and HEIN., Mus. Hein. Th., iii, p. 33 (note 11) (1860).

Thaumatias milleri, BOX., Rev. and Mag. Zool. (1854), p. 255.

Leucolia milleri, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 225.

Hub. Columbia.

Adult. This is a diminutive of the *T. viridiceps*, and can be distinguished from it only with difficulty. It is, however, much smaller in size. Total length, $3\frac{1}{5}$ in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{5}{16}$ in. Culmen, $\frac{5}{8}$ in.

5. *Agyrtria candida.*

Trochilus candidus, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), t. ix, p. 326.—ID., Rev. Zool. (1846), p. 319.

Ornismya senex, LESS., Rev. Zool. (1838), p. 315, no. 11 (albino)?

Polytmus candidus, GRAY, Gen. Birds, vol. i, p. 108, sp. 45.

Thaumatias candidus, BOX., Consp. Gen. Av., vol. i, p. 78 (1850).—GOULD, Mon. Troch., vol. v, pl. 292.—ID., Intr. Troch., octavo ed., p. 151 (1861).—ELLIOT, Ibis (1878), p. 43.

Agyrtria margaritaceus, REICH. (nec GMEL.), Troch. Enum., p. 7, t. 758, figs. 4747-48 (1855).

Agyrtria candida, CAB. and HEIN., Mus. Hein. Th., iii, p. 33 (note 8).

Thaumatias candidus, BOX., Rev. and Mag. Zool. (1854), p. 255.

Leucolia candida, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 233.

Hub. Mexico and Central America to Nicaragua.

Adult. Upper parts and flanks bronzy-green, inclining to brown on the crown. Throat, abdomen, and under tail coverts white. Wings purple. Tail greenish-bronze with a subterminal black bar. Maxilla and tip of mandible black, rest of

bill flesh-color. Feet black. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{4}$ in.

6. **Agyrtria norrisii*.

- Trochilus norrisii*, BOURC., P. Z. S. (1847), p. 47.
Polytmus norrisii, GRAY, Gen. Birds, vol. i, p. 108, sp. 71.
Amazilia norrisii, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8 (1855).
Amazilius norrisii, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.
Pyrrhophæna norrisii, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (note 10) (1860).
Hemistilbon norrisii, GOULD, Intr. Troch., octavo ed., p. 150 (1861).
Leucodora norrisi, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 309.
Thaumatias norrisi, ELLIOT, Ibis (1878), p. 44.
Thaumatias lardi, DEOCA, La Naturaleza Mex., tom. iii (1874), p. 24, sp. 7.

Hab. Mexico.

Adult. Upper parts golden-green. Throat and sides of the neck metallic golden-green; breast white; abdomen and flanks pale rufous; upper tail coverts light grayish-green; under tail coverts grayish-white. Wings pale green. Tail shining grayish-green. Feet flesh-color. Bill flesh-color black at the point. Wings, 55 mm. Tail, 35 mm. Bill, 18 mm. This description is taken from Bourcier's in the P. Z. S. (1847), p. 47.

7. *Agyrtria brevirostris*.

- Trochilus brevirostris*, LESS., Ois. Mouch., pp. xxxv and 211, pl. 77 (1829).
Basilinna brevirostris, LESS., Ind. Gen. and Syn. Gen. Troch., p. xxvi (1831).
Trochilus versicolor, NORDM. in Erm. Reise (1835), atl., pl. 1, figs. 1, 2, 3?
Polytmus brevirostris, GRAY, Gen. Birds, vol. i, p. 108, sp. 44.
Hylocharis versicolor, GRAY, Gen. Birds, vol. i, p. 115, sp. 45.—BON., Consp. Gen. Av. vol. i, p. 74, sp. 9 (1850).
Thaumatias brevirostris, BON., Consp. Gen. Av., vol. i, p. 78 (1850).—GOULD, Mon. Troch., vol. v, pl. 298.—ID., Intr. Troch., octavo ed., p. 152 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 242.—ELLIOT, Ibis (1878), p. 44.
Agyrtria versicolor, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, pl. 759, figs. 4750-51 (1855).
Agyrtria brevirostris, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, t. 759, fig. 4749.—CAB. and HEIN., Mus. Hein. Th., iii, p. 34, sp. 70.
Thaumatias versicolor, BON., Rev. and Mag. Zool. (1854), p. 255.
Thaumatias brevirostris, BON., Rev. and Mag. Zool. (1854), p. 255.
Thaumatias affinis, GOULD, Mon. Troch., vol. v, pl. 299.—ID., Intr. Troch., octavo ed., p. 153 (1861).
Agyrtria affinis, CAB. and HEIN., Mus. Hein. Th., iii, p. 33 (note 12) (1860).

Hab. Brazil.

Adult. Upper surface, sides of neck (and sometimes nearly all the throat), and flanks glittering bronzy-green. Centre of throat and abdomen white. Under tail coverts bronze-brown. Tail pale bronze-green, subterminal brown band, and tip dusky. Maxilla and tip of mandible black, rest of latter flesh-color. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

8. **Agyrtria compsa*.

- Agyrtria compsa*, HEIN., Journ. für Ornith. (1863), p. 185.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 256.
Agyrtria mellisuga, CAB. and HEIN., Mus. Hein. Th., iii, p. 34 (1860).
Thaumatias compsa, ELLIOT, Ibis (1878), p. 45.

Hab. Guiana.

"*Similis breviori, sed paulo minor, rostro longiore, splendide aurco-viridis; subtus alba maculis nitidis aureo-viridibus varia, pectoris epigastriique lateribus unicoloribus smaragdino-viridibus, abdomine medio unicolore albo tectricibus, caudae inferioribus nitidi-smaragdineis; remigibus fuscis; rectricis nigro-chalybeo-cyaneis; maxilla fusco, mandibula brunnescente cornea; pedibus fuscis. Long. tot., 3'' 3''' ; al., 1'' 8''' ; caud., 1'' 1''' ; rostr. culm., 7'''.*"—(Hein., loc. cit.)

9. **Agyrtria neglecta.*

Ornismya bicolor, D'ORB. and LAFR. (nec LESS., 1829), Syn. Av., ii, p. 30, sp. 21 (1838).

Thaumantias neglectus, ELLIOT, Ibis (1877), p. 140.—(1878), p. 53.

Hab. Yungas and Moxos, Bolivia.

Male. Top of head, nape, and mantle metallic-green; throat and upper part of breast brilliant metallic-blue, white base of the feathers showing amid the blue; back, rump, and upper tail coverts light greenish-bronze. Wings purplish. Flanks and lower parts of breast shining green. Abdomen whitish. Under tail coverts pale brown, margined with white. Tail pale greenish-bronze, with a subterminal black bar on lateral feathers. Maxilla black, mandible flesh-color. Feet black. Total length, $3\frac{1}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Bill, $\frac{3}{4}$ in.

Female. Upper parts, sides of throat, and flanks shining green. Centre of throat and under parts whitish, spotted with light metallic-green. Tail as in the male, tips of lateral feathers whitish. Under tail coverts white. Wings purple. Bill like the male. Feet black. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{4}$ in. Bill, $\frac{3}{4}$ in.

10. *Agyrtria bartletti.*

Thaumantias bartletti, GOULD, P. Z. S. (1866), p. 194.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 255.—ELLIOT, Ibis (1878), p. 53.

Hab. Banks of the Upper Ucayali, eastern Peru.

Adult. Upper parts and flanks dark grass-green. Throat and breast purplish-blue. Centre of abdomen grayish-white. Under tail coverts blackish-brown margined with grayish-white; upper tail coverts bronzy-green. Tail steel-black (in the female tipped with gray). Maxilla brownish, mandible flesh-color; feet blackish-brown. Wings purple. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

11. **Agyrtria nitidifrons.*

Thaumantias nitidifrons, GOULD, P. Z. S. (1860), p. 308.—Id., Mon. Troch., vol. v, pl. 297.—Id., Intr. Troch., octavo ed., p. 153 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 238.—ELLIOT, Ibis (1878), p. 52.

Hab. Venezuela?

Adult. "Crown of the head, face, chest, and neck glittering green; abdomen and flanks golden-green; back, shoulders, and rump bronzy-green; tail pale bronzy grayish-green, with a zone of purplish-brown crossing the four lateral feathers on each side near their tips; under tail coverts gray with a patch of bronzy-green in

the centre of each; tarsi grayish-brown; upper mandible black; under mandible yellow-black at tip. Total length, $3\frac{1}{4}$ in. Bill, $\frac{3}{4}$ in. Wing, $1\frac{7}{8}$ in."—(Gould, loc. cit.)

12. **Agyrtia cœruleiceps*.

Thaumatias cœruleiceps, GOULD, P. Z. S. (1860), p. 307.—ID., Intr. Troch., octavo ed., p. 152.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 240.—ELLIOT, Ibis (1878), p. 52.

Hab. Columbia.

Adult. "Crown of the head and back of the neck deep shining greenish-blue; back and shoulders green, passing into bronzy-green on the rump and upper tail coverts; tail nearly uniform bronze, with a very faint indication of a zone of brown across the outer feathers near the tip; wings purplish-brown; sides of the neck glittering bluish-green, the blue tint predominating on the ear and immediately under the eye; centre of the throat and chest broken glittering green and white; flanks bronzy-green; under tail coverts gray with brown centres; upper mandible dark brown; under mandible yellow, except the tip, which is dark brown. Total length, $3\frac{1}{2}$ in. Bill, $1\frac{5}{16}$ in. Wing, $2\frac{1}{8}$ in. Tail, $\frac{1}{2}$ in."—(Gould, loc. cit.)

13. *Agyrtia tephrocephala*.

Trochilus tephrocephalus, VIEILL., Nouv. Dict. Hist. Nat., tom. 23, p. 430.

Ornismya tephrocephala, LESS., Ois. Mouch., p. 182, pl. 62 (1829).

Ornismya albiventris, LESS., Ois. Mouch., p. 209, pl. 76 (1829).—ID., Troch., p. 94, pl. 32 (1831).—D'ORB. and LAFRES., Syn. Av., ii, p. 30, sp. 18 (1838).

Polytmus thaumatias, GRAY, Gen. Birds, vol. i, p. 108, sp. 40 (partim).

Thaumatias albiventris, BON., Consp. Gen. Av., vol. i, p. 78 (1850).—GOULD, Mon. Troch., vol. v, pl. 301.—ID., Intr. Troch., octavo ed., p. 153 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 245.—ELLIOT, Ibis (1877), p. 138.

Cœligena tephrocephala, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 3, pl. 687, fig. 4518 (1855).

Thaumatias albiventris, BON., Rev. and Mag. Zool. (1854), p. 255.

Agyrtia albiventris, REICH., Troch. Enum., p. 7, pl. 757, fig. 4744-45.—CAB. and HEIN., Mus. Hein. Th., iii, p. 32 (1860).

Thaumatias tephrocephalus, ELLIOT, Ibis (1878), p. 48.

Hab. Brazil.

Adult. Upper surface dark green. Wings purple. Throat and chest shining grass-green, flanks dull green. Abdomen and under tail coverts white. Median rectrices, except the tips and basal portions of the rest, bronzy-green. Central parts of lateral ones blackish, tips gray. Tips of median pair blackish. Maxilla and point of mandible black, rest of latter flesh-color. Feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

14. *Agyrtia tobaci*.

Trochilus tobaci, GMEL., Syst. Av. (1788), p. 498.

Trochilus tobagensis, LATH., Ind. Orn. (1790), vol. i, p. 316.

Trochilus maculatus, VIEILL., Ois. Der., t. i, p. 87, pl. 44 (1802).

Trochilus tobago, SHAW., Gen. Zool., vol. viii, p. 350.

Ornismya viridissima, LESS., Ois. Mouch., p. 207, pl. 75 (1829).

Saucerottia viridipectus, REICH., Aufz. der Colib., p. 7 (1853).

- Chlorestes malvina*, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, pl. 696, figs. 4550-51 (1855)?
Chlorestes (Saucerottia) viridipectus, REICH., Troch. Enum., p. 4, pl. 702, figs. 4573-75 (1855).
Hylocharis lactea, REICH., Troch. Enum., p. 7, pl. 773, fig. 4792 (1855).
Caligena maugei, ♀, REICH., Mus. Berol. (teste Cab.).
Agyrtria maculata, CAB. and HEIN., Mus. Hein. Th., iii, p. 33 (1860).
Thaumatias linnæi, GOULD, Mon. Troch., vol. v, pl. 302.—ID., Intr. Troch., octavo ed., p. 153 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 248.
Agyrtria malvina, CAB. and HEIN., Mus. Hein. Th., iii, p. 33 (note 9) (1860).
Thaumatias tobaci, ELLIOT, Ibis (1878), p. 49.

Hab. Tobago, Trinidad, Venezuela, Guiana, Brazil.

Adult. Upper surface bronzy-green. Wings purplish-brown. Throat and breast glittering grass-green, becoming dull green on the flanks. Centre of abdomen and under tail coverts white. Median rectrices bronze-green, lateral ones black with pale tips. Maxilla and point of mandible black, rest of latter flesh-color. Feet black. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{7}{8}$ in.

15. *Agyrtria fluviatilis*.

- Thaumatias fluviatilis*, GOULD, Intr. Troch., octavo ed., p. 154 (1861).—SCLAT. and SALV., P. Z. S. (1866), p. 194.—ELLIOT, Ibis (1878), p. 51.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 253.
Agyrtria fluviatilis, HEINE, Journ. für Ornith. (1863), p. 184.

Hab. Eastern Peru.

Adult. Upper parts and flanks dark grass-green. Throat and breast luminous grass-green with a bluish tinge. A narrow streak of white on the abdomen. Vent white. Under tail coverts dark brown margined with white. Tail black. Maxilla and point of mandible black, rest of latter flesh-color. Feet black. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in.

16. *Agyrtria apicalis*.

- Thaumatias apicalis*, GOULD, Intr. Troch., octavo ed., p. 154 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 252.—ELLIOT, Ibis (1878), p. 51.
Agyrtria apicalis, HEINE, Journ. für Ornith. (1863), p. 184.
Agyrtria terpna, HEINE, Journ. für Ornith. (1863), p. 184, sp. 9.

Hab. Columbia.

Adult. Upper parts bronzy-green. Throat and breast golden-green. Centre of abdomen white, under tail coverts white with dark brown centres. Median rectrices green, broadly tipped with bluish-black; lateral feathers black tipped with white. Maxilla and tip of mandible black, rest of latter flesh-color, perhaps red. Feet black. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{7}{8}$ in.

I place among the synonyms of this species the *A. terpna*, Heine, as from his description (l. c.) I cannot perceive any difference sufficient for the creation of a new species.

17. **Agyrtria maculicauda*.

- Thaumatias maculicaudus*, GOULD, Intr. Troch., octavo ed., p. 154 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 250.—ELLIOT, Ibis (1878), p. 51.
Agyrtria maculicauda, HEINE, Journ. für Ornith. (1863), p. 184, sp. 10.

Hab. Guiana.

Adult. "This is a very little species, with a long thin bill; its breast is green as in the others. Centre of the abdomen white; under tail coverts white, except in the centre, when they are dark brown; two centre tail feathers bronzy-green, except at the extreme tip which is greenish-black, the next on each side bronze for half their length, then black; the three outer ones on each side bronzy-green at base, then broadly zoned with black, next to which they are green, and lastly white. Total length, $3\frac{1}{2}$ in. Bill, $\frac{7}{8}$ in. Wing, 2 in. Tail, $1\frac{1}{8}$ in."—(Gould, loc. cit.)

18. **Agyrtria luciae*.

Thaumatias luciae. LAWRE., Proc. Acad. Nat. Sc. Phil. (1867), p. 233.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 241.—ELLIOT, Ibis (1878), p. 52.

Hab. Honduras.

"Upper plumage dull bronzy dark green, crown duller; upper tail coverts a lighter bronzy-green, somewhat golden; tail feathers dull bronzy-green, all except the two central ones broadly marked near their ends with dark purplish-bronze, the tips being ashy-gray; the throat and breast are glittering bluish-green, middle of the abdomen white; wings brownish-purple. Upper mandible black, the under yellow with the end blackish; feet black. Length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{3}{8}$ in. Bill, $\frac{1\frac{3}{8}}{16}$ in."—(Lawr., loc. cit.)

19. *Agyrtria nigricauda*.

Thaumatias nigricauda, ELLIOT, Ibis (1878), p. 47.

Hab. Trinidad, Guiana, northeastern Brazil.

Adult. Upper parts bronzy-green, darkest on the head, and shading into purple on the upper tail coverts. Throat and breast shining metallic grass-green. Flanks dark green with scarcely any lustre. Middle of abdomen, vent, and under tail coverts pure white. Tail steel-black, the two outermost feathers greenish-gray at their tips, the next merely edged with white on the tip. Maxilla brownish-black; mandible flesh-color, tip black. Feet black. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Bill on culmen, $\frac{5}{8}$ in. (From type in my collection.)

20. *Agyrtria nitidicauda*.

Thaumatias nitidicauda, ELLIOT, Ibis (1878), p. 48.

Hab. Guiana.

Adult. Upper part bright bronze-green, with a slight coppery tinge on the head. Chin white. Throat, breast, and sides of the neck bright metallic grass-green. Flanks and abdomen dull green. Middle of abdomen, vent, and under tail coverts pure white. Median rectrices bronze-green. Lateral ones purplish-black, the edges of the outer webs and tips bronze-green. Wings purplish-brown. Bill flesh-color (perhaps red in life), with a dark tip. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Bill along culmen, $\frac{3}{4}$ in. (Type in my collection.)

Genus CIV.—ARINIA.

Arinia, Muls., Ann. Soc. Linn., 1877 (Oct.).

TYPE.
A. boucardi.

Ch. Bill subcylindrical, until near the point, when it is slightly swollen; shorter than half the body. Tail slightly forked. Wings narrow, reaching for three-fourths the length of the median rectrices. The external rectrices are slightly shorter than the ones next to them. Sexes unlike in plumage.

Range. Costa Rica.

But one species is known, brought from Costa Rica by M. Boucard. It is very close to the genus AGYRTRIA, and were the male alone known, the propriety of separating it from that genus might possibly be questioned, but as the female is quite different in the coloring of her plumage from the male, while the sexes of AGYRTRIA do not differ in their dress, it would seem to be best to allow the present species a distinct generic rank. This genus connects AGYRTRIA with ELVIRA.

1. **Arinia boucardi*.

Arinia boucardi, Muls., Ann. Soc. Linn., Lyon, 1877 (Oct.).

Male. Upper surface and flanks bronzy-green, darkest on the head. Throat and breast shining bluish-green. Abdomen and under tail coverts pure white. Median pair of rectrices dark bronze-green; next bronze-green with black tip, remaining lateral feathers bronze-green at base, rest black, the bronze-green decreasing in extent as it goes towards the external feather. All the lateral feathers edged with white at their tips. Maxilla black, mandible flesh-color, tip black. Feet black. Total length, $3\frac{1}{6}$ in. Wing, 2 in. Tail, $1\frac{9}{16}$ in. Culmen, $\frac{1}{6}$ in.

Female. Differs in having the middle of the throat, breast, and under parts pure white. Median rectrices bronzy-green, lateral feathers green at base, then black and tipped with gray. Rest like the male.

Allied to the members of the genus AGYRTRIA are the two species placed respectively by Messrs. Lawrence and Gould in the genera EUPHERUSA and THAUMATIAS. They, however, differ in many ways from the members of those genera, especially in the shape of the bill, and the dissimilarity in the plumage of the sexes. I have employed for these birds the term ELVIRA, proposed by M. Mulsant, as I consider they represent a very distinct generic form. They are small in size, with the greater portion of the plumage metallic-green, but the tails are almost entirely pure white, a very uncommon feature among the Trochilidæ.

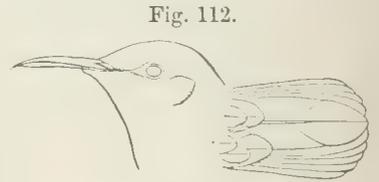
Genus CV.—ELVIRA.

TYPE.

Elvira, MULS. and VERR., Class. Troch. (1865), p. 32 (nec 1875, Cat. Ois. Mouch. p. 9). *T. chionurus*, Gould.

Ch. Bill shorter than the head, curved, nostrils partly exposed. Wings long, narrow, pointed. Tail very slightly rounded. Tarsi clothed. Sexes dissimilar.

Range. Costa Rica and Veragua.
Two species are known.

*Elvira cupreiceps*. Costa Rica. Van Patten.*Key to the species.*

- A. Under parts shining green. Under tail coverts pure white.
- a. Median rectrices coppery-bronze, lateral ones white tipped with bronze. 1. *E. cupreiceps*.
 - b. Median rectrices bronzy-green; lateral ones white, apical portions black. 2. *E. chionura*.

1. *Elvira cupreiceps*.*Eupherusa cupreiceps*, LAWRE., Ann. N. Y. Lyc. Nat. Hist. (1866), vol. viii, p. 348.*Thaumatias cupreiceps*, SCLAT. and SALV., Nomencl., p. 92 (1873).*Elvira cupreiceps*, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 268.*Hab.* Costa Rica.

Male. Top of head shining coppery-green; upper surface bronzy-green, changing to coppery-red on the upper tail coverts. Under surface luminous emerald-green, brightest on the throat and breast. Vent and under tail coverts pure white. Wings purple. Median rectrices coppery-bronze; lateral ones white tipped with bronze. Bill and feet black. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{9}{16}$ in.

Female differs in having the top of head bronzy-green, and entire under parts except the flanks pure white. Otherwise like the male.

2. *Elvira chionura*.*Trochilus (Thaumatias?) chionurus*, GOULD, P. Z. S. (1850), p. 162.*Leucippus chionurus*, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 8, pl. 780, figs. 4813-15 (1855).*Thaumatias chionura*, BON., Rev. and Mag. Zool. (1854), p. 255.*Agyrtria chionura*, CAB. and HEIN., Mus. Hein. Th., iii, p. 32 (note 7) (1860).*Thaumatias chionurus*, GOULD, Mon. Troch., vol. v, pl. 300.—ID., Intr. Troch., octavo ed., p. 153 (1861).—ELLIOT, Ibis (1878), p. 48.*Elvira chionura*, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 266.*Hab.* Veragua and Costa Rica.

Male. Upper surface dark grass-green; under surface luminous emerald-green, lightest on the throat, centre of abdomen and under tail coverts white. Wings purple. Median rectrices bronzy-green; lateral ones white, with their apical portions black. Bill black, flesh-colored spot at base of mandible. Feet black. Total length, $3\frac{1}{3}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Differs in having the under surface white, except the flanks which are green, and by having the white lateral tail feathers crossed obliquely by a black bar. In all other respects she resembles the male.

Genus CVI.—CALLIPHARUS.

Clotho, MULS., Cat. Ois. Mouch. (1875), p. 9 (nec FANJ., 1808, Mollus., nec WALK., Arachn., 1809, nec GRAY, Rept., 1840).

TYPE.

E. nigriventris, Lawr.

Ch. Bill about as long as the head, straight, wide at base graduating to a point at the tip. Frontal feathers not projecting on to the culmen. Wings long and broad for their length. Tail moderate, slightly rounded. Under tail coverts reaching half the length of the rectrices. Feet small; tarsi partly clothed. Sexes entirely unlike in the color of their plumage.

Fig. 113.



Callipharus nigriventris, ♂. Veragua. Salvin.

Range. Costa Rica and Veragua.

But one species is known, a miniature EUPHERUSA in many particulars, which seems to find its natural place between the members of that genus and those of ELVIRA. The term *Clotho*, bestowed on this species by M. Mulsant, having been previously employed in various branches of zoology, I propose in its place CALLIPHARUS.

1. *Callipharus nigriventris*.

Eupherusa nigriventris, LAW., Proc. Acad. Nat. Sc. Phila. (1867), p. 232.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 270.

Eupherusa (Clotho) nigriventris, MULS., Cat. Ois. Mouch. (1875), p. 9.

Thaumatias nigriventris, SCLAT. and SALV., Nomencl., p. 92 (1873).

Hab. Costa Rica and Veragua.

Male. Forehead and entire under surface jet-black. Occiput and upper surface bronzy-green. Four central rectrices purplish-black, three lateral ones pure white tipped with brownish-black. Wing coverts bronzy-green; secondaries chestnut at their bases, tips purple. Vent and under tail coverts white. Bill and feet black. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{5}{8}$ in.

Female. Upper surface bronzy-green. Under surface grayish-white, washed on the flanks with green. Four median rectrices dark grass-green, remainder white. Maxilla and apical half of mandible black, basal half of latter flesh-color. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

In the style of coloration observed in the wing, this species resembles those of the next genus.

The members of the genus EUPHERUSA are birds of moderate size, differing chiefly in the coloration of their tails. They resemble each other in the hues of their

plumage, which is mainly metallic-green and white; and also in having the secondaries chestnut. The sexes are very different in their appearance.

Genus CVII.—EUPHERUSA.

Eupherusa, GOULD, Mon. Troch., pt. xiv (1857); and Intr. Troch., octavo ed., p. 145 (1861).

TYPE.

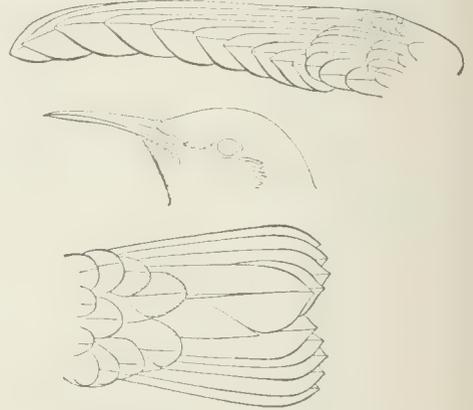
O. eximia, Delattr.

Fig. 114.

Ch. "Bill nearly straight and longer than the head; wing rather long; tail rounded; tarsi clothed; feet small; hind toe rather shorter than the middle toe." (Gould, loc. cit.)—Sexes dissimilar.

Range. Mexico and Central America.

Three species are here allotted to this genus.



Eupherusa eximia. ♂. Guatemala. COOK

Key to the species.

- | | |
|---|---------------------------|
| A. Tail, two median rectrices light bronze-green, lateral ones white margined with purplish-gray. | 1. <i>E. poliocerca</i> . |
| B. Tail dark greenish-bronze; two outermost feathers with basal two-thirds of inner webs white. | 2. <i>E. eximia</i> . |
| C. Tail, four median rectrices dark greenish-bronze, remainder white margined with black. | 3. <i>E. egregia</i> . |

1. *Eupherusa poliocerca*.

Eupherusa poliocerca, ELLIOT, Ann. and Mag. Nat. Hist. (1871), p. 266.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 271.—SCLAT. and SALV., Nomencl., p. 92 (1873).

Hab. Putla, Mexico.

Adult male. Top of head and upper surface bronzy-green; entire under parts brilliant grass-green. Wings purple; secondaries chestnut-red. Under tail coverts pure white. Two central tail feathers light bronze-green, purplish at the tips, remaining ones white, purplish-gray on the edges of outer webs and on the tips. Bill black, feet flesh-color. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

Female. Unknown.

2. *Eupherusa eximia*.

Ornismya eximia, DELATT., Echo du Monde Sav. (1843), p. 1069.

Saucerottia eximia, REICH., Aufz. der Colib., p. 8 (1853).—BON., Rev. and Mag. Zool. (1854), p. 255.

Amazilia eximia, REICH., Troch. Enum., p. 8, pl. 776, fig. 4802 (1855).

Eupherusa eximia, GOULD, Mon. Troch., vol. v, pl. 324.—ID., Intr. Troch., octavo ed., p. 163 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 272.

Hab. Guatemala.

Male. Upper surface dark shining green, becoming bronzy on the upper tail coverts. Under surface luminous grass-green. Base of primaries and secondaries chestnut-red, rest of primaries purplish-brown. Under tail coverts white. Tail very dark greenish-bronze, almost black on the lateral feathers, with the basal two-thirds of inner webs of the two outermost rectrices white. Bill black, feet brown. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Differs in having the entire under surface grayish-white, mottled with green and buff on the flanks. Base of four middle tail feathers bronzy-green, tips black. Rest of plumage like that of the male. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{5}{16}$ in. Culmen, $1\frac{1}{16}$ in.

3. *Eupherusa egregia.*

Eupherusa egregia, SCLAT. and SALV., P. Z. S. (1868), p. 389; (1870), p. 210.—LAWR., ANN. N. Y. Lyc. Nat. Hist. (1869), p. 146.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 274.

Hab. Costa Rica, Veragua.

Male. Plumage of body as in *E. eximia*. Tail differs in having the four central feathers dark greenish-bronze, remainder white margined with black. Bill black, feet flesh-color. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

The three species comprising the next genus have been assigned to various positions among the Trochilidæ, but I think they are best placed here. They possess characters that would ally them to various genera, and it cannot be said that they are especially related to the members of any particular one of those known. This of course makes it impossible to find a position for them as yet, which it would seem they are especially designed to fill, and as is the case with many others, we must wait further discoveries in the Family, before their exact place can be ascertained. They are rather large birds, with a green plumage, and tails of green and white, the feathers being narrow and pointed.

Genus CVIII.—POLYTMUS.

TYPE.

Polytmus, BRISS., Ornith. (1760).

Thaumatias, BON., Compt. Rend. (1850), p. 382, vol. 30.

Chrysobronchus, BON., Rev. and Mag. Zool. (1854), p. 252.

T. thaumantias, Linn.

T. thaumantias, Linn.

T. thaumantias, Linn.

¹ Bonaparte expressly states in the article here indicated that "*Thaumatias* a pour type *T. thaumantias* (lege *thaumantias*), Linn.," which clearly proves, as I have already shown in the Ibis, 1878, p. 36, that Mr. Gould and others are in error to refer Bonaparte's term to the members of the genus AGYRTRIA, with which the *T. thaumantias* has nothing whatever to do. The fact that Bonaparte afterwards classed with the type of his genus, species of AGYRTRIA is not surprising, as his knowledge of the Trochilidæ was limited, and he knew many species only by their names; therefore, it was not unusual for him in his writings to group together under one genus, numerous species with little or no relationship, and belonging to very different genera. By no method can *Thaumatias*, BON., be properly construed as intended for any other species than the one here given as *Polytmus thaumantias*, and its allies included in the same genus.

Ch. Bill much longer than the head, slightly curved; wide at the base, graduating to a point; nostrils exposed. Wings long and pointed, reaching to two-thirds the length of the tail. Rectrices narrow; tail rounded. Sexes alike.

Range. Trinidad, Venezuela, Guiana, Amazonian region of Brazil and Peru.

Three species are recognized.



Polytmus thaumantias. ♂ ad. Cayenne. Bourcier.

Key to the species.

- | | |
|---|-----------------------------|
| A. Tail green, with a stripe of white on basal portion of outer web of the lateral feathers and their tips grayish-white. | 1. <i>P. thaumantias</i> . |
| B. Tail entirely metallic-green. | |
| a. Under coverts metallic dark green. | 2. <i>P. viridissimus</i> . |
| b. Under coverts white. | 3. <i>P. leucorrhous</i> . |

1. *Polytmus thaumantias*.

Trochilus thaumantias, LINN., Syst. Nat. (1766), vol. i, p. 489.

Trochilus virescens, DUMONT., Dict. Sc. Nat. (1818), p. 49.

Trochilus chrysobronchus, SHAW., Gen. Zool., vol. viii, p. 287.

Trochilus viridis, VIEILL., Nouv. Dict. Hist. Nat., tom. vii, p. 354 (1817).—D'ORB. and LAFRES., Syn. Av., ii, p. 32, sp. 30 (1838).

Ornismya viridis, LESS., Ois. Mouch., p. 178, t. 60 (1829).—ID., Troch., p. 144, pl. 54, juv. (1831).

Polytmus chrysobronchus, GRAY, Gen. Birds, vol. i, p. 108, sp. 52.

Agyrtria thaumantias, REICH., Aufz. der Colib., p. 10.—ID., Troch. Enum., p. 7, t. 756, figs. 4738-39 (1855).

Leucippus chrysobronchus, REICH., Aufz. der Colib., p. 11 (1853).—ID., Troch. Enum., p. 8, pl. 781, figs. 4816-17.

Thaumantias linnaei, BON., Rev. and Mag. Zool. (1854), p. 255, sp. 245.

Chrysobronchus virescens, BON., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Mon. Troch., vol. iv, pl. 230.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 276.

Polytmus thaumantias, CAB. and HEIN., Mus. Hein. Th., iii, p. 5 (1860).

Polytmus virescens, GOULD, Intr. Troch., octavo ed., p. 126 (1861).—ELLIOT, Ibis (1877), p. 142.

Hab. Trinidad, Venezuela, and Brazil.

Adult. Upper surface golden-green; under surface metallic yellowish-green. Vent white. Under tail coverts shining green edged with white. Tail shining green, the lateral feathers having a stripe of grayish-white on the outer web at the base, and the tips grayish-white. Maxilla black, mandible and feet flesh-color. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{7}{8}$ in.

Young. Under surface fawn, with a line of yellowish-green feathers in the centre of the throat.

2. *Polytmus viridissimus*.

Trochilus viridissimus, VIEILL. (nec GMEL.), Ois. Dor., tom. i, p. 84, pl. 42 (1802).

Ornismya viridis, LESS., Troch., p. 96, pl. 33 (1831).

Trochilus theresia, DASILVA, Mai. Min. Bras. (1843) p. 2.

Amazilia viridissima, BON., Consp. Gen. Av., vol. i, p. 77 (1850).

Smargaditis viridissima, REICH., Aufz. der Colib., p. 7? (1853).

Chrysobronchus viridissimus, BON., Rev. and Mag. Zool. (1854), p. 252.—GOULD, Intr. Troch., octavo ed., p. 127 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 279.

Chrysobronchus viridicaudus, GOULD, Mon. Troch., vol. iv, pl. 231.

Chlorestes viridissimus, REICH., Troch. Enum., p. 4, pl. 695, figs. 4547-48 (1855).

Thaumatias viridissimus, BURM., Th. Bras., tom. ii, p. 344 (1856).

Thaumatias chrysurus, BURM., Th. Bras., tom. ii, p. 345 (1856).

Polytmus theresiæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 5 (1860).

Hab. Guiana and Venezuela.

Adult. Upper surface bronzy-green; under parts shining grass-green. Tail metallic grass-green. Under tail coverts grass-green. Bill, maxilla black, mandible flesh-color, tip black. Total length, 4 in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{7}{8}$ in. Culmen, $\frac{3}{4}$ in.

Young. Beneath gray washed with green. Under tail coverts green margined with white.

3. *Polytmus leucorrhous*.

Polytmus leucorrhous, SCLAT. and SALV., P. Z. S. (1867), p. 584.—GOULD, P. Z. S. (1871), p. 505.

Polytmus leucoproctus, GRAY, Handl. B., pt. i, p. 128, no. 1626.

Chrysobronchus leucorrhous, SCLAT. and SALV., Nomencl., p. 89.

Hab. Rio Negro, Brazil (Wallace), Rio Huallaga, Peru (Bartlett).

Male. Entire plumage shining green, except the head which is brown above, and the under tail coverts which are pure white. Tail like *C. viridissimus*. Total length, $3\frac{5}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female differs in having the outer tail feathers tipped with white.

In the following genus, I have placed species, which, although they differ in coloration, possess so far as I can perceive the same generic characters. They have been divided by various authors into a number of genera, of which the chief if not the only character has, in certain cases at least, been that of color. Messrs. Sclater and Salvin in their Nomenclator have reduced the genera to two, AMAZILIA and SAUCEROTTIA, but having been unable to find characters that were essentially structural to distinguish these, I have suppressed the latter also. As I have frequently said in this work, color cannot be considered a generic character for Humming-birds, when unsupported by any structural peculiarities, for if it is accepted in one instance, to be consistent, it must be in all, and then but few *species*, comparatively, could be passed over without being elevated to *generic* rank. The birds that are now reviewed are of moderate size, certain species having a greater or less resemblance to each other in their style of coloration, and the sexes are alike in plumage. In numbers it is one of the most extensive genera of the Trochilidæ.

¹Genus CIX.—AMAZILIA.

- Amazilis*, LESS., Ind. Gen. and Syn. du Gen. Trochilus (1832), p. xxvii.
Amazilia, REICH., Avium Syst. Nat., pl. 39 (1849).
Amazilius, BON., Consp. Gen. Av., vol. i, p. 77 (1850).
Pyrrhophæna, CAB. and HEIN., Mus. Hein. Th., iii, p. 35 (1860).
Hemithylaca, CAB. and HEIN., Mus. Hein. Th., iii, p. 37 (1860).
Hemistilbon, GOULD, Intr. Mon. Troch., p. 149 (1860).
Eranna, HEINE, Journ. für Ornith., p. 187 (1863).
Eratina, HEINE, Journ. für Ornith., pp. 190, 191 (1863).
Ariana, MULS. and VERR., Class. Troch. (1865), p. 36.
Ariana, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 315.
Myletes, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 284.
Saucerottia, BON., Compt. Rend., p. 381 (1850).
Erythronota, GOULD, Intr. Troch., octavo ed., p. 160 (1861).
Eratopis, HEINE, Journ. für Ornith. (1863), p. 191.
Erasuria, HEINE, Journ. für Ornith. (1863), p. 191.
Lisoria, MULS., Cat. Ois. Mouch. (1875), p. 11.

Ch. Bill as long as the head, slightly curved; broad at base, graduating to an acute point. Feathers of forehead not projecting on to the culmen. Nostrils exposed, covered by a scale. Wings rather long, pointed. Tail even or slightly forked. Tarsi clothed. Sexes alike.

Range. Mexico, Central America, Tres Marias Islands, Columbia, Ecuador, and Peru.

Twenty-four species are here recognized as belonging to this genus.

TYPE.

- O. amazili*, LESS.
O. amazili, LESS.?
O. amazili, LESS.
O. amazili, LESS.
T. niveiventris, GOULD.
A. ocai, GOULD.
O. cinnamomea, LESS.
T. iodurus, HEINE.
T. niveiventris, GOULD.
T. fuscicaudatus, FRAS.
T. yucatanensis, CABOT.
O. erythronota, LESS.
T. saucerottii, BOURC.
O. erythronota, LESS.
T. cyanifrons, BOURC.
E. elegans, GOULD.
H. warszewiczi, CAB.

Fig. 116.

*Amazilia pristina*. ♂. Peru. Bourcier.

¹ I can find no generic characters by which the species, that have been placed under *Amazilia*, *Pyrrhophæna*, *Erythronota*, *Saucerottia*, *Hemithylaca*, *Hemistilbon*, etc., can be separated or distinguished. Even those authors, who consider that the color of the plumage alone is sufficient to constitute a genus, have not been able to arrange the birds, here kept in the one genus *Amazilia*, so as to make the members of each of their groups similar in coloration. Thus the *Pyrrhophæna* as restricted by Gould in the Introduction to the Trochilidæ do not all have metallic breasts (witness *P. cinnamomea*); nor do the *Erythronotæ* all have red backs (vide *E. feliciæ*); which last species, although closely allied to *E. antiqua*, Gould, is almost identical in its coloration with species of *Saucerottia*; while *Hemithylaca cyanifrons* has only its blue head to present as a claim for generic distinction.—M. Mulsant, who has carried the generic divisions of this Family to a far greater extent than any other author, and whose characters are almost entirely those of color, has not been successful in the separations of his groups, as his *Amaziliæ* do not all have white and red breasts (vide *cinnamomea* and *graysoni*), but are a mixture of species with non-metallic and metallic coloring of the body; in *Leucodora* he has placed with *edwardi* and *niveiventris*, the *T. norrissi*, Bourc., which has the coloration of *AGYRTIA*, and apparently belongs to that genus; and with *Ariana* (!) he has grouped together such species as *fuscicaudata*, Fras., and *erythronota* and *cyanifrons* (!). It will thus be seen that when color is taken as the generic guide, it is impossible to make a satisfactory arrangement, unless, indeed, the group is still farther divided until there would be almost as many genera as species. Believing, therefore, that there are already far too many genera instituted for this especial group of birds, I have preferred to keep them all under the one genus *AMAZILIA*.

Key to the species.

- A. Chest white.
- a. Tail pale chestnut.
- a'. Abdomen and flanks rufous.
- a''. Throat metallic emerald-green. 1. *A. pristina*.
- b''. Throat metallic golden-green. 2. *A. leucophaea*.
- b'. Abdomen white, flanks rufous. 3. *A. alticola*.
- b. Tail pale bronzy-green. 4. *A. dumerili*.
- B. Entire under parts rufous.
- a. Tail deep chestnut tipped with bronze. 5. *A. cinnamomea*.
- b. Large race of above, "tail cinnamon tipped with golden-bronze." 6. *A. graysoni*.
- C. Throat and breast metallic-green.
- a. Abdomen and under tail coverts fawn. 7. *A. yucatanensis*.
- b. Abdomen and flanks bronzy-green.
- a'. Wings purplish-brown.
- a''. Tail reddish-chestnut. 8. *A. fuscicaudata*.
- b''. Tail shining dark violet. 9. *A. viridiventris*.
- b'. Wings purplish-brown, base of primaries and secondaries chestnut-red.
- a''. Tail greenish-bronze. 10. *A. ocai*.
- b''. Tail shining purplish-bronze. 11. *A. beryllina*.
- c. Abdomen white.
- a'. Tail bronzy-purple. 12. *A. edwardi*.
- b'. Tail purplish-black. 13. *A. niveiventris*.
- D. Entire under surface green.
- a. Wings purplish-brown, base of primaries and secondaries chestnut-red at base.
- a'. Upper tail coverts dark purple, tail brilliant purple. 14. *A. mariæ*.
- b'. Upper and under tail coverts and tail deep blue. 15. *A. cyanura*.
- c'. Tail purplish-violet; under tail coverts white. 16. *A. iodura*.
- b. Wings all purplish-brown.
- a'. Upper tail coverts golden-bronze, tail reddish-bronze, tip black. 17. *A. lucida*.
- b'. Rump and upper tail coverts coppery-red. Tail steel-blue. 18. *A. erythronota*.
- c'. Rump green like the back, upper tail coverts and tail bluish-black. 19. *A. feliciæ*.
- d'. Upper tail coverts and tail deep-blue.
- a''. Rump bronzy-purple. 20. *A. sophiæ*.
- b''. Rump green like the back. 21. *A. warszewiczi*.
- e'. Upper tail coverts and tail steel-black. 22. *A. saucerotti*.
- f'. Top of head deep blue. 23. *A. cyanifrons*.
- g'. Upper tail coverts purplish-red, tail long forked, purplish-violet. 24. *A. elegans*.

1. *Amazilia pristina*.

Orthorhynchus amazili, LESS., Voy. Coq., pl. 31, fig. 3 (1826).

Ornismya amazili, LESS., Ois. Mouch., pp. xxvii, 67, pls. 12, 13 (1829).—ID., Ind. Syn. Genr. Troch., p. xxvii (1831).

Trochilus (Lampornis) amazilia, Tschud., Consp. Av., p. 37.—ID., Faun. Per., p. 246 (1844-46).

Polytmus amazili, GRAY, Gen. Birds, vol. i, p. 108, sp. 70.

Amazilia latirostris, BON. (nec SWAIN.), Consp. Gen. Av., vol. i, p. 77 (1850).

Amazilia pristina, GOULD, Mon. Troch., vol. v, pl. 303.—ID., Intr. Troch., octavo ed., p. 155 (1861).

Pyrrhophæna amazilia, CAB. and HEIN., Mus. Hein. Th., iii, p. 35 (1860).

Amazilia lessoni, Muls., Hist. Nat. Ois. Mouch., tom. i, p. 293.

Hab. Ecuador and Peru.

Adult. Upper surface greenish-bronze. Throat emerald-green; chest white; under surface rufous. Under tail coverts white washed with rufous. Upper tail coverts rufous. Tail pale chestnut, glossed on the edges and tips of central feathers with bronze. Wings purple. Bill flesh-color, tip black. Feet brown. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

2. *Amazilia leucophæa*.

Amazilia leucophæa, REICH., Aufz. der Colib., pp. 10, 24 (1853).—GOULD, Mon. Troch., vol. v, pl. 306.—ID.,

Intr. Troch., octavo ed., p. 156.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 291.

Amazilia amazicula, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, pl. 777, figs. 4803-4 (1855).

Pyrhophæna leucophæa, CAB. and HEIN., Mus. Hein. Th., iii, p. 35 (1860).

Hab. Peru.

Adult. Top of head and back golden-green; rump and upper tail coverts rufous. Wings pale brown. Throat and sides of neck metallic golden-green; chest white; under surface rufous; under tail coverts buffy-white. Bill flesh-color, tip brownish-black; feet black. Tail rufous, median feathers washed with bronze at the tips. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in.

3. *Amazilia alticola*.

Amazilia alticola, GOULD, P. Z. S. (1860), p. 309.—ID., Mon. Troch., vol. v, pl. 304.—ID., Intr. Troch., octavo ed., p. 156 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 289.

Hab. Ecuador.

Adult. Upper parts bronzy-green, darkest on the head. Upper parts of throat and sides of the neck golden metallic-green. Rest of under parts white except flanks which are buff. The white under tail coverts are washed with buff. Upper tail coverts and tail chestnut, median rectrices tipped with bronzy-green. Wings purplish-brown. Bill flesh-color with a black tip; feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{4}$ in.

Specimens vary in their coloration, and some are almost entirely white beneath, with just a few feathers of the throat tipped with golden-green.

4. *Amazilia dumerili*.

Ornismya dumerili, LESS., Ois. Mouch. Supp., p. 172, pl. 36 (1831).—ID., Ind. Gen. and Syn. Troch., p. xxviii.

Polytmus dumerili, GRAY, Gen. Birds, vol. i, p. 109, sp. 79.

Amazilius dumerili, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.

Amazilia dumerili, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, pl. 777, figs. 4805-6.—

GOULD, Mon. Troch., vol. v, pl. 305.—ID., Intr. Troch., octavo ed., p. 156 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 287.

Pyrhophæna dumerili, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (note 7) (1860).

Hab. Ecuador.

This species is distinguished from the three preceding by having the upper tail coverts and tail bronzy-green. In other respects it is very similar in its coloration;

having a metallic-green throat, white breast, rufous abdomen and flanks, and white under tail coverts. Bill flesh-color, tip black. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

5. *Amazilia cinnamomea*.

Ornismya cinnamomea, LESS., Rev. Zool. (1842), p. 175.

Ornismya rutila, DELATT., Echo Monde Savant (1843), p. 1069.

Trochilus corallirostris, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), t. ix, p. 328.

Amazilius erythrorhynchus, BON., Compt. Rend. (1850), p. 382.

Amazilius hæmatorhynchus, BON., Compt. Rend. (1850), p. 382.

Amazilius corallirostris, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.

Amazilia corallirostris, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, pl. 776, figs 4800-1 (1855).—GOULD, Mon. Troch., vol. v, pl. 307.

Pyrrhophæna corallirostris, CAB. and HEIN., Mus. Hein. Th., iii, p. 35 (note 6) (1860).

Pyrrhophæna cinnamomea, GOULD, Intr. Troch., octavo ed., p. 156 (1861).

Eranna cinnamomea, HEINE, Journ. für Ornith. (1863), p. 187.

Hab. Guatemala and Costa Rica.

Adult. Upper surface bronzy-green. Wings purplish-brown. Entire under surface bright cinnamon. Tail deep chestnut tipped with bronze, sometimes margined with black. Bill red, feet brown. Total length, 4 in. Tail, $1\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Culmen, $\frac{7}{8}$ in. (Bourcier's type.)

6. **Amazilia graysoni*.

Amazilia (Pyrrhophæna) graysoni, LAWR., Ann. N. Y. Lyc. Nat. Hist. (1867), p. 404.

Amazilia graysoni, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 286.

Hab. Islands of Tres Marias.

Like *A. cinnamomea*, but larger. Total length, $4\frac{3}{4}$ in. Wing, $2\frac{1}{6}$ in. Tail, $1\frac{7}{8}$ in. Bill, $\frac{1}{6}$ in.

7. *Amazilia yucatanensis*.

Trochilus yucatanensis, CABOT, Proc. Nat. Hist. Soc. Bost. (1845), p. 74.

Amazilia yucatanensis, GOULD, Mon. Troch., vol. v, pl. 308.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 295.

Amazilius cerviniventris, GOULD, P. Z. S. (1856), p. 150.

Pyrrhophæna yucatanensis, GOULD, Intr. Troch., octavo ed., p. 157 (1861).

Amazilia cerviniventris, GOULD, Mon. Troch., vol. v, pl. 309.

Pyrrhophæna cerviniventris, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (note 9) (1860).—GOULD, Intr. Troch., octavo ed., p. 157.

Eranna yucatanensis, HEINE, Journ. für Ornith. (1863), p. 187.

Eranna cerviniventris, HEINE, Journ. für Ornith. (1863), p. 187.

Hab. Mexico and Yucatan.

Adult. Upper surface bronzy-green. Throat and breast metallic emerald-green: flanks grass-green. Abdomen and under tail coverts dark fawn. Thighs white. Tail chestnut-red tipped with bronze. Wings purple. Bill flesh-color, tip black. Total length, 4 in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{3}{8}$ in.

I can perceive no difference between Mexican and Yucatan specimens, and have placed the *A. cerviniventris*, Gould, as a synonym of Cabot's species.

8. *Amazilia fuscicaudata*.

- Trochilus fuscicaudata*, FRAS., P. Z. S. (1840), p. 17.
Trochilus riefferi, BOURC., Rev. Zool. (1843), p. 103.
Trochilus aglaia, BOURC. and MULS., Ann. Soc. Phys. and Sc., Lyon (1846), p. 329.—ID., Rev. Zool. (1846), p. 318.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 319.
Hylocharis fuscicaudatus, GRAY, Gen. Birds, vol. i, p. 114, sp. 26.
Amazilia riefferi, REICH., Auf. Av. Syst. Nat., pl. 39 (1849).—ID., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, t. 775, figs. 4798-99 (1855).—GOULD, Mon. Troch., vol. v, pl. 311.
Amazilius aglaia, BON., Consp. Gen. Av., vol. i, p. 71 (1850).
Amazilius riefferi, BON., Consp. Gen. Av., vol. i, p. 78 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.
Trochilus dubusi, BOURC., Soc. Agr., Lyon (1852), p. 141.
Polytmus aglaia, GRAY, Gen. Birds, vol. i, p. 109, sp. 73 (1844-49).
Saucerottia aglaia, REICH., Aufz. der Colib., p. 10 (1853).
Amazilia dubusi, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, t. 778, figs. 4809-10 (1855).
Saucerottia fuscicauda, REICH., Troch. Enum., p. 8, t. 696, fig. 4552-53.
Amazilius dubusi, BON., Rev. and Mag. Zool. (1854), p. 254.
Chlorestes aglaia, REICH., Troch. Enum., p. 4 (1855).
Pyrrhophæna riefferi, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (1860).—GOULD, Intr. Troch., octavo ed., p. 158 (1861).
Pyrrhophæna dubusi, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (1860).
Pyrrhophæna suavis, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (note 8) (1860).
Hemithylaca aglaia, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (note 13) (1860).
Eranna jacunda, HEINE, Journ. für Ornith. (1863), p. 188.

Hab. Mexico, Central America, Columbia, and Ecuador.

Adult. Upper surface bronze-green. Throat and breast brilliant grass-green. Abdomen and flanks bronzy-green, pale brown near the vent. Under tail coverts rufous. Upper tail coverts and tail reddish-chestnut, the latter with bronze tips. Wings purple. Bill flesh-color, tip black. Feet black. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

9. *Amazilia viridiventris*.

- Trochilus viridigaster*, BOURC., Rev. Zool. (1843), p. 105.
Hylocharis viridigaster, BON., Consp. Gen. Av., vol. i, p. 74, sp. 5 (1850).—GRAY, Gen. Birds, vol. i, p. 115, sp. 41.
Saucerottia viridiventris, REICH., Aufz. der Colib., p. 8 (1853).—ID., Troch. Enum., p. 4, pl. 699, figs. 4564-65 (1855).
Saucerottia viridigastra, BON., Rev. and Mag. Zool. (1854), p. 255.
Amazilia viridigaster, GOULD, Mon. Troch., vol. v, pl. 314.
Hemithylaca viridiventris, CAB. and HEIN., Mus. Hein. Th., iii, p. 38 (1860).
Pyrrhophæna viridigaster, GOULD, Intr. Troch., octavo ed., p. 159 (1861).
Ariana viridigaster, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 320.

Hab. Columbia.

Adult. Top of head and back bronzy-green, lower part of back grayish-brown shading into purple on the upper tail coverts. Under parts shining green, passing into smoky-brown on the abdomen; under tail coverts grayish-buff with light edges. Tail shining dark violet. Wings purple-brown. Bill and feet black. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

10. *Amazilia ocai.

Amazilia ocai, GOULD, Ann. Mag. Nat. Hist., vol. iv (1859), 3d ser., p. 96.—ID., Mon. Troch., vol. v, pl. 289.
Pyrrhophæna ocai, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (note 11) (1860).
Hemistilbon ocai, GOULD, Intr. Troch., octavo ed., p. 150 (1861).

Hab. Xalapa, Mexico.

Adult. "Crown, sides of the head, throat, and breast glittering grass-green, with a few of the white bases of the feathers showing on the centre of the throat; back of the neck, and upper part of the back deep green; upper and under wing coverts, flanks, lower part of the back, upper tail coverts and tail greenish-bronze; under surface of the base of the outer tail feathers reddish-buff; wings purplish-brown; base of the secondaries reddish-buff; abdomen pale brown; under tail coverts light bronze margined with white, bill black, lighter beneath; feet brown."—(Gould, Mon. Troch.) Total length, 4 in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{16}$ in.

11. Amazilia beryllina.

Trochilus beryllinus, LICHT., Preis-Verz., Mex. Thier. ges. v. Deppe und Schiede (1830), no. 26.
Ornismya arsinöe, LESS., Supp. Ois. Mouch., pp. 154, 156, pls. 28, 29 (1829).—ID., Rev. and Mag. Zool. (1838), p. 314, and (1839), p. 18.
Polytmus arsinöe, GRAY, Gen. Birds, vol. i, p. 109, sp. 9.
Amazilius arsinöe, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—ID., Rev. and Mag. Zool. (1854), p. 254.
Amazilia arsinöe, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, t. 774, figs. 4794-97 (1855).
Amazillia beryllina, GOULD, Mon. Troch., vol. v, pl. 312.
Amazilia castaneiventris, GOULD, P. Z. S. (1856), p. 150.—ID., Mon. Troch., vol. v, pl. 309.
Pyrrhophæna beryllina, CAB. and HEIN., Mus. Hein. Th., iii, p. 36 (partim, 1860).—GOULD, Intr. Troch., octavo ed., p. 158.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 303.
Pyrrhophæna castaneiventris, GOULD, Intr. Troch., octavo ed., p. 157 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 300.
Eranna castaneiventris, HEINE, Journ. für Ornith. (1863), p. 187.

Hab. Mexico, Columbia?

Adult. Head and back shining bronzy-green; rump and upper tail coverts purplish-bronze. Throat and breast metallic grass-green. Abdomen and under tail coverts dark reddish-fawn, the latter edged with pale buff. Tail shining purplish-bronze. Primaries and secondaries chestnut-red at base, remainder purple. Maxilla black. Mandible flesh-color, tip black; feet black. Total length, 4 in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{3}{4}$ in.

The specimen described by Mr Gould (l. c.) as *A. castaneiventris*, I believe to be only a somewhat lighter-colored individual of this species, and have, therefore, placed it among the synonyms.

12. Amazilia edwardi.

Trochilus edward, DELATT. and BOUCC., Rev. Zool. (1846), p. 308.
Polytmus edwardsii, GRAY, Gen. Birds, vol. i, p. 109, sp. 77 (1844-49).
Amazilius edwardi, BON., Consp. Gen. Av., vol. i, p. 78 (1850).
Saucerottia edwardsii, REICH., Aufz. der Colib., p. 8 (1853).
Thaumantias edward, BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes edwardsii, REICH., Troch. Enum., p. 4, pl. 698, figs. 4658-59 (1855).

Erythronota edwardi, GOULD, Mon. Troch., vol. v, pl. 318.—ID., Intr. Troch., octavo ed., p. 161 (1861).

Hemithylaca edwardi, CAB. and HEIN., Mus. Hein. Th., iii, p. 37 (1860).

Eratina edwardi, HEINE, Journ. für Ornith. (1863), t. ix, p. 191.

Leucodora edwardi, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 311.

Hab. Panama.

Adult. Top of head and back green, rump and upper tail coverts bronzy-purple. Throat, breast, and flanks glittering grass-green. Abdomen white. Under tail coverts dark brown bordered with grayish-white. Wings purple. Tail bronzy-purple. Maxilla and tip of mandible black, rest of latter flesh-color. Feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

13. *Amazilia niveiventris*.

Trochilus (—?) *niveoventer*, GOULD, P. Z. S. (1850), p. 164.

Saucerottia niveiventer, REICH., Aufz. der Colib., p. 8 (1853).—SCLAT. and SALV., Nomencl., p. 92 (1873).

Chlorestes niveiventris, REICH., Troch. Enum., p. 4, pl. 700, figs. 4566-67 (1855).

Thaumantias niveiventer, BON., Rev. and Mag. Zool. (1854), p. 255.

Hemithylaca niveiventris, CAB. and HEIN., Mus. Hein. Th., iii, p. 37 (1860).

Erythronota niveiventris, GOULD, Mon. Troch., vol. v, pl. 319 (1861).—ID., Intr. Troch., octavo ed., p. 161.

Leucodora niveiventris, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 313.

Hab. Veragua, Panama.

Adult. This species in its general plumage is almost precisely like the *A. edwardi*, but may be at all times distinguished by its tail, which is *purplish-black*, instead of bright bronzy-purple. Total length, $3\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

14. *Amazilia mariæ*.

Trochilus mariæ, BOURC., Ann. Soc. Agr., Lyon (1846), t. ix, p. 319.

Trochilus devillei, BOURC., Rev. Zool. (1848), p. 272.—GRAY, Gen. Birds, vol. iii, app., p. 30a.

Hylocharis mariæ, BON., Consp. Gen. Av., vol. i., p. 74 (1850).

Amazilia devillei, REICH., Aufz. der Colib. (1853), p. 10.—ID., Troch. Enum., p. 8, t. 778, figs. 4807-8 (1855).

—GOULD, Mon. Troch., vol. v, pl. 313 (1861).

Smaragdites mariæ, REICH., Aufz. der Colib., p. 7 (1855).

Amazilius divillei, BON., Rev. and Mag. Zool. (1854), p. 254.

Saucerottia maria, BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes mariæ, REICH., Troch. Enum., p. 4, pl. 695, fig. 4549 (1855).

Panychlora mariæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 49 (note) (1860).

Amazilia dumerili, SALV., Ibis (1860), p. 270.

Eranna devillei, HEINE, Journ. für Ornith. (1863), p. 188.

Hab. Guatemala.

Adult. Head and back dark green. Rump bronze. Upper tail coverts dark purple. Wings purplish-brown, base of primaries and secondaries rufous. Under surface metallic grass-green. Thighs white. Under tail coverts rufous with light edges. Tail brilliant purple. Maxilla and tip of mandible black, rest of latter flesh-color. Feet brownish-black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{3}{16}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{16}$ in.

The *T. mariæ*, BOURC., is this species not fully adult, and the name takes precedence of *devillei*, which has been generally employed.

15. *Amazilia cyanura.

Amazilia cyanura, GOULD, Mon. Troch., pt. xviii (1850), and vol. v, pl. 315.

Hemithylaca cyanura, CAB. and HEIN., Mus. Hein. Th., iii, p. 38 (note 14) (1860).

Pyrrhophæna cyanura, GOULD, Intr. Troch., octavo ed., p. 160 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 308.

Hab. Guatemala, Nicaragua.

Adult. "Head, all the upper surface, and wing coverts dark bronzy-green, passing into coppery-bronze on the lower part of the back; wings purplish-brown; the base of the primaries and secondaries both above and beneath chestnut-red; under surface shining grass-green; upper and under tail coverts and tail dark steel-blue, the under coverts fringed with gray; thighs white. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{4}$ in. Bill, $\frac{7}{8}$ in."—(Gould, Mon. Troch.)

16. *Amazilia iodura.

Trochilus iodurus, SAUCEROTTE, Mus. Hein.

Saucerottia iodura, REICH., Aufz. der Colib., p. 8 (1853).

Chlorestes iodurus, REICH., Troch. Enum., p. 4, t. 698, figs. 4560-61 (1855).

Hemithylaca iodura, CAB. and HEIN., Mus. Hein. Th., iii, p. 39 (1860).

Pyrrhophæna iodura, GOULD, Intr. Troch., octavo ed., p. 159 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 299.

Eratina iodura, HEINE, Journ. für Ornith. (1863), p. 190.

Hab. Columbia.

"Capite, collo, pectore, dorso superiore, tectricibusque alarum splendide virescentibus, gula paululum albo intermixta; alis cæruleo-virescentibus latissime pallide fulvescente-limbatis; cauda splendide purpureo-violacea; abdomine fulvescente; crisso albido.—Long. tot., 3'' 3'''; al., 2''; caud., 1'' 2'''; rostr. culm., 9'''.—" (Cab. and Hein., loc. cit.)

I have not seen this species.

17. Amazilia lucida.

Amazilia lucida, ELLIOT, Ann. and Mag. Nat. Hist. (1877).

Hab. Columbia.

Adult. Crown of the head dark metallic grass-green; upper surface shining grass-green, lighter than the head. Upper tail coverts golden-bronze. Throat, breast, abdomen, and flanks metallic grass-green, a light mouse-colored spot on the lower part of the abdomen. Thighs white, feathers fluffy. Under tail coverts dark bronzy-brown, edged with white. Wings dark purple. Tail reddish-bronze, darkest in the centre of the feathers along the shafts, with the tips of the lateral rectrices bluish-black, their edges reddish-bronze. This bluish-black color almost resolves itself into a subterminal bar, and is especially conspicuous on the under side of the tail. Bill brownish-red, flesh-color in life, tip blackish. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

18. *Amazilia erythronota*.

Ornismya erythronotos, LESS., Ois. Mouch., pl. 61, p. 181 (1829).

Ornismya erythronotus, LESS., Rev. Zool. (1839), p. 19.

Polytmus erythronotus, GRAY, Gen. Birds, vol. i, p. 108, sp. 78.

Saucerottia erythronota, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—REICH., Aufz. der Colib., p. 8 (1853).—
BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes erythronotus, REICH., Troch. Enum., p. 4, t. 699, figs. 4562-63 (1855).

Hemithylaca erythronota, CAB. and HEIN., Mus. Hein. Th., iii, p. 37 (1860).

Erythronota antiqua, GOULD, Mon. Troch., vol. v, pl. 316.—ID., Intr. Troch., octavo ed., p. 160 (1861).

Ariana erythronota, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 323.

Hab. Islands of Tobago and Trinidad, Venezuela, and Columbia.

Adult. Forehead and upper part of back shining green; nape, lower part of back, and upper tail coverts coppery-red. Wings purple. Under surface shining grass-green. Under tail coverts vary, in some specimens they are rufous, in others gray. A patch of white on the flanks. Tail steel-blue. Maxilla black, mandible flesh-color, tip black. Feet black. Total length, $3\frac{5}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

19. *Amazilia feliciæ*.

Ornismya feliciæ, LESS., Rev. Zool. (1840), p. 72.

Ornismya feliciana, LESS., Rev. Zool. (1844), p. 433.

Saucerottia feliciæ, REICH., Aufz. der Colib., p. 7 (1853).—BON., Rev. and Mag. Zool. (1854), p. 255.

Saucerottia feliciæ, BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes feliciæ, REICH., Troch. Enum., p. 4, t. 697, figs. 455-57 (1855).

Hemithylaca feliciæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 38 (note 10) (1860).

Erythronota feliciæ, GOULD, Mon. Troch., vol. v, pl. 317.—ID., Intr. Troch., octavo ed., p. 161 (1861).

Hab. Venezuela.

Adult. General plumage shining grass-green, darkest on the head, and lightest and most brilliant on the under parts. Thighs white. Upper tail coverts and tail bluish-black. Under tail coverts dark bronzy-brown, margined with white. Maxilla black, mandible flesh-color, tip black. Feet black. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{1}{16}$ in.

20. *Amazilia sophiæ*.

Trochilus sophiæ, BOURC. and MULS., Ann. Soc. Agr., Lyon (1846), t. ix, p. 318.—ID., Rev. Zool. (1846), p. 316.

Trochilus caligatus, GOULD, P. Z. S. (1848), p. 14.

Polytmus sophiæ, GRAY, Gen. Birds, vol. i, p. 109, sp. 76.

Amazilius sophiæ, BON., Consp. Gen. Av., p. 78 (1850).

Saucerottia caligata, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—REICH., Aufz. der Colib., p. 8 (1853).

Saucerottia sophiæ, REICH., Aufz. der Colib., p. 8 (1853).—BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes sophiæ, REICH., Troch. Enum., p. 4, t. 697, figs. 4554-55? (1855).

Chlorestes caligata, REICH., Troch. Enum., p. 4 (1855).

Hemithylaca hoffmanni, CAB. and HEIN., Mus. Hein. Th., iii, p. 38, sp. 80 (1860).

Hemithylaca caligata, CAB. and HEIN., Mus. Hein. Th., iii, p. 39, sp. 82 (1860).

Hemithylaca sophiæ, CAB. and HEIN., Mus. Hein. Th., iii, p. 38 (note 11) (1860).

Saucerottia sophiæ, GOULD, Mon. Troch., vol. v, pl. 322.—ID., Intr. Troch., octavo ed., p. 162 (1861).

Hemithylaca braccata, HEINE, Journ. für Ornith. (1863), p. 193.

Ariana sophiæ, MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 328.

Hab. Costa Rica.

Adult. Head and upper surface dark green; purplish-red on the rump. Under parts shining grass-green. Thighs white. Upper tail coverts and tail deep blue, the under coverts fringed with grayish-white. Wings purple. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{2}{8}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

21. *Amazilia warszewiczi.*

Hemithylaca warszewiczi, CAB. and HEIN., Mus. Hein. Th., iii, p. 38 (1860).

Saucerottia warszewiczi, GOULD, Intr. Troch., octavo ed., p. 163 (1861).

Ariana warszewiczi, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 327.

Hab. Columbia, Bank of the Magdalena.

Adult. This species differs from *A. sophiæ* in being slightly smaller, in having the rump green like the back, and the tail a brighter blue. Total length, $3\frac{2}{8}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

22. *Amazilia saucerottii.*

Trochilus saucerottei, BOURC. and DELATT., Rev. Zool. (1846), p. 311.

Polytmus saucerottii, GRAY, Gen. Birds, vol. i, p. 108, sp. 67.

Saucerottia typica, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—ID., Rev. and Mag. Zool. (1854), p. 255.—

REICH., Aufz. der Colib., p. 7 (1853).—GOULD, Intr. Troch., octavo ed., p. 162 (1861).

Chlorestes typica, REICH., Troch. Enum., p. 4, pl. 701, figs. 4569-70 (1855).

Erythronota saucerottei, GOULD, Mon. Troch., vol. v, pl. 321.—MULS., Hist. Nat. Ois. Mouch., tom. i, p. 331.

Hemithylaca saucerottei, CAB. and HEIN., Mus. Hein. Th., iii, p. 38 (note 12) (1860).

Ariana saucerottei, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 316.

Hab. Columbia.

Adult. Top of head and upper surface dark grass-green; under surface luminous green, much lighter than the upper parts. Vent white. Under tail coverts dark bronzy-brown edged with grayish-white. Wings purple. Upper tail coverts and tail steel-black. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

23. *Amazilia cyanifrons.*

Trochilus cyanifrons, BOURC., Rev. Zool. (1843), p. 100.—ID., Ann. Soc. Agr., Lyon (1843), p. 42.

Polytmus cyanifrons, GRAY, Gen. Birds, vol. i, p. 108, sp. 66 (1844-49).

Thalurania cyanifrons, BON., Consp. Gen. Av., p. 77 (1850).

Saucerottia cyanifrons, REICH., Aufz. der Colib., p. 8 (1853).—BON., Rev. and Mag. Zool. (1854), p. 255.—

GOULD, Mon. Troch., vol. v, pl. 323.

Chlorestes cyanifrons, REICH., Troch. Enum., p. 4, pl. 701, figs. 4571-72 (1855).

Hemithylaca cyanifrons, CAB. and HEIN., Mus. Hein. Th., iii, p. 39, sp. 83 (1860).—GOULD, Intr. Troch., octavo

ed., p. 163 (1861).

Eratopis cyanifrons, HEINE, Journ. für Ornith. (1863), p. 191.

Ariana cyanifrons, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 332.

Hab. Columbia.

Adult. Top of head deep blue; upper surface bronzy-green. Under surface luminous grass-green. Under tail coverts purplish-olive, margined with grayish-

white. Tail bluish-black. Maxilla black, mandible flesh-color, tip black. Feet brownish-black. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in. (Type in my collection.)

24. **Amazilia elegans*.

Erythronota? elegans, GOULD, P. Z. S. (1860), p. 307.—ID., Intr. Troch., octavo ed., p. 162 (1861).

Erasinia elegans, HEINE, Journ. für Ornith. (1863), p. 191.

Sporadinus incertus, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 76.

Hab. —?

“Crown and all the under surface of the body glittering light green; back of the neck and back golden or orange-green; upper tail coverts purplish-red or puce color; tail long forked, and of a purplish-violet hue with green reflections on the tips of the two centre feathers; wings purplish-brown; tarsi white; under tail coverts gray with bronzy-purple centres; maxilla flesh-color at the base, and black for the remainder of its length; mandible flesh-color except at the tip, which is black. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{8}$ in. Tail, $\frac{7}{8}$ in. Bill, $1\frac{1}{2}$ in.”—(Gould, Mon. Troch.)

The members composing the next genus, usually known as *Heliopædica*, Gould, but which is antedated thirty years by BASILINNA, Boie, have usually been placed, since Mr. Gould's arrangement was published, near to CÆLIGENA (*Delatiria*). I do not see that it has any affinity whatever for the species of that genus, but is closely related to EUCEPHALA. Indeed, if the *B. leucotis* is compared with the *E. GRAYI*, it will readily be seen how close is the resemblance of the two birds, the principal difference being that *leucotis* has a stripe over the eye, and which was one of the chief reasons, it would seem, that these birds were placed near CÆLIGENA.—The two species are small birds, with brilliant metallic plumage, and the sexes are altogether differently clothed.

Genus CX.—BASILINNA.

Basilinna, BOIE, Isis (1831), p. 546.

Heliopædica, GOULD, Intr. Troch., octavo ed. (1861), p. 60.

Ch. Bill straight, about equal to the head. Wings long. Tail almost square, feathers broad; tarsi clothed; hind toe shorter than the middle one. Sexes dissimilar in plumage.

Range. Cape St. Lucas, California, Mexico, Guatemala.

Two species are known.

Key to the species.

A. Upper parts bronzy-green.

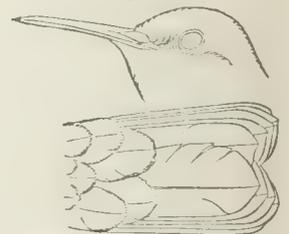
- a. Median rectrices bronze-green, rest black, bronze tips.
- b. Tail deep chestnut, tipped with bronze.

TYPE.

T. leucotis, Vieill.

T. leucotis, Vieill.

Fig. 117.



Basilinna leucotis, ♂. Oaxaca. Sallé.

1. *B. leucotis*.
2. *B. xanthusi*.

1. *Basilinna leucotis*.

- Trochilus leucotis*, VIEILL., Nouv. Dict. Hist. Nat., 2d ed. t. xxii, p. 428.—Ency. Méth., vol. ii, p. 559.
Trochilus melanotis, SWAIN., Phil. Mag. (1827), p. 441.
Ornismya arsenii, LESS., Ois. Mouch., p. 60, pl. 9 (1829).
Hylocharis leucotis, GRAY, Gen. Birds, vol. i, p. 114, sp. 28.
Basilinna leucoti, BOIE, Isis (1831), p. 546.—REICHEN., Aufz. der Colib., p. 13 (1853).—ID., Troch. Enum., p. 11 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 45.
Heliopædica melanotis, GOULD, Mon. Troch., vol. ii, pl. 64.—ID., Intr. Troch., octavo ed., p. 60 (1861).
Thaumatias leucotis, BON., Consp. Gen. Av., p. 78 (1850).
Sapphironia lucida, SCLAT., P. Z. S. (1858), p. 297, and (1859), p. 386.
Caligena leucotis, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 187.

Hab. Mexico and Guatemala.

Male. Front and chin sapphire-blue. Occiput bronze. Upper parts grass-green on back shading into bronze on the rump. Throat and breast metallic emerald-green. Ear coverts black; a white line above and behind the eye. Abdomen and under tail coverts grayish-brown. Wings purple. Median rectrices bronze-green, rest black with bronze edges and tips. Bill red, with black tips. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{2}{3}$ in. Culmen, $\frac{5}{8}$ in.

Female. Feathers of the crown rufous, margined with dark brown. Under surface buffy-white spotted with green. Rectrices like the male, but the lateral ones are tipped with grayish-white. Bill black.

2. *Basilinna xanthusi*.

- Amazilia xanthusi*, LAWR., Ann. Lyc. Nat. Hist., N. Y. (1860), p. 109 ♀.
Heliopædica castaneo-cauda, LAWR., Ann. Lyc. Nat. Hist., N. Y. (1860), p. 145, ♂.
Heliopædica xanthusi, GOULD, Mon. Troch., vol. ii, pl. 64.—ID., Intr. Troch., octavo ed., p. 60 (1861).—ELLIOT, B. N. Amer., vol. i, pl. 22 (1859).
Celigena xanthusi, MULS., Hist. Nat. Ois. Mouch., tom. i, p. 190.

Hab. Cape St. Lucas, California.

Male. Differs from the *B. leucotis*, in having the under parts rufous; throat pale grass-green; and tail dark chestnut tipped with bronze. Bill red, tip black. Total length, $3\frac{3}{8}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{2}{3}$ in. Culmen, $\frac{5}{8}$ in.

Female or young male. Upper parts shining green. Front and entire under parts uniform rufous. Median rectrices green, lateral rufous with black spots on the webs near the tips.

One of the least understood of the various groups composing the Trochilidæ is that one forming the genus EUCEPHALA, and this arises mainly from the great rarity of the majority of the birds, for six of the types I believe, out of the nine known species, still remain unique.—They are small birds, the prevailing tints of whose plumage is metallic-blue and green; the females differing greatly from the males in appearance.

Genus CXI.—EUCEPHALA.

TYPE.

- Eucephala*, REICH., Aufz. der Colibri. (1853), p. 10.
Chlorestes, REICH., Aufz. der Colib., p. 7 (1853).

- T. grayi*, Delatt. and Bourc.
T. cyanogenys, Wied.

Halia, MULS. and VERR., Class. Troch. (1865), p. 41.

Ulysses, MULS., Cat. Ois. Mouch., p. 12 (1875).—ID., Hist. Nat. Ois. Mouch., tom. ii, p. 41.

T. cæruleus, Vieill.

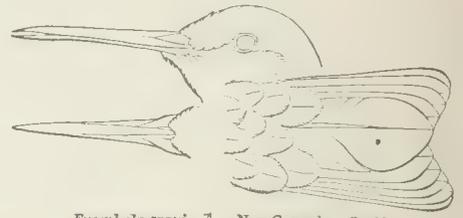
T. grayi, Delatt. and Bourc.

Ch. Bill slightly longer than the head, rather broad at base, sharply pointed at tip, nostrils exposed. Wings long and pointed. Tarsi clothed. Tail rounded or slightly forked. Sexes dissimilar.

Range. Island of Trinidad, Venezuela, Guiana, Brazil, and Ecuador.

Nine species are known.

Fig. 118.



Eucephala grayi, ♂. New Granada. Gould.

Key to the species.

- | | |
|--|---------------------------------|
| A. Top of head blue. | |
| a. Chin deep blue; under surface golden-green. | 1. <i>E. grayi</i> . |
| b. Chin greenish-blue, under surface grass-green. | 2. <i>E. smaragdo-cærulea</i> . |
| c. Throat and chest bright greenish-blue. | 3. <i>E. cæruleo-lavata</i> . |
| B. Top of head green. | |
| a. Throat and chest blue. Abdomen brownish-black, under tail coverts brown, centres blue. | 4. <i>E. scapulata</i> . |
| b. Throat and chest blue, upper tail coverts reddish-bronze, under brownish-black. | 5. <i>E. hypocyanea</i> . |
| c. Throat, breast, and abdomen cærulean-blue, upper and under tail coverts dark green. | 6. <i>E. subcærulea</i> . |
| d. Chin blue, under surface glittering green. | 7. <i>E. cærulea</i> . |
| e. Chin, throat, and breast shining grass-green. Under tail coverts olive margined with white. | 8. <i>E. chlorocephala</i> . |
| f. Entire under parts green, with a bluish-shade on the throat. | 9. <i>E. cyanogenys</i> . |

1. *Eucephala grayi*.

Trochilus grayi, DELATT. and BOURC., Rev. Zool. (1846), p. 307.

Hylocharis grayi, GRAY, Gen. Birds, vol. i, p. 115, sp. 38.—BON., Consp. Gen. Av., vol. i, p. 74 (1850).

Eucephala grayi, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, t. 772, figs. 4789-91.—GOULD, Mon. Troch., vol. v, pl. 330.—ID., Intr. Troch., octavo ed., p. 166 (1861).—CAR. and HEIN., Mus. Hein. Th., iii, p. 43 (1860).—ELLIOT, Ibis (1874), p. 88.

Sapphironia grayi, BON., Rev. and Mag. Zool. (1854), p. 256.

Ulysses grayi, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 41.

Hab. Ecuador.

Male. Head and chin shining deep blue. Upper and under surface golden-green. Wings purplish-brown. Under tail coverts shining green edged with grayish-white. Tail steel-blue. Bill red, tip brownish-black. Feet brown. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{7}{8}$ in.

Female. Upper parts golden-green. Under parts white spangled with bronzy-green. Under tail coverts gray with dark centres. Base of tail bronzy-green shading into blue, and tipped on the outer feathers with grayish-white. Bill red, tip black. Total length, $3\frac{7}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{7}{8}$ in. (Type in my collection.)

2. **Eucephala smaragdo-cærulea*.

Augasma smaragdineum, GOULD, P. Z. S. (1860), p. 305.

Eucephala smaragdo-cærulea, GOULD, Mon. Troch., vol. v, pl. 331.—ID., Intr. Troch., octavo ed., p. 166 (1861).

—ELLIOT, Ibis (1874), p. 88.

Eucephala smaragdinea, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 37.

Hab. Brazil, Novo Friburgo.

“Crown of the head and throat glittering greenish-blue, imperceptibly passing into the glittering green of the breast, back of the neck and upper surface golden-green; upper tail coverts grass-green; under tail coverts green, inclining to purple on some of the feathers; thighs brown; tail bluish-black, the two outer feathers on each side slightly tipped with white; bill black with the exception of the basal half of the under mandible which is flesh-color. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{2}$ in. Tail, $1\frac{3}{8}$ in. Bill, $\frac{7}{8}$ in.”—(Gould, loc. cit.)

3. **Eucephala cæruleo-lavata*.

Eucephala cæruleo-lavata, GOULD, P. Z. S. (1860), p. 306.—ID., Mon. Troch., vol. v, pl. 333.—ID., Intr. Troch., octavo ed., p. 166 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 40.—ELLIOT, Ibis (1874), p. 88.

Hab. Brazil, Province of San Paulo.

“Crown of the head greenish-blue, not very brilliant, but having a few conspicuous small bright blue feathers intermingled; throat and chest bright greenish-blue, passing into purer green on the flanks; back of the neck and back deep grass-green; wings purplish-brown; upper tail coverts bronzy-orange; under tail coverts bronzy purplish-brown; two middle tail feathers deep purplish-bronze, the next on each side is washed with bronze on its outer margin, the remaining feathers purplish-black; thighs grayish-white, the bill appears to have been reddish flesh-color at the base of both mandibles, and black at the tip. Total length, $3\frac{3}{4}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{1}{2}$ in. Bill, $\frac{7}{8}$ in.”—(Gould, loc. cit.)

4. **Eucephala scapulata*.

Eucephala scapulata, GOULD, Intr. Troch., octavo ed., p. 166 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 34.—ELLIOT, Ibis (1874), p. 88.

Hab. Guiana?

“Crown of the head, back of the neck, and lower part of the back very deep dull green; throat and chest glittering greenish-blue, imperceptibly passing into the dull brownish-black of the abdomen; under tail coverts brown, with a wash of dull blue in the centre of each feather; a mark of blue on each side at the insertion of the wing, forming an indistinct band across the back; upper tail coverts bronzy-green; tail steely-black, rather short for the size of the bird, and slightly forked; wings deep purplish-brown; tarsi clothed with intermingled grayish-white and brown feathers; upper mandible black; basal half of the under mandible fleshy, the apical half black. Total length, $3\frac{3}{4}$ in. Bill, $\frac{7}{8}$ in. Wing, $2\frac{1}{6}$ in. Tail, $1\frac{3}{8}$ in.”—(Gould, loc. cit.)

5. **Eucephala hypocyanea*.

Eucephala hypocyanea, GOULD, P. Z. S. (1860), p. 306.—ID., Mon. Troch., vol. v, pl. 334.—ID., Intr. Troch., octavo ed., p. 166 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 36.—ELLIOT, Ibis (1874), p. 88.

Hab. Brazil?

“Crown of the head, back of the neck, back and flanks, somewhat dull green; throat and chest brilliant blue, passing into glittering green on the centre of the abdomen; wings purplish-brown; upper tail coverts reddish-bronze; under tail coverts brownish-black, with bronzy tips; tail steel-black; thighs brown; upper mandible black; basal two-thirds of the lower mandible flesh-color, the apical third black. Total length, $3\frac{1}{4}$ in. Bill, $\frac{3}{4}$ in. Wing, 2 in. Tail, $1\frac{3}{8}$ in.”—(Gould, loc. cit.)

6. *Eucephala subcærulea*.

Eucephala subcærulea, ELLIOT, Ibis (1874), p. 87.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 35.

Hab. Brazil?

Adult. Upper part of head and back dull green, rest of back and upper tail coverts dark green, with a rufous tinge dispersed all over those parts; throat, breast, and centre of abdomen beautiful metallic cærulean-blue; flanks shining grass-green. Lower part of abdomen covered by fluffy-white feathers. Under tail coverts metallic-green. Wings purple. Tail bluish-black. Maxilla black; mandible yellow (in life possibly red) for its entire length, save the tip which is black. Feet brownish-black. Thighs buffy-white. Total length, $3\frac{1}{4}$ in. Wing, 2 in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in. (Type in my collection.)

7. *Eucephala cærulea*.

Trochilus cæruleus, VIEILL., Nouv. Dict. Hist. Nat., tom. 7, p. 361 (1817).

Ornismya audebertii, LESS., Ois. Mouch., pp. xxx, 164, pl. 51 (1829).

Trochilus audeberti, PRINZ. MAX., Betr., t. iv, p. 67.

Hylocharis cærulea, GRAY, Gen. Birds, vol. i, p. 114, sp. 34.—BON., Rev. and Mag. Zool. (1854), p. 255.

Thaumatias cæruleus, BON., Consp. Gen. Av., vol. i, p. 78 (1850).

Chlorestes cærulea, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 692, figs. 4534-35 (1855).

—CAB. and HEIN., Mus. Hein. Th., iii, p. 46 (note) (1860).

Eucephala cærulea, GOULD, Mon. Troch., vol. v, pl. 335.—ID., Intr. Troch., octavo ed., p. 167 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 32.—ELLIOT, Ibis (1874), p. 89.

Chlorestes mentalis, CAB., Journ. für Ornith. (1866), p. 159.

Hab. Trinidad, Venezuela, Guiana, Brazil.

Male. Upper surface dark grass-green; chin shining deep blue; entire under surface luminous yellowish-green, very brilliant. Wings purplish-brown. Tail steel-blue, maxilla black, mandible flesh-color, tip black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

Female. Differs in having the under parts white, feathers of the throat and flanks tipped with green. Rest like the male. Total length, $3\frac{2}{16}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{5}{8}$ in.

8. **Eucephala chlorocephala*.

Hylocharis chlorocephala, BOURC., Rev. and Mag. Zool. (1854), p. 457.—BON., Rev. and Mag. Zool. (1854), p. 255.

Agyrtria chlorocephala, REICH., Troch. Enum., p. 7 (1855).

Lepidopygia chlorocephala, CAB. and HEIN., Mus. Hein. Th., iii, p. 40 (note 2) (1860).

Eucephala chlorocephala, GOULD, Mon. Troch., vol. v, pl. 332.—ID., Intr. Troch., octavo ed., p. 166 (1861).

Hylocharis chlorocephalus, BON., Rev. and Mag. Zool. (1854), p. 255.

Hab. Ecuador.

Top of head greenish-blue; upper parts bronzy-green, upper tail coverts coppery-bronze. Chin, throat, and abdomen shining grass-green; thighs white; under tail coverts dark olive margined with white. Tail steel-blue. Bill black, base of mandible flesh-color. "Length of bill, 33 millim.; wing, 55 millim.; tail, 38 millim.; middle feathers, 30 millim."—Bourc.

9. **Eucephala cyanogenys*.

Trochilus cyanogenys, PRINZ. MAX., Beit., t. iv, p. 10 (1825-33).

Ornismya wiedi, LESS., Supp. Ois. Mouch., p. 150, pl. 26 (1829).

Hylocharis cyanogenys, GRAY, Gen. Birds, vol. i, p. 115, sp. 40.

Saucerottia cyanogenys, BON., Consp. Gen. Av., vol. i, p. 77 (1850).

Chlorestes cyanogenys, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, pl. 692, figs. 4536-37 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 46, sp. 101 (1860).

Hylocharis wiedi, BON., Rev. and Mag. Zool. (1854), p. 255.

Eucephala cyanogenys, GOULD, Intr. Troch., octavo ed., p. 167 (1861).—ELLIOT, Ibis (1874), p. 89.

Hab. Brazil.

Male. Maxilla and feet black, the mandible flesh-color, tip black. Upper part golden-green with reddish-bronze reflections. Primaries purplish-brown. Tail dark steel-blue with blue and golden reflections. Chin beautiful blue as in *E. caeruleus*. Anal region white. Total length, about 3 in. Wing, $1\frac{1}{6}$ in. Tail, $\frac{7}{8}$ in. Bill, $\frac{5}{8}$ in.

Female differs in having the under parts grayish-white.—(Pr. Max., l. c.)

I have never seen a specimen of this species; and the type which should be in the American Museum of Natural History, New York, appears to have been lost.

Genus CXII.—TIMOLIA.

Timolia, MULS., Cat. Ois. Mouch. (1875), p. 23.

TYPE.

T. lerchi, Muls. and Verr.

Fig. 119.



Timolia lerchi. ♂. New Granada (Type)

Ch. Nearly allied to EUCEPHALA. Bill longer than head, curved; feathers of forehead projecting on to the culmen, nostrils hidden. Tail forked. Tarsi clothed.

Range. Columbia.

But one species is known.

1. *Timolia lerchi*.

Thalurania lerchi, MULS. and VERR., Ann. Linn. Soc., Lyon (1868).—SALV. and ELLIOT, Ibis (1873), p. 360.

ELLIOT, Ibis (1874), p. 264.

Timolia lerchi, MULS., Cat. Ois. Mouch. (1875), p. 23.

Hab. Columbia.

Male. Fore part of head and a spot on the chin shining deep blue. Upper parts dark grass-green, passing into reddish-bronze on the upper tail coverts. Entire under parts grass-green. Under tail coverts olive-green. Wings purplish-brown. Tail steel-black. Maxilla black, mandible flesh-color, tip black. Total length, $4\frac{1}{8}$ in. Wing, $2\frac{1}{4}$ in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{1}{16}$ in. (Type in my collection, unique.)

Following EUCEPHALA comes the genus JULIAMYIA, composed of small birds, with plumage of glittering green and dark blue. Two species only are known, differing from each other in the coloration of their crowns.

Genus CXIII.—JULIAMYIA.

Juliamyia, BON., Rev. and Mag. Zool. (1854), p. 255.

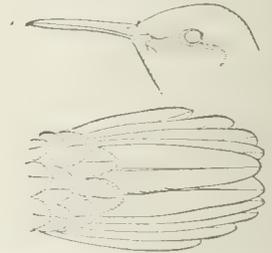
TYPE.

T. julie, Bourc.

Fig. 120.

Ch. Bill as long as the head, straight, slender; nostrils partly exposed. Tail cuneate, feathers narrow and pointed. Wings moderate. Tarsi bare. Sexes unlike.

Range. Panama, Columbia, and Ecuador.



Juliamyia typica. ♂ 24752. New Granada.

Key to the species.

- A. Throat and breast glittering green. Abdomen rich blue.
 a. Top of head dull green.
 b. Top of head metallic grass-green.

1. *J. typica*.
 2. *J. feliciana*.

This genus was established by Bonaparte (l. c.), employing as his type (if the first species given is to be so considered) the *Trochilus julie*, Bourc., and the *T. amabilis*, Gould, as the second species. A year previous, Reichenbach, Aufz. der Colib., p. 7, instituted the genus *Damophila* with *T. julie*, Bourc., as his type, and *T. amabilis* as the other species. Strictly speaking I suppose Reichenbach's term would stand for the *T. julie*, but in order to avoid confusion I have employed the term JULIAMYIA for *typica* and its ally, and DAMOPHILA for *amabilis*, as has been done by other authors.

1. *Juliamyia typica*.

Ornismyia julie, BOURC., Rev. Zool. (1842), p. 373.

Ornismyia julie, BOURC., Ann. Soc. Agr., Lyon (1842), t. v, p. 345, pl. xxi.

Hylocharis julie, GRAY, Gen. Birds, vol. i, p. 114, sp. 24.

Damophila julia, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 3, t. 681, figs. 4494-95 (1855).

—CAB. and HEIN., Mus. Hein. Th., iii, p. 40 (1860).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 56.

Juliamyia typica, BON., Rev. and Mag. Zool. (1854), p. 255.—GOULD, Intr. Troch., octavo ed., p. 168 (1861).

Juliamyia typica, GOULD, Mon. Troch., vol. v, pl. 337.

Hab. Panama and Columbia.

Male. Top of head and upper parts dark green passing into bronze on the lower part of the back. Sides of the neck and throat glittering metallic grass-green. Rest of under parts shining prussian-blue. Under tail coverts blue-black. Tail steel-black. Wings purplish-brown. Maxilla black, mandible flesh-color, tip black. Total length, 3 in. Wing, $1\frac{3}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{9}{16}$ in.

Female. Differs in having the entire under surface grayish-white, washed with green on the flanks; and the outer tail feathers tipped with white.

2. *Juliamyia feliciana*.

Ornismyia feliciana, LESS., Rev. Zool. (1844), p. 433.

Hylocharis feliciana, GRAY, Gen. Birds, vol. i, p. 114, sp. 27.

Juliamyia feliciana, GOULD, Intr. Troch., octavo ed., p. 168 (1861).

Damophila feliciana, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 60.

Hab. Ecuador.

Male. This species is precisely like the *J. typica*, except that the crown of the head is metallic glittering green like the throat. In all other respects it is a fac-simile of the preceding species. Total length, 3 in. Wing, $1\frac{3}{4}$ in. Tail, $\frac{1}{2}$ in. Culmen, $\frac{1}{2}$ in.

Female like that of *J. typica*.

Genus CXIV.—DAMOPHILA.

Damophila, REICH., Aufz. der Colib., p. 7 (1853).

Polyerata, HEINE, Journ. für Ornith. (1863), p. 194.

TYPE.

T. julie, Bourc.

T. amabilis, Gould.

Fig. 121.

Ch. Bill longer than the head, straight, rather broad at base, terminating in a sharp point. Nostrils exposed. Tail even, or slightly forked when open. Feet small, tarsi clothed. Sexes dissimilar.

Range. Costa Rica, Panama, Columbia, Ecuador.

But one species is known, and is apparently properly placed after JULIAMYIA.



Damophila amabilis. ♂. 7113 Panama.

1. *Damophila amabilis*.

Trochilus (—?) *amabilis*, GOULD, P. Z. S. (1851), p. 115.

Damophila amabilis, REICH., Aufz. der Colib., p. 7 (1853).—ID., Intr. Troch. Enum., p. 3, t. 681, figs. 4496-97 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 40 (1860).—GOULD, Mon. Troch., vol. v, pl. 341.—ID., Intr. Troch., octavo ed., p. 170 (1861).

Juliomya amabilis, BON., Rev. and Mag. Zool. (1854), p. 53.

Polyerata amabilis, HEINE, Journ. für Ornith. (1863), p. 194.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 52.

Hab. Costa Rica, to and including Ecuador.

Male. Top of head shining metallic-green. Under surface bronzy-green; chin black; throat and breast violet-blue. Sides of neck green like the crown. Under surface gray washed with green on the flanks. Upper tail coverts and median rectrices reddish-bronze, lateral rectrices black. Wings purplish-brown. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{1}{4}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{4}$ in.

Female. Above bronzy-green, beneath gray. Median rectrices bronzy-green, lateral ones bronze at base, then black, and tipped with grayish-white. Dimensions like the male.

Some specimens have the metallic-green of the crown continued on to the occiput, even on to the nape. I do not think, however, that this in any way indicates the existence of two species.

Next to DAMOPHILA comes the genus IACHE, consisting of three species, two of which are extremely rare and but little known. They are small birds with considerable brilliancy in their plumage, and it is believed that the coloration of the sexes is totally unlike in all the species. The generic term *Circe*, in which these birds have generally been placed, cannot be continued, as it is preoccupied for a group of Acaleps; I therefore propose IACHE, which I believe has not been previously employed.

Genus CXV.—IACHE.¹

Circe. GOULD, Intr. Troch., octavo ed., p. 168 (nec MERT., 1835, Acal.).

Ch. "Bill rather longer than the head, slightly curved, and tapering towards the tip; wings rather long; primaries rigid (!); tail rather short and slightly forked, the feathers broad; tarsi clothed; feet small; hind toe short."—(Gould, l. c.) Sexes unlike.

Range. Mexico.

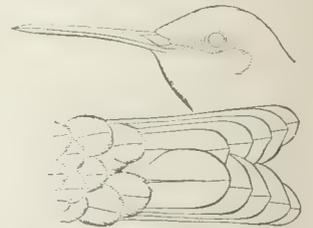
Key to the species.

- A. Top of head not brilliant.
 - a. Throat sapphire-blue.
 - b. Throat metallic bluish-green.
- B. Top of head brilliant metallic, throat shining dark blue.

TYPE.

C. latirostris, Swains.

Fig. 122.

*Iache latirostris*. ♂. Mexico. Dresser.

- 1. *I. latirostris*.
- 2. *I. magica*.
- 3. *I. doubledayi*.

¹ Ιαχη, Nom. Prop.

1. *Iache latirostris*.

- Cynanthus latirostris*, SWAINS., Phil. Mag. (1827), p. 441.
Ornismya lessoni, DELATT., Rev. Zool. (1839), p. 15. ♀.
Cyanophaia lazula, REICH., Aufz. der Colib., p. 10 (1853).
Amazilia latirostris, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8 (1855).
Hylocharis lazula, REICH., Troch. Enum., pl. 770, figs. 4783-84 (1855).
Amazilius latirostris, BON., Rev. and Mag. Zool. (1854), p. 254.
Hylocharis doubledayi, CAB. and HEIN., Mus. Hein. Th., iii, p. 44 (partim) (1860).
Circe latirostris, GOULD, Mon. Troch., vol. v, pl. 338.—ID., Intr. Troch., octavo ed., p. 169 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 46 (1876).

Hab. Mexico.

Male. Upper and under surface bronzy-green, brownish on top of the head. Throat bright sapphire-blue. Under tail coverts white. Wings pale brown. Tail steel-blue, tipped with gray. Bill red, tip black. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{9}{16}$ in. Culmen, $\frac{7}{8}$ in. (Type in my collection.)

Female. Differs in having entire under parts dark gray. Tail bronzy-green at base, rest bluish-black, the lateral feathers tipped with gray.

2. *Iache magica*.

- Hylocharis magica*, MULS. and J. VERR., Ann. Soc. Linn., Lyon (1872), t. xviii, p. 110.
Circe magica, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 49.—SCLAT. and SALV., Nomencl., p. 93.

Hab. Mazatlan, Lower California.

Male. Upper parts reddish-bronze. Throat and upper parts of breast metallic bluish-green; under parts bronzy-green with a coppery lustre. Under tail coverts white. Wings pale brown. Tail brownish-black, lateral feathers slightly tipped with gray. Bill red, tip black. Total length, $3\frac{1}{4}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{1}{8}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

3. *Iache doubledayi*.

- Trochilus doubledayi*, BOURC., P. Z. S. (1847), p. 46.—ID., Rev. Zool. (1847), p. 259.
Hylocharis doubledayi, GRAY, Gen. Birds, vol. i, p. 114, sp. 32.
Thaumatias doubledayi, BON., Consp. Gen. Av., vol. i, p. 78 (1850).
Cyanophia doubledayi, REICH., Aufz. der Colib., p. 10 (1853).
Sapphironia doubledayi, BON., Rev. and Mag. Zool. (1854), p. 256.
Sapphironia circe, BON., Rev. and Mag. Zool. (1854), p. 256.
Hylocharis (Cyanophaia) circe, REICH., Troch. Enum., p. 8, pl. 771, figs. 4786-88 (1855).
Circe doubledayi, GOULD, Mon. Troch., vol. v, pl. 339.—ID., Intr. Troch., octavo ed., p. 169 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 44 (1876).
Hylocharis doubledayi, CAB. and HEIN., Mus. Hein. Th., iii, p. 44 (partim) (1860).

Hab. Mexico, Tehuantepec (Chihuitan).

Male. Top of head metallic bluish-green. Upper surface and abdomen dark bronzy-green, with a bluish shade on the abdomen. Throat brilliant blue. Under tail coverts dark brown edged with gray. Wings pale brown. Tail steel-blue tipped with gray. Bill red, tip black. Total length, $3\frac{3}{16}$ in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{5}{16}$ in. Culmen, $1\frac{1}{16}$ in. (Bourcier's specimen in my collection.)

The next genus *HYLOCHARIS*, which follows naturally the last one, also consists of three species, the males robed in different shades of blue and green. They are slightly larger birds than the members of the genus *LACHE*, with one exception, and as is the case with the species of that genus, the sexes are very differently attired.

Genus CXVI.—HYLOCHARIS.

Hylocharis, BOIE, Isis (1831), p. 546.

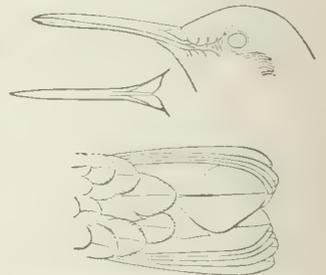
Sapphironia, BON., Rev. and Mag. Zool. (1854), p. 256.

TYPE.

T. sapphirinus, Gmel.

T. sapphirinus, Gmel.

Fig. 123.



Hylocharis sapphirina. ♂. 24,758. Brazil.

Ch. Bill longer than head, straight, broad and flat at base; wings long, pointed, reaching nearly to the end of the tail. Tail even; feet large; tarsi clothed. Sexes unlike.

Range. Brazil.

Key to the species.

- A. Throat and sides of the neck violet-blue.
 B. Chin rufous; breast bright sapphirine-blue.
 C. Chin whitish; breast shining dark blue, with violet reflections.

1. *H. lactea*.
 2. *H. sapphirina*.
 3. *H. cyanea*.

1. *Hylocharis lactea*.

Le Saphir, LESS., Hist. Nat. Ois. Mouch., pl. 56 (1829).

Ornismya lactea, LESS., Ind. Gen. Syn. Ois. Genr. Troch., p. xxxviii (1831).

Hylocharis lactea, GRAY, Gen. Birds, vol. i, p. 115, sp. 37.—BON., Consp. Gen. Av., vol. i, p. 74 (1850).—CAB. and HEIN., Mus. Hein. Th., iii, p. 43 (note) (1860).—GOULD, Mon. Troch., vol. v, pl. 343.—ID., Intr. Troch., octavo ed., p. 171 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 23 (1876).

Cyanochloris lactea, REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 8, pl. 773, fig. 4793 (1855).

Sapphironia lactea, BON., Rev. and Mag. Zool. (1854), p. 256.

Hab. Brazil.

Male. Upper parts brownish bronzy-green; throat and sides of neck shining violet-blue; flanks gray washed with green. Middle of abdomen, vent, and under tail coverts white. Total length, $3\frac{2}{3}$ in. Wing, 2 in. Tail, $1\frac{2}{3}$ in. Culmen, $\frac{5}{8}$ in.

The sexes of this species are apparently alike in plumage; but I have not seen an authenticated female.

2. *Hylocharis sapphirina*.

Trochilus sapphirinus, Gmel., Syst. Nat. (1788), tom. i, p. 496.—LATH., Ind. Orn., tom. i, p. 313 (1790).

Trochilus fulvifrons, LATH., Ind. Orn. Supp., vol. ii, p. 172 (1790).

Trochilus latirostris, WIED., Beitr., vol. iv, p. 64 (1825).

Ornismya sapphirina, LESS., Ois. Mouch., p. 172, ts. 55, 57 (1829).—ID., Troch., p. 53, pl. 14 (1831).

Hylocharis sapphirina, GRAY, Gen. Birds, vol. i, p. 115, sp. 36.—REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, pl. 769, figs. 4780-82 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 43 (1860).—GOULD, Intr. Troch., octavo ed., p. 171 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 16.

Hylocharis latirostris, REICH., Aufz. der Colib., p. 10 (1853).

Sapphironia sapphirina, BON., Rev. and Mag. Zool. (1854), p. 256.

Hylocharis sapphirinus, GOULD, Mon. Troch., vol. v, pl. 342.—BON., Consp. Gen. Av., vol. i, p. 74 (1850).

Hub. Brazil.

Male. Upper surface, flanks, and abdomen shining dark grass-green. Chin rufous; throat and breast dark sapphirine-blue. Upper tail coverts reddish-bronze; under chestnut. Wings purple. Middle rectrices reddish-bronze, lateral ones chestnut, edged with blackish. Bill flesh-color, tip black. Total length, 4 in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female. Under surface grayish-white. Rectrices purple-bronze, lateral ones tipped with white. Chin rufous, rest of plumage like the male.

3. *Hylocharis cyanea*.

Trochilus cyaneus, VIEILL., Nouv. Dict. Hist. Nat., tom. xxiii, p. 426.

Ornismya bicolor, LESS., Ois. Mouch., p. 161, pls. 49, 50 (1829).—ID., Troch., p. 58, pl. 16? (1831).

Ornismya cyanea, LESS., Ois. Mouch., p. 199, pl. 71 (1829); Supp., p. 143, pl. 23 (1831).

Ornismya cayana, D'ORB. and LAFRES., Syn. Av., ii, p. 30, sp. 17 (1838).

Hylocharis cyanea, GRAY, Gen. Birds, vol. i, p. 114, sp. 31.—REICH., Aufz. der Colib., p. 10 (1853).—ID., Troch. Enum., p. 7, pl. 768, figs. 4777-79 (1855).—CAB. and HEIN., Mus. Hein. Th., iii, p. 44 (1860).—GOULD, Intr. Troch., octavo ed., p. 171 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 19.—ELLIOT, Ibis (1877), p. 138.

Thaumatias cyaneus, BON., Consp. Gen. Av., vol. i, p. 78 (1850).

Hylocharis cyaneus, GOULD, Mon. Troch., vol. v, pl. 344.

Hub. Brazil.

Male. Head, throat, and breast shining dark blue with violet reflections; few feathers on the chin white; back bronzy-green passing into reddish-bronze on the rump and upper tail coverts; under surface green; under tail coverts blue-black with grayish-edges. Tail blue-black. Bill flesh-color, tip black. Total length, $3\frac{1}{2}$ in. Wing, $2\frac{1}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{3}{4}$ in.

Female. Differs in having the throat spotted with pale blue, the under surface gray glossed with green on the flanks; and the lateral tail feathers tipped with white.

We now come to CYANOPHAI A, which, although it is allied to the preceding genera, we may consider as the one which commences the series of "green" humming-birds. The species have a highly metallic plumage, are of moderate size and graceful forms; one species having a blue breast, and the others green, while the sexes are very different in their coloration.

Genus CXVII.—CYANOPHAI A.

TYPE.

Cyanophaia, REICH., Aufz. der Colib., p. 10 (1853).

Hylocharis, BON. (nec BOIE, 1831), Rev. and Mag. Zool. (1854), p. 255.

Lepidopyga, REICH., Troch. Enum., p. 7 (1855).

Emilia, MULS. and VERR., Class. Troch. (1865), p. 41.

T. cæruleigularis, Gould.

T. goudoti, Bourc.

T. cæruleigularis, Gould.

T. goudoti, Bourc.

Ch. Bill a little longer than the head, slightly curved. Tail forked, feathers narrow and pointed. Wings long, narrow. Feet small, tarsi covered. Sexes unlike.

Range. Veragua and Columbia.
Three species are recognized.

Fig. 124.



Cyanophaia goudoti. ♂ (Type) See Plate 124.

Key to the species.

- | | |
|--|-------------------------------|
| A. Throat and chest violet-blue, abdomen green. | 1. <i>C. caruleigularis</i> . |
| B. Under parts glittering yellowish-green; under tail coverts white, centres metallic-green. | 2. <i>C. goudoti</i> . |
| C. Entire under parts deep bluish-green; under tail coverts dark green edged with gray. | 3. <i>C. leucosticta</i> . |

There appears to be some confusion in reference to the generic term for these species. In 1853, Reichenbach (l. c.) instituted the genus *Cyanophaia*, including in it various species now considered to belong to different genera. The first one named by him is *Trochilus bicolor*, Linn. (1766).—There is no such species given by Linneus, and the *T. bicolor*, Gmelin, is the species generally known as *Thalurania wayleri*. The next species *Trochilus carulescens*, "Lodd.," is the *T. caruleigularis*, Gould, which should be the type of *CYANOPHAIA*, as the other species named *T. lazulus*, Vieill., and *T. doubledayi*, Bourc., belong respectively to *HYLOCHARIS*, BOIE, and *IACHE*, of this work. There remains only *duchassaingii*, Bourc. which is the same as *CERULEIGULARIS*, Gould.—In 1854, Bonaparte in *Rev. and Mag. Zool.*, p. 256, proposed the genus *SAPPHIRONIA*, including many species of various genera. His first species is *grayi*, belonging to *EUCEPHALA*, Reich., and then follow *lacida*, Shaw (= *Basilinna leucotis*), *circe*, Bourc., and *doubledayi*, Bourc., (now placed in the genus *IACHE*); *lactea*, Less., and *sapphironia*, Gmel., comprised in *HYLOCHARIS*, Boie; *bicolor*, Linn. (!) not existing, *duchassengii*, Bourc., and *caruleigularis*, Gould, forming Reichenbach's genus *CYANOPHAIA*. Under these circumstances Bonaparte's term *Sapphironia* must become a synonym of *HYLOCHARIS*, Boie, and Reichenbach's *CYANOPHAIA* be employed for *CERULEIGULARIS* and *GOUDOTI*. *LEPIDOPYGA*, Reich., and *EMILIA*, Muls., are unnecessary.

1. *Cyanophaia caruleigularis*.

Trochilus caruleigularis, GOULD, P. Z. S. (1850), p. 163.

Trochilus duchassaingii, BOURC., *Compt. Rend.*, tom. xxxii, p. 187 (1851), ♂, juv.

Cyanophaia carulescens, "LODD.," REICH., *Aufz. der Colib.*, p. 10 (1853).—*Id.*, *Troch. Enum.*, p. 8 t. 759 fig. 4785.

Cyanophaia duchassaingii, REICH., *Aufz. der Colib.*, p. 10.—*Id.*, *Troch. Enum.*, p. 8 (1855).

Cyanochloris caruleigularis, REICH., *Aufz. der Colib.*, p. 10 (1853).

Lepidopyga caruleigularis, REICH., *Troch. Enum.*, p. 7. t. 764, fig. 4768-70 (1855).—*CAB. and MUS.*, *Hein. Th.*, iii, p. 40 (1860).

Sapphironia duchassaingii, BON., *Rev. and Mag. Zool.* (1854), p. 256.

Sapphironia cæruleigularis, BON., Rev. and Mag. Zool. (1854), p. 256.—GOULD, Mon. Troch., vol. v, pl. 346.

—ID., Intr. Troch., octavo ed., p. 172 (1861).

Thalurania calina, BOURC., Rev. and Mag. Zool. (1856), p. 552.

Lepidopyga cæruleo-gularis, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 68 (1876).

Hab. Veragua.

Male. Upper parts, abdomen, and flanks grass-green; throat and chest violet-blue. Wings purplish-brown. Tail, central feathers bronzy-green; lateral ones black. Under tail coverts shining green margined with grayish-white. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{3}{8}$ in. Wing, 2 in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{11}{16}$ in.

Young male. Like the male, but lighter beneath, and the throat only spotted with blue. (Type of *T. duchassaigni*, Bourc., in my collection.)

Female. Upper parts green; tail purplish-black, two central feathers glossed with bronze, the four lateral ones tipped with white; centre of the throat, abdomen, and under tail coverts white.—(Gould, Mon. Troch.)

2. *Cyanophaia goudoti*.

Trochilus goudoti, BOURC., Rev. Zool. (1843), p. 100.—ID., Ann. Soc. Agr., Lyon (1843), p. 47.

Polytmus goudoti, GRAY, Gen. Birds, vol. i, p. 77, sp. 6.

Saucerottia goudoti, BON., Consp. Gen. Av., vol. i, p. 77 (1850).

Chalybura goudoti, REICH., Aufz. der Colib., p. 10 (1853).

Hylocharis goudoti, BON., Rev. and Mag. Zool. (1854), p. 255.

Agyrtia goudoti, REICH., Troch. Enum., p. 7, t. 763, fig. 4765-66 (1855).

Sapphironia goudoti, GOULD, Mon. Troch., vol. v, pl. 345.—ID., Intr. Troch., octavo ed., p. 172 (1861).

Lepidopyga goudoti, CAB. and HEIN., Mus. Hein. Th., iii, p. 40 (note 3) (1860).

Emilia goudoti, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 64.

Hab. Columbia.

Adult. Upper surface grass-green; beneath glittering yellowish-green with a slight tinge of blue on the throat. Under tail coverts white, with metallic-green centres. Median rectrices bronzy-green; lateral ones purplish-black. Wings purplish-brown. Maxilla black, mandible flesh-color, tip black. Total length, $3\frac{1}{2}$ in. Wing, 2 in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{3}{4}$ in. (Type in my collection.)

3. **Cyanophaia luminosa*.

Sapphironia luminosa, LAWR., Ann. N. Y. Lyc. Nat. Hist. vol. vii (1862), p. 458.

Lepidopyga luminosa, HEINE, Journ. für Ornith. (1863), p. 194.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 67 (1875).

Hab. Columbia.

“Upper plumage glittering grass-green, inclining to golden on the rump, the crown not so bright and of a very deep green; entire under surface of a very brilliant bluish-green, the sides of the neck golden-orange; tail forked and of a rich steel-blue, the two middle feathers green like the rump, the next feather bronzed on the outer web at the end; wings dull purple; under tail coverts deep green, very narrowly edged with bluish-white, thighs clothed with grayish-white feathers; upper mandible black, under yellowish with the end black; feet and claws black. Length, $3\frac{3}{4}$ in. Wing, $1\frac{7}{8}$ in. Bill, $\frac{11}{16}$ in. Tail, $1\frac{1}{4}$ in.”—(Lavr., l. c.)

Two generic terms were originally proposed for the following birds, *v. z.*, *Riccordia*, Reich., and *Sporadinus*, Bon. The first has priority of date by almost a year; but the latter has always been employed by the majority of writers. As neither of these genera was ever defined, I should be authorized, I suppose, in rejecting both; but as my desire is to unravel the existing confusion in this Family and not to increase it, I have retained Bonaparte's term as being most generally familiar to Ornithologists. To create a new generic name for these birds would only make matters worse. The three known species are of moderate size, possessing graceful forms, and deeply forked tails, and while the males are clothed in a highly metallic plumage, the females have in comparison a very sombre appearance. They lead us naturally to the genus *Chlorostilbon*.

Genus CXVIII.—SPORADINUS.

Riccordia, Reich., Aufz. der Colib. (1853), p. 10.

Sporadinus, Bon., Rev. and Mag. Zool. (1854), p. 255.

Sporadicus, Cab. and Heis., Mus. Hein. Th., iii (1860), p. 25.

Erasmia, Heise, Journ. für Ornith. (1863), p. 191.

Maryas, Meis. (nec OPEL, 1815, nec PETZ., 1845), Cat. Ois. Mouch., p. 13 (1875), and Hist. Nat. Ois. Mouch., tom. ii, p. 77.

Types.

O. riccordi, Guss.

O. riccordi, Guss.

T. elegans, Aud. and Vieill.

T. maugæi, Vieill.

Fig. 125.



Ch. Bill as long as the head, straight, nostrils exposed; wings long, reaching two-thirds the length of the tail. Tail long, deeply forked, feathers narrow. Tarsi partly clothed. Sexes unlike.

Range. West India Islands.

Three species are recognized.¹

¹ *SPORADINUS BRACELI*, LAWRE., N. Y. Acad. Scien., vol. i (1877), p. 50.

Male. Crown and gorget of a glittering pale green; back, upper tail coverts, the two central and the next pair of tail feathers, bronzed golden-green; the other tail feathers are purplish black with their outer edges bronzed green; quills blackish-purple; breast and abdomen dull hoary green; under tail coverts dark ash bordered with white; bill and feet black. Length, 3½ in.; wing 1½ in.; tail, 1½ in.; bill, — in. Type in National Museum, Washington.

Hab. Island of New Providence, Bahamas.—(Lawr., loc. cit.).

The unique type of this form was described by Mr. Lawrence as above. It is a non-type, and the feathers of the body are consequently much disarranged, and the tail feathers are not fully developed. It much resembles the *S. riccordi*, and I compared the specimen with the type of that species in the Paris Museum, but was not able to satisfy myself that it was certainly distinct. More specimens of this bird, and perfect ones, are necessary before its proper specific position can be fully determined.

Key to the species.

- | | |
|---|-------------------------|
| A. Throat metallic-green, under surface dull green, breast black. | 1. <i>S. elegans</i> . |
| B. Under surface glittering grass-green. | |
| a. Under tail coverts white. | 2. <i>S. riccordi</i> . |
| b. Under tail coverts green. | 3. <i>S. maugæi</i> . |

1. *Sporadinus elegans*.

- Trochilus elegans*, VIEILL., Ois. Dor., vol. i, p. 32, pl. 14 (1802).
Ornismya swainsonii, LESS., Ois. Mouch., pp. xvii, 197, pl. 70 (1829).
Trochilus swainsonii, Nat. Libr. Humming-birds, vol. ii (1833), p. 132, pl. 30.
Hylocharis elegans, GRAY, Gen. Birds, vol. i, p. 114, sp. 18 (1844-49).
Lampornis elegans, BON., Consp. Gen. Av., vol. i, p. 72 (1850).
Riccordia elegans, REICH., Aufz. der Colib., p. 8 (1853).
Sporadinus elegans, BON., Rev. and Mag. Zool. (1854), p. 255.—GOULD, Mon. Troch., vol. v, pl. 347.—ID., Intr. Troch., octavo ed., p. 173 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 72.
Chlorestes elegans, REICH., Troch. Enum., p. 4, pl. 704, figs. 4587 (1855).
Sporadicus elegans, CAB. and HEIN., Mus. Hein. Th., iii, p. 25 (1860).

Hab. Island of Hayti.

Male. Upper surface, flanks, and abdomen dark green. Throat metallic grass-green. Breast black. Wings purplish-brown. Tail black, with a bronze lustre. Under tail coverts dark green. Maxilla black; mandible flesh-color, tip black. Total length, $4\frac{1}{4}$ in. Wing, $2\frac{3}{8}$ in. Tail, 2 in. Culmen, $\frac{5}{8}$ in.

Female. Upper parts bronzy-green, top of head brownish. Under parts brownish-gray. Central tail feathers bronzy-green, lateral ones gray, with a subterminal black bar, and glossed with green. Wings purplish-brown. Total length, 4 in. Wing, $2\frac{3}{8}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{8}$ in.

2. *Sporadinus riccordi*.

- Trochilus riccordi*, GERV., Rev. and Mag. Zool. (1835), pls. 41, 42.—BON., Consp. Gen. Av., vol. i, p. 81 (1850).
Ornismya parzudaki, LESS., Rev. Zool. (1838), p. 315.
Orthorhynchus riccordi, R. DELA SAGRA, Hist. de Cuba, p. 128, t. 21, fig. 2 (1840).
Hylocharis riccordi, GRAY, Gen. Birds, vol. i, p. 114, sp. 23.
Riccordia raimondi, REICH., Aufz. der Colib., p. 8 (1853).
Sporadinus riccordi, BON., Rev. and Mag. Zool. (1854), p. 255.—GOULD, Mon. Troch., vol. v, pl. 348.—ID., Intr. Troch., octavo ed., p. 173 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 74 (1875).
Chlorestes raimondi, REICH., Troch. Enum., p. 4, pl. 704, figs. 4584-86 (1855).
Chlorestes riccordi, GUNDL., Journ. für Ornith. (1856), p. 99.
Sporadicus riccordi, CAB. and HEIN., Mus. Hein. Th., iii, p. 25 (note 2) (1860).

Hab. Cuba; and Abajo of the Bahamas.

Male. General plumage bronzy-green, very luminous on the under surface. Wings purplish-brown. Four central rectrices dark bronze; rest black, glossed with bronze. Under tail coverts white. Maxilla black; mandible flesh-color, tip black. Total length, $3\frac{3}{8}$ in. Wing, 2 in. Tail, $1\frac{3}{4}$ in. Culmen, $\frac{5}{8}$ in.

Specimens vary considerably in their coloration, some, perhaps the majority, being bronzy-green as described above, while others are a bright golden-green. The hue of the mandible also varies, and I have seen examples with this portion of the bill almost entirely black, like the maxilla. Also, the length of the bill is not always

the same. These differences are, however, of no specific importance, but are characteristic of nearly all species of "green Humming-birds."

Female. Differs in having the throat and centre of abdomen pale buff, and under tail coverts buffy-white.

3. *Sporadinus maugæi*.

Trochilus maugæus, VIEILL., Dict. Hist. Nat., tom. vii (1817), p. 568.—ID., Ois. Dor., t. i, pp. 77, 78, 79, 80, pls. 37, 38.—ID., Ency. Méth., tom. ii, p. 567.

Orniemya maugæi, LESS., Ois. Mouch., p. 194, pls. 68, 69 (1829).

Thaumatias ourisia, BOS., Consp. Gen. Av., vol. i, p. 79 (1850).

Sporadinus maugæi, BOS., Rev. and Mag. Zool. (1854), p. 255.—GOULD, Mon. Troch., vol. v, pl. 349. ID., Intr. Troch., octavo ed., p. 173 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 77.

Chlorestes gertrudis, GUNDEL., Journ. für Ornith. (1874), p. 315.

Chlorolampis gertrudis, CAB., Journ. für Ornith. (1875), p. 223.

Sporadinus (Masayas) maugæi, MULS., Cat. Ois. Mouch. (1875), p. 13.

Hab. Porto Rico.

Male. Crown glittering green, upper surface dark green, under surface glittering green, with a wash of blue on the breast. Tail steel-blue; under tail coverts green. Maxilla black, mandible reddish, tip black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{7}{8}$ in. Tail, $\frac{3}{4}$ in. Culmen, $\frac{2}{3}$ in.

Female. Differs in having the under surface grayish-white. Central tail feathers green; rest greenish-gray at the base, with a steel-blue band near the tip; the two outermost rectrices tipped with grayish-white.

The species of *CHLOROSTILBON* have always been most perplexing to all Ornithologists, caused,—by the variation in the colors of individuals belonging to the same species—by the close relationship of the various species—and by the great want of sufficient specimens to enable these facts to be adequately appreciated. I would refer those who desire to study this interesting though perplexing group to my review of the genus published in the *Ibis* for the year 1875, p. 149.—The plumage is metallic-green of various shades, and the species can only be distinguished apart by the coloring of the bills, and the shape of the tails.—In one case only does the hue of the abdomen and breast distinguish a species.—They are all very small birds, and the sexes are totally unlike in the color of their plumage.—The *Key* given of the species will enable each one to be readily identified.

Genus CXIX.—*CHLOROSTILBON*.

Chlorostilbon, GOULD, Mon. Troch., pt. v (1853); and Intr. Troch., octavo ed., p. 175 (1861).

Chlorestes, REICH., Aufz. der Colib. (1853), p. 10.

Chlorolampis, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 47.

Prasitis, CAB. and HEIN., Mus. Hein. (1860) Th., iii, p. 49.

Chloanges, HEINE, Journ. für Ornith. (1863), p. 200.

Merion, MULS., Hist. Nat. Ois. Mouch., tom. ii (1875), p. 92.

Chrysomirus, MULS., Catal. Ois. Mouch. (1875), p. 13.

TYPE

T. pusillus, BOON.
T. cyanogenus, WOOD.
T. augustipennis, FRAS.
O. prasina, LESS.
T. aeneiceps, GOULD.
C. h. (Chloanges), REICH.
T. anceps, FRAS.

Ch. Bill about as long as the head, straight, rather broad and flat at base, and terminating in a sharp point. Wings long, reaching nearly to the end of the tail. Tail rather short, forked, or even. Feet small; tarsi clothed. Sexes unlike.

Range. Mexico, Central America, Venezuela, Trinidad, Guiana, Brazil, Argentine Republic, Ecuador, Peru, and Bolivia.

Eight species are here recognized as belonging to this genus.

Key to the species.

- | | |
|--|-----------------------------|
| A. Bill flesh-color, point only brownish-black. | |
| a. Rectrices tipped with gray. | |
| a'. Tail long, deeply forked, rectrices very narrow. | 1. <i>C. auriceps.</i> |
| b'. Tail moderately forked, rectrices rather broad. | 2. <i>C. caniveti.</i> |
| b. Rectrices entirely bluish-black. | |
| a'. Lower part of breast and abdomen green. | 3. <i>C. pucherani.</i> |
| b'. Lower part of breast and abdomen golden-red. | 4. <i>C. splendidus.</i> |
| B. Bill black, basal half of mandible flesh-color. | 5. <i>C. haberlini.</i> |
| C. Bill entirely black. | |
| a. Tail moderately long, forked. | 6. <i>C. angustipennis.</i> |
| b. Tail short, scalloped. | 7. <i>C. atala.</i> |
| c. Tail short, slightly rounded, almost even. | 8. <i>C. prasinus.</i> |

1. *Chlorostilbon auriceps.*

Trochilus auriceps, GOULD, Jard. Contr. Orn. (1852), p. 137.

Sporadinus auriceps, BON., Rev. and Mag. Zool. (1854), p. 223.

Chlorostilbon auriceps, GOULD, Mon. Troch., vol. v, pl. 350.—ELLIOT, Ibis (1875), p. 168.

Chlorolampis auriceps, CAB. and HEIN., Mus. Hein. Th., iii, p. 48 (note 7) (1860).—GOULD, Intr. Troch., octavo ed., p. 174 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. iii, p. 79 (1876).

Hab. Northwest Mexico.

Male. Top of head metallic-golden; upper surface golden-green; throat metallic yellowish-green; under surface metallic golden-green. Vent white. Wings pale brown. Tail long, deeply forked, black, all but the outermost feather tipped with gray. Bill reddish at base, black at tip. Total length, $3\frac{3}{4}$ in. Wing, $1\frac{3}{4}$ in. Tail, 2 in. Culmen, $\frac{1}{2}$ in.

Female. Upper surface bronzy-green, under surface dull gray. Median rectrices shining green, rest (except the external one) green at base, then black with gray tips; the outermost green at base, then gray, then black, and tips grayish-white.

2. *Chlorostilbon caniveti.*

Ornismya caniveti, LESS., Ois. Mouch., pp. 174, 177, pls. 37, 38 (1829).

Hylocharis caniveti, GRAY, Gen. Birds, vol. i, p. 114, sp. 19.

Thaumatias caniveti, BON., Consp. Gen. Av., vol. i, p. 78 (1850).

Riccordia caniveti, REICH., Aufz. der Colib., p. 8 (1853).

Sporadinus caniveti, BON., Rev. and Mag. Zool. (1854), p. 224.

Fig. 126.



Chlorostilbon splendidus.
♂. 53816. Puenos Ayres.

- Chlorestes canivetti*, REICH., Troch. Enum., p. 4, t. 703, figs. 4581-83 (1855).
Chlorolampis caniveti, CAB. and HEIS., Mus. Hein. Th., in, p. 47 (note 4) (1860).—GOULD, Intr. Troch., octavo ed., p. 391 (1861).—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 81 (1875).
Chlorostilbon caniveti, GOULD, Mon. Troch., vol. v, pl. 351.—ELLIOT, Ibis (1875), p. 168.
Chlorostilbon osberti, GOULD, P. Z. S. (1860), p. 309.—ID., Mon. Troch., vol. v, pl. 352.
Chlorolampis salvini, CAB. and HEIS., Mus. Hein. Th., iii, p. 48 (1860).—GOULD, Intr. Troch., octavo ed., p. 174.
Chlorolampis osberti, GOULD, Intr. Troch., p. 174, sp. 395 (1861).

Hab. Mexico, Guatemala, Honduras, Costa Rica.

Male. Crown of the head metallic-golden; upper surface bright bronzy-green, under surface metallic grass-green, with a golden hue on the flanks. Wings purplish-brown. Tail black, all the central feathers with gray tips. Bill red at base, rest black. Total length, $3\frac{1}{2}$ in. Wing, $1\frac{3}{4}$ in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{5}{16}$ in.

Female. Upper surface and flanks bronzy-green, with a brownish shade on the crown; under surface gray. Middle pair of rectrices bronze-green, the next three are green at base, then steel-blue, tip edged with gray; the outermost one gray crossed by a broad steel-blue band. Ear coverts blackish-brown; behind the eye a narrow line of white. Total length, 3 in. Wing, $1\frac{1}{2}$ in. Tail, $1\frac{1}{4}$ in. Culmen, $\frac{1}{2}$ in.

3. *Chlorostilbon pucherani*.

- Trochilus pucherani*, BONC. and MULS., Rev. Zool. (1848), p. 271, juv. ♂.
Trochilus nitidissimus, LICHT., Mus. Berol.
Hylocharis similis, BOS., Consp. Gen. Av., vol. i, p. 74 (1850).
Chlorestes nitidissima, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 755, figs. 4588-89, 4590-91.
Chlorestes pucherani, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 755, fig. 4586.
Hylocharis pucherani, BOS., Rev. and Mag. Zool. (1854), p. 255.
Chlorostilbon prasinus, GOULD (nec LESS.), Mon. Troch., vol. v, pl. 355.—ID., Intr. Troch., octavo ed., p. 176 (1861).
Chlorostilbon nitidissimus, CAB. and HEIS., Mus. Hein. Th., iii, p. 47 (1860).
Chlorostilbon igneus, GOULD, Intr. Troch., p. 176 (1861).
Hylocharis flavifrons, VOS PELZ., Ornith. Bras., p. 33 (1871).
Chlorostilbon insularis, LAWRE., Ann. N. Y. Lyc. Nat. Hist., vol. vii, p. 457.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 100.
Chlorostilbon cyregius, HEISE, Journ. für Ornith. (1863), p. 197.
Chlorostilbon pucherani, ELLIOT, Ibis (1875), p. 161.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 97.

Hab. Southeastern Brazil.

Male. Crown golden-green; upper parts dark green; throat metallic bluish-green; under parts metallic yellowish-green. Wings purplish-brown. Tail blue-black. Bill red at base, tip black. Total length, $3\frac{1}{4}$ in. Wing, 2 in. Tail, $1\frac{1}{2}$ in. Culmen, $\frac{9}{16}$ in.

Female. Upper surface bronzy-green; under parts gray. Tail steel-blue, the four middle feathers glossed with green, the two outer ones tipped with grayish-buff.

4. *Chlorostilbon splendidus*.

- Trochilus splendidus*, VIEILL., Nouv. Dict. Hist. Nat., tom. vii, p. 361 (1817).—ID., Ency. Méth., p. 362, vol. 9.
Ornismya aureiventris, D'ORB. and LAPRES., Syn. Av., ii, p. 28 (1838).
Trochilus phathon, BONC., Rev. Zool. (1848), p. 274.—GRAY, Gen. Birds, vol. iii, app., p. 300.
Chlorestes phathon, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 755, figs. 4784-85, 4786.
Trochilus flavifrons, GOULD, Voy. Beag. (Birds), p. 110.
Hylocharis phathon, BOS., Rev. and Mag. Zool. (1854), p. 255.

Hylocharis aureiventris, BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes aureiventris, REICH., Troch. Enum., p. 4, t. 754, figs. 4729-30 (1855).

Chlorostilbon phæthon, GOULD, Mon. Troch., vol. v, pl. 354.—ID., Intr. Troch., octavo ed., p. 175 (1861)

Chlorostilbon bicolor (nec Gmel., 1788), CAB. and HEIN., Mus. Hein. Th., iii, p. 46 (1860).

Chlorolampis phæthon, CAB. and HEIN., Mus. Hein. Th., iii, p. 48 (note 5) (1860).

Chlorostilbon aureiventris, GOULD, Intr. Troch., p. 176, sp. 400 (1861).

Chlorostilbon splendidus, ELLIOT, Ibis (1875), p. 165.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 93.

Hab. Buenos Ayres to Mendoza, Bolivia.

Male. Upper surface golden-bronze, greenish on the upper tail coverts. Throat and breast metallic light green; abdomen golden-red; under tail coverts green. Tail black. Bill flesh-color, tip black. Wings purplish-brown. Total length, 3-3½ in. Wing, 2 in. Tail, 1-1¼ in. Culmen, ½ in.

Female. Above bronzy-green, beneath gray, flanks bronzy. Tail black, two lateral feathers tipped with grayish-white.

5. *Chlorostilbon haberlini*.

Chlorestes haberlini, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 703, figs. 4578-80 (1855).

Chlorostilbon haberlini, CAB. and HEIN., Mus. Hein. Th., iii, p. 48 (note 6) (1860).—GOULD, Intr. Troch., octavo ed., p. 175 (1861).—ELLIOT, Ibis (1875), p. 160.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 100.

Chlorolampis haberlini, CAB. and HEIN., Mus. Hein. Th., iii, p. 48 (note 6) (1860).

Chlorostilbon nitens, LAWRE., Ann. N. Y. Lyc. Nat. Hist. (1861), p. 305.—GOULD, Intr. Troch., octavo ed., p. 179 (1861).

Hab. Panama, Columbia, Venezuela.

Male. Upper parts golden-green, in some specimens very brilliant on the forehead. Under parts glittering yellowish-green, sometimes washed with bluish. Tail black. Maxilla black, mandible flesh-color at base, tip black. Total length, 3 in. Wing, 1¾ in. Tail, 1½ in. Culmen, ⅞ in.

Female is like that of *C. pucherani*.

6. *Chlorostilbon angustipennis*.

Trochilus angustipennis, FRAS., P. Z. S. (1840), p. 18.

Trochilus chrysogaster, BOURC., Rev. Zool. (1843), p. 101.

Trochilus phæopygus, TSCH., Faun. Pernan., p. 247, sp. 11 (1844).

Hylocharis angustipennis, GRAY, Gen. Birds, vol. i, p. 114, sp. 21.

Hylocharis chrysogaster, GRAY, Gen. Birds, vol. i, p. 115, sp. 43.—BON., Consp. Gen. Av., vol. i, p. 74 (1850).

—ID., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes chrysogastra, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 693, figs. 4540-41 (1855).

Chrysuronia phæopyga, BON., Consp. Gen. Av. (1850), vol. i, p. 75.

Chlorolampis chrysogastra, CAB. and HEIN., Mus. Hein. Th., iii, p. 47 (1860).

Prasites phæopyga, CAB. and HEIN., Mus. Hein. Th., iii, p. 49 (1860).

Chlorostilbon smaragdina, CAB. and HEIN., Mus. Hein. Th., iii, p. 48 (1860).

Chlorostilbon angustipennis, GOULD, Mon. Troch., vol. v, pl. 353.—ID., Intr. Troch., octavo ed., p. 175 (1860).

—ELLIOT, Ibis (1875), p. 153.

Chlorostilbon assimilis, LAWRE., Ann. N. Y. Lyc. Nat. Hist., p. 292 (1860).

Chlorostilbon melanorhynchus, GOULD, P. Z. S. (1860), p. 308.

Chlorolampis angustipennis, HEINE, Journ. für Ornith. (1863), p. 201.

Chlorostilbon pumilus, GOULD, Ann. and Mag. Nat. Hist. (1872), vol. ix, p. 195.

Chrysimirus angustipennis, MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 102 (1875).

Hab. Veragua, Panama, Venezuela, Columbia, Ecuador.

Male. Crown of the head golden; upper surface bronzy-green; throat metallic emerald-green, under surface metallic yellowish-green. Under tail coverts luminous grass-green. Wings purplish-brown. Tail forked, blue-black. Bill black. Total length, $3\frac{1}{8}$ in. Wing, 2 in. Tail, $1\frac{5}{8}$ in. Culmen, $\frac{1}{10}$ in.

Female. Upper parts bronzy-green, brownish on the crown, and purer green on the rump and upper tail coverts. Under parts grayish-white. Central tail feathers green at base, rest blue-black; the lateral ones green at base, then blue-black and tipped with white; external one on each side gray at base, then crossed by a broad steel-blue band, and tipped with white. Bill black. The dimensions and coloring of this species vary greatly among individuals, so that these have no specific value, and the only reliable method of determining that a specimen belongs to it, is, that it possesses the *entirely black bill* together with a tail *rather deeply forked for its length*.

7. *Chlorostilbon atala*.

Ornismya atala, LESS., Hist. Nat. Troch., p. 118, pl. 42 (1831).

Hylocharis atala, GRAY, Gen. Birds, vol. i, p. 115, sp. 47 (1844-49).

Chlorostilbon atala, GOULD, Mon. Troch., vol. v, pl. 356.—ID., Intr. Troch., octavo ed., p. 177 (1861) — *Ibis* (1875), p. 159.

Saucerottia atala, BON., Consp. Gen. Av., vol. i, p. 77 (1850).—REICH., Aufz. der Colib., p. 7 (1853).

Chlorestes atala, REICH., Troch. Enum., p. 4, pl. 700, fig. 4568 (1855).

Chlorostilbon caribaens, LAW., Ann. N. Y. Lyc. Nat. Hist., vol. x, p. 2.

Chrysomirus atala, MELLS., Hist. Nat. Ois. Mouch., tom. ii, p. 105 (1875).

Hab. Trinidad.

Male. Upper surface golden-green, very brilliant on the crown. Under surface metallic light green. Wings purplish-brown. Tail steel-black. Bill black. Total length, 3 in. Wing, $1\frac{7}{8}$ in. Tail, $1\frac{3}{8}$ in. Culmen, $\frac{2}{8}$ in.

Female. Upper parts bronzy-green. Under surface grayish-white. Tail steel-black, lateral feathers tipped with grayish-white. Bill black. Dimensions the same as the male.

8. *Chlorostilbon prasinus*.

The All-green Humming-bird, EDWARDS, Gleanings (1764), p. 316, pl. A, 360, fig. 1.

L'Orvert, BEV., Plan. Eulum., tom. vii, pl. 13 (text only).

Ornismya prasina (*L'orvert*), LESS., Ois. Mouch., p. 188, pl. 65 (1829).

Ornismya mellisuga, D'ORB. and LAFRES., Syn. Av., ii, p. 30, sp. 20 (1838).

Argyrtia phoebe, LESS. and DELATT., Rev. Zool. (1839), p. 17, juv.

Hylocharis prasinus, BON., Consp. Gen. Av., vol. i, p. 74 (1850).

Helianthea phoebe, REICH., Aufz. der Colib., p. 9 (1853).—ID., Troch. Enum., p. 6 (1855).

Hylocharis phoebe, BON., Rev. and Mag. Zool. (1854), p. 255.

Trochilus daphne, BON., M.S.

Hylocharis prasinus, BON., Rev. and Mag. Zool. (1854), p. 255.

Hylocharis daphne, BON., Rev. and Mag. Zool. (1854), p. 255.

Chlorestes prasina, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 691, figs. 4529-30 (1855).

Prasitis prasina, CAB. and HEIN., Mus. Hein. Th., iii, p. 49 (1860).

Chlorostilbon peruanus, GOULD, Intr. Troch. (1861), p. 177, sp. 405, octavo ed.

Chlorostilbon napensis, GOULD, Intr. Troch., octavo ed., p. 177 (1861).

Chlorostilbon brevicaudatus, GOULD, Intr. Troch., octavo ed., p. 178 (1861).

Agryrtia media, PRIZ., Orn. Brazil, p. 29.

Agryrtia meliphila, PRIZ., Orn. Brazil, p. 29.

Chlorostilbon prasinus, ELLIOT, *Ibis* (1875), p. 163.

Chrysomirus prasinus, MELLS., Hist. Nat. Ois. Mouch., tom. ii, p. 108 (1875).

Hab. Venezuela, Cayenne, Amazonian region of Brazil, Peru.

Male. Upper parts bright green, rather brilliant on the crown. Under surface luminous green, washed more or less with blue upon the throat, sometimes even extending to the breast. Tail nearly even, blue-black. Bill black. Wings purplish-brown. Total length, $3\frac{1}{8}$ in. Wing, $1\frac{3}{4}$ in. Tail, 1 in. Culmen, $\frac{5}{8}$ in.

Female resembles that of *C. atala*.

I close the list of the Trochilidæ with the genus PANYCHLORA; not that it essentially should be placed here, and nowhere else, but because, in the arrangement of the groups that appears most natural to me after many years of study, and which I suggest in this Synopsis, the species of this genus seem to find here their appropriate position. The three forms given below are among the very smallest of Humming-birds, and are chiefly distinguished from the members of CHLOROSTILBON by their short, square, *green* tails, the feathers of which in one species are attenuated and pointed.—Different shades of green, very luminous, are the prevailing, indeed the only colors of the males; the females differing in their gray under surface, and variously colored rectrices.

Genus CXX.—PANYCHLORA.

Panychlora, CAB. and HEIN., Mus. Hein. Th., iii (1860), p. 49.

Ch. Bill as long as the head, straight; feathers of forehead projecting on culmen, nostrils hidden. Wings long, reaching nearly to the end of the tail. Tail short, even. Feet very small, tarsi partly clothed. Sexes unlike.

Range. Venezuela and Columbia.

Three species are known.

Key to the species.

- A. Tail shining grass-green, bill long.
- B. Tail very dark green, bill moderately long.
- C. Tail bright green, outer rectrices extremely narrow and pointed.

TYPE.

T. alicia, Bourc.

Fig. 127.



Panychlora alicia, ♂. 24730.
New Granada.

- 1. *P. poortmani*.
- 2. *P. alicia*.
- 3. *P. stenura*.

1. Panychlora poortmani.

Ornismya poortmani, BOURC., Rev. Zool. (1843), p. 2.—ID., Ann. Soc. Sci. Phys., Lyon (1843), p. 39.
Hylocharis poortmani, GRAY, Gen. Birds, vol. i, p. 115, sp. 48.—BON., Consp. Gen. Av., vol. i, p. 74 (1850).
Chlorestes poortmani, REICH., Aufz. der Colib., p. 7 (1853).—ID., Troch. Enum., p. 4, t. 691, figs. 4531-32 (1855).
Smaragdites esmeralda, REICH., Aufz. der Colib., p. 7 (1853).
Chlorostilbon esmeralda, REICH., Troch. Enum., p. 4, t. 694, figs. 4542-43 (1855).
Chlorostilbon poortmani, BON., Rev. and Mag. Zool. (1854), p. 238.—GOULD, Mon. Troch., vol. v, pl. 358.
Panychlora poortmanni, CAB. and HEIN., Mus. Hein. Th., iii, p. 50 (1860).—GOULD, Intr. Troch., octavo ed., p. 180 (1861).—ELLIOT, Ibis (1875), p. 170.—MULS., Hist. Nat. Ois. Mouch., tom. ii, p. 112 (1875).

Hab. Columbia.

Male. Upper surface shining green, some specimens with the crown golden-orange. Under surface luminous grass-green; vent white. Tail bright grass-green. Wings purplish-brown. Bill black. Total length, 3 in. Wing, $1\frac{3}{8}$ in. Tail, 1 in. Culmen, $\frac{3}{8}$ in.

Female. Head golden-orange, upper surface grass-green; under surface gray. Median pair of rectrices green, rest green at base passing into black and tipped with white. Bill black. Total length, 3 in. Wing, $1\frac{3}{8}$ in. Tail, $\frac{7}{8}$ in. Culmen, $\frac{3}{8}$ in.

2. *Panychlora aliciaë.*

Trochilus alicia, BONC. and MEIS., Rev. Zool. (1848), p. 274.

Chlorostilbon alicia, BONC., Rev. and Mag. Zool. (1854), p. 239.—GOULD, Mon. Troch., vol. v, pl. 357.

Smaragdites alicia, REICH., Aufz. der Colib., p. 7 (1853).

Smaragdites euchloris, REICH., Aufz. der Colib., pp. 7, 23 (1853).

Smaragdites maculicollis, REICH., Aufz. der Colib., p. 7 (1853).

Chlorestes maculicollis, REICH., Aufz. der Colib., p. 23 (1853).—ID., Troch. Enum., p. 4, pl. 694, figs. 4543-45 (1855).

Chlorestes alicia, REICH., Troch. Enum., p. 4, t. 754, figs. 4732-33 (1855).

Chlorestes mellisuga, REICH., Troch. Enum., p. 4, t. 754, fig. 4731 (1855).

Chlorestes euchloris, REICH., Troch. Enum., p. 4, t. 694, fig. 4544 (1855).

Panychlora alicia, CAB. and HEIN., Mus. Hein. Th., iii, p. 50 (note 6) (1860).—GOULD, Intr. Troch. octavo ed., p. 411 (1861).—ELLIOT, Ibis (1875), p. 171.—MEIS., Hist. Nat. Ois. Mouch., tom. ii, p. 115.

Panychlora aurata, CAB. and HEIN., Mus. Hein. Th., iii, p. 50? (1860).

Panychlora maculicollis, CAB. and HEIN., Mus. Hein. Th., iii, p. 49 (note 4) (1860).

Hab. Venezuela.

Male. Crown golden-green; upper surface bronzy-green; under surface luminous yellowish-green. Under tail coverts shining grass-green. Wings purplish-brown. Tail very dark green. Bill black. Total length, $2\frac{3}{4}$ in. Wing, $1\frac{1}{2}$ in. Tail, 1 in. Culmen, $\frac{9}{16}$ in. (Type in my collection.)

Female. Above bronzy-green, beneath grayish-white. Central tail feathers green, lateral ones green at base, then black and tipped with gray, increasing in extent towards the external ones.

3. **Panychlora stenura.*

Panychlora stenura, CAB. and HEIN., Mus. Hein. Th., iii, p. 50 (note 7) (1860).—GOULD, Intr. Troch. octavo ed., p. 180 (1861).—ELLIOT, Ibis (1875), p. 171.—MEIS., Hist. Nat. Ois. Mouch., tom. ii, p. 117.

Chlorostilbon acuticaudus, GOULD, P. Z. S. (1860), p. 308.

Panychlora alicia, WYATT., Ibis (1871), p. 379.

Hab. Merida, Venezuela, Ocaña, Columbia.

Male. Crown glittering-green; upper surface and tail golden-green. Under surface shining grass-green. Wings purplish-brown. Bill black. Total length, 3 in. Wing, $1\frac{3}{8}$ in. Tail, 1 in. Bill, $\frac{3}{8}$ in.

Female or *young male* has the rectrices golden-green, the lateral ones with ashy tips. Under parts gray. Upper parts golden-green.

This species is remarkable for its extremely narrow and pointed outer rectrices, which readily serve to distinguish it from its relatives.

APPENDIX.

ONE hundred and twenty genera have been recognized in this work, nearly all of which could, probably, readily be identified by any one tolerably conversant with this group of birds. Many of them are, however, very closely allied to others, and in order to facilitate the determination as much as possible of any particular genus, the following 'Key' has been prepared, which it is hoped, in connection with the drawings to be found at the head of every genus illustrating their salient characters, may prove useful in rendering this, perhaps at times, greatly needed service.

KEY TO THE GENERA.

- | | |
|--|------------------------|
| A. Bill decurved to the extent of one-third of a circle. | 1. EUTOXERES, p. 2. |
| B. Bill twice as long as head, tip hooked, cutting edges serrated. | 2. RHAMPHODON, 4. |
| <i>a.</i> No metallic coloring. Tail long, rounded. | 3. ANDRODON, 5. |
| <i>b.</i> Coloring partly metallic. Tail short, broad. | 4. GLAUCIS, 5. |
| C. Bill long, rather stout, decurved, high at base. Tail rounded, feathers pointed in young. Sexes alike. | 5. DOLEROMYA, 8. |
| D. Bill straight, short, flat and fleshy at base. First primary pointed. Sexes alike. No brilliant hues. | 6. PHŒOPTILA, 9. |
| <i>a.</i> Tail even, external rectrices pointed. | 7. PHŒTHORNIS, 10. |
| <i>b.</i> Tail forked. | 8. EUPETOMENA, 21. |
| E. Median pair of rectrices elongated considerably beyond the rest, sometimes pointed, generally attenuated. Bill decurved or straight, nearly as long as body. | 9. SPHENOPROCTUS, 22. |
| F. Shafts of primaries broad and flattened. | 10. CAMPYLOPTERUS, 23. |
| <i>a.</i> Tail very long, deeply forked. | 11. APHANTOCHROA, 28. |
| <i>b.</i> Tail long, cuncate, central pair of rectrices lengthened beyond the rest. | 12. CŒLIGENA, 29. |
| <i>c.</i> Tail moderately long, rounded, feathers broad. | 13. LAMPROLEMA, 32. |
| G. Shafts of primaries thickened at base. Bill short, stout. Tail square, broad. | 14. OREOPYRA, 33. |
| H. Bill straight, rather stout, as long, or slightly longer than the head. Tail rounded, long, ample, the rectrices broad. Brilliant metallic hues restricted to the throat. | (249) |
| I. Bill short, slender, straight. Tail long, forked, feathers broad. Metallic hues equally brilliant upon throat and breast. Sexes unlike. | |
| J. Bill straight, rather stout, about as long as the head. Tail moderately long, forked. Plumage generally metallic. Sexes very dissimilar. | |

- K. Bill longer than the head, decurved.
- a. Metallic hues most brilliant on the throat. Sexes unlike.
 - a'. Tail long, feathers narrow and pointed, the external rectrices on either side longer than the rest. Tarsi clothed. 15. ORECTROCHILUS, 34.
 - b'. Tail long, feathers moderately broad and rounded. Tarsi bare. 16. LAMPORNIS, 37.
 - c'. Tail even, or slightly forked. Upper tail coverts highly metallic. Sexes alike. 17. ECLAMPIS, 42.
 - d'. Inner web of first primary very narrow. Tail nearly even, feathers pointed; the under coverts two-thirds the length of the rectrices. Sexes unlike. 18. LAFRESNAYA, 43.
 - I. Bill straight, long as head. Tail long, with the under coverts greatly developed, plume-like. Sexes unlike. 19. CHALYBURA, 45.
 - M. Bill strong, straight, about as long as the head. Tail ample long, the under coverts reaching nearly to the tips of median rectrices. 20. FLORISUGA, 47.
 - X. Bill rather stout, longer than head.
 - a. Frontal feathers projecting over and covering the nostrils. Size large.
 - a'. Sexes alike. Bill straight.
 - a''. Tail broad, ample, rounded. Ear coverts and breast metallic. 21. PETASOPIDRA, 49.
 - b''. Tail forked when closed, square when spread. General hues metallic. 22. PANOPLETES, 55.
 - c''. Tail short, slightly forked. Brilliant metallic hues confined to crown of the head. 23. PHEGILEMA, 56.
 - b'. Sexes dissimilar.
 - a''. Tail long, forked. Brilliant metallic hues chiefly on the throat and centre of crown and forehead. Bill straight. 24. CLYTOLEMA, 56.
 - b''. Tail long, deeply forked. Metallic hues brilliant on forehead, or lower part of throat, sometimes both. Bill straight. 25. IOLEMA, 57.
 - c''. Tail large, forked when spread. Bill decurved. Throat and breast metallic. 26. STERNOCLYTA, 59.
 - d''. Tail moderate, slightly forked. Throat and crown metallic. Bill straight. 27. EUGENES, 60.
 - e''. Tail ample, nearly square. Throat and breast metallic. Bill slender, straight. 28. UROCHIROA, 61.
 - f''. Tail very long and deeply forked; the feathers narrow and slightly pointed. Feathers of forehead and under parts highly metallic. Bill straight. 29. EUGENIA, 62.
 - g''. Tail as long as body, deeply forked; the feathers broad, and pointed. Plumage generally highly metallic. Bill straight. 30. LAMPRASTER, 65.
 - i''. Tail long, forked, feathers rounded at tip. Plumage of centre of crown, throat, and breast highly metallic. 31. HELIODOXA, 63.
 - i''. Tail very long and ample, feathers broad. Wings very large, falcate. Plumage shining, not brilliantly metallic. Bill curved upward slightly at point. 32. PTEROPIANES, 66.

- b.* Feathers of forehead only partly covering the nostrils.
a'. Tail long, broad, and forked. Wings very long, pointed. No metallic hues on plumage. Sexes alike. 33. PATAGONA, 67.
- O.* Bill longer than the body and head, inclining upwards at tip. Sexes unlike. 34. DOCIMASTES, 68.
- P.* Bill very long, straight, slender.
a. Sexes dissimilar.
a'. Tail long, deeply forked. Forehead and crown brilliantly metallic. Tarsi partially clothed. 35. DIPHLOGÆNA, 69.
b'. Tail slightly forked. Plumage generally metallic. Tarsi feathered. 36. HELIANTHEA, 70.
- b.* Sexes similar.
a'. Tail long, broad, slightly forked. Metallic hues in the majority of the species, mainly on the head, throat, and rump. Tarsi bare. 37. BOURCIERIA, 74.
b'. Tail much rounded, rectrices broad. Metallic hues restricted to forehead. 38. HEMISTEPHANIA, 80.
- Q.* Bill lengthened. Crown and throat metallic. Sexes dissimilar.
a. Gorget not elongated.
a'. Nostrils exposed, maxilla broad, denuded at base. Tail rounded. Bill straight. 39. FLORICOLA, 82.
b. Gorget elongated.
a'. Tail forked, feathers rounded at tip. Bill straight. 40. LEPIDOLARYNX, 84.
b'. Tail deeply forked, rectrices narrow and pointed. Bill slightly curved. 41. HELIOMASTER, 86.
- R.* Bill short, about as long as the head, straight. Spot on forehead and throat metallic. Sexes unlike.
a. Tail long and forked. No white on breast. 42. HELIOTRYPHA, 86.
b. Tail broad and rounded. White band on breast. 43. HELIANGELUS, 89.
- S.* Bill straight, slender, longer than the head. Tail slightly forked. Throat metallic. Sexes unlike. 44. UROSTICTE, 91.
- T.* Bill shorter than head, nostrils covered. Tail rounded. Sexes very different, both with metallic hues, more on the female than male. Size large. 45. EUSTEPHANUS, 92.
- U.* Rectrices on either side of the median pair narrow and elongated far beyond the rest. Bill stout, decurved, longer than the head. Metallic hues common to both sexes, but their plumage dissimilar. 46. TOPAZA, 94.
- V.* Lateral rectrix, next the outermost one on either side, three times the length of the rest. Bill longer than the head, wide at base. Tail forked. Head crested. Sexes unlike. Tail of female moderately long, rounded, the lateral rectrices pointed. 47. AITHURUS, 96.
- W.* Bill longer than the head, stout, slightly decurved. Nostrils covered. Tail very long, deeply forked, the external rectrix twice the length of the one next to it, very broad, and narrowing to a point. Plumage generally metallic. Size large. Sexes —? 48. HYLONYMPHA, 97.
- X.* Bill moderate, slightly decurved. Tail slightly forked. Tarsi clothed, metallic hues on crown or throat, sometimes on both. Sexes unlike. 49. THALURANIA, 98.
- Y.* Size minute. Bill short, straight, delicate. Metallic hues wanting.
a. Tail short, slightly forked. Sexes similar. 50. MELLISUGA, 103.
b. Tail short, square, slightly rounded. Sexes unlike. Nostrils hidden. Crown white. 51. MICROCHERA, 104.

- Z. Size small. Bill straight, slender. Metallic hues on head or throat, sometimes on both. Sexes unlike.
- a. Gorget not elongated, metallic.
- a'. Tail forked, rectrices pointed, outermost ones narrowest. Female has the tail short and rounded. 52. TROCHILUS, 105.
- b. Gorget elongated.
- a'. Head and throat metallic. Tail forked and short, the three outer feathers narrow and slightly incurved. Tarsi covered. Tail of female rounded. 53. CALYPTA, 106.
- b'. Metallic hues confined to the throat; in one species only, including both head and throat. Tail rounded, rectrices sharply pointed and generally narrow. 54. SELASPHORUS, 108.
- c'. Throat alone metallic.
- a''. Tail very short, square 55. CATHARMA, 112.
- b''. Tail short, and much rounded. 56. ATTHIS, 113.
- d'. Throat partly metallic. Tail slightly forked in the male, feathers rounded at tip. Tail of female slightly rounded. 57. STELLULA, 114.
- AA. Size moderately large. Bill long, decurved, and wide at base. Nostrils hidden. Tail long, deeply forked, rectrices narrow and graduated to their tips. Tarsi clothed. Throat metallic. Sexes unlike. 58. RHODOPIS, 115.
- BB. Bill slender, straight. Tufts of metallic feathers on either side of the head. Four median rectrices longest, and nearly equal, broad at base, graduating to a point. Sexes unlike. 59. HELIACTIN, 116.
- CC. Median rectrices very short, almost hidden in the upper coverts. Throat metallic. Size small. Bill longer than the head, slender. Tail forked in the male, rounded in the female. Sexes dissimilar.
- a. Bill broad at base, decurved for its entire length; outermost rectrix sometimes nearly bare of webs, gorget elongated. 60. CALOTHORAX, 117.
- b. Bill slightly arched. Two outer rectrices filamentous, almost bare of webs. 61. ACESTRURA, 119.
- c. Bill straight. Outermost rectrix half the length of one next to it, filiform and graduating to a point. Two succeeding ones longest, equal and uniform in breadth. 62. CHEILOCERCUS, 120.
- d. Rectrix on either side of middle pair greatly elongated; remainder short and decreasing in length to the outermost one. 63. THAUMASTURA, 122.
- e. Tail forked, long. Outermost rectrix on either side considerably longer than the one next to it. Bill slender, decurved. 64. DORICHA, 123.
- f. Four lateral rectrices on either side of middle pair elongated, and nearly equal in length. 65. MYRDIS, 126.
- g. Tail deeply forked. Outermost rectrix longest, tapering rapidly at the tip, and curved inwards. 66. TELMAMURA, 128.
- DD. Tail rather long, deeply forked. Throat metallic.
- a. Bill longer than the head, straight, slender. Wings very short, about one-third the length of the body.
- a'. Rectrices uniform in width. 67. SMARAGDOCHRYSES, 129.
- b'. Median rectrices very short, lateral ones narrow, and the outer ones curving slightly inwards. 68. PODOPTERA, 129.

- b.* Bill shorter than the head, slightly decurved at extreme tip, rectrices narrow, longest curving slightly outwards, median pair very short.
69. CALLIPHLOX, 130.
- EE. Feathers of the neck lengthened, forming ruffs, and projecting outwards and upwards. Bill straight, short, weak. Sexes dissimilar.
70. LOPHORNIS, 131.
- FF. Tail deeply forked, median rectrices very short, outermost one bare of web near the tip. Bill about as long as the head, straight.
- a.* No spatula at tip of external rectrix. All tail feathers terminating in sharp points.
71. GOULDIA, 137.
- b.* Outermost rectrix longest, and terminating in a moderate spatula.
- a'.* Second and third outer rectrices nearly equal, and about three-fourths the length of external one, pointed at tips.
72. DISCURA, 140.
- b'.* Second outer rectrix about one-third the length of external one, and one-third longer than the next inner one. Tips rounded.
73. STEGANURA, 141.
- c'.* Outer tail feathers entirely bare of webs, spatules very large. Wings diminutive.
74. LODDIGESIA, 144.
- GG. Tail very long, deeply forked.
- a.* Bill about as long as the head, straight.
- a'.* Rectrices narrow, outermost one greatly exceeding the others in length; the tips alone slightly metallic. Throat metallic.
75. LESBIA, 145.
- b'.* Rectrices broad, external one nearly square at tip, remainder slightly pointed, all metallic at the tip, each one from the median pair one-third shorter than the next outer one. Throat metallic.
76. ZODALIA, 149.
- c'.* Rectrices moderately broad, even; external one two-thirds longer than the one next to it; the exposed surface of all highly metallic. Top of head and throat luminous.
77. CYNANTHUS, 150.
- d'.* Bill longer than the head, arched. Rectrices broad, rounded at tip, external one, a third longer than the next one; exposed portions of all extremely luminous. Throat metallic.
78. SAPPHO, 153.
- HH. Feathers of throat elongated into a pendent tuft. Tail forked.
- a.* Head crested.
- a'.* Bill short, straight, feeble. Tarsi naked.
79. OXYPOGON, 155.
- b.* Head not crested. Elongated throat feathers metallic at tips.
- a'.* Bill longer than the head, stout, slightly decurved. Tarsi clothed.
80. OREONYMPHA, 157.
- c.* Bill shorter than the head, straight, rather stout.
81. RHAMPHOMICRON, 158.
- II. Bill turned upwards at the tip.
- a.* Bill shorter than the head. Tail slightly forked. Rectrices not luminous.
82. AVOCETTINUS, 161.
- b.* Bill longer than the head. Tail rounded. Rectrices exceedingly luminous.
83. AVOCETTULA, 162.
- JJ. Rectrices broad, highly metallic. Sexes unlike.
- a.* Bill straight, shorter than the head. Tarsi bare.
84. METALLURA, 163.

- b.* Bill longer than the head, slightly decurved, broad at base and flat. Tarsi clothed.
- a'*. Tail rounded. Head and throat metallic. 85. CHRYSURONIA, 167.
- b'*. Tail square. Forehead and throat metallic. 86. AUGASTES, 170.
- KK. Bill straight, about as long as the head. Tarsi bare. 87. PHILOGOTHILUS, 171.
- LL. Bill longer than the head, wedge-shaped at tip.
- a.* Tail rounded, feathers broad. Tarsi partly clothed. 88. SCHISTES, 172.
- b.* Tail rounded, feathers rather narrow; outer rectrix but two-thirds the length of median pair; upper tail coverts reaching two-thirds the length of the tail. Tarsi clothed to the toe. 89. HELIOTHRIX, 174.
- MM. Feathers of forehead projecting on to the culmen. Nostrils hidden. Bill about as long as the head. Tail round. Tarsi bare. Sexes unlike.
- a.* Head not crested. Top of head and throat metallic. 90. CHRYSOLAMPIS, 173.
- b.* Head crested.
- a'*. Crest broad at base, pointed at tip, metallic. 91. BELLONA, 178.
- b'*. Crest terminating in one or more narrow feathers, extending far beyond the rest. Partly metallic. 92. CEPHALOLEPIS, 179.
- NN. Bill as long as the head, straight. Nostrils exposed.
- a.* Tail rounded, tarsi bare. Metallic hues confined to small spots on the throat. Sexes alike. 93. ADELOMYIA, 181.
- b.* Tail almost square; no metallic hues. Wings long and pointed. Tarsi feathered. 94. ANTHOCEPHALA, 183.
- OO. Bill shorter than the head, straight, weak. Wings reaching nearly to the end of the tail, which is forked. Sexes dissimilar. Size small. Metallic hues confined to the throat. 95. ABELLIA, 183.
- PP. Bill longer than the head, straight, wide at base. Tarsi clothed. Tail rounded. 96. KLAVIS, 184.
- QQ. Rump metallic; luminous. Bill straight.
- a.* Primaries falcate. Tail forked, feathers pointed. Tarsi partly clothed. 97. AGLEACTIS, 185.
- b.* Tail forked, feathers rounded. Tarsi hidden in tufts of downy feathers. 98. ERIOCNEMIS, 188.
- RR. Bill short and straight, slender. First primary slightly falcate. Tail forked, feathers pointed. Tarsi bare. Plumage generally metallic. Sexes alike. 99. PANTERPE, 195.
- SS. Tail rounded. Tarsi clothed. Sexes alike. Bill longer than head, straight.
- a.* Bill broad, flat at base. Nostrils exposed. 100. URANOMITRA, 195.
- b.* Bill narrow and slender at base, nostrils exposed. 101. LEOCEPES, 198.
- c.* Bill wide at base, nostrils hidden. 102. LEOCOCHLORIS, 200.
- d.* First primary slightly falcate; nostrils exposed. 103. AGYRIEA, 201.
- TT. Tail slightly forked. Sexes unlike. Bill subcylindrical, point swollen. 104. ARINIA, 209.
- UU. Tarsi clothed. Nostrils exposed.
- a.* Sexes unlike.
- a'*. Tail rounded.
- a''.* Bill shorter than the head, decurved. 105. ELVIRA, 210.
- b''.* Bill long as the head, straight, wide at base. Under tail coverts half as long as rectrices. 106. CALLIPHARUS, 211.
- c''.* Bill longer than the head, straight. 107. EUPHERUSA, 212.

- b.* Sexes alike.
- a'*. Tail rounded. Bill much longer than the head, decurved, wide at base. Rectrices narrow. 108. POLYTMUS, 213.
- b'*. Tail even. Bill as long as head, straight. 109. AMAZILIA, 216.
- VV. Sexes unlike. Bill as long as, or slightly longer than the head.
- a.* Tarsi clothed.
- a'*. Bill straight, nostrils exposed.
- a''*. Tail square, feathers broad. 110. BASILINNA, 226.
- b''*. Tail rounded or slightly forked. 111. EUCEPHALA, 227.
- b'*. Bill decurved, nostrils hidden. 112. TIMOLIA, 231.
- b.* Tarsi bare.
- a'*. Bill straight, nostrils hidden. 113. JULIAMYIA, 232.
- WW. Bill longer than the head, rather broad and flat at base, and terminating in a sharp point. Wings long, over two-thirds the length of the tail. Tarsi clothed. Sexes dissimilar.
- a.* Nostrils exposed.
- a'*. Bill straight, tail even, slightly forked when spread; rectrices rather broad. Luminous metallic hues confined to the top of the head. 114. DAMOPHILA, 233.
- b'*. Bill slightly decurved. Tail short, slightly forked, feathers broad. 115. IACHE, 234.
- c'*. Bill straight and broad on top. Wings reaching to nearly the end of the tail, which is even. 116. HYLOCHARIS, 236.
- d'*. Bill slightly decurved. Tail forked, feathers narrow and pointed. 117. CYANOPHAIJA, 237.
- e'*. Bill straight. Tail long, deeply forked. 118. SPORADINUS, 240.
- f'*. Size small. Bill straight. Tail short forked or even. Plumage generally metallic. 119. CHLOROSTILBON, 242.
- b.* Nostrils hidden.
- a'*. Bill straight, frontal feathers projecting on to the culmen. Tail very short, even. Plumage luminous. 120. PANYCHLORA, 247.

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F E V E R:

A STUDY IN MORBID AND NORMAL PHYSIOLOGY.

BY

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ADVERTISEMENT.

THE following paper gives the results of experiments made, partly at the expense of the Smithsonian Institution, by Dr. H. C. Wood, of Philadelphia, in 1876 and 1877, to determine the nature and cause of fever.

The memoir was submitted to the Institution in 1878 and referred to a commission consisting of Dr. S. Weir Mitchell and Dr. J. J. Woodward, and on their recommendation it was accepted for publication in the Contributions to Knowledge.

SPENCER F. BAIRD,

Secretary of Smithsonian Institution.

WASHINGTON, October, 1880.

P R E F A C E.

THE present memoir is the outcome of labor, which has occupied during many years all the hours that could be spared from pressing professional engagements. Like other works, which have grown up rather than been fully conceived of in the beginning, it has taken a final form somewhat different from that which originally shaped itself in the author's mind, having been especially modified by the hand of death laid upon those who were to have been co-workers to the end.

It was intended that the memoir should be a complete discussion of the subject on which it treats; including in its scope the chemistry of fever and the relation of the febrile state to ingestion and elimination. I am not a practical chemist, but Dr. Horace Hare was to have had charge of the chemical portion of the research, which would have been published under our joint names. After some months spent in devising, preparing, and testing apparatus, Dr. Hare was overtaken by the malady which ultimately caused his death. This deranged all our plans, and resulted in my continuing alone the share of work originally allotted to me.

It is, perhaps, allowable for me in this place to pay a brief tribute to the memory of one who took an active part in preparing the groundwork of the present research. Fitted by natural endowments and by careful scientific training both in this country and abroad, Dr. Horace Hare, had he lived, would have proved himself worthy to bear the name of his grandfather, Prof. Hare, who so long gave lustre to the chemical chair in the Medical Department of the University of Pennsylvania. By industry and originality he was fitted to shine as an investigator; by his remarkable personal winsomeness and his gifts as a public lecturer he was destined to have become a great teacher of his favorite science—had not death ended all. To him the author owes, not only memories of many hours spent most pleasantly and instructively, but gratitude for suggestions, for manifold aid, given at a time when the task, now completed, seemed hopeless in its complexity and magnitude.

I also desire to acknowledge great personal indebtedness to Dr. B. F. Lautenbach, whose young life was put out by the same fatal disease that ended the career of Dr. Hare. First as a pupil and afterwards as an assistant, Dr. Lautenbach was

associated with me for years, and did a large amount of work upon the present research. Indeed, at one time, it was proposed that the paper should appear under our joint names. Circumstances, however, led the doctor away from Philadelphia, and his work was generously placed at my disposal. He certainly performed some hundreds of hours' labor as my assistant, and was of much service in the discussion of plans and methods. In only one experiment, however, reported in the Memoir did I not myself take part, and almost all of the final thermometrical readings were made by myself, except in the case of the fever experiments, when I usually allowed my assistants to carry on the work through the alternate nights. Most of this night-work was personally superintended by Dr. Lautenbach, although I am under obligations to Drs. G. Evans Abbot, Jno. Marshall, Edward T. Reichert, W. W. Jaggard, and others for aid, without which the research could never have reached completion. Almost all of the calculations were originally made by myself, but were revised, and indeed recalculated by Mr. T. D. Dunn and Dr. W. W. Jaggard. The few carbonic acid examinations reported were made by Drs. Abbott and Marshall.

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FEVER.

A STUDY IN MORBID AND NORMAL PHYSIOLOGY.

CHAPTER I.

THE ESSENTIAL SYMPTOM OF FEVER.

IN approaching a physiological or pathological process for the purpose of studying its mechanism and nature, its essential symptom should, if possible, be first determined as a guide in the unravelling of the mysteries of the process. Fever has been defined to be "an acute derangement of all the functions"; this it certainly is. Yet the definition gives to the mind no idea of the phenomena of fever. When these are analyzed, it will be found that the most important of them are capable of being grouped in four sets: acceleration of the heart's beat, and disturbance of the circulation; nervous disturbance; elevation of bodily temperature; disturbance of nutrition, including secretion.

It is evident that these four symptomatic groups may have one of two relations: one condition may be the cause of the other, or they may all be simply the result of a common cause. If it can be found by experimentation that each of these conditions can be singly provoked without the remaining conditions being at the same time evolved, it is at once rendered exceedingly probable that the relation between these conditions is not causal, *i. e.*, that no one condition is the cause of the others, and that their interdependence does not extend beyond their being the result of some common cause. On the other hand, if experimentation shows that one of these symptoms or conditions is capable of producing the other conditions, the natural inference is that this is a primary condition, and is really the cause of the others, which are, therefore, secondary states or symptoms of fever.

The nervous disturbances of fever may be summed up as paresis or convulsions, stupor, coma, delirium. Clinical experience abundantly demonstrates that these do not necessarily induce high temperature or accelerated circulation. The proof of this is so evident that it is not necessary to do more than to allude to it. Again, it is equally sure that increased activity of circulation is not sufficient to induce the high temperature of fever. It is, indeed, true that increased activity of blood movement has some effect upon the animal heat, but this effect is, comparatively speaking, slight. By means of excessive exercise, or by the use of certain

drugs, the circulation can be excited much beyond the point that it reaches in fever, but under these circumstances the elevation of temperature never approaches that of high fever.

Disturbances of nutrition, including secretion and excretion, are certainly capable of causing fever, but that such disturbances are not always the cause of the febrile state is shown by the circumstance that fever may be generated in the normal animal by external heat without a previous appreciable alteration of secretion or nutrition. It would indeed appear that derangement of nutritive functions is frequently a secondary and not a primary phenomenon of fever.

From the considerations just brought forward it would appear that such disorders of circulation, innervation, or nutrition as constitute the gross symptoms of fever are not essential to fever, *i. e.*, capable of producing the other phenomena of the febrile state, and that if any one fever symptom be the cause of the other fever symptoms, it must be the elevated temperature.

When we desire to heat any inorganic body we do it by applying to it heat, but the living animal body has power of resisting the absorption of heat by means so well known as not to require consideration here. This power is, however, limited, and we are able to heat the animal provided the external warmth be sufficient and be applied with sufficient persistency.

The following series of experiments was performed to determine the effect of heating the animal body. In the first two trials natural heat was employed. A box was constructed rudely with a slanting glass lid, like a miniature green-house. It was simply placed upon a brick pavement, when used, in such a way that the sun could exert its fullest power upon it. In the other experiments artificial heat was employed.

EXPERIMENT 1.

Exposed a two-thirds-grown rabbit in a box covered with glass.

1 p. m.—Temperature in rectum, 104°.5 F. Temperature of box, 120° F.

1:15 p. m.—Temperature, 106°.5. Respiration very hurried.

1:30 p. m.—Temperature, 109°.5. Has convulsive attacks, in which he jumps, and kicks with hind legs with great fury.

1:45 p. m.—Temperature, 112°. Seems very weak and relaxed; breathing 220 a minute. Lies on side, with every now and then the attacks alluded to; slobbering greatly.

2:10 p. m.—Temperature of box, 120°. Rabbit on side, exceedingly weak, gasping; squeaking faintly at intervals.

2:15 p. m.—Temperature, 114°.5. Perfectly unconscious; lies relaxed and motionless on the cool ground in the shade.

2:20 p. m.—Only gasping at long intervals; heart still beating, although laboredly, and somewhat irregularly, yet pretty steadily, and with some force.

2:21 p. m.—Dead.

Autopsy.—Heart: right side and left auricle full of blood; left side containing blood, not contracted. The heart made a few very imperfect and feeble attempts at beating when it was cut across. Blood coagulating with great rapidity and firmness; alkaline. Brain not congested. Muscles all failing to show the slightest sign of contraction under the strongest faradic current, except some of the leg muscles, which contracted very feebly, and only when the current was very intense.

EXPERIMENT 2.

Two-thirds-grown rabbit. Put in the box at 11:30 A. M. Rectal temperature, 104°.5.

12 M.—Rectal temperature, 109°. Temperature of box, 112°.

12:25 P. M.—Rectal temperature, 110°.5. Rabbit weak, slobbering a great deal; breathing with great rapidity.

1:15 P. M.—Rabbit conscious, lying quietly on his side; not slobbering; breathing not nearly so rapid, but deep and labored. Rectal temperature, 111°.5.

1:35 P. M.—Rabbit found dead. Rectal temperature, 112°.

Autopsy.—Heart: left ventricle empty, very firmly contracted, with a very evident white spot at apex. Galvanic (induced) current very strong, giving rise to no muscular movements whatever, either of heart or voluntary muscles. Blood coagulating slowly and imperfectly; reaction neutral, or at least so feebly alkaline as to be uncertainly so. Muscular reaction very decidedly acid. Spinal cord not congested. Right side of heart gorged with blood.

EXPERIMENT 3.

A large adult rabbit.

12:11 P. M.—Rectal temperature, 105°. Just put in box, whose temperature is 130°, heated by very hot brick flues, on which the rabbit lies.

12:15 P. M.—Rectal temperature, 107°. Breathing excessively hurried.

12:17 P. M.—Rectal temperature, 109°.

12:21 P. M.—Rectal temperature, 111°. Had a moment since what was apparently a convulsion, and has had numerous convulsive twitchings since. Appears semi-unconscious.

12:25 P. M.—Dead. Temperature in abdomen after death, 111°. Respiration ceased some time before heart. The thorax was opened, and the heart was felt by the finger to be pulsating. On more complete exposure, the heart was seen to be very distinctly pulsating, and gradually becoming filled with dark blood. The heart was punctured, and blood allowed to escape; it made one or two pulsations, and then at once became rigid. After this the diaphragm was tried with the galvanic current, and responded to it. The muscles of the hinder extremity did not respond, those of the front legs did. Peristaltic action of the intestines was moderately active when the body was opened, and on galvanic excitation became very active.

EXPERIMENT 4.

A moderate-sized dog.

1 P. M.—Put in the hot box.

1:15 P. M.—Rectal temperature, 106°.

1:30 P. M.—Rectal temperature, 110°.

1:40 P. M.—Rectal temperature, 110°.75. Just dead.

Autopsy.—As soon as respiration ceased, the body was opened. Heart still beating, gorged with dark blood. Veins full of dark blood. Blood on being shaken in test-tubes rapidly clotting, and slowly changing its color to an arterial hue. The vessels were carefully examined; no clots were found in them.

EXPERIMENT 5.

An adult pigeon.

11:40 A. M.—Rectal temperature, 109°. Just put in box; the temperature in box, 130°; besides, the pigeon was in direct contact with the very hot brick flue.

11:45 A. M. Respirations very weak.

12 M.—Has been unable to stand for some time; has been semi-unconscious. Just had a convulsion, followed by persistent opisthotonos.

12:2 P. M.—Anal temperature, 120°?. (My thermometer did not mark higher than 120°, to which the mercury rose; the hand could hardly bear the heat of the flesh.) Dead. Respiration certainly

ceased before the heart's action. Rigidity came on almost before heart ceased beating. The body opened as soon as heart ceased action. The heart was found rigidly contracted like a muscle. Muscles acid.

Experiments 6, 7, 8, 9, were the counterparts of Experiment 5.

In Experiment 10, a cat was employed. The result was as follows:—

EXPERIMENT 10.

12:16 P. M.—Temperature of box, 130°.

12:35 P. M.—Temperature of box, 130°. The cat ever since it was put in the box has been struggling violently and savagely, and for the last five minutes has been evidently growing weaker but perfectly conscious. Just seized with a sudden tetanic convulsion, which instantly arrested all respiration, and persisted with absolute rigidity for about five minutes (not by actual death). When the cat was taken from the box the pupils were widely dilated, the heart beating strongly and regularly. She was plunged into cold water, but never made an effort at breathing and perfect relaxation of the muscles soon came on. The body was opened: heart found to be not beating and distended with blood; after a considerable time it was seen to gradually stop beating and the left side contracting expelled all the blood from it, and became rigid. The diaphragm responded, though somewhat feebly, to the galvanic current fully fifteen minutes after respiration had ceased.

These experiments suffice to show that in animals heating the body artificially produces disturbances of circulation and of innervation similar to those present in ordinary fever. In man the phenomena of sunstroke, or, as I prefer to call it, thermic fever, show that exposure to external heat may produce all the symptoms of the febrile state. The following description of the symptoms present in that disorder, given by Dr. Bonnyman (*Edinburgh Med. Journal*, 1864), shows how precisely they agree with those of ordinary severe fever.

“Where premonitory symptoms show themselves, they are sometimes well marked. Those usually observed are—inaptitude and disinclination for any exertion, drowsiness, or a desire to sleep, vertigo, headache, and slight confusion of ideas; the patient feels weak, sighing frequently; the appetite is gone, thirst is increased, and the bowels are constipated; the symptoms become aggravated, and the patient either passes into the state of profound coma, or symptoms of the first or progressive form of the malady are complained of, viz, distressing headache, with a feeling of weight and heat in the occiput, tightness, distention, and throbbing in the forehead and temples, anxiety at the præcordia, nausea, and a disposition to vomit. A sensation of sinking or of insupportable weight, or uneasiness, is referred to the pit of the stomach, and a feeling of horror or of impending calamity, with a tendency to weep, is experienced. The breathing is natural, or slow and sighing. The face is generally natural or somewhat flushed, eyes bright, pupils either natural or somewhat contracted. The skin is very hot and dry; the pulse is full and accelerated, tongue white, thirst intense, bowels confined, the urine suppressed. If these symptoms persist, tetanic convulsions suddenly appear, and the patient passes into the second or severe form of the disease.”

After death from thermic fever the condition of the blood so closely resembles that seen after a malignant fever as to have caused various skillful physicians to

believe that the symptoms of sunstroke are due to the presence of a poison in the blood.¹

That high temperature is capable of causing most fatal nutritive disturbances of almost every tissue is therefore shown not only by experiments upon the lower animals, but also by the natural (if the expression be allowable) experiment of sunstroke upon man. The peculiar odor and the offensive perspiration of thermic fever in man, the altered or suppressed urine, the frequent watery, exceedingly offensive, involuntary passages, the broken-down crassis of the blood found after death, are all of them important witnesses of the profound influence excessive temperature has upon the general nutrition.

Without occupying more space it may be claimed that by the evidence brought forward the following proposition has been demonstrated:—

External heat applied to the body of the normal animal, so as to elevate the temperature, produces derangement of the functions of innervation, of circulation, of nutrition and secretion, similar to those seen in natural fever; the intensity of the disturbances being directly proportionate to the rise in temperature.

Bearing closely upon this proposition are various experiments that have been made as to the effect of external heat upon the brain and heart when applied directly to them.

There is no difficulty in applying heat directly to the brain of the cat and rabbit by surrounding the head with a double bonnet of india-rubber, or, as I have used, of pig's bladder, and allowing hot water to run through this. Vallin is, so far as I know, the only observer who has made any such experiments. It is evident that there are two points especially to be determined in this inquiry: first, How do the symptoms produced compare with those of ordinary sunstroke? second, What is the temperature at which the functional power of the brain is lost? In only two instances did Vallin succeed in causing death by the hot-water bonnet, and in neither of these cases was any attempt made to measure the temperature of the brain. The symptoms are not described by Vallin as closely as is desirable, but appear to have been insensibility—whether coming on gradually or suddenly is not stated—with convulsions.

¹ It is perhaps allowable here to notice a criticism of Prof. J. J. Picot (*Leçons de Pathologie Générale. Les Grands Processes Morbides. Tome I. Paris, 1876, p. 35*).

“Sans doute aussi, en 1863, H. C. Wood (cité dans ‘Revue critique du mécanisme de la mort par la chaleur extérieure,’ par le docteur E. Vallin. *Arch. Gén. de Méd.*, 1871:) a prétendu que chez les animaux qui succombent à la suite de l'exposition à une température excessive, on trouve le sang acide, et cette assertion a été reproduite par Obernier en 1867; mais les expériences sur lesquelles ces auteurs ont appuyé une semblable constatation manquent complètement de base scientifique, et, je le pense avec M. Vallin (*loc. cit.*), il n'y a pas lieu d'en tenir compte.”

In 1863 I had made no experiments on animals. When in 1872 I did make such experiments, I wrote simply, “that the alkalinity of the blood was impaired.” I had reported in 1863 cases of sunstroke, in which among other new observations I had found the *blood acid at the autopsies* performed two or three hours after death. That the acidity was present during life I did not assert, and do not know; but of its presence at the autopsies there can be no mistake. Very possibly it was the result of chemical disintegration of the blood commenced during life, but not reaching the point of acidity until after death.

My own experiments with the hot-water bonnet are as follows:—

EXPERIMENT 11.

A full-grown rabbit. Rectal temperature 102°.5 F.

TIME.	TEMP. OF WATER.	REMARKS.
12:41 P.M.	140° F.	
12:49	175	Puffiness and great swelling of the scalp, with very hurried respiration and exceedingly rapid pulse, with violent struggles, constitute the only effects as yet produced.
12:51	175	A sudden, severe convulsion, followed by a state of semi-unconsciousness.
1:04	150	Rectal temperature, 104°.5 F.
1:10	140	Lies quiet, semi-unconscious; but the cornea are very sensitive.
1:15	180	Convulsions.
1:20		Died in a stupor, a gradual deepening of the previous semi-unconsciousness. The respiration ceased before heart's action.

Autopsy.—Skull opened instantly after death, just sufficiently to allow a thermometer to be placed in the brain; it indicated 117° F. The heart was soft and flaccid; the right side full of blood, the left empty. The muscles responded well to galvanic stimulus, but rigor mortis set in in a few minutes.

EXPERIMENT 12.

A full-grown rabbit.

TIME.	TEMP. OF WATER.	RECTAL TEMP.	REMARKS.
12:38 P.M.	190° F.		
12:50	140	103°.75 F.	
1:05	135		
1:15		104.25	Pupils not contracted.
1:20	174		
1:30			Before this there have been struggles, apparently semi-convulsive, and contracted pupils. Now a true convulsion, followed by unconsciousness and complete relaxation. The breathing is accompanied by fine, sonorous rales.
1:50	150	106	The rabbit has lain for some time in a perfectly comatose state, with occasional convulsions. The hot-water bonnet was now removed from the head, and cold water poured over the latter; almost immediately the animal showed signs of recovering, and after awhile died perfectly. The next day, excepting in regard to the local trouble on the scalp, etc., the rabbit seemed well.

EXPERIMENT 13.

A young, half-grown cat. The hot-water bonnet was adjusted to its head, and the water allowed to run through it.

TIME.	TEMP. OF WATER.	REMARKS.
11:15 A.M.	162° F.	
11:25		Cat has had several convulsions not preceded by signs of nervous disturbance, coming on suddenly and followed by insensibility, with partial anaesthesia of cornea.
11:40	140	
11:41	162	
11:55	170	There have been repeated convulsions, during which pupils would dilate some, although the eye was in the full blaze of sunlight. Almost constant convulsions, sometimes affecting very markedly even the eye-muscles. The cat is all the time apparently unconscious. Cat died at 11:57, the respiration ceasing at least four minutes before the heart ceased to beat. On opening the body the right heart was found with blood, and, on being cut, the ventricle pulsated again. The brain was exposed as soon as possible after death. Its temperature was 113° F. The muscles responded to galvanism apparently not so actively as normal, and <i>rigor mortis</i> came on in about fifteen minutes (not timed with watch) after death.

EXPERIMENT 14.

A very large, powerful tomcat was used, and bladder fitted to head at 10:30 A. M.

TIME	TEMP. OF WATER.	REMARKS.
10:35 A. M.	175° F.	
11	140	Very hurried breathing.
11:30	180	---
12 M.	160	Cat is now unconscious: the unconsciousness came on in a very short space of time, but not with absolute abruptness; no convulsions; respiration slower.
12:15 P. M.	175	Cat just dead. The respiration certainly ceased before the heart some seconds, or probably a minute or two. No convulsion.

Autopsy.—Brain opened instantly after death. The thermometer plunged directly into the substance rose above 114° F.; when placed, however, so as to be in contact with the inside of the skull, it marked 115°. There was decided, but not extraordinary, congestion of the brain.

As these experiments are painful ones, I have not repeated them further. They seem sufficient to establish the following conclusions: *First.* A temperature of the brain of from 113° to 117° F. is sufficient, if maintained, to produce death in a short space of time in mammals by arrest of the respiration. *Second.* That the chief symptoms induced are insensibility and convulsions, preceded by exceedingly rapid respirations and action of the heart, and unaccompanied by any general rise of temperature. *Third.* That these symptoms come on very quickly in all cases, at times with absolute abruptness.

The resemblance of these symptoms, induced by the local application of heat to the head, to the nervous phenomena of sunstroke, is very striking, both in regard to the symptoms themselves and also to the suddenness of their onset. A reference to the account of the exposure of cats to a general high heat, will show that in these animals the nervous symptoms are much more sudden and severe than in rabbits; in fact, approaching what is seen in man. The experiments just detailed demonstrate that a temperature of 113° to 114° F. is fatal to the brain of the cat, whilst, at least in some cases, that of 117° F. is required to destroy the vitality of a rabbit. The nervous system of the cat is much more excitable, and much more impressible, than that of the rabbit, and consequently feels the abnormal temperature more acutely. The brain of a man is much more highly organized, and no doubt correspondingly more sensitive, than that of a cat; and if a temperature below 113° F. be fatal to the brain of a cat, whose normal temperature is 102°.5 F., it seems very certain that the temperature of some cases of insolation (113° F.) is sufficient in itself to cause death in man, whose normal temperature is 99° F.

In connection with the above experiments, I have performed others to determine whether, when heat is applied to the head, coma is developed at the same temperature as it is when the whole body is heated. In these the hot-water bonnet was applied to the head of the animal.

EXPERIMENT 15.

A full-grown cat.

TIME.	TEMP. OF WATER.	REMARKS.
12 M.	130° to 170° F.	during the hour.
1 P.M.	140	Cat has been for some time very quiet, evidently semi-comatose; at times arming herself. Pupils moderately contracted.
1:15	180	Cat was so comatose that an attempt was made to open the head. The first attempt was not noticed; but the second aroused her.
1:30	180	The pupils have been strongly contracted, and cat quiet and semi-comatose. Suddenly pupils at once dilated widely, and a severe convulsion came on. This was so severe that I think the cat would have died in it. In the midst of the fit, the skull was opened and the thermometer plunged into the brain. It indicated 110° F.

EXPERIMENT 16.

A young kitten.

TIME.	TEMP. OF WATER.	REMARKS.
1:40 P.M.	170° F.	
1:55		Kitten has been semi-comatose, with strongly contracted pupils, for some time. Suddenly its pupils dilated, and a general epileptiform convulsion, commencing in the muscles of the jaw, set in. In the midst of this the thermometer was plunged into the brain. It indicated 107.5 F.

The only objection of any force which I can imagine capable of being raised against the conclusion drawn from the previous experiments is, that the results were not really due to the immediate action of the heat, but to a determination of blood to the head and consequent congestion of the brain.

The want of validity of this objection is apparently demonstrated by the following facts:—

1. Sudden epileptiform convulsion is not generally the result of congestion of the brain.
2. Opening the skull through the longitudinal sinus, although necessarily affording immediate relief of any existent congestion, did not stop the convulsion.
3. Abstraction of the heat by pouring cold water over the head, sufficed to produce immediate cure.

It having been proven that the local application of heat to the brain will produce the cerebral phenomena exhibited when the brain reaches a febrile temperature, it is next in order to study the relation of the heart to fever heat. I have made no experiments upon this subject, such having been rendered unnecessary by an admirable paper by Dr. T. Lauder Brunton (*St. Bartholomew's Hospital Reports*, vol. vii.). In this memoir it is shown that when the cut-out heart of a frog is exposed to a rising temperature, the cardiac pulsations constantly become more and more rapid until a heat limit is nearly reached, at which the action of the heart ceases. The increase in the rapidity of the movements of the heart is not in a direct relation to the increment of temperature; at first the increase of movement is slow, but the rapidity of the increase becomes more and more rapid as the temperature rises until the maximum rate is reached. Panum has found that the cut-out heart of the rabbit responds to heat in the same way as does that of the frog, and Brunton has experimented by bringing the rabbit profoundly under the influence of chloral, and then surrounding him with a jacket of hot water. These

experiments of Brunton are of course completely parallel with those in which I exposed animals in hot air; in both instances there was a great rise in the rapidity of the cardiac action.

It is of course impossible to experiment directly upon man, but the brain and the heart of man must be subject to the same laws, so far as regards such forces as heat, as are the same organs of other animals. It is simply inconceivable that what has been proven as true of the lower animals is not true of man. Moreover, we have very direct evidence that heat does affect the organs of man as it does those of animals.

Thus we have an elaborate study on the action of fever heat upon the pulse of man, by Dr. C. Liebermeister, who analyzed the records of 280 cases of acute disorder not directly affecting the brain or heart, accompanied by a rise of temperature, and mostly observed by himself. The following table represents the minimum, maximum, and mean:—

Temperature (Centigrade),	37°	38°	39°	40°	41°	42°
Pulse { Minimum,	45	44	52	64	66	88
{ Maximum,	124	148	160	158	160	168
{ Mean,	71.6	88.1	97.2	105.3	109.6	121.7

There are so many factors entering into the causation of increased action of the circulation in febrile diseases, that it is to be expected that the minimum and maximum will not obey any fixed law, but in a very large number of observations the action of the general cause of the increased pulse-rate becomes manifest, and the table shows with what great regularity the pulse rises with the temperature.

When these clinical studies are placed in conjunction with the experiments of Lauder Brunton, they show that elevated temperature acts directly in increasing the pulse-rate, and that it is apparently capable of producing all the circulatory phenomena of fever. Consequently, the following proposition may be considered as demonstrated: Heat applied locally to the brain or to the heart produces in the functions of the organ those disturbances which are familiar phenomena of fever, the intensity of the disturbances being directly proportionate to the excess of heat.

And if heat be the cause of the symptoms of fever, and if the propositions just stated be true, the withdrawal of the heat should be followed by a subsidence of the symptoms. It is plain, however, that if the heat have persisted too long it may have wrought permanent alteration in the nervous system. Hence the withdrawal of the heat must be sufficiently early to be a fair test of the truth of the conclusion reached by *a priori* reasoning.

The following experiments were performed to determine the results of an early withdrawal of heat.

EXPERIMENT 17.

A young rabbit was put in a glass box set in the sun; in twenty minutes he was apparently totally unconscious, having passed through all the ordinary symptoms. He was now taken out, and put in a bucket of water. The temperature of his body rapidly fell to the normal, that of the water rising two degrees, and consciousness was restored at once. He was very weak, but in a few minutes was able to walk some, and the next day was as well as ever.

EXPERIMENT 18.

A pigeon of full age, with rectal temperature $108^{\circ}.5$, was placed in a box (130° F.) at 11:42 A. M. At 12 M. it had a convulsion, followed by persistent opisthotonos, with complete insensibility, which indeed had been nearly complete before the convulsion.

12:2 P. M.—The pigeon was taken out, utterly unconscious, and at one time I thought it was dead; there were only a few gasps at long intervals. I plunged it into a tub of cold water, and kept it there. Its respiration slowly improved; but after it had been in some three or four minutes it had a violent convulsion, after which for a while it again appeared to be dead. It however slowly grew better again, and in about fifteen minutes was taken out of the water and put in the air. It was now perfectly conscious, and breathing slowly and regularly, but was not able to walk. In three or three minutes it was able to push itself rapidly forward with its feet, on its breast, but was unable to raise its body from the ground. Its rectal temperature was 100° . It was now left in a box at 1 P. M., apparently improving.

At 2 P. M. it was found dead, still warm. I saw the body at 4 P. M. There was general rigidity, and the blood was not coagulated anywhere.

EXPERIMENT 19.

A full-sized pigeon.

TIME.	TEMP. OF BOX.	RECTAL TEMP.	REMARKS.
11:40 A. M.	120° F.	105° F.	
11:48	120	112	
11:55	120	117	The pigeon had previously struggled violently, but its struggles were apparently voluntary. It was so weak as not to be able to stand, and was now taken out of the box. It was unable to push itself along. At 12:8 P. M. the rectal temperature $112^{\circ}.5$; pigeon is now able to push itself along, although not to stand. 12:30 P. M. pigeon is apparently all right, but not disposed to fly, and its feathers seem to be falling out. It died some time between 2 and 5 P. M.

Autopsy made twenty-four hours afterwards showed that the blood was fluid, and very dark.

EXPERIMENT 20.

An adult pigeon. Rectal temperature, $109^{\circ}.5$.

At 12:29 P. M. it was put in hot air chamber.

12:39 P. M.—Rectal temperature, 112° .

12:53 P. M.—Rectal temperature, $117^{\circ}.5$. Bird lying on back and side, apparently dying. It was plunged in cold water for several minutes, and when taken out its rectal temperature was 100° . It was unable to make any effort; with very irregular, jerking breathing, so that I momentarily expected it to die. It was not again put in water.

2 minutes (after taking out of water).—Temperature 107° .

3 minutes.—General condition growing worse.

10 minutes.—Reviving. Able to push itself along.

12 minutes.—Temperature 101° . On application of galvanic current, muscles respond well.

25 minutes.—Although pigeon has been in a warm place, its temperature is 96° .

2 hours.—Pigeon much better; lies quiet all the time, but can walk, though somewhat stiffly. It is still better. It has been dry and in a warm place for two hours, but its temperature is only 100° .

3 hours.—Left as before.

5 hours.—Found dead, cold, and rigid. Blood as first taken out dark and fluid, but on standing in a test-tube forming into a firm coagulum.

These experiments certainly show that in the lower animals the abstraction of heat by external cold, after the animal has been artificially heated, is followed at once by the subsidence of the symptoms, provided that the high temperature has

not been continued so long as to permanently damage the tissues. In Experiments 18, 19, and 20, it is remarkable that, although the injury wrought was sufficient to cause death, yet the peculiar nervous symptoms all subsided upon the withdrawal of the excessive heat.

I have had two opportunities of performing upon men under very favorable conditions experiments entirely parallel to those last detailed.

The first of these was upon the person of a burly Scotchman, who was carried into the Centennial Hospital on a hot July day in 1876. He had fallen unconscious about twenty minutes before. Upon entering the ward he was in a state of unconsciousness, muttering delirium, profoundly relaxed, with a pungently hot, dry skin, rapid, feeble pulse, and greatly disturbed respiration. Death was apparently so imminent that no time was lost in making observations, but he was placed in a full bath of ice-water, with ice in great chunks piled over his exposed shoulders, neck, and head. After about five minutes his mouth temperature was $107^{\circ}.5$ F. From this time it steadily fell, and after some fifteen minutes it had reached 104° F., when very distinct signs of consciousness were developed, the man trying to get out of the bath. By the time his temperature had fallen to 102° F. he was entirely conscious, but the damage wrought was such that it was several days before he was perfectly clear in his statements. In this case the cause of the high temperature of the body was simply external heat. In the instance, detailed below, rheumatic irritation was the *materies morbi*.

This man was apparently doing fairly in a relapse of acute rheumatism, although his temperature had shown a distinct tendency to be very high. At 10:30 A. M. of the day in question he was seen by the Resident Physician of the Hospital, Dr. Bruen, who states: "When I saw him at 10:30 A. M. there was much less inflammation of the joints than on the preceding morning, and although his temperature was as it had been, 104° F., and, as I thought, a pericardial friction-sound could be heard, yet the man was doing fairly; perfectly rational, with a good pulse."

When I entered the ward about half-past twelve the patient was apparently dying. The pulse was between 160 and 170, exceedingly feeble and thready; the pupils strongly contracted, though not to pin-points; the respirations fifteen per minute, exceedingly irregular, mostly deep, jerking, and interrupted; the skin pale and dry; the consciousness completely lost, violent shaking and shouting in the ear only eliciting a few grunts; the temperature in the axilla $108^{\circ}.8$ F.; the wrists pale, and no signs of pain elicited by violently moving them. On ausculting the heart I could find no murmur; the first sound was very feeble, somewhat prolonged, and the second sharply accentuated.

Orders were immediately given to put the patient in a cold bath. The following is the record made at the time:—

- 1:24 P. M.—Patient put in a full bath at 60° F.
- 1:25½.—Shows signs of consciousness; will put out the tongue when loudly asked to do so.
- 1:27.—Seems to recognize that the bath is very cold, and struggles to get out.
- 1:30½.—Man has a fair degree of rationality. He has been in six minutes and a half, and is now ordered to be taken out at once.

One minute after the bath.—The patient was partially wiped and laid directly upon an ordinary blanket, and covered only with a sheet, in a room whose temperature was about 65° to 70° F. He has just received a hypodermic injection of six grains of quinine.

Three minutes.—Temperature in axilla, 94° F.; in mouth, 105°·6 F.

Eight minutes.—Temperature has been steadily falling; is now 103° F. in mouth. The man has become perfectly rational, and answers to his name.

The further history of this case is omitted as not pertinent to the matter in hand, with the statement that recovery finally took place.¹

This patient was not in the bath more than a minute and a half before he exhibited very distinct signs of returning consciousness, and in three minutes had sense enough to attempt to get out of the tub. What could the bath do to affect the man so much but withdraw the heat? That the heat was withdrawn, the thermometer proved. If the drowsiness had been due to simple congestion of the brain, very certainly would the bath, by driving the blood from the surface, have increased the trouble.

These cases might be abundantly paralleled and duplicated from medical records, but are sufficient to show that in man as well as in the lower animals the early withdrawal of the excess of heat is followed by subsidence of the symptoms. The result may be formulated in the following proposition:—

The withdrawal of the excess of heat in acute fever is followed by a relief of the nervous and circulatory disturbances.

Conclusions.—By the experiments and arguments set forth in this chapter, the following propositions have been proven:—

First. External heat applied to the body of normal animals, including man, so as to elevate the internal temperature, produces derangements of the functions of innervation, of respiration, of circulation, etc. etc. precisely similar to those seen in natural fever; the intensity of the disturbance being directly proportionate to the rise in temperature.

Second. Heat applied locally to the nerve centres and to the heart produces in the functions of these organs those disturbances which are familiar phenomena of fever, the intensity of the disturbances being directly proportionate to the excess of heat.

Third. The withdrawal of the excess of heat in acute fever is followed by a relief of the nervous and circulatory disturbances.

It would appear to follow as a direct corollary to these propositions that *excessive temperature is the essential symptom of fever.*

This seems to be true not only of severe, acute fever such as has been discussed here, but also of the lower grades of the febrile state. It must be borne in mind, however, that the course of the fever may modify or entirely suppress the symptoms which the increased temperature would normally produce. Thus it is conceivable that there should be a poison, which should at the same time increase tissue-change

¹ A full report may be found in my *Lecture on Fever*. *Smithsonian Miscellaneous Collections*, No. 292, February, 1875; *ib.* vol. xv., 1878.

and depress the heart, and thereby lower the frequency of the cardiac beat, and reduce the force of the circulation although distinctly causing fever. It is notorious that in disease, fever coexists with almost every conceivable condition of the circulation, and indeed, if we can believe clinical records at all, may occur or continue after the cessation of circulation, *i. e.* in the post-mortem rise of temperature. This clinical fact abundantly confirms the conclusion reached in our propositions, and at the same time reveals the effect of modifying circumstances upon the typical phenomena of fever. Peculiarities of symptoms found in continued fevers, therefore, do not militate against the theory here inculcated. Every clinician who has employed the cold water treatment of typhoid and other fevers must have noted the subsidence of the nervous and circulatory disturbance under the use of cold; results which are the counterpart of those which occurred in the more acute cases heretofore reported in this paper. The elaborate researches of Zenker (*Ueber die Veränderungen der willkürlich. Musk. in Typhus Abdominalis*, Leipzig, 1864) have demonstrated the profound nutritive disturbances which occur in febrile diseases—apparently the direct result of continued heat of a mild type. These researches have been confirmed by the experiments of Dr. M. Litten (*Virchow's Archiv*, May, 1876). This observer found that, when guinea pigs are kept for some days in air heated steadily to from 96°.8 to 98°.6 F., fatty degeneration of most of the tissues is produced. The liver is usually affected first, the heart next, then the kidneys, the striated muscles, and finally the cellular tissue and to some extent the mucous membranes become involved.

It would appear therefore that after these many centuries we must acknowledge, as now demonstrated, the aphorism evolved from shadowy premises by the genius of Galen, *nam essentia quidem febrium est in caloris præternaturem* (*De Diff. Febr.*, Liv. i., chap. i.).

Having reached the conclusion just announced, two questions naturally offer themselves as requiring answer before it will be possible to determine the true nature and mechanism of the fever process.

First. What is the mechanism by which the production and dissipation of animal heat is regulated in the animal organism?

Second. Is the rise of temperature in fever due to the excessive retention or to the abnormal production of heat, or to both of these conjointly?

To the consideration of these questions the next two chapters of this memoir are devoted.

CHAPTER II.

CONCERNING THE METHODS BY WHICH THE ANIMAL ORGANISM CONTROLS THE PRODUCTION AND DISSIPATION OF HEAT.

IN 1837, Sir Benj. Brodie (*Medico-Chirurg. Trans.*, 1837) observed the case of a man in whom, after a traumatic section of the spinal cord, the temperature rose in the course of a few hours to 111° F. Acting upon this hint, he made experiments upon animals, and found that in them, under certain circumstances, the temperature rose very greatly after division of the cord.

Studies of the effect of section of the cord upon the temperature have, since the time of Brodie, been made by very many observers, notably by Bernard (*Compt. Rend.*, 1852, 1853), Schiff (*Untersuchungen zur Physiologie des Nervensystems*, Frankfurt, 1855), Chossat (*Meckel's Archiv*, 1852), Tscheschichin (*Hierholzer's Archiv*, 1866), Naunyn and Quincke (*Ibid.* 1869), Rosenthal (*Centralblatt*, April, 1869), Binz (*Virchow's Archiv*, 1870), Henri Parinaud (*Archiv. de Physiologie*, 1871). It is hardly necessary to trace, step by step, the various views which have been held by these authors, and I shall only speak of the results obtained by the more recent observers—results which I have myself experimentally determined to be correct.

If the cord of a rabbit or other small mammal be cut in the lower cervical region, the temperature, as measured in the victim, at once falls; and if the air of the apartment be decidedly below the warmth of the body this fall is permanent, and even progresses so that at death the animal heat is several degrees below the normal. If however the animal be thoroughly wrapped in raw cotton or in wool, and if the external temperature be not too low, the fall just spoken of is but temporary, and is succeeded by a rise of temperature which passes beyond the normal point, so that the animal dies in a state of fever. In my own experiments, the cooling of the body after death has often taken place more slowly than normal, but I have never seen that post-mortem rise of temperature which has been noted by Naunyn and Quincke, and by other observers, but which appears to be only an occasional phenomenon that is absent in the majority of cases. According to my own experience, (and the testimony of other investigators is in accord with it,) if the external temperature be much below that of the body of the animal, no amount of wrappings will suffice to bring about the febrile reaction; and if an animal in which the fever has already come on be exposed to external cold, the temperature falls. The time that elapses between the division of the cord and the rise of temperature varies from a few minutes to many hours, and is dependent upon the external conditions.

If the animal be in a heated room, breathing heated air, the period of fall is a very short one. In none of my own trials, however, and in none of those reported by other observers, so far as I am aware, has the fall of temperature been altogether absent. In the experiments of Naunyn and Quincke, although the animal was put at once into a warm chest where the temperature was between 80° and 90° F., yet it was always several hours before the normal temperature was reached. The question here naturally arises, is the subsequent rise of temperature really due to the division of the cord, or is it due simply to the external heat to which the animal is exposed? An experiment apparently crucial as to this point was performed by Naunyn and Quincke. They first placed the uninjured animal in the warm box, and when after some hours no rise of its bodily temperature had occurred, divided the cord and replaced the animal in the warm chest, when intense fever came on in a very short time. Again these observers opened the spinal canal so as to completely expose the cord without cutting it, and placed the animal in the warm chest for the space of ten hours; at the end of this time the bodily heat had then risen six-tenths of a degree only. The following day the cord was divided and the animal replaced in the warm chest; in the first twenty minutes the bodily temperature fell nearly one degree, but rose three degrees in the next hour and twenty minutes, at the end of which time death occurred.

This comparatively rapid rise of temperature does not, however, always occur: thus in an experiment of Henri Parinaud (*op. cit.*, vi. p. 313), although the temperature of the uninjured animal finally rose higher than that of the injured, it at first rose more slowly. I have in a large number of cases seen the rise of temperature produced by exposure of an animal with cut cord to excessive heat (Experiments 41 to 46, in my paper on Nitrite of Amyl, *American Journal of the Medical Sciences*, July, 1871), but have performed only four experiments in which comparison was made.

EXPERIMENT 21.

A bitch.

TIME.	TEMP. OF CHEST	RECTAL TEMP.	REMARKS.
12:56 P. M.	83° 24 F.	102° 4 F.	
1:11	83.75		
1:26	82.76		
1:45	83.36		
1:56	83.53	104.9	Rise of temperature 2° 5 in hour; average temperature of chest, 83° 53.
2:20	.....	.....	Cord cut.
2:40	87.44	104.25	
2:55	87.55		
3:06	86.63		
3:25	86.18		
3:40	85.06	104	Fall of temperature 0° 25 in one hour; average temperature of chest, 86° 61.

EXPERIMENT 22.

A dog.

TIME.	TEMP. OF CHEST.	RECTAL TEMP.	REMARKS.
12:51 P. M.	89° 33 F.	103° 1 F.	
1:05	93.6		
1:20	94.7		
1:35	94.7		

Time.	Temp. of Chest.	Rectal Temp.	REMARKS.
1:51 p. m.	98° F.	107.6 F.	Rise 4°.5 in one hour; average temperature of hot chest, 94.
2	.....	.....	Cord cut at first dorsal vertebra.
2:31	89.42	101.5	
2:46	90.68		
3:10	87.8		
3:16	89.3	104.9	Rise 3°.4 in ½ hour—an hourly rate of 4°.6; average temperature of hot chest, 89°.3.

EXPERIMENT 23.

A dog.			REMARKS.
Time.	Box Temp.	Rectal Temp.	
12:33 p. m.	102°.1 F.	102°.65 F.	
1:48	99.7	105.44	Rise of rectal temperature, 2°.79; average box temp. 100.
2:50	.....	.....	Cord cut in upper dorsal region.
3:35	102.1	97.25	
4:35	100.17	99.05	Rise of rectal temperature, 1°.8; average box temperature 99.1.

EXPERIMENT 24.

A dog.			REMARKS.
Time.	Box Temp.	Rectal Temp.	
12:7 p. m.	99°.6 F.	103°.2 F.	
1:22	98.38	104.4	Rise of rectal temperature, 1°.2; average box temperature 99.
1:45	.....	.....	Cord cut in upper dorsal region.
1:52	99.3	103.1	
2:52	98.3	106	Rise of rectal temperature, 2°.9; average box temperature 98.3.

In looking over these experiments it will be seen that in the first the rise of the rectal temperature was nearly 2°.5 in an hour, before section of cord, but that after the operation the rectal temperature fell 0°.25, although the surrounding air was 3° warmer after than before the division of the cord. In the second experiment the rectal temperature rose practically at the same rate after and before division of the cord, although the surrounding temperature was over 5° lower after than before the section. In the third experiment in atmospheres of equal heat, before section the rectal temperature rose about one-half more than it did after section; whilst in the last trial the rise was double after section, although the surrounding temperature was less.

These experiments, taken in conjunction with those of Binz, Naunyn and Quincke, Parinaud, etc., lead to the conclusion that usually the animal heat rises faster in a hot atmosphere after than before section of the cord, but that in some cases the reverse occurs. According to my experience the stronger the animal the more probability there is of an excessive rise after division of the spinal cord.

Various theories have been propounded to account for the changes of temperature which follow section of the spinal cord. Any one of these theories may or may not be correct, all of them resting upon merely deductive reasoning, and no one of them having been demonstrated. Indeed up to the present moment, the primary question—Is the first fall of temperature due to a lessened production, or to an abnormal throwing off, of bodily heat?—really remains unanswered. It is to solve this problem that the next series of experiments, recorded in this chapter, were attempted.

According to Lavoisier (*Elements of Chemistry*, Robt. Kerr's Translation, p. 343, Edinburgh, 1790) the first person to make an instrument to measure heat given

off from a body was M. de la Place. The first to apply the calorimeter to the measuring of animal heat was M. Dulong, who detailed the account of his experiments to the French Academy in 1822, but did not publish it in full until 1841 (*Annales de chimie et de physique*, 3me série, tome i. p. 440). In June, 1823, M. Despertz obtained a prize from the French Academy for his paper upon the Causes of Animal Heat (*Annales de chimie et de physique*, tome xxvi. p. 337). In 1872 Dr. Senator (*Archiv für Anatomie, Physiologie und Wissensch. Medecin*, p. 1) gave to the world a very important paper, entitled Untersuchungen über die Wärmebildung, in which he described a calorimeter differing from that previously employed, in that the outer case was surrounded by a non-conducting medium. I shall not enter into a detailed description of any of these instruments, as elaborate historical matter is foreign to the intention of the present paper. It does, however, seem proper to state that the apparatus used by myself is similar in the general principles of its construction to that employed by Senator.

As some difficulty was met in making an apparatus which should stand the test of continuous work, and as the value of the present memoir is dependent upon the accuracy of the apparatus employed, a detailed account of it as finally perfected is offered.

The essential portion of the apparatus consists of a double metallic box, which is placed in some non-conducting substance contained in a wooden case or box. For the metal work the so-called "galvanized sheet-iron" was selected. It has stood the test of three years' intermittent work without rusting, and is much less expensive than copper.

The inner box, which rests on feet, (Pl. II. fig. 1, A) has in the end a movable circular lid (fig. 2, a) or door formed of heavy galvanized iron. Around the edge of the opening upon which this door fits is a series of screw posts (fig. 2, B), and in the lid are holes corresponding with these posts; just inside the line of these orifices is soldered a heavy wire. A piece of thick, soft rubber is also so shaped and perforated as to cover the box opening and to allow the posts to come through. When the outer iron covering and this piece of rubber are in position, thumb-screw nuts are tightly screwed down, so that the inner rim of the lid nips the india-rubber and makes a thoroughly water-tight joint.

The inner box (fig. 1, a) has running up from it at each end, a vertical pipe (B), tipped with a brass flange joint, of such length that, when the apparatus is in working position, it just reaches through the lid of the outer box, so that when a nozzle is screwed firmly down upon a leather washer a water-tight joint is formed. One of these pipes reaches nearly to the bottom of the inner box, the other opens at the top. In this way air forced in through one and out through the other has to circulate through the box. It is necessary to protect by heavy semicircular wires the long tube so that the animal cannot disturb it.

The outer box, also of galvanized iron, has a movable lid over its whole top. Some difficulty was experienced in getting a joint which, whilst allowing the lid to be easily shifted, should be both durable and tight. The following device was found to answer perfectly: The iron of the upright sides and ends of the outer box is so bent at right angles, first outwards and then upwards, as to offer a flat

horizontal surface of an inch in width, with an outer upright flange of at least an inch and a half in height. In order to make all tight, solder must be freely used at the corners of the box. In the space thus formed is cemented, by means of soft rubber dissolved in benzine, a thick piece of unvulcanized india-rubber. Upon the inner edge of the lid (fig. 3) is soldered a heavy wire (fig. 3, a). When the lid is placed in position, a strip of hard wood is laid over each edge and three or more clamps (fig. 1, x) are tightly screwed down upon it. The wire of course buries itself in the soft rubber, and a perfectly tight joint is obtained.

The lid has in it five holes, two of these (fig. 3, c) receive the tubes from the inner box; through a third (x) the stirrer projects, and the remainder (y) are fitted with milled screw-caps so that they can be opened or closed at will. These are for taking the temperature of the water as well as for the purpose of filling and emptying the box; they must be so placed that they are exactly over the space between the inner and the outer box, in order to allow the thermometer to descend readily.

When water is put into the large box the inner box floats upward with great force; to obviate this a pair of projecting pieces of iron (fig. 1, x) are riveted upon the inside of the larger box in such a way that when a bar is slipped under them it will hold the smaller box down in position. The stirrer consists of a broad piece of iron the length of the width of the inner box, with an iron rod fastened at right angles to it; the flat part when the apparatus is in working condition lies upon the bottom, and as it can be drawn up and down by the iron rod, it affords an efficient means of producing agitation in the water.

When the apparatus (fig. 1) is arranged for use, the animal is placed in the inner box, and between the boxes is a layer of water (w), and surrounding the whole is sawdust, cow's hair, or other non-conductor (s). One of the tubes from the inner box communicates directly with the open air, the other with a pump which draws a current of air through the box and through a gas meter. The air drawn from the box passes around and about a thermometer bulb, so that its temperature is readily taken. If the temperature of the air as it enters and as it leaves the box be known, and also its quantity, and if, likewise, the quantity of the water and the weight of the iron containing it, and also their temperature when the animal is put in and when it is taken out be ascertained, it is a very simple matter to calculate the amount of heat given off by the animal.

The calorimeter, as described thus far, makes no provision for estimating the heat lost or gained by vaporization or condensation of moisture within the chamber. In some European instruments this difficulty is avoided by leading the exit tube at some length around through the water which is kept at a low temperature so as to condense all the vapor. The objections to this arrangement are to my thinking apparent. In the first place, heat may be obtained by condensation of vapor coming in with the external air, especially as the water should be cooler than the air, for reasons to be mentioned directly; in the second place, the completeness of the condensation is always uncertain. A more accurate plan is found in the analysis for moisture, of a measured sample of the air leaving the box, and also of that entering the box, by means of sulphuric acid bulbs or chloride of calcium tubes.

In some of our experiments the samples drawn off from the main currents of air

were examined not only for moisture but also for carbonic acid gas, so that the elimination of carbonic acid was studied along with the development of animal heat.

There is, of course, loss of heat from the most perfect calorimeter. At first sight this may appear of no importance in relative experiments. Experience, however, has shown that the instrument, unless used with great care, yields the most fallacious results. In testing the apparatus, of the two non-conducting packing materials employed, fine, perfectly dry sawdust seemed to yield the best results. But even with it, especially when the water was much above the temperature of the air, the loss of heat was more or less irregular, unless great care was employed. The first precaution to be taken is to have the apparatus itself of a uniform temperature throughout; so that water, iron, and sawdust should all be one in this respect. Over-warming the apparatus previous to use, or using it when it is decidedly below the temperature of the water, is equally fatal to accuracy.

The amount of loss from the calorimeter is of course directly dependent upon the relation between its temperature and that of the external air; the greater the difference the greater the loss.

The question very early arose as to whether the temperature of the water should approximate that of the air or that of the animal. A trial soon showed that when the water was near the temperature of the animal, the loss of heat from the calorimeter was not only enormous but also very irregular on account of the difficulty of heating the apparatus uniformly through to such a temperature. Again, an animal taken out of an ordinary room and thrust into a confined chamber heated to 100° F. or thereabouts, suffers violence in its environment, and is put under such unnatural conditions as to vitiate more or less the result. The correct use of the calorimeter evidently depends upon the keeping of its temperature equable, and as near as may be to that of the external air. It should always, in winter, be used in a room heated steadily to 70° F.

In order to show in a measure the loss of heat from the apparatus, the following series of trials were made with the two calorimeters with which nearly all the work of the paper was performed. In these trials the temperature of the water was a little above that of the external air, and the air was drawn through the inner box at a steady rate.

Trial No. 1.—Largest Calorimeter.

TIME.	BOX TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX.
2:30 P. M.	76.91 F.	71.96 F.		
2:45		71.33		
3		71.33		
3:15		72.42		
3:30	76.52	72.72	0.39 F.	5.76 F.

Trial No. 2.—Largest Calorimeter.

TIME.	BOX TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX.
10:53 A. M.	74.3 F.	65.12 F.		
11:10		64.22		
11:25		64.31		
11:40		64.31		
11:53	74	64.58	0.3 F. ¹	9.7 F.

¹ The apparatus had been running several hours before at a very high temperature, 100°, and though effort was made to get it uniformly cooled, the amount of loss may have been affected.

TIME.	Box TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX
12:08 P. M.	74.52 F.	64.58 F.		
12:23		64.67		
12:38		64.67		
12:55		64.88		
1:08		65.12		
1:23		64.80		
1:38	73.79		0.23 F.	9.1 F.
1:48	70.34	65.90		
2:05		65.66		
2:20		65.96		
2:35		65.96		
2:48	70.16	66.68	0.18	4.2
3:05		66.68		
3:20		66.56		
3:35		66.56		
3:48	69.98	66.68	0.18	3.4

Trial No. 3.—Largest Calorimeter.

TIME	Box TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX.
10:33 A. M.	62.96 F.	59 ^o .5 F.		
10:48		58.9		
11:03		58.9		
11:18		59.5		
11:33	62.72	59.7	0.24 F.	3 ^o .84 F.
11:48		58.9		
12:03 P. M.		60.1		
12:18		60.4		
12:32		60.5		
12:48		60.7		
1:03		60.8		
1:18	62.32	61.4	0.23	2.52
1:33		61.1		
1:48		61.1		
2:03		60.4		
2:18	62.20	60.5	0.12	1.42
2:33		61.3		
2:48		61.3		
3:03		61.5		
3:18		61.6		
3:33	62.01	61.7	0.08	0.60
3:48		61.6		
4:03		61.6		
4:18		61.6		
4:33	62.00	61.5	0.09	0.60

Trial No. 4.—Largest Calorimeter.

TIME	Box TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX.
11:39 A. M.	70.79 F.	65.48 F.		
11:54		65.40		
12:09 P. M.		65.48		
12:24		65.48		
12:39		65.90		
12:54				
1:09	70.43	66.68	0.24 F.	4.9 F.
1:25		67.76		
1:40		68.00		
1:55		67.54		
2:09	70.25	68.36	0.18	2.75
2:20		68.63		
2:35		68.63		
2:45		69.62		
3:09	70.11	70.52	0.14	1.00

¹ The apparatus had been running several hours before at a very high temperature, and though effort was made to get it uniformly cooled, the amount of loss may have been a little less.

Trial No. 1.—Small Calorimeter.

TIME.	BOX TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX.
11:56 A. M.	82°.01 F.	74°.57 F.		
12:15 P. M.		74.66		
12:30		74.48		
12:45		75.29		
12:56	81.41	75.38	0°.63 F.	6°.85 F.
1:15		75.08		
1:30		75.38		
1:45		75.80		
1:56	80.63	76.37	0.78	5.40
2:15		76.46		
2:30		76.28		
2:45		76.19		
2:56	80.14	76.19	0.49	4.10
3:15		75.56		
3:30		75.80		
3:45		75.47		
3:56	79.70	75.47	0.44	4.20

Trial No. 2.—Small Calorimeter.

TIME.	BOX TEMP.	AIR TEMP.	HOURLY LOSS OF BOX TEMP.	AVERAGE DIFF. BET. AIR AND BOX.
1:32 P. M.	82°.22 F.	72°.68 F.		
1:47		72.41		
2:02		72.32		
2:17		72.77		
2:32		73.66		
2:47		72.95		
3:02	81.22	73.04	0°.67 F.	8°.90 F.
3:17		73.55		
3:32		73.55		
3:47		74.30		
4:02	80.60	74.39	0.62	7.14
4:17		73.76		
4:32		74.48		
4:47		74.12		
5:02	80.12	74.21	0.48	6.17

Extended comment upon these tables does not seem necessary. They appear to show conclusively that the nearer the apparatus is in temperature to the air the less the chance of serious error; also that in comparative experiments, when the calorimeter is above the temperature of the air, the least chance of serious error is to be obtained by maintaining the conditions uniform during the whole experiment, rather than by attempting to calculate the amount of heat lost by the calorimeter under varying conditions. Besides the trials reported, a number of others were performed in which the calorimeter was *below* the temperature of the air. These conclusively proved what is, *à priori*, probable, that, when the difference of temperature is not more than three degrees, the calorimeter works with almost exact accuracy; there is of course no loss of heat from the calorimeter, and its power of absorbing caloric from the air seems to be nil. Unfortunately I did not appreciate the importance of having the calorimeter cooler than the air until late in the investigation, but relied for accuracy upon maintaining similar conditions throughout each single experiment, and keeping the difference between the temperatures of the air and calorimeter as little as possible. The chief safeguard against error has seemed to me to be found in having a number of experiments. If in such a series of similar relative experiments upon animals the result is at the same time fairly uniform and very decided in one direction, it is practically demonstrated that the

errors of the instrument are decidedly less than the margin of increase or decrease of the heat lost.

The complete apparatus¹ which I have employed consists of two parts: 1st, the apparatus for analyzing the air of the room; 2d, the calorimetric apparatus proper. The first of these is composed of an aspirator, meter, barium tubes, and sulphuric acid bulbs, or chloride of calcium tubes. The second (Pl. I.) consists of the calorimeter proper (a) already described, sulphuric acid bulbs (b), tubing, two meters, and a large and small air pump. When it is arranged and working, the air, whose temperature is measured by a thermometer hanging near by, enters the calorimeter at x, and emerges at y; immediately after this the current is tapped by means of a side pipe (z) whose end projects as a sort of nipple into the centre of the lower of the larger tubes. Directly afterwards the main current passes over the bulb of the thermometer (t), by the scale of which its temperature may be read. It then passes on to the large or "air meter" (m) and out through the air pump (p). The sample, immediately after being drawn out at z, passes through the sulphuric acid bulbs and is robbed of its water; travelling onward it loses its carbonic acid in the tubes (b) which contain a solution of caustic barium. Finally, having registered its quantity in the small or "sample meter" (m'), it is drawn into the aspirating bottles (v v). It is plain that the sum of the amounts registered in the large and small meters is the quantity of the air which has in any given time passed through the box. There are one or two details in the running of the apparatus, not yet mentioned, worthy of specific notice. It is necessary to take especial precautions that no moisture is deposited in the tubing before the bulbs (s) are reached; hence the bulbs should be placed as near as possible to the orifice (y), and the tubes should be made exclusively of wood and rubber. In order to render the thermometer-joint tight, melted paraffine should be poured into it.

Before detailing the calorimetric experiments, it is perhaps best to give an explanation of the methods of recording and of calculation. This can be done most clearly and briefly by presenting as an example the report of a portion of an actual experiment.²

TIME.	AIR TEMP. (Fahr.)	TEMP. (Fahr.)	BOX TEMP. (Fahr.)	RECTAL TEMP. (Fahr.)	GEN. METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM (grms.)	...
1:59 p.m.	61.3	67.3	67.2	102.9	169.88	98.725	17.1079	11.0000	...
2:14	64.9	66.6							...
2:29	65.1								...
2:44	66.2	66.6							...
3:14	67.	67.8							...
3:29	66.2	67.4	67.6	100.76	253.12	98.9601	17.4142	11.1184	...
	65.62 (mean)	67.11	0.4 (gain)	2.14 (loss)	83.24	0.2351	0.3063	0.1184 (gain)	...
		65.62			0.2351				...
		1.52			83.4751				...

¹ It is allowable to state that great pains had been taken to insure accuracy in the apparatus. The meters were "Godwin's Experimental Meters," tested with the greatest care. The tubes were all laboriously compared with the normal one in the physical laboratory of the University. Tables were formed of their variations, and the recorded temperatures are corrected temperatures.

² In this memoir, unless otherwise distinctly stated, the temperatures are according to Fahrenheit scale; the air measures (general, sample, and air meters) in cubic feet; and the carbonic acid (also CO, when mentioned) in grammes.

In examining this table it will be seen that the first four narrow columns, after the time record, are taken up with registers of temperature: the first of these represents the temperature of the air as it enters the box; the second that of the air as it leaves the box, both taken every fifteen minutes. The figures at the bottom of these two columns represent the respective averages, and it is plain that if the smaller number be subtracted from the larger the average gain or loss of heat by the air during its passage will be ascertained. Thus in the table given, the second column, that of exit, gives an average of 67°.14; whilst the first column, that of entrance, gives an average of 65°.62, showing that the air gained an average of 1°.52 during its passage. If, however, the average of the first column had been 67°.14, and that of the second 65°.62, it would have shown that the air had cooled 1°.52 during its passage. It is plain that the gain or loss of heat by the air in flowing through the box must be respectively added to or subtracted from the heat given to the calorimeter by the animal in order to determine the dissipation of heat by the latter. To do this it is necessary that the calculation be made in heat units. I have adopted the English unit of heat, namely, the amount of heat required to raise one pound of water one degree Fahrenheit, because the scales of the various instruments employed conform most readily with this standard.

The amount of heat employed in elevating the temperature of any body is calculated by the well-known formula $Q = W \times t \times \text{sp. h.}$, in which Q is the quantity of heat employed, W the weight of the body, t the temperature which it is raised, and sp. h. the specific heat of the body. In applying this formula to the air in the experiments a difficulty presented itself. The quantity of the air which has passed through the box and been cooled or heated is easily known. The first broad column of the table gives the readings of the general meter before and after the experiment; subtracting the first number from the second gives the amount of air which has passed through the large general meter; add to this the amount which has passed through the sample meter (registered in second broad column), and the whole quantity of air which has been drawn through the box is known. The weight of a cubic foot of air at 32° F. is 0.08073 lb. The air in the box is of various temperatures in different experiments, and is always much expanded by the heat; hence it is necessary to reduce by calculation the volume of the air to what it would be if the box were cooled to 32° F. In doing this I have considered the temperature of the air of the box as that at which it emerges. This is not strictly correct, but the error is so small as to be of no possible importance. Taking then this temperature, and using the following letters to signify as given below, the calculation becomes a simple one. V = quantity of air in cubic feet at 32°. V' = known quantity of air at a known temperature. t' = number of degrees this quantity is heated above 32°. Then $V + [V \times t' \times 0.002035$ (coefficient of expansion)] = V' . Using as a type the experiment recorded above, we have

$$V' = 83.475. \quad t' = 67°.14 - 32° = 35.14. \quad V + (V \times 35.14 \times 0.002035) = 83.475.$$

$$V + 0.0715 V = 83.475. \quad V = \frac{83.475}{1.0715} = 77.9 \text{ cub. ft.}$$

The quantity of air at 32° being known, the weight is readily ascertained:

$$W = V \times 0.08073 \text{ (weight of 1 cubic foot at 32° F.)} = 6.289 \text{ lbs.}$$

The elevation of the temperature of the air during its passage, in the experiment under discussion, is $t = 1.52$ in the formula, $Q = W \times t \times \text{sp. h.}$ The specific heat of air is 0.2374, and the formula becomes

$$Q = 6.289 \times 1.52 \times 0.2374 = 2.2694.$$

The heat given to the air by the animal is therefore 2.2694 units.¹

The animal in the box is constantly giving off moisture, and heat is becoming in this way insensible; condensation of moisture also may or may not be going on in the box. In order to estimate the disturbance of heat in this way, as already explained, calcium tubes or sulphuric acid bulbs were employed. The gain of weight of the sample in calcium tubes, as shown in its appropriate column, is 0.1184 gramme. In order to determine how much moisture is in the air coming from the box, the amount of the sample (0.2351) is divided into the whole amount of air passed through the box, and the moisture in the sample is multiplied by the resultant, which represents the proportion between air and sample, and is known in this

measure as the *quotient for the box*. Thus $\frac{83.4751}{0.2351} = 355 = \text{quotient for the box.}$

Thus $0.1184 \text{ gramme} \times 355 = 42.032 = \text{whole amount of moisture coming from the box.}$ By a similar process the amount of moisture entering the box is calculated. The "*quotient for air*" is obtained by dividing the whole amount of air passed through the box by the amount of the air analyzed in the outside apparatus. Then this is multiplied by the amount of moisture found in the analyzed air.

Thus $\frac{83.4751}{0.3063} = 272.5 = \text{quotient for air.}$ $272.5 \times 0.0579 = 15.778 = \text{moisture}$

entering the box.	Moisture leaving box,	42.032 grammes.
	Moisture entering box,	15.778 grammes.
	Moisture evaporated in box,	26.254 grammes.

¹ Strict accuracy would of course require that allowance be made for barometrical variations, and that the pressure be reduced to the standard pressure 29.92 inches. This has not been done in any of my experiments, because the resultant error is so small as to be of no importance whatever. The experiments were mostly performed in the course of a few successive hours, and changes in the barometer in such a period rarely amount to 0th.5. Assuming 30 inches as the standard, and that in the present instance the barometrical pressure was 30th.5, the calculation would be

$$V = \frac{V'' \rho''}{\rho'} = \frac{83.475 \times 30.5}{30} = 84.87, \quad V' = \frac{84.87}{1.0745} = 79.2, \quad W = V' \times 0.08073 = 6.394$$

$$Q = 6.394 \times 1.52 \times 0.2374 = 2.3072.$$

It will be seen that the difference between this result and that arrived at is only 0.0378. When it is borne in mind that the supposed barometrical variation is extreme, that the experiments are so relative, and that in final comparisons of results no decimals are of any importance, it is plain that no injury is done by the omission of barometrical allowances. Even in the fever experiments, assuming for a possible barometrical variation of one inch, only the second decimal would be affected and to a very slight extent. It must be borne in mind that absolute accuracy cannot be expected in any of these measurements of heat production, and that the truth of a fact can only be established by the variations of heat production being so large and so constant as to remove the danger of error. Errors must sometimes preponderate in one direction, sometimes in another, and if results are generally the same, the error must be unimportant.

This is then divided by 497.603 to reduce it to pounds, and becomes 0.05276 lb. A pound of water requires 79.25 heat units to vaporize it; and $0.05276 \times 79.25 = 4.181 =$ units of heat expended in process of vaporization in the box. The same result will of course be obtained by dividing the 26.255 by 6.2789, since $\frac{497.603}{79.25} = 6.2789$.

In the fourth column of the tabulated report of the experiment, is given the temperature of the water in the box at the commencement and at the end of the time during which the animal was in the calorimeter; the difference, which is stated at the bottom of the column, of course represents the gain of temperature by the water, and in the present instance is 0.4. It is evident that the metal of the calorimeter shares with the water in this increase of temperature, and that this heat must be estimated. The most convenient form is to calculate first the thermal equivalent of the calorimeter as the basis of experimentation. Thus, in the largest instrument employed in my experiments, there were 157 pounds of water and 60 pounds of iron. The specific heat of water at the temperature of 60° is very nearly 1.002, of iron 0.11379, suppose $t = 1$.

$$\begin{aligned} q &= w \times t \times \text{sp. h.} = 157 \times 1 \times 1.002 = 157.314 \\ q &= w \times t \times \text{sp. h.} = 60 \times 1 \times 0.11379 = 6.8274 \end{aligned}$$

The amount of heat required to raise calorimeter 1° F. 164.1414 units.

In the experiment under consideration it is plain that $164.1414 \times 0.4 = 65.6565$ units = the amount of heat imparted to the calorimeter.

Finally the calculation is summarized as follows:—

Heat given to air	2.2694
Heat expended in vaporization	4.181
Heat given to calorimeter	65.6565
Total gain of heat in 1½ hours, in excess of that lost by the apparatus	72.1069
Hourly gain of heat, in excess of that lost by the apparatus, expressed in English units	48.0713

In many of the experiments an attempt was made not only to measure the amount of heat given off, but also the production of carbon dioxide. The sample of air taken from the box current was analyzed, and the amount of carbon dioxide contained in it on being multiplied by the quotient for the box gave the total amount (a) of carbon dioxide coming from the box. Then the amount of gas contained in the sample of air analyzed multiplied by the quotient for the air gave the quantity of the dioxide which entered the box (b). Subtracting these results, b from a, the total elimination of carbonic acid by the animal became known.

One of the most common methods employed in the determination of carbon dioxide (CO₂) consists in conducting the evolved gas into a solution of calcium hydrate, and after allowing sufficient time for the amorphous calcium carbonates to become crystalline, filtering it. After washing it is decomposed with an acid, and the

liberated CO_2 caught in weighed soda-lime tubes, or Liebig's bulbs, and the amount of CO_2 ascertained by the difference in weight.

The method of Pettenkofer for the absorption and estimation of gaseous carbon dioxide is far superior to the above procedure, and was, therefore, the one adopted in the investigation.

It is as follows: Normal solutions of barium hydrate and oxalic acid are first prepared. The solution of the latter is so arranged that one litre will contain 2.8636 grms. crystallized oxalic acid. The latter should not show any signs of weathering or be moist; should be dried several hours over H_2SO_4 before use. The water employed in the experiments is freed from carbon dioxide by boiling. The concentration of the barium hydrate is so arranged that 1 cub. cm. of it will correspond to 3 cub. cms. of oxalic acid; but, when only small quantities of CO_2 are to be absorbed, the concentration of both liquids is about the same, *i. e.*, 1 cub. cm. of $\text{Ba}(\text{HO})_2 = 1$ cub. cm. of $\text{C}_2\text{H}_2\text{O}_4$.

After having prepared these solutions of known strength, and by experiment satisfied yourself as to the relation they bear to each other, introduce a measured volume of $\text{Ba}(\text{HO})_2$ into one or more long glass tubes, which are placed in an inclined position, and permit the carbon dioxide to stream through the liquid. When the absorption is complete, and the experiment finished, the liquid $\text{Ba}(\text{HO})_2$ is titrated and the quantity of CO_2 ascertained from the difference in the first and second titrations.

In the first series of experiments of this chapter the amount of heat dissipated and carbon dioxide produced hourly having been obtained in the uninjured animal, the spinal cord was divided and the dog replaced in the apparatus. On his removal the hourly dissipation of heat and production of carbonic acid were determined, and it became a very simple matter to estimate the change of heat dissipation and of carbonic acid production which followed the section of the cord.

The experiments are as follows: In some of them the heat lost in vaporization was not noted, but the variation in the vaporization before and after section was so slight in the experiments in which it was noted, that the omission does not at all invalidate the results.

EXPERIMENT 25.

A dog; weight 18 pounds.

Time.	Air TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	A CALCIUM TUBE. (grms.)	
1:59 P.M.	64.3	67.3	67.2	102.9	169.88	98.725	17.1079			
2:14	64.9	66.6								
2:29	65.1									
2:44	66.2	66.6								
3:14	67.	67.8								
3:29	66.2	67.4	67.6	100.76	253.12	98.9601	17.4142			CO_2 in sample
	65.62 (mean)	67.14 (gain)	0.4 (gain)	2.14 (loss)	83.24	0.2351	0.3063	0.1184 (gain)	0.0579 (gain)	CO_2 in air
		1.52 (gain)			83.4751					

4 P. M. — Cord cut at 5th cervical vertebra; very little bleeding; complete paraplegia.

4:15 P. M. — Rectal temperature, $101^\circ.5$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS. (grms.)
4:45 P.M.	65.3	67.9	68.05		277.23	98.9601	17.4142			
5	65.4	68.0								
5:15	65.2	67.8								
5:30	65.2	68.0								
5:45	65.7	68.1								
6	66.1	68.2								CO ₂ in sample 0.018
6:15	66.7	68.2	68.9	89	358.34	99.0573	17.5905			CO ₂ in air 0.0065
	65.66	68.03	0.85		81.110	0.0972	0.1763	0.0651	0.0409	
	(mean)	65.66	(gain)					(gain)	(gain)	
		2.37			81.2072					
		(gain)								

BEFORE SECTION.

Quantity of air (V') = 83.4751 at 67°-32° = 35.14 = t'. $V + (V \times t' \times 0.002035) = V'$.

$$V = \frac{83.4751}{1.0715} = 77.9. \quad W = V \times 0.08073 = 6.289.$$

Rise in temp. of air 1.52 = t. $Q = W \times t \times \text{sp. h.} = 6.289 \times 1.52 \times 0.2374 = 2.2694 = \text{heat given to air.}$

Quotient for box $\frac{83.4751}{0.2351} = 355 \times 0.1184 = 42.032 = \text{moisture leaving box.}$

Quotient for air $\frac{83.4751}{0.3063} = 272.5 \times 0.0579 = 15.778 = \text{moisture entering box.}$

$26.254 = \text{moisture vaporized in box.}$

$\frac{26.254}{6.2789} = 4.181 = \text{heat expended in vaporization.}$

Rise in temp. of water $0.4 \times 164.1414 = 65.6565 = \text{heat given to calorimeter.}$

$2.2694 = \text{heat given to air.}$

$4.181 = \text{heat expended in vaporization.}$

$72.1069 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$

Hourly dissipation of heat 48.0713

AFTER SECTION.

Quantity of air (V') = 81.2072 at 68°-32° = 36.03 = t'. $V + (V \times t' \times 0.002035) = V'$.

$$V = \frac{81.2072}{1.073} = 75.6. \quad W = V \times 0.08073 = 6.1.$$

Rise in temp. of air 2.37 = t. $Q = W \times t \times \text{sp. h.} = 6.1 \times 2.37 \times 0.2374 = 3.4321 = \text{heat given to air.}$

Quotient for box $\frac{81.2072}{0.0972} = 835.4 \times 0.0651 = 54.3845 = \text{moisture leaving box.}$

Quotient for air $\frac{81.2072}{0.1763} = 460.6 \times 0.0409 = 18.8385 = \text{moisture entering box.}$

$35.546 = \text{moisture vaporized in box.}$

$\frac{35.546}{6.2789} = 5.661 = \text{heat expended in vaporization.}$

Rise in temp. of water $0.85 \times 164.1414 = 139.5202 = \text{heat given to calorimeter.}$

$3.4321 = \text{heat given to air.}$

$5.661 = \text{heat expended in vaporization.}$

$148.6133 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$

Hourly dissipation of heat 99.0755

SUMMARY.

Hourly dissipation of heat after section 99.0755

Hourly dissipation of heat before section 48.0713

Gain in hourly dissipation of heat following section 51.0042

Carbonic Acid.

BEFORE SECTION.

$$0.0357 \times 355 = 12.6735 \text{ grammes CO}_2 \text{ leaving box.}$$

$$0.007125 \times 272.5 = 1.9415 \text{ grammes CO}_2 \text{ entering box.}$$

Production of carbonic acid in 1½ hours 10.732 grammes.

Hourly production of carbonic acid 7.1547 grammes.

AFTER SECTION.

$$0.018 \times 835.4 = 15.0372 \text{ grammes CO}_2 \text{ leaving box.}$$

$$0.0065 \times 460.6 = 2.9939 \text{ grammes CO}_2 \text{ entering box.}$$

Production of carbonic acid in 1½ hours 12.0433 grammes.

Hourly production of carbonic acid 8.0288 grammes.

SUMMARY.

Hourly production of carbonic acid after section 8.0288 grammes.

Hourly production of carbonic acid before section 7.1547 grammes.

Increase of hourly production of carbonic acid following section 0.8741 grammes.

EXPERIMENT 26.

A large terrier; weight 25 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	Scale Reading
12:12 P. M.	81° 6	80° 96	76° 7	102° 4	610.51	77.002
12:27	82.4	81.3				
12:42	81.6	81.4				
12:57	83.2	81.9				
1:15	82	81.9				
1:30	82.3	82.2				
1:45	83.3	83.6				
2	83.6	84.4				
2:12	84.5	84.2	79.2	103.46	777.04	77.0017
	82.72	82.43	2.5	1.06	166.53	0.3405
	82.43	(mean)	(gain)	(gain)	0.3405	
	0.29 (loss)				166.8705	

Cord cut between second and third dorsal vertebrae at 2:41 P. M.; rectal temperature 103° 46.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	Scale Reading
3:20 P. M.	85° 7	86°	75° 8	864.25	77.001
3:35	85.4	85.5			
3:50	85.2	85.			
4:5	85.9	86.4			
4:20	85.5	85.5			
4:35	85.3	85.			
4:50	85.3	84.4			
5:5	85.	83.9			
5:20	84.8	84.5	79.4	1031.04	77.0088
	85.34	85.13	3.6	166.79	0.3178
	85.13	(mean)	(gain)	0.3178	
	0.21 (loss)			167.1078	

BEFORE SECTION.

Quantity of air (V') = 166.8705 at $82^{\circ}.43 - 32^{\circ} = 50.43 = t'$. $V + (V \times t' \times 0.002035) = V'$

$V = \frac{V'}{1.1} = 151.7$. $W = V \times 0.08073 = 12.24$. Fall in temp. of air $0.29 = t$.

$Q = W \times t \times \text{sp. h.} = 12.24 \times 0.29 \times 0.2374 = 0.8427 = \text{heat taken from air.}$

Rise in temp. of water 2.5. $164.1414 \times 2.5 = 410.3535 = \text{heat given to calorimeter.}$

$0.8427 = \text{heat taken from air.}$

$409.5108 = \text{heat dissipated in two hours.}$

Hourly dissipation of heat 204.7554

AFTER SECTION.

Quantity of air (V') = 167.1078 at $85^{\circ}.13 - 32^{\circ} = 53.13 = t'$. $V + (V \times t' \times 0.002035) = V'$.

$V = \frac{167.1078}{1.108} = 150.8$. $W = V \times 0.08073 = 12.17$. Fall in temp. of air $0.21 = t$.

$Q = W \times t \times \text{sp. h.} = 12.17 \times 0.21 \times 0.2374 = 0.6067 = \text{heat taken from air.}$

Rise in temp. of water 3.6 $\times 164.1414 = 590.909 = \text{heat given to calorimeter.}$

$0.6067 = \text{heat taken from air.}$

$590.3023 = \text{heat dissipated in two hours.}$

Hourly dissipation of heat 295.1511

SUMMARY.

Hourly dissipation of heat after section 295.1511
 Hourly dissipation of heat before section 204.7554

Hourly increase of heat dissipation following section 90.3957

Carbonic Acid.—In this experiment the apparatus for the analysis of the air broke down, and consequently no account was obtained of the amount of carbonic acid entering the box. *Before section*, however, the whole amount of carbonic acid, which was contained in the air leaving the box, was 2.457954 grammes; whilst, after section, the air yielded 4.41007 grammes of the acid. It is evident, therefore, that there was a decided increase in the elimination of the gas following section, although it is not possible to state exactly the amount of such increase.

EXPERIMENT 27.

A long-haired cur; weight 32 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METEOR. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS (grms.)
12:52 P. M.	68 ^o .9	68 ^o .8	67 ^o .3	102 ^o .5	413.311	0.0	28.6			
1:17	68.1	68.9								
1:22	68.4	68.8								
1:37	68.1	68.5								
1:52	68.6	69.2								
2:7	69.4	69.4								CO ₂ in sample 0.016125.
2:22	69.5	70	68.45	102.5	488.03	0.0937	28.7067			CO ₂ in air 0.0055.
	68.71 (mean)	69.08	1.15 (gain)	0.0	74.719	0.0937	0.1067	0.0509 (gain)	0.0236 (gain)	
		0.37 (gain)			74.8127					

2:40 P. M.—Cord cut at 5th cervical vertebra. The breathing instantly became very labored; at 3:4 P. M. the animal was intensely cyanotic, the lips and mouth blue. Rectal temp. 102^o.5.

TIME.	AIR TEMP. (Fah.)	TEMP. TUBE. (Fah.)	TEMP. BOX (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (GRMS.)	AIR CALCIUM TUBE. (GRMS.)	CO ₂ in
3:19 P.M.	71.8	71.1	67.5		506.07	0.0937	7067			
3:34	70.9	71.2								
3:49	70.8	71.1								
4:1	71.3	71.1								
4:19										
4:34	72.1	72.1								CO ₂ in
4:49	72.9	72.9	69.2	97.16	579.65	0.1689	28.9022			CO ₂ in
	71.63 (mean)	71.58	1.7 (gain)		73.58	0.0752	0.1955	0.0412 (gain)	0.0427 (gain)	
		0.05 (gain)			73.6552					

BEFORE SECTION.

Quantity of air (V) = 74.8127 at 69° 08'—32° = 37.08 = V.

$V + (V \times v \times 0.002035) = V'$. $V = 70$. $W = V \times 0.08073 = 5.651$.

Rise in temp. of air 0.37 = t. $Q = W \times t \times \text{sp. h.} = 5.651 \times 0.37 \times 0.2374 = 0.4963 = \text{heat given to air.}$

Quotient for box $\frac{74.8127}{0.0937} = 798.4 \times 0.0509 = 40.6385 \text{ grammes} = \text{moisture leaving box.}$

Quotient for air $\frac{74.8127}{0.1067} = 701.1 \times 0.0236 = 16.5459 \text{ grammes} = \text{moisture entering box.}$

24.0926 grammes = moisture vaporized in box.

24.0926 = 3.837 = heat expended in vaporization.

6.2789

Rise in temp. of water 1.15 $\times 164.1414 = 188.7626 = \text{heat given to calorimeter.}$

3.837 = heat expended in vaporization.

0.4963 = heat given to air.

193.0959 = heat dissipated in 1½ hours.

Hourly heat dissipation 128.7306

AFTER SECTION.

Air practically unchanged in temperature in its passage through the box.

Quotient for box $\frac{73.6552}{0.0752} = 979.4 \times 0.0412 = 40.3513 \text{ grammes} = \text{moisture coming from box.}$

Quotient for air $\frac{73.6552}{0.1955} = 376.7 \times 0.0427 = 16.085 \text{ grammes} = \text{moisture entering box.}$

24.2663 grammes = moisture vaporized in box.

24.2663 = 3.865 = heat expended in vaporization.

6.2789

Rise in temp. of water 1.7 $\times 164.1414 = 279.0403 = \text{heat given to calorimeter.}$

0.0 = heat given to air.

3.865 = heat expended in vaporization.

282.9053 = heat dissipated in 1½ hours.

Hourly heat dissipation 188.6035

SUMMARY.

Hourly dissipation of heat after section 188.6035

Hourly dissipation of heat before section 128.7306

Hourly increase of heat dissipation following section 59.8729

Carbonic Acid.

BEFORE SECTION

0.016125 $\times 798.4 = 12.8742 \text{ grammes CO}_2 \text{ leaving box.}$

0.0055 $\times 701.1 = 3.8561 \text{ grammes CO}_2 \text{ entering box.}$

9.0181 grammes = CO₂ produced in 1½ hours.

CO₂ produced in 1 hour 6.012 grammes.

AFTER SECTION.

$$0.0155 \times 979.4 = 15.1807 \text{ grammes CO}_2 \text{ leaving box.}$$

$$0.0075 \times 376.7 = 2.8252 \text{ grammes CO}_2 \text{ entering box.}$$

$$12.3555 \text{ grammes} = \text{CO}_2 \text{ produced in } 1\frac{1}{2} \text{ hours.}$$

$$\text{CO}_2 \text{ produced in 1 hour } 8.237 \text{ grammes.}$$

SUMMARY.

$$\text{CO}_2 \text{ produced hourly after section } 8.237 \text{ grammes.}$$

$$\text{CO}_2 \text{ produced hourly before section } 6.012 \text{ grammes.}$$

$$\text{Hourly increase in carbonic acid production following section } 2.225 \text{ grammes.}$$

EXPERIMENT 28.

A moderate sized poodle dog. Weight 18 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	REMARKS.
12:33 P.M.	82°.5	80°.2	73°.3	102°.2	146.348	73.2068	
1:3	83.5	80.7					Evaporated moisture not noted because the air meter met with an accident which rendered its readings void.
1:18	84.7	81.3					
1:33	84.7	81.6					
1:48	84.7	82.04					
2:3	83.43	81.48					
2:18	83.22	82.04					
2:33	83	83.06	74.72	102.2	295.312	73.5164	
	83.7	81.5	1.42	0.0	148.964	0.3096	
	81.5	(mean)	(gain)		0.3096		
	2.2 (loss)				149.2736		

2:45 P.M.—Cord cut at second dorsal vertebra. 2:47 P.M. Rectal temp. 102° .38. 2:48 P.M. Rectal temp. 103° .3. 3:3 P.M. Rectal temp. 103° .68. 3:10 P.M. Rectal temp. 103° .4

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)
3:48 P.M.	83° .9	83° .8	74° .9	103°	357.41	73.5165
4:2	83	81.9				
4:17	82.2	81.3				
4:32	81.9	81.1				
4:54	81.8	81.1				
5:9	81.6	81				
5:18	81.4	81.2	76.3	96.44	479.61	73.7914
	82.26	81.6	1.4	6.56	122.2	0.2749
	81.6	(mean)	(gain)	(loss)	0.2749	
	0.66 (loss)				122.4749	

BEFORE SECTION.

$$\text{Quantity of air (V')} = 149.2736 \text{ at } 81^{\circ}.5 - 32^{\circ} = 49.5 = t'.$$

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{V'}{1.1} = 135.7. \quad W = V \times 0.08073 = 10.9.$$

$$\text{Fall in temp. of air } 2.2 = t. \quad Q = W \times t \times \text{sp. h.} = 10.9 \times 2.2 \times 0.2374 = 5.6928 = \text{heat taken from air.}$$

$$\text{Rise in temp. of water } 1.42 \times 164.1414 = 233.0808 = \text{heat given to calorimeter.}$$

$$5.6928 = \text{heat taken from air.}$$

$$227.388 = \text{heat dissipated in 2 hours.}$$

$$\text{Hourly dissipation of heat } 113.694$$

AFTER SECTION.

Quantity of air (V) = 122.4749 at 81°.6—32° = 49.6 = t.

$$V + (V \times t \times 0.002035) = V'. \quad V = \frac{122.4749}{1.1} = 111.3. \quad W = V \times 0.08073 = 8.985$$

Fall in temp. of air 0.66 = t. Q = W × t × sp. h. = 8.985 × 0.66 × 0.2374 = 1.4077 = heat taken from air.

Rise in temp. of water 1.4 × 164.1414 = 229.798 = heat given to calorimeter.

1.4077 = heat taken from air.

228.3903 = heat dissipated in 1½ hours.

Heat dissipated in one hour 152.2602

SUMMARY.

Hourly dissipation of heat after section	152.2602
Hourly dissipation of heat before section	113.694

Hourly increase in dissipation of heat following section 38.5662

EXPERIMENT 29.

A cur.—Weight 20 pounds

Time.	Air TEMP. (Fah.)	True TEMP. (Fah.)	Box TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
2:5 P. M.	60.5	63.5	67.5	103°.62	786.61	78.03	16.6123
2:20	61.8	63.7					
2:35	61.8	64					
2:50	60.9	63.8					
3:20	61.7	63.3					
3:35	62.3	63.8	68.1	102.56	876.07	78.1414	16.9647
	61.5	63.7	0.6	1.06	89.46	0.1114*	0.3524
	(mean)	61.5	(gain)	(loss)	0.1114		
		2.2			89.5714		
		(gain)					

3:55 P. M.—Cord cut at sixth cervical vertebra; much blood (5 to 6 ounces) lost.

4:11 P. M.—Rectal temperature 101°.4.

Time.	Air TEMP. (Fah.)	True TEMP. (Fah.)	Box TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
4:56 P. M.	62.4	65.1	69.44		935.77	78.1924	16.9647
5:11	63.9	67					
5:26	64.6	66.7					
5:41	64.4	66.2					
5:56	64.04	65.5	70.1	89°.6	992.015	78.404	17.1079
	63.9	66.1	0.66		56.245	0.2116	0.1432
	(mean)	63.9	(gain)		0.2116		
		2.2			56.4566		
		(gain)					

BEFORE SECTION.

Quantity of air (V) = 89.5714 at 63°.7—32° = 31.7 = t.

$$V + (V \times t \times 0.002035) = V'. \quad V = \frac{95.7}{1.0} = 84.4. \quad W = V \times 0.08073 = 6.8.$$

Rise in temp. of air 2.2. Q = W × t × sp. h. = 6.8 × 2.2 × 0.2374 = 3.5515 = heat given to air.

Rise in temp. of water 0.6 × 164.1414 = 98.4848 = heat given to calorimeter.

3.5515 = heat given to air.

102.0363 = heat dissipated in 1½ hours.

Hourly dissipation of heat 68.0242

* In some of the experiments detailed in this paper the loss or gain of heat by evaporation or condensation of moisture was disregarded. The result has not been in any case perceptibly affected thereby.

AFTER SECTION.

Quantity of air (V) = 56.4566 at 66°.1—32° = 34.1 = t'.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{56.4566}{1.07} = 52.7$. $W = V \times 0.08073 = 4.25$
 Rise in temp. of air 2.2 = t. $Q = W \times t \times \text{sp. h.} = 4.25 \times 2.2 \times 0.2374 = 2.2196 = \text{heat given to air.}$
 Rise in temp. of water $0.66 \times 164.1414 = 108.3333 = \text{heat given to calorimeter.}$
 2.2196 = heat given to air.

Heat dissipated in one hour 110.5529

SUMMARY.

Hourly heat dissipation after section 110.5529
 Hourly heat dissipation before section 68.0242

Hourly increase in heat dissipation following section 42.5287

Carbonic Acid Calculation.

BEFORE SECTION.

Quotient for box $\frac{89.5714}{0.1114} = 804.0 \times 0.0337 = 27.0948 \text{ grammes} = \text{CO}_2 \text{ leaving box.}$
 Quotient for air $\frac{89.5714}{0.3524} = 254.2 \times 0.00625 = 15.8875 \text{ grammes} = \text{CO}_2 \text{ entering box.}$
 11.2073 grammes = CO₂ produced in 1½ hours.
Hourly production of CO₂ 7.4714 grammes.

AFTER SECTION.

Quotient for box $\frac{56.4566}{0.2116} = 266.8 \times 0.02775 = 7.4037 \text{ grammes} = \text{CO}_2 \text{ coming from box.}$
 Quotient for air $\frac{56.4566}{0.1432} = 394.2 \times 0.004 = 1.5768 \text{ grammes} = \text{CO}_2 \text{ entering box.}$
Hourly production of CO₂ 5.8269 grammes.

SUMMARY.

Hourly production of CO₂ before section 7.4714 grammes.
 Hourly production of CO₂ after section 5.8269 grammes.

Hourly diminution in the production of CO₂ following section 1.6445 grammes.

EXPERIMENT 30.

A cur pup. Weight 16 lbs.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	RECT. TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
11:52 A. M.	64° 94	67° 4	64° 64	101° 25	188.642	25.9358	7.2471	127.4098	111.5750
12:5 P. M.	64.31	66.68							
12:20	64.49	66.29							
12:35	64.4	67.02							
12:52	64.76	66.56	65.72	101.25	253.386	26.0248	7.2853	127.4444	111.5836
	64.58	66.79	1.08	0	64.744	0.089	0.0382	0.0346	0.0086
	(mean)	64.58	(gain)		0.089			(gain)	(gain)
		2.21			64.833				
		(gain)							

1:10 P. M.—Spinal cord cut between the first and second dorsal vertebræ.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	RECT. TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
1:30 P. M.	65° 48	67° 6	65° 185	101° 75	272.426	26.0248	7.2857	127.4444	111.5836
1:45	65.3	68							
2:6	65.21	67.8							
2:15	65.95	67.9							
2:30	65.96	68.09	66.38	94.25	338.56	26.0968	7.3245	127.4760	111.5942
	65.58	67.88	1.195	7.5	66.134	0.072	0.0388	0.0316	0.0106
	(mean)	65.58	(gain)	(loss)	0.072			(gain)	(gain)
		2.3			66.206				
		(gain)							

BEFORE SECTION.

Quantity of air (V') = 64.833 at 66.79—32° = 34.79 = v' .
 $V + (V \times v' \times 0.002035) = V' = \frac{64.833}{1.07} = 60.6$. $W = V \times 0.08073 = 4.9$
 Rise in temp. of air 2.21 = t . $Q = W \times t \times \text{sp. h.} = 4.9 \times 2.21 \times 0.2374 = 2.5686 = \text{heat given to air.}$
 Quotient for box $\frac{64.833}{0.089} = 728.6 \times 0.0346 = 25.2095 = \text{moisture coming from box.}$
 Quotient for air $\frac{64.833}{0.0382} = 1697 \times 0.0086 = 14.5942 = \text{moisture entering box.}$
 10.6153 = moisture vaporized in box.
 10.6153 = 1.6906 = heat expended in vaporization.
 6.2789
 Rise in temp. of water 1.08 \times 164.1414 = 177.2727 = heat given to calorimeter.
 2.5686 = heat given to air.
 1.6906 = heat expended in vaporization.

Hourly dissipation of heat 181.5319

AFTER SECTION.

Quantity of air (V') = 66.206 at 67° 88—32° = 35.88 = v' .
 $V + (V \times v' \times 0.002035) = V' = \frac{66.206}{1.073} = 61.7$. $W = V \times 0.08073 = 5$
 Rise in temp. of air 2.3 = t . $Q = W \times t \times \text{sp. h.} = 5 \times 2.3 \times 0.2374 = 2.7301 = \text{heat given to air.}$
 Quotient for box $\frac{66.206}{0.072} = 919.5 \times 0.0316 = 29.0562 = \text{moisture leaving box.}$
 Quotient for air $\frac{66.206}{0.0388} = 1706.3 \times 0.0106 = 18.0867 = \text{moisture entering box.}$
 10.9695 = moisture vaporized in box.
 10.9695 = 1.747 = heat expended in vaporization.
 6.2789
 Rise in temp. of water 1.195 \times 164.1414 = 196.149 = heat given to calorimeter.
 2.7301 = heat given to air.
 1.747 = heat expended in vaporization.

Hourly dissipation of heat 200.6261

SUMMARY

Hourly dissipation of heat following section	200.6261
Hourly dissipation of heat before section	181.5319
<i>Hourly increase of dissipation of heat following section</i>	19.0942

EXPERIMENT 31.

A bitch. Weight 15 pounds.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	RECT. TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
1:51 P.M.	77.6	77.3	73° 5	103° 2	145.855	0.35	0.9958	146.4048	146.7329
2	77.4	76.5							
2:21	77.4	76.6							
2:36	77.2	76.5							
2:51	77.4	76.8	74.23	103.2	206.725	0.4077	1.032	146.4379	146.747
	77.4	76.71	0.73	0	60.87	0.0577	0.0362	0.0331	0.0141
	76.74	(mean)	(gain)		0.0577			(gain)	(gain)
	0.66				60.9277				
	(loss)								

1.073 = Heat of vaporization of water at 67° F. — Normal temperature 100° F.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS. (grms.)
5:17 P. M.	80 ^o .5	78 ^o .7	73 ^o .3	104 ^o	238.028	0.41	1.03	146.4379	146.747	
5:32	79.7	78.1								
5:47	79.8	78.2								CO ₂ in sample 0.00338
6:2	79.8	78.6								CO ₂ in air 0.00175
6:17	79.7	78.8	74.23	97.5	291.66	0.4286	1.47	146.4581	146.7707	
	79.9	78.48	0.93	6.5	53.632	0.0186	0.44	0.0202	0.0237	
	78.48	(mean)	(gain)	(loss)	0.186					
	1.42				53.6506					
	(loss)									

BEFORE SECTION.

Quantity of air (V') = 60.9277 at 76^o.74-32^o = 42.74 = t'.
 $V + (V \times t \times 0.002035) = V'$. V = 56. W = V × 0.08073 = 4.52
 Fall in temp. of air 0.66 = t. Q = W × t × sp. h. = 4.52 × 0.66 × 0.2374 = 0.6074 = heat taken from air.
 Quotient for box $\frac{60.9277}{0.0577} = 1056 \times 0.0331 = 34.9536 =$ moisture leaving box.
 Quotient for air $\frac{60.9277}{0.0362} = 1683 \times 0.0141 = 23.7303 =$ moisture entering box.
 11.2233 = moisture vaporized in box.
 $\frac{11.2233}{6.2789} = 1.7874 =$ heat expended in vaporization.
 Rise in temp. of water 0.73 × 164.1414 = 119.8232 = heat given to calorimeter.
 1.7874 = heat expended in vaporization.
 121.6106
 0.6074 = heat taken from air.
 Heat dissipated in one hour 121.0032

AFTER SECTION.

Quantity of air (V') = 53.6506 at 78^o.48-32^o = 46.48 = t'.
 $V + (V \times t \times 0.002035) = V'$. V = $\frac{53.6506}{1.095} = 49$. W = V × 0.08073 = 3.956
 Fall in temp. of air 1.42 = t. Q = W × t × sp. h. = 3.956 × 1.42 × 0.2374 = 1.3335 = heat taken from air.
 Quotient for box $\frac{53.6506}{0.0186} = 2885 \times 0.0202 = 58.2770 =$ moisture leaving box.
 Quotient for air $\frac{53.6506}{0.44} = 122 \times 0.0237 = 2.8914 =$ moisture entering box.
 55.3856 = moisture vaporized in box.
 $\frac{55.3856}{6.2789} = 8.8209 =$ heat expended in vaporization.
 Rise in temp. of water 0.93 × 164.1414 = 152.6515 = heat given to calorimeter.
 8.8209 = heat expended in vaporization.
 161.4724
 1.3335 = heat taken from air.
 Heat dissipated in one hour 160.1389

SUMMARY.

Heat dissipated hourly after section 160.1389
 Heat dissipated hourly before section 121.0035
 Gain in hourly heat dissipation following section 39.1354

Carbonic Acid.

BEFORE SECTION.

0.00875 × 1056 = 9.24 grammes = CO₂ leaving box.
 0.001725 × 1683 = 2.9031 grammes = CO₂ entering box.
 CO₂ produced in an hour 6.3369 grammes.

AFTER SECTION.

$0.00338 \times 2885 = 9.7513$ grammes = CO, leaving box.

$0.00175 \times 1229 = 2.135$ grammes = CO, entering box.

CO, produced in an hour = 7.6163 grammes.

In studying these experiments it will be seen that in each there was a very decided increase in the throwing off of heat by the animal after division of the cord. In Experiment 26 the cord was cut in its middle region between the second and third dorsal vertebra, above the origin of the great splanchnic nerves, there was, therefore, vaso-motor paralysis affecting almost the entire trunk and the lower extremities. The hourly increase of heat loss was enormous, equalling one-third of the original amount. In Experiment 28 the cord was cut in very nearly the same place as in the preceding experiment, but the increase of heat dissipation, although decided, was not nearly so great. In Experiment 30 the section was practised one vertebra higher up, but the increase of heat dissipation was comparatively very slight, not amounting to more than 13 per cent. of the original. The animal was, however, a pup, and in this fact probably lies the reason of the comparative poverty of increase. In Experiment 31 the cord was cut in the upper dorsal region, above the origin of the splanchnics, and the increase of heat dissipation amounted to nearly 30 per cent.

In the remaining experiments of the series the cord was divided in the cervical region. In Experiment 25 the division was between the fifth and sixth cervical vertebra, and the increase of heat dissipation amounted to over 50 per cent. of the original yield. In Experiment 27 the section was practised slightly higher, and although dissipation was profoundly affected, the rate of heat dissipation rose over 30 per cent. In Experiment 29 the cord was cut about the same place, at the sixth cervical vertebra, and the increase of heat evolution was over 50 per cent. although considerable blood was lost.

The experiments just detailed would seem to prove that section of the cord is always followed by a decided increase in the giving off of animal heat, and that the amount of the increase is in direct proportion to the nearness of the section to the brain, provided respiration be not seriously interfered with.

The following series of experiments shows, however, that this generalization is at least too sweeping.

EXPERIMENT 32.

A small Spitz dog; weight 18 lbs.

Time	AIR TEMP. (Fah.)	TEMP. TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER (cub. ft.)
12:34 P. M.	79.8	78.5	78.18	104°	371.63	77.8258
12:48	79.5	78.7				
1:18	79.3	77.2				
1:34	77.2	78.2				
1:48	78.8	79.5				
2:3	80.2	80				
2:18	80.6	78.8				
2:34	79.5	79.1	78.5	102.3	518.61	77.9098
	79.3	78.7	0.32	1.7	146.98	0.084
	78.7	(mean)	(gain)	(loss)	0.084	
	0.6				147.064	
	(loss)					

3 P. M.—Cord cut at junction of cervical and dorsal vertebrae.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)
3:37 P. M.	79°·3	79°	78°·8		544.78	77.9098
4:7						
4:22	78.5	79.4				
4:37	78.2	78.9				
4:52	77.9	78.9				
5:7	77.5	80	79		629.93	78.0445
	78.28 (mean)	79.24	0.2 (gain)		85.15	0.1347
		0.96 (gain)			85.2847	

BEFORE SECTION.

Quantity of air (V') = 147.064 at 78°·7—32° = 46.7 = t'.

$$V + (V \times t \times 0.002035) = V'. \quad V = \frac{147.064}{1.0951} = 134.3. \quad W = V \times 0.08073 = 10.842$$

Fall in temp. of air 0.6 = t. Q = W × t × sp. h. = 10.842 × 0.6 × 0.2374 = 1.5443 = heat taken from air.

Rise in temp. of water 0.32 × 164.1414 = 52.5252 = heat given to calorimeter.

1.5443 = heat taken from air.

54.0695 = heat dissipated in two hours.

Hourly dissipation of heat 27.0348

AFTER SECTION.

Quantity of air (V') = 85.2847 at 79°·24—32° = 47.24 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{85.2847}{1.096} = 77.8. \quad W = V \times 0.08073 = 6.28$$

Rise in temp. of air 0.96 = t. Q = W × t × sp. h. = 6.28 × 0.96 × 0.2374 = 1.4315 heat given to air.

Rise in temp. of water 0.2 × 164.1414 = 32.8283 = heat given to calorimeter.

1.4315 = heat given to air.

34.2598 = heat dissipated in 1½ hours.

Hourly dissipation of heat 22.8398

SUMMARY.

Hourly dissipation of heat before section 27.0348

Hourly dissipation of heat after section 22.8398

Decrease of heat dissipation following section 4.195

EXPERIMENT 33.

A cur; weight 17 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECTAL TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS. (grms.)
10:45 A. M.	76°·4	73°·9	70°·3	102°·7	973.185	0.2491	0.7203	70.7463	67	
11	77.5	74.9								
11:15	78.8	75.8								
11:30	79.5	76.2								
11:45	80.6	76.6								CO ₂ in sample 0.01475
12 M.	80.7	77.1								CO ₂ in air 0.00225
12:15 P. M.	81.2	77.8	71.6	102.2	1051.462	0.3075	0.8052	70.7791	67.0297	
	79.2	76	1.3 (gain)	0.5 (loss)	78.277	0.0584	0.0849	0.0328 (gain)	0.0297 (gain)	
	76 (mean)				0.0584					
	3.2 (loss)				78.3354					

12:50 P. M.—Spinal cord cut in lower dorsal region.

Time.	Air Temp. (Fah.)	Room Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	GENERAL METER (cub. ft.)	SAMPLE METER (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE (grms.)	AIR CALCIUM TUBE. (grms.)	CO ₂ in air
1:37 P. M.	80.3	78.7	73.56	104	109.03	0.3085	0.805	70.77915	67.0297	
1:52	80.8	78.9								
2:7	80.7	79.								
2:22	80.6	79.2								
2:37	80.85	79.4								CO ₂ in air
2:52	82	80								CO ₂ in air
3:7	84.15	80.4	74.79	98	187.06	0.3674	0.995	70.785	67.0753	
	81.3	79.4	1.23	6	78.03	0.0589	0.19	0.00585	0.0456	
	79.4	(mean)	(gain)	(loss)	0.0589			(gain)	(gain)	
	1.9				78.0889					
	(loss)									

BEFORE SECTION.

Quantity of air (V) = 78.3354 at 76°-32° = 44 = v'.
 $V + (V \times v' \times 0.002035) = V'$. $V' = \frac{78.3354}{1.0895} = 71.9$. $W = V \times 0.08073 = 5.8$
 Fall in temp. of air 3.2. $Q = W \times t \times \text{sp. h.} = 5.8 \times 3.2 \times 0.2374 = 4.4061$ heat taken from air.
 Quotient for box $\frac{78.3354}{0.0584} = 1341.3 \times 0.0328 = 44.061 =$ moisture leaving box.
 Quotient for air $\frac{78.3354}{0.0849} = 922.6 \times 0.0297 = 27.4012 =$ moisture entering box.
 16.6598 = moisture vaporized in box.
 $16.6598 = 2.6533 =$ heat expended in vaporization.
 6.2789
 Rise in temp. of water 1.3 $\times 164.1414 = 213.3838 =$ heat given to calorimeter.
 4.4061 = heat taken from air.
 208.9777
 2.6533 = heat expended in vaporization.
 211.6310 = heat dissipated in 1½ hours.
Hourly dissipation of heat 141.0873

AFTER SECTION.

Quantity of air (V) = 78.0889 at 79.4-32° = 47.4 = v'.
 $V + (V \times v' \times 0.002035) = V'$. $V' = \frac{78.0889}{1.096} = 71.2$. $W = V \times 0.08073 = 5.74$.
 Fall in temp. of air 1.9 = t. $Q = W \times t \times \text{sp. h.} = 5.74 \times 1.9 \times 0.2374 = 2.5897 =$ heat taken from air.
 Quotient for air $\frac{78.0889}{0.19} = 411 \times 0.0456 = 18.7416 =$ moisture entering box.
 Quotient for box $\frac{78.0889}{0.0589} = 1325.7 \times 0.00585 = 7.7553 =$ moisture leaving box.
 10.9863 = moisture condensed in box.
 $10.9863 = 1.75 =$ heat gained from condensation.
 6.2789
 Rise in temp. of water 1.23 $\times 164.1414 = 201.8939 =$ heat given to calorimeter.
 2.5897 = heat taken from air.
 199.3042
 1.75 = heat gained from condensation.
 197.5542 = heat dissipated in 1½ hours.
Hourly dissipation of heat 131.7028

SUMMARY

Heat dissipated hourly before section 141.0873
 Heat dissipated hourly after section 131.7028

Decrease of heat dissipation following section 9.3845

Carbonic Acid.

BEFORE SECTION.

$$0.01475 \times 1341.3 = 19.7984 \text{ grammes} = \text{CO}_2 \text{ leaving box.}$$

$$0.00225 \times 922.6 = 2.0758 \text{ grammes} = \text{CO}_2 \text{ entering box.}$$

$$\text{Hourly production of CO}_2 \quad \underline{\hspace{1.5cm}} \quad 17.7226 \text{ grammes.}$$

AFTER SECTION.

$$0.0138 \times 1325.7 = 18.2946 \text{ grammes} = \text{CO}_2 \text{ leaving box.}$$

$$0.00525 \times 411 = 2.1577 \text{ grammes} = \text{CO}_2 \text{ entering box.}$$

$$\text{Hourly production of CO}_2 \quad \underline{\hspace{1.5cm}} \quad 16.1369 \text{ grammes.}$$

SUMMARY.

$$17.7226 \text{ grammes} = \text{hourly CO}_2 \text{ production before section.}$$

$$16.1369 \text{ grammes} = \text{hourly CO}_2 \text{ production after section.}$$

$$\text{Decrease of CO}_2 \text{ production following section} \quad \underline{\hspace{1.5cm}} \quad 1.5857$$

In studying Experiment 32, the feature which first attracts attention is the smallness of the hourly dissipation of heat. This evidently was dependent upon the excessively thick coating of very long hair which covers the Spitz dog, and which must interfere in a very great degree with the throwing off of heat. After section of the cord there was a reduction instead of an increase in the dissipation of heat. I cannot help believing that the excessive coating of hair played an important part in the production of this anomalous result. In Experiment 33, the diminution of heat dissipation only amounted to about 8 per cent. It will be noted that the cord was cut very low down, below the origin of the splanchnic nerves. The discussion of the cause of the discrepancies between the results of these two experiments, and those previously obtained, will be best carried out, after the consideration of the causes of the increased heat dissipation, which usually follows section of the cord. What then is the cause of this increased loss of heat

Tscheschichin, in his experiments (*op. cit.*, pp. 154, 177), found that after section of the cord the temperature in the interior of the body sank more rapidly than that of the external parts; thus, in one experiment, the mercury in two thermometers, which had their bulbs respectively in the intestines and underneath the skin of the animal, differed before the operation in height eight-tenths degree F., whilst some time after the operation they only differed one-tenth degree F.

I have performed and reported elsewhere (*A Study of the Nature and Mechanism of Fever*) a single experiment in which the surface did not maintain its temperature more persistently than did the deep tissues. But in the recent elaborate studies of Henri Parinaud the researches of Tscheschichin have been substantially confirmed. Observations were made with thermometers placed in the rectum, axilla, and groin, and upon the surface of the front and hind feet. It was found that after section of the cord both the rectal temperature and that of the deep parts of the paralyzed portions of the body as measured in the groin or axilla always fell, but the surface temperature underwent a distinct primary transient rise. Section of the cord undoubtedly paralyzes the vaso-motor nerves and dilates the bloodvessels; it makes, therefore, the ways of communication between the outer and inner portions of the body more open and free, and places more upon a level of temperature the

interior and exterior of the organism. It is certain that the normal animal has some method of controlling the loss of bodily heat, at least within certain limits. Modification of the amount of perspiration is in man very influential, but in the dog, the general surface having no perspiratory glands, this factor sinks into insignificance. The only methods which are at the control of the dog for regulating heat loss are through the respiration and through the external circulation. Thus when heat is to be retained, a partially cooled layer is maintained between the inner hot body and the external cold air by shutting off in a measure the circulation from the superficial parts. On the other hand, when the superficial capillaries are dilated, the heated surface rapidly gives up its caloric. After section of the cord, the superficial capillaries cannot be contracted, and as a natural result, the animal, so far as concerns heat dissipation, is purely dependent upon its environment, and an increased loss of heat must occur in a cool atmosphere. Lowered bodily temperature, with increased loss of heat, is the usual and normal result of a section of the cord practised low enough down to cause a wide-spread vaso-motor palsy. In the Spitz dog (Experiment 32) this increased loss did not occur, probably because the extraordinary protection of the body by the very thick outer coat interfered with surface cooling. The extremely minute quantity of heat dissipated by the hairy Spitz has already been indicated. In Experiment 33 there was no decided increase in loss of heat because the cord was cut so low down that a very insignificant portion of the vaso-motor system was affected.

The immediate effects of section of the cord upon the loss of heat having been determined, it seems natural to inquire whether there also is an increased heat production following the operation. Before entering upon this investigation, however, it is well to determine whether the increased dissipation of heat be persistent, or whether it occur only in the few hours immediately following section. It is plain, if the increased loss of heat be permanent, there must be an increased production as well as an increased dissipation of caloric. At first the heat stored up in the body may be drawn upon, but this source of supply is of course soon exhausted, and any increased dispersion then means increased production of heat. The converse of this, however, does not of necessity follow, for it is possible to have a primary increase with a later decrease of production. Thus it is chemically very conceivable, that merely lowered temperature can check tissue change, *i. e.*, production of caloric. It is well known that external heat, by raising the internal temperature, is capable of causing fever, with its excessive metamorphosis of tissue: and it would seem probable that cold checks chemical movements inside as well as outside of the body. The history of hibernating animals is a case in point; in them, with lowered temperature there is lowered chemical activity.

The next experiments were therefore directed to deciding whether the increased dissipation of heat, after section of the cord, is persistent or lasts only a few hours.

EXPERIMENT 34.

This experiment is a continuation of Experiment 26.

TIME.	AIR TEMP. (Fah.)	TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL WEIGHT (cub. ft.)	SAMPLE WEIGHT (cub. ft.)
2:17 P. M.	72°·4	77°·3	77°·5	104°	131·42	77·7088
2:32	72·4	77·6				
2:47	73·5	77·8				
3: 2	72·4	78·1				
3:17	72·	78·3				
3:32	71·7	78·5				
3:47	72·2	78·1				
4:17	72·7	78·8	78·9	102·4	303·21	77·826
	72·41 (mean)	78·06 72·41	1·4 (gain)	1·6 (loss)	171·79 0·1172	0·1172
		5·65 (gain)			171·9072	

Heat Dissipation.

o

Quantity of air (V) = 171.9072 at 78°·06—32° = 46·06 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{171.9072}{1.0937} = 157.1. \quad W = V \times 0.08073 = 12.68$$

Rise in temp. of air 5.65 = t. $Q = W \times t \times \text{sp. h.} = 12.68 \times 5.65 \times 0.2374 = 17.0078 = \text{heat given to air.}$

Rise in temp. of water 1.4 $\times 164.1414 = 229.798 = \text{heat given to calorimeter.}$

17.0078 = heat given to air.

246.8058 = heat dissipated in 2 hours.

Hourly dissipation of heat 123.4029

In comparing the dissipation of heat here recorded with what was yielded before and immediately after section (see page 29), we arrive at the following:—

Before section, hourly dissipation of heat	204.7554
Forty-eight hours after section, hourly dissipation of heat	123.4029
<i>Diminished hourly heat dissipation in second period after section of cord</i>	81.3525
Immediately after section, hourly dissipation of heat	295.1511
Forty-eight hours after section, hourly dissipation of heat	123.4029
<i>Diminished hourly dissipation in second period as compared with first period after section</i>	172.7482

This experiment, taken along with others previously discussed, proves that after section of the cord heat dissipation is usually first increased and afterward diminished. The late diminution of heat dissipation, the temperature of the animal remaining at normal or below it, shows that there is diminished heat production some hours after the section of the cord. The question offers itself, whether, directly after section of the cord, when the dissipation of caloric is abnormally great, the heat production is increased or diminished? In answering this question, it is necessary to remember that all heat dissipated but not produced in a certain period must be obtained by a lowering of the temperature of the body which gives it off. In determining whether the increased dissipation, which follows spinal section, is solely at the expense of the accumulated heat of the body, or whether it is obtained in part by an increased production of heat, it is evidently necessary to know the absolute

amount both of the heat thrown off, and also of that lost by the animal from its bodily store; for the bodily temperature may fall in such a case, but not enough to cover the increased dissipation, and under such circumstances there would be of course increased production of heat. Hereafter in this memoir the heat which is stored up in the animal, will be spoken of as "*heat reserve*." In calculating its amount, it is necessary to know the specific heat of the organism. Accurate experimental determination of this I have found almost impossible. At first, it seemed sufficient to kill the animal, plunge its body in a known weight of water in a closed wooden vessel, and study the elevation of the temperature of the water and the depression of that of the body. A single experiment showed the fallacy of this method. Chemical operations undoubtedly continue after death, and the amount of heat yielded was so markedly in excess as to show that there was a notable continuous production of the force. Heating the body of an animal long dead might do better, but presents many practical difficulties. To heat the carcass uniformly through is very troublesome, and requires so much time, that chemical changes, coagulation, absorption of water, etc., would with great difficulty, if at all, be avoided. Moreover, as the composition of the body is constantly varying, so must also its specific heat. I have been led by these considerations to despair of any experimental solution of the problem as to the specific heat of animals.

Fortunately, in the present instance, an estimation of the specific heat, sufficiently accurate for our purpose, can be made by taking advantage of the law that the specific heat of a mass is the proportionate mean of the specific heat of its component parts.

According to the generally accepted results of Moleschott 68 per cent. of the body is water; the specific heat of which may be taken as 1. Supposing the specific heat of the remaining dried solids to be that of stone 0.22, the calculated specific heat of the body would be 0.75. This may, I think, be taken as a fair average of the ever varying specific heat of the body. With it the experiments already detailed may be further studied for the purpose of determining whether section of the cord is followed by increased or diminished heat production.

EXPERIMENT 25.

BEFORE SECTION.		
	Heat dissipated hourly	48.0713
	Heat lost from reserve ¹ ($18 \times 1.43 \times 0.75$)	19.305
	Hourly heat production	28.7663
AFTER SECTION.		
	Heat dissipated hourly	99.0755
	Heat taken from reserve ($18 \times 6.25 \times 0.75$)	81.375
		14.7005
SUMMARY.		
	Heat produced hourly before section	28.7663
	Hourly production of heat immediately after section	14.7005
	<i>Hourly loss of heat production following section</i>	14.0658

¹ The formula $w \times t \times \text{sp. h.}$, is not repeated here, only the value of the respective factors of the equation being given; t is always taken as the fall or rise of the animal temperature in one hour.

EXPERIMENTS 26 AND 34.

BEFORE SECTION.	Hourly dissipation of heat	204.7554
	Heat added to reserve ($25 \times 0.53 \times 0.75$)	9.9375
	Hourly production of heat	194.8179
AFTER SECTION.	<i>First Period—</i>	
	Record of animal temperature lost and hence calculation impossible.	
AFTER SECTION.	<i>Second Period—</i>	
	Heat dissipation	123.4029
	Loss from heat reserve ($25 \times 0.8 \times 0.75$)	15
		108.4029
SUMMARY.	Hourly heat production before section	194.8179
	Hourly heat production 48 hours after section	108.4029
	<i>Hourly loss of heat production following section</i>	86.415

EXPERIMENT 27.

BEFORE SECTION.	No change in heat reserve.	
	Hourly dissipation = hourly production of heat	128.7306
AFTER SECTION.	Hourly dissipation of heat	188.6035
	Loss from heat reserve ($32 \times 3.05 \times 0.75$)	73.2
	Heat produced hourly	115.4035
SUMMARY.	Heat produced hourly before section	128.7306
	Heat produced hourly after section	115.4035
	<i>Hourly loss of heat production following section</i>	13.3271

EXPERIMENT 28.

BEFORE SECTION.	No change in heat reserve.	
	Hourly dissipation = hourly production of heat	113.694
AFTER SECTION.	Hourly heat dissipation	152.2602
	Loss from heat reserve ($18 \times 4.37 \times 0.75$)	58.995
		93.2652
SUMMARY.	Hourly production of heat before section	113.694
	Hourly production of heat following section	93.2652
	<i>Hourly loss of heat production following section</i>	20.4288

EXPERIMENT 29.

BEFORE SECTION.	Hourly dissipation of heat	68.0242
	Loss from heat reserve ($20 \times 0.707 \times 0.75$)	10.605
	Hourly production of heat	57.4192
AFTER SECTION.	Hourly dissipation of heat	110.5529
	Hourly loss from heat reserve ($20 \times 6.74 \times 0.75$)	101.1
	Hourly production of heat	9.4529

SUMMARY.	Hourly production of heat before section	57.4192
	Hourly production of heat after section	9.4529
	<i>Hourly loss of heat production following section</i>	47.9663

EXPERIMENT 30.

BEFORE SECTION.	No change in heat reserve.	
	Hourly dissipation = hourly production of heat	181.5319
AFTER SECTION.	Hourly dissipation of heat	200.6261
	Loss from heat reserve ($16 \times 7.5 \times 0.75$)	90
SUMMARY.	Hourly heat production	110.6261
	Hourly heat production before section	181.5322
	Hourly heat production after section	110.6261
	<i>Hourly loss of heat production following section</i>	70.9061

EXPERIMENT 31.

BEFORE SECTION.	No change of heat reserve.	
	Hourly dissipation = hourly production of heat	121.0032
AFTER SECTION.	Hourly dissipation of heat	160.1389
	Hourly loss from heat reserve ($15 \times 6.5 \times 0.75$)	73.125
SUMMARY.	Hourly production of heat	87.0139
	Hourly production of heat before section	121.0032
	Hourly production of heat after section	87.0139
	<i>Hourly loss of heat production following section</i>	33.9893

EXPERIMENT 32.—In this experiment there was diminished heat dissipation, but through neglect the temperature of the body was not taken at the close of the experiment, hence it cannot be determined how far the production of heat was affected.

EXPERIMENT 33.

BEFORE SECTION.	Hourly heat dissipation	141.0873
	Loss from heat reserve ($17 \times 0.33 \times 0.75$)	4.2075
AFTER SECTION.	Hourly heat production	136.8798
	Hourly heat dissipation	131.7028
SUMMARY.	Loss from heat reserve ($17 \times 4 \times 0.75$)	51
	Hourly heat production	80.7028
	Hourly production of heat before section	136.8798
	Hourly production of heat after section	80.7028
	<i>Hourly loss of heat production following section</i>	56.177

The results in all of these experiments save one are in accord, and in the exceptional case the difference is one of degree and not of kind. Nevertheless the variance is a rather wide one. How it is to be accounted for it is difficult to decide. My own belief is that the experiment was not accurately performed. It was about the third or fourth time I had ever used the calorimeter, and it is very possible that some slight misreading of thermometers may have occurred. Again, the profound disturbance of breathing may have affected the result, or I may not have completely severed the cord. In every experiment there was diminished heat production following the section, the several percentages of loss being as follows: in the 25th experiment, 50 per cent.; 26th, forty-eight hours after section, 41 per cent.; 27th, 10 per cent.; 28th, 18 per cent.; 29th, 83 per cent.; 30th, 40 per cent.; 31st, 28 per cent.; 33d, 41 per cent.; average percentage of loss in the seven experiments (omitting the 27th) 43 per cent.

Leaving out of sight the 27th experiment I think we may consider the following proposition as demonstrated.

Section of the spinal cord above the origin of the splanchnic nerves, is usually followed by an immediate very decided increase in the amount of heat dissipated from the body, and also by a decided lessening of the amount of heat produced.

The known influences which follow section of the spinal cord, capable of affecting the production of heat, are vaso-motor paralysis, lessening of the cardiac force, muscular quiet, diminished respiration, lowering of temperature. Of these, diminished respiration may be left out of the question, because lessened production of heat follows even when the cord has been cut so low down as not to embarrass respiration; muscular quiet seems also of little importance, because the animal in the present series of experiments was always confined in a small dark chamber, and was usually perfectly quiet in the first portion of the comparative experiment, *i. e.*, before section. The lowering of the cardiac force by section of the cord is so indirect and so slight that it is hardly probable that it is a factor of much importance. So that the conclusion seems forced upon us that the primary cause of the lessened heat production is vaso-motor¹ paralysis, which probably acts directly, and also indirectly by causing an excessive loss of heat, and such a lowering of the internal temperature as to check chemical reactions in the body. How general vaso-motor paralysis acts directly upon heat production is easily perceived. A local vaso-motor palsy causes increased and quickened circulation in the part; but a general dilatation of all the vessels produces a sluggishness in the movements of the blood in all parts of the body. It is universally recognized that excessive activity of the circulation in a part tends to produce excessive chemical action, and it seems a logical inference that lessened circulation predisposes to lessened chemical activity.

In order to determine whether the chief role in the diminution of the production

¹ With these facts known, the reason why in Experiments 42 and 43 there was not increased heat dissipation becomes apparent. In both cases there was a diminished production of heat, and in one case owing to the great protection of the surface of the body by the thick coat, and in the other case to the section of the cord being below the centres which supply the vessels of the surface of the body, the customary rush of heat from within the body to without did not occur, and the diminished production was able to make itself felt in the heat dissipation.

of animal heat is played by the lowering of the internal temperature through excessive dissipation of the heat or by other causes, the following experiments were undertaken.

EXPERIMENT 35.

A long-haired bitch, weight 20 pounds.

Time	Air Temp. (Fah.)	Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	Sample Calorimeter (Fah.)	Air Calorimeter (Fah.)
12:56 P. M.	73°·3	83°·21	97°·35	102°·38	94.79	27.531	8.216	98.825	12.8214
1:11	74.12	83.76							
1:26	72.32	83.76							
1:45	71.96	83.36							
1:56			97	104.9	150.443	27.5749	8.2565	98.825	12.8214
	72.92 (mean)	83.53	0.35 (loss)	2.52 (gain)	55.653	0.0439	0.0405	98.825	12.8214
		10.61 (gain)			55.6969				

2:10 P. M.—Cord cut at first dorsal vertebra.

Time	Air Temp. (Fah.)	Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	Sample Calorimeter (Fah.)	Air Calorimeter (Fah.)
2:40 P. M.	74°·03	87°·44	96°·2	104°·25	184.04	27.575	8.2567	98.825	12.8214
2:55	74.12	87.75							
3:6	73.1	86.63							
3:25	73	86.18							
3:40	73.64	85.06	95.3	104	233.288	27.7071	8.4183	98.825	12.8214
	73.58 (mean)	86.61	0.9 (loss)	0.25 (loss)	49.248	0.1321	0.1616	98.825	12.8214
		13.03 (gain)			49.3801				

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 55.6969 at 83°·53—32° = 51.53 = t'.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{55.6969}{1.1049} = 50.41$. $W = V \times 0.08073 = 4.07$
 Rise in temp. of air 10.61 = t. $Q = W \times t \times \text{sp. h.} = 4.07 \times 10.61 \times 0.2374 = 10.251$ = heat given to air.
 Fall in temp. of water 0.35 = t. $Q = 164.1414 \times 0.35 = 57.4495$ = heat lost by calorimeter.
 Quotient for box $\frac{55.6969}{0.0439} = 1268.7 \times 0.0210 = 26.6427$ = moisture leaving box.
 Quotient for air $\frac{55.6969}{0.0405} = 1375.2 \times 0.0053 = 7.2885$ = moisture entering box.
 $\frac{19.3542}{6.2789} = 3.082$ = heat expended in vaporization.
 10.2516 = heat given to air.
 3.0823 = heat expended in vaporization.
 13.3339 = heat absorbed by air and in vaporization.
 57.4495 = heat lost by calorimeter.
 13.3339 = heat absorbed by air and in vaporization.

Heat lost by calorimeter and not accounted for 44.1156

AFTER SECTION.

Quantity of air (V') = 49.3801 at 86°·61—32° = 54.61 = t'.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{49.3801}{1.11} = 44.4$. $W = V \times 0.08073 = 3.58$.
 Rise in temp. of air 13.03 = t. $Q = W \times t \times \text{sp. h.} = 3.58 \times 13.03 \times 0.2374 = 11.6116$ = heat given to air.
 Fall in temp. of water 0.9 = t. $Q = 164.1414 \times 0.9 = 147.7273$ = heat lost by calorimeter.

Quotient for box $\frac{49.3801}{0.1321} = 373.8 \times 0.0181 = 6.7658 =$ moisture leaving box.

Quotient for air $\frac{49.3801}{0.1616} = 305.6 \times 0.0375 = 11.46 =$ moisture entering box.

$4.6942 =$ moisture condensed in box.

$\frac{4.6904}{6.2789} = 0.7476 =$ heat from condensed vapor.

147.7273 = heat lost by calorimeter.

0.7476 = heat gained by condensation.

148.4749

11.0741 = heat given to air.

Heat lost by calorimeter and not accounted for 137.4008

SUMMARY.

Hourly loss of heat by calorimeter after section 137.4008

Hourly loss of heat by calorimeter before section 44.1156

Hourly excess of unaccounted heat loss from calorimeter after section 93.2852

Heat Production.

BEFORE SECTION.

$W = 20$. Rise of bodily temperature $2.52 = t$.

$Q = W \times t \times \text{sp. h.} = 20 \times 2.52 \times 0.75 = 37.8 =$ heat added to reserve.

AFTER SECTION.

$W = 20$. Rise of bodily temperature $0.25 = t$.

$Q = W \times t \times \text{sp. h.} = 20 \times 0.25 \times 0.75 = 3.75 =$ heat added to reserve.

SUMMARY.

Heat added to reserve before section 37.8

Heat added to reserve after section 3.75

Heat added to reserve before section in excess of that after section 34.05

Excess of loss by calorimeter after section 93.2852

Excess of gain of heat reserve before section 34.05

Excess of hourly heat production before section, supposing calorimeter loses heat regularly 59.2352

EXPERIMENT 36.

A dog, weight about 15 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)
12:51 P. M.	70 ^o .76	89 ^o .33	103 ^o .2	103 ^o .1	649.63
1:5	70.52	93.6			
1:20	71.06	94.7			
1:35	71.06	94.7			
1:51	71.87	98	101.9	107.6	691.499
	71.06	94.06	1.3	4.5	41.869
	(mean)	71.06	(loss)	(gain)	
		23			
		(gain)			

2:10 P. M.—Cord cut at upper dorsal vertebra. 2:15 P. M.—Rectal temperature 101^o.48 F.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)
2:31 P. M.	70 ^o .16	89 ^o .42	104 ^o .3	101 ^o .5	721.125
2:46	68.72	90.68			
3:10	68.12	87.8			
3:16			102.3	104.9	750.18
	69.	89.3	2	3.4	29.055
	(mean)	69	(loss)	(gain)	
		20.3			
		(gain)			

3:20 P. M.—Rectal temperature 104^o.9.

BEFORE SECTION.

Quantity of air (V') = 41.869 at $94^{\circ}.06 - 32^{\circ} = 62.06 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{41.869}{1.117} = 37.2$. $W = V \times 0.08073 = 3$.

Rise in temp. of air $23 = t$. $Q = W \times t \times \text{sp. h.} = 3 \times 23 \times 0.2374 = 16.3806$ heat gained by air.

Fall in temp. of water $1.3 = t$. $Q = 164.1414 \times 1.3 = 213.3838 = \text{heat lost by calorimeter.}$
 $16.3806 = \text{heat given to air.}$

Heat lost in one hour by calorimeter beyond that accounted for } 197.0032

AFTER SECTION.

Quantity of air (V') = 29.055 at $89^{\circ}.3 - 32^{\circ} = 57.3 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{29.055}{1.117} = 26$. $W = V \times 0.08073 = 2.1$.

Rise in temp. of air $20.3 = t$. $Q = W \times t \times \text{sp. h.} = 2.1 \times 20.3 \times 0.2374 = 10.1204 = \text{heat gained by air.}$

Fall in temp. of water $2 \times 164.1414 = 328.2828 = \text{heat lost by calorimeter.}$
 $10.1204 = \text{heat gained by air.}$

Loss of heat by calorimeter in $\frac{1}{2}$ hour beyond that accounted for } 318.1624

Hourly loss by the calorimeter beyond that accounted for 424.2165

SUMMARY.

Hourly loss of heat after section in excess of that accounted for 424.2165
 Hourly loss of heat before section in excess of that accounted for 197.0032

Heat Production.

Rise in bodily temperature before section $4.5 = t$. $W = 15$.

$Q = W \times t \times \text{sp. h.} = 15 \times 4.5 \times 0.75 = 50.625 = \text{heat added to reserve.}$

Rise in bodily temperature after section 3.42 in $\frac{1}{2}$ of an hour = 4.56 per hour. $t = 45.6$

$W \times t \times \text{sp. h.} = 15 \times 4.56 \times 0.75 = 51.3 = \text{heat added to reserve.}$

SUMMARY.

Gain in heat reserve after section 51.3
 Gain in heat reserve before section 50.625
 Excess of loss by calorimeter after section 424.2165
 Hourly excess of gain of heat reserve before section 197.0032

Excess of hourly heat production before section, supposing calorimeter loses heat 197.0032

EXPERIMENT 37.

Dog, weight 21. lbs.

TIME.	AIR TEMP. (Fah.)	TRAC. TEMP. (Fah.)	RECT. TEMP. (Fah.)	BOX TEMP. (Fah.)	HEAT PRODUCTION
12:33 P. M.	66 ^o .8	90 ^o .6	102 ^o .65	102 ^o .1	178
12:48	69	92.9			
1:3	69.4	95.4			
1:18	69.8	96.2			
1:33	70	95.8			
1:48	70.2	96	105.44	99.7	185.5
	69.2 (mean)	94.5 69.2	2.79 (loss)	2.4 (loss)	185.5
		25.3 (gain)			

3:50 P. M. — Cord cut in upper dorsal region.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:35 P. M.	72°	94°·1	102°·1	97°·29	303.5
3:50	69.5	91.2			
4:5	68.8	89.5			
4:20	69.9	89.3			
4:35	70.2	88.6	100.1	102.65	401
	70.1 (mean)	90.5 70.1	2 (loss)	5.36 (gain)	97.5
		20.4 (gain)			

BEFORE SECTION.

Quantity of air (V') = 93.5 at $94^{\circ}\cdot 5 - 32^{\circ} = 62^{\circ}\cdot 5 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{93.5}{1.126} = 83. \quad W = V \times 0.08073 = 6.7$$

Rise in temp. of air $25.3 = t$. $Q = W \times t \times \text{sp. h.} = 6.7 \times 25.3 \times 0.2374 = 40.2417 = \text{heat given to air.}$

Fall in temp. of water $2.4 \times 130.8589^* = 314.0614 = \text{heat lost from calorimeter.}$

$40.2417 = \text{heat given to air.}$

*Heat lost by the calorimeter in $1\frac{1}{4}$ hours
beyond that accounted for* } 273.8197

AFTER SECTION.

Quantity of air (V') = 97.5 at $90^{\circ}\cdot 5 - 32^{\circ} = 58^{\circ}\cdot 5 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{97.5}{1.119} = 87.1. \quad W = V \times 0.08073 = 7.03$$

Rise in temp. of air $20.4 = t$. $Q = W \times t \times \text{sp. h.} = 7.03 \times 20.4 \times 0.2374 = 34.046 = \text{heat given to air.}$

Fall in temp. of water $2 \times 130.8589 = 261.7178 = \text{heat lost from calorimeter.}$

$34.046 = \text{heat given to air.}$

*Heat lost by the calorimeter in 1 hour
beyond that accounted for* } 227.6718

Heat Production.

BEFORE SECTION.

$Q = W \times t \times \text{sp. h.} = 21.5 \times 2.79 \times 0.75 = 44.9888 = \text{heat added to reserve.}$

Heat lost from calorimeter beyond that accounted for 273.8197

Heat added to reserve 44.9888

Heat lost in $1\frac{1}{4}$ hours over and above that produced by animal 228.8309

Hourly loss of heat from calorimeter over and above that produced 183.0647

AFTER SECTION.

$Q = W \times t \times \text{sp. h.} = 21.5 \times 5.36 \times 0.75 = 86.43 = \text{heat added to reserve.}$

Heat lost from calorimeter beyond that accounted for 227.6718

Heat added to reserve 86.43

Hourly loss of heat from calorimeter over and above that produced 141.2418

SUMMARY.

Heat lost in 1 hour from calorimeter over that produced before section 183.0647

Heat lost in 1 hour from calorimeter over that produced after section 141.2418

Hourly gain in heat production following section 41.8129

* Three calorimeters were used in this research; their respective thermic equivalents are—No. 1, 164.1474; No. 2, 130.8589; No. 3, 79.544.

EXPERIMENT 38.

A long-haired cur, weight 31 lbs.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	GEN. METER
12:47 P. M.	63.07	88 ^o .34	94 ^o .2	103.6	987
1:2	69.35	89.87			
1:17	69.71	90.68			
1:32	69.08	90.44			
1:47	68.72	88.28	93.52	104.2	996
	67.99	89.52	0.68	0.6	49
	(mean)	67.99	(loss)	(gain)	
		21.53			
		(gain)			

At 2:20 P. M. — Cord cut at first dorsal vertebra; at 3 P. M. dog put in the hot box, and taken out at 3:25 P. M.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	GEN. METER
3:35 P. M.	75 ^o .02	88 ^o .25	93 ^o .7	104.4	1003
3:50	74.6	89.87			
4:5	74.85	89.36			
4:20	72.63	88.04			
4:35	72.32	87.71	93.4	104.2	1011
	73.88	88.65	0.3	0.2	38
	(mean)	73.88	(loss)	(loss)	
		14.77			
		(gain)			

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 49 at 89^o.52—32^o = 57.52 = t' .
$$V + (V \times t' \times 0.002035) = V' \quad V = \frac{49}{1.117} = 43.86. \quad W = V \times 0.08073 = 3.54$$
Rise in temp. of air 21.53 = t . $Q = W \times t \times \text{sp. h.} = 3.54 \times 21.53 \times 0.2374 = 18.094 = \text{heat given to air.}$ Fall in temp. of water 0.68 \times 130.8589 = 88.984 = heat lost from calorimeter.

18.094 = heat given to air.

Heat lost by calorimeter beyond that } 70.890
accounted for

AFTER SECTION.

Quantity of air (V') = 38 at 88^o.65—32 = 56.65 = t' . $V + (V \times t' \times 0.002035) = V'$.
$$V = \frac{38}{1.115} = 34.08. \quad W = V \times 0.08073 = 2.751$$
Rise in temp. of air 14.77 = t . $Q = W \times t \times \text{sp. h.} = 2.751 \times 14.77 \times 0.2374 = 9.646 = \text{heat given to air.}$ Fall in temp. of water 0.3 \times 130.8589 = 39.2577 = heat lost from calorimeter.

9.646 = heat given to air.

Heat lost by calorimeter beyond that } 29.6117
accounted for

Heat Production.

BEFORE SECTION.

 $Q = W \times t \times \text{sp. h.} = 31 \times 0.6 \times 0.75 = 13.95 = \text{heat added to reserve.}$

Heat lost from calorimeter above dissipation 70.890

Heat added to reserve 13.95

Heat lost from calorimeter above that produced 56.940

AFTER SECTION.

$Q = W \times t \times \text{sp. h.} = 31 \times 0.2 \times 0.75 = 4.65 = \text{heat lost from reserve.}$

Heat lost from calorimeter beyond that accounted for	29.6117
Heat lost from reserve	4.65
	34.2617
<i>Heat lost from calorimeter above that produced</i>	
Heat lost from calorimeter above that produced before section	56.94
Heat lost from calorimeter above that produced after section	34.2617
	22.6783
<i>Apparent loss of heat production following section</i>	

EXPERIMENT 39.

A dog, weight 31.5 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	METER. (cub. ft.)
12:7 P. M.	75 ^o .2	93 ^o .9	99 ^o .65	103 ^o .2	589
12:22	74.4	95.7			
12:37	74.4	95.5			
12:52	73.8	96.7			
1:7	74.1	96.7			
1:22	74.9	96.1	98.3	104.4	713.42
	74.47 (mean)	95.77 74.47	1.35 (loss)	1.2 (gain)	124.42
		21.3 (gain)			

1:45 P. M.—Cord cut in the upper dorsal region.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	METER. (cub. ft.)
2:37 P. M.	75 ^o .9	92 ^o .3	99 ^o .3	103 ^o .1	739
2:52	74.5	91.8			
3:7	74.2	91			
3:22	74	92.4			
3:37	74.4	93.2			
3:52	72.5	93.5	98.3	106	816
	74.25 (mean)	92.36 74.25	1 (loss)	2.9 (gain)	77
		18.11 (gain)			

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 124.42 at 95^o.77—32^o = 63.77 = v' .
 $V + (V \times v' \times 0.002035) = V'$. $V = \frac{124.42}{1.13} = 110$. $W = V \times 0.08073 = 8.88$
 Rise in temp. of air 21.3 = t . $Q = W \times t \times \text{sp. h.} = 8.88 \times 21.3 \times 0.2374 = 44.9028 = \text{heat given to air.}$
 Fall in temp. of ⁸⁰⁰⁰water 1.35 \times 130.8589 = 176.6595 = heat lost from calorimeter
 44.9028 = heat given to air.
 Heat lost in 1 $\frac{1}{4}$ hours from calorimeter } 131.7567
 beyond that accounted for }
Hourly loss from calorimeter beyond that accounted for 105.4053

AFTER SECTION.

Quantity of air (V') = 77 at 92^o.36—32^o = 60.36 = v' .
 $V + (V \times v' \times 0.002035) = V'$. $V = \frac{77}{1.123} = 68.6$. $W = V \times 0.08073 = 5.54$
 Rise in temp. of air 18.11 = t . $Q = W \times t \times \text{sp. h.} = 5.54 \times 18.11 \times 0.2374 = 23.8182 = \text{heat given to air.}$
 Fall in temp. of water 1 \times 130.8589 = 130.8589 = heat lost from calorimeter.
 23.8182 = heat given to air.
 Heat lost in 1 $\frac{1}{4}$ hours from calorimeter } 107.0407
 beyond that accounted for }
Heat lost in one hour from calorimeter beyond that accounted for 85.6325.

Heat Production.

BEFORE SECTION.

$Q = W \times t \times \text{sp. h.} = 31.5 \times 0.96 \times 0.75 = 22.68 = \text{heat added to reserve.}$	
Heat lost from calorimeter	105.4053
Heat added to reserve	22.68
<i>at lost from calorimeter beyond that produced</i>	82.7253

AFTER SECTION.

$Q = W \times t \times \text{sp. h.} = 31.5 \times 2.32 \times 0.75 = 54.81 = \text{heat added to reserve.}$	
Heat lost from calorimeter	85.6325
Heat added to reserve	54.81
<i>Heat lost from calorimeter above that produced</i>	30.8225

SUMMARY.

Heat lost from calorimeter above that produced before section	82.7253
Heat lost from calorimeter above that produced after section	30.8225
<i>Apparent gain of heat production following section</i>	51.9028

In studying the series of experiments just reported, the excessive loss of heat by the calorimeter at once attracts attention. As already stated (page 19), the apparatus when worked at high temperatures is very unsatisfactory, the loss of heat from it being not only very great but also irregular. By the previous use of water at 100° F., and other precautions, the attempt was made to have the calorimeter heated equally throughout, but very careful experimental tests have shown that this is almost impossible, and that all experiments made in the manner of those just recorded must be received with great reserve. The results are, however, so decided as perhaps to be beyond the probable limits of error, especially as they seem coincident with the results obtained by exposing animals to a hot atmosphere before and after section of the cord. It was found that in strong animals the temperature rose faster after section of the cord than before, while in weak animals the reverse was the case. In Experiment 35 the animal temperature rose much faster before than after section, and the production of heat was much less after the operation. The same is true of Experiment 36. In Experiment 37 the hourly rise of rectal temperature was not quite 0.2° F. faster after than before section, and the production of heat 31 units more; in Experiment 38 the animal was very hot when put in the box the second time, and the temperature did not rise materially; this time the heat production was slightly diminished by the section. Finally, in Experiment 39 the rectal temperature rose more than twice as fast after the division of the cord, and the gain of heat production was corresponding.

If these experiments be of any value whatever they show two things: *First.* That the fall of temperature of the body usually following spinal section has a very important effect in lessening the amount of heat produced, *i. e.*, the chemical movements of the body. *Second.* That when the effect of the cooling of the body is done away with, section of the cord is sometimes followed by a decreased, sometimes by an increased heat production, and that the latter occurs especially in robust animals. I desire to repeat that these conclusions must be received with

reserve, because we cannot rely upon the working of the calorimeter at a high temperature as accurate.

The conclusions reached, if correct, would indicate that after section of the cord there are two distinct antagonistic forces at work, the one depressing, the other increasing, the production of animal heat. As has already been stated, section of the spinal cord causes vaso-motor paralysis, to which is believed to be due in great part if not altogether the thermic changes in the animal economy which follow the operation. It is of course entirely possible that the thermic changes may be the result of some unknown influences. This could be definitely settled if we had the power to isolate the action of the vaso-motor system by dividing the cord in such a way as to leave intact the vaso-motor nerves whilst severing all other fibres. Since this cannot be done, the question naturally suggests itself: is it possible to cut the spinal cord above the vaso-motor centres; and if this be possible, what is the effect of such division upon the thermic functions of the body? The answering of these questions comes so imperatively into the present inquiry that it is necessary to step aside for a time from what might be considered the direct line of investigation.

The usual test for the integrity of the vaso-motor system is the effect of the galvanization of a sensitive nerve upon the blood pressure after the animal has been quieted with woorara and the pneumogastrics severed. Under these circumstances normally there is a very great rise of arterial pressure, and if this fail to occur vaso-motor paralysis is known to exist.

Dr. C. Dittmar (*Berichte über die Verhandlungen der Königl. Sachs. Gesellschaft der Wissenschaften zu Leipzig. Math. Phys. Classe.* 1870, Bd. xxii.) is the first experimenter to whose original paper I have had access, who proved that, after separation of the medulla from the pons, irritation of a sensitive nerve still causes a great increase of the arterial pressure. Thus in his experiment *a* (p. 33) on a rabbit, the medulla having been previously cut at its junction with the pons, the pressure rose 29 millimetres of mercury in 16 seconds, and in experiment *b*, both peduncles of the crura cerebri having been previously divided, the rise amounted to 30 millimetres.

I. Owsjannikow (*Berichte, etc.*, Bd. xxiii.) has experimented very elaborately, and has found that in cats and rabbits the dominant vaso-motor centre is in a region whose upper boundary is one or two millimetres below the corpora quadrigemina, and whose lower boundary is four to five millimetres above the point of the calamus scriptorius.

Owsjannikow divided the nerve centres with very fine knives, and employed the effect upon the arterial pressure of galvanizing a sensitive nerve as a test of the integrity of the vaso-motor centre. His experiments have every appearance of care and accuracy.

R. Heidenhain (*Pflüger's Archiv*, 1871, Bd. iv. p. 552) has also, in numerous experiments, determined that separation of the medulla from the pons in dogs does not prevent the rise of arterial pressure when a sensitive nerve is irritated.

The results obtained separately by Dittmar, Owsjannikow, and Heidenhain, are

therefore in accord, and indicate that the chief vaso-motor centre is in the medulla oblongata, probably in the exact position indicated by Owsjannikow.

It is true that Prof. Cyon (*Mélanges Biologiques tirés du Bulletin de l'Académie Impériale des Sciences de St. Petersbourg*, t. vii.) found that when the cerebral hemispheres are removed, the medulla oblongata and the cerebellum being left unharmed, irritation of a sensitive nerve is not followed by a rise of arterial pressure. The shock and the bleeding from such an operation are, however, so great that the results of the experiments are of little value; certainly the loss of blood and the nervous disturbance might very conceivably of themselves paralyze the vaso-motor centres, or their controlling influence, if these latter were in the medulla oblongata. Therefore it cannot be allowed that the experiments of Prof. Cyon really contradict those which have just been cited.

Recently the correctness of the conclusion of Dittmar and his corroborators has been further called in question (Dupuy, *Transactions American Neurology Society*, 1877), and it seems therefore necessary to report the following records of experiments which entirely confirm those of Dittmar, Owsjannikow, and Heidenhain, and which demonstrate that the chief or governing vaso-motor centre is situated in the lower part of the fourth ventricle.

EXPERIMENT 40.

A stout dog. Medulla cut, pneumogastrics severed at 12:20 P. M.

12:30 P. M.—Arterial pressure 120. On galvanizing a sensitive nerve the pressure at first fell but soon rose to 185, although there were no convulsions or muscular movements except in the muscles directly tributary to the nerve.

Autopsy.—Medulla nearly severed obliquely at its junction with the pons.

EXPERIMENT 41.

A terrier.

1:35 P. M.—Section made; at 3 P. M. the animal breathing quietly, the carotid was connected with the manometer, and the sciatic nerve exposed.

TIME.	ARTERIAL PRESSURE. (Millimetres.)	IRRITATION.	REMARKS.
3:5 P. M.	90-100*	.....
3:30	90-100	Began.	
3:10	125-120	Ceased.	
3:16	.....	.....	Par vagum cut.
3:21	65-9	.....
3:24	65-95	Began.	
3:26	120-125	Ceased.	No convulsive movements have been produced by the current except in the distal muscles supplied by the nerve.

Autopsy.—Right half of medulla completely separated at its junction with the pons except a small band on each side; left side cut through except a narrow band at the outer edge.

* The pressure experiments reported in this paper are all of them relative experiments; the pressures are in millimetres, but the zero is different in different experiments, always, however, being uniform throughout each experiment; the numbers do not, therefore, mark absolute amounts of pressure; the rise or fall is, of course, an absolute quantity.

EXPERIMENT 42.

A terrier.

2 P. M.—Section made; 3:55 P. M. kymographion connected with the carotid, the sciatic nerve exposed, and one pneumogastric cut.

TIME. M. Sec.	ARTERIAL PRESSURE. (Millimetres.)	IRRITATION.	REMARKS.
0	195-200	.....
0:30	.....	.....	Remaining pneumogastric cut.
1	200-210	.....
2:30	190-197	Began.	Moderate current.
3	195-200	.....
3:30	195-200	Ceased.	
4	195-200	.....
4:30	195-200	.....
5	194-202	.....
5:30	196-201	Began.	Current is very intense, full force of Du Bois Reymond coil, with a large (quart) Siemens' and Halske's cell.
6:30	200-203	Ceased.	
7	200-203	.....
9	.....	.....	Animal killed.

Autopsy.—Medulla wounded deeply upon right side, which is practically destroyed from within about four lines below to one line above the extreme point of calamus.

EXPERIMENT 43.

A large dog. The section was made as proven by autopsy just below the point of the calamus, entirely through the right side of the medulla, and more than half through the left side. Galvanization of the sciatic nerve with an intense current had no effect upon blood pressure.

An examination of these experiments will show that they fully confirm those of Dittmar, Owsjannikow, and Heidenhain. In Experiments 41, 42, section was practised entirely above the region of the calamus, and rise of arterial pressure followed upon galvanization of a nerve, as in the normal animal. In Experiments 42, 43, the injury to the nerve centres was within a space of four lines below and above the point of the calamus, and the vaso-motor palsy was complete. I have repeated these experiments at various times with identical results, and the evidence seems to me conclusive that the chief governing vaso-motor centre is placed in the lower portion of the floor of the fourth ventricle near the point of the calamus.

The position of the autoeratic vaso-motor centre having been determined, the next step in the investigation naturally is a study of the effect of wounds of the medulla, below and above this centre, upon the bodily temperature. The following experiments were performed to determine the results of sections of the medulla which cause vaso-motor palsy.

EXPERIMENT 44.

A small rabbit.

TIME.	RECT. TEMP.	REMARKS.
11:44 A. M.	102°.5 F.	Skull previously bared.
11:45	.....	Section with a very fine tenotome; almost instantaneous fall of temperature.
11:47	99.5	Arterial pressure 92 millimetres; galvanic irritation of the sciatic nerve caused no rise of pressure until the current was so strong as to produce general tetanic contractions; then the mercury rose very slowly 3 millimetres.
11:50	99.5	
12:15 P. M.	.....	Arterial pressure 92 millimetres; the most violent irritation of the sciatic does not affect it.
12:20	93.5	Animal breathing regularly; killed.

Autopsy.—Very few clots; wound a full $\frac{1}{4}$ inch below the lower edge of the cerebellum, nearly severing right half of the cord and wounding the left half.

EXPERIMENT 45.

A large dog		
Time.	Rect. Temp.	REMARKS.
1:45 p. m.	102°.92 F.	Section made.
1:50	103.4	
3:15	94.28	
3:45	.....	Testing arterial pressure shows complete palsy of the vaso-motor system.

Autopsy.—Partial section just below the point of the calamus.

These experiments prove that severe injuries of the medulla below the calamus produce results similar to but greater than those caused by section of the cord, namely, fall of the animal temperature and of the arterial pressure, and confirm the belief that the fall of temperature is due to vaso-motor paralysis.

The effects on the dissipation and production of animal heat of injury either in the immediate neighborhood of, or below the vaso-motor centre having been determined, attention naturally next directs itself to the results produced by wounding the medulla so far above the vaso-motor centre as to avoid injuring it.

Tscheschichin, in a single experiment, found that division of the medulla at its junction with the pons was followed by an immediate and very marked rise of the temperature of the body. J. Bruck and A. Günter (*Pflüger's Archiv*, Bd. iii, p. 579) have also experimented upon the effect of section of the medulla oblongata at the border of the pons on the temperature. They used rabbits, and operated without opening the skull. In seven operations they found that in one the temperature rose enormously after the section, in another it rose very decidedly (1°.1 C.) and in four cases it fell continuously.

I have myself practised a number of experiments of this character, in most cases upon dogs, but in a few instances upon rabbits. I have found it a matter of difficulty to make a clean, complete section of the medulla at its junction with the pons without inducing serious hemorrhage or injuring some other portion of the medulla. The chief trouble lies with the bleeding. The various venous and arterial anastomoses at the base of the brain are always in great danger, and the slightest injury to them invalidates the experiment by causing pressure on the vaso-motor, respiratory, and other important centres. Various methods of experimenting have been practised. Thus, I have tried entering laterally, boring through the skull with a suitable knife, or opening it with a trephine. Again, various attempts have been made to enter through the foramen magnum. At one time a knife, invented by Dr. Lautenbach, acting somewhat on the principle of Bellocque's canula, was employed, the canula being passed up along the medulla through the foramen magnum, and the knife pushed out when sufficiently far in. A thorough trial demonstrated that this plan is impracticable. All other methods of operating were finally abandoned for the following:—

With a small trephine open the skull in the triangular space below the occipital protuberance, so as to enter between the diverging branches of the great longitudinal sinus. Then have the head of the animal firmly held vertically with the nose downwards, pass a narrow dull-pointed knife in, and when sufficiently entered bend

the handle forward so as to direct the point of the knife against the base of the skull, taking care in doing this to throw the point of the knife to one side so as to avoid the basilar artery. Having steadied the knife against the skull, withdraw the point one or two lines so as to avoid the meningeal vessels, and make a sweeping cut. By this procedure the medulla is readily separated from the pons, but no care can ensure the basilar vessels from injury. The cerebellum is of course wounded to some extent, but my experience shows that this has no influence upon the result so far as the thermic or other appreciable symptoms are concerned.

The following experiments exemplify the effect of section of the medulla high up, upon animal temperature.

EXPERIMENT 46.

A large powerful mongrel dog.

TIME.	RECT. TEMP.	REMARKS.
12 M.	102 ^o .25 F.	
12:20 P. M.	.....	Since last note, the skull has been opened above the foramen magnum with a trephine; in doing this a sinus has undoubtedly been wounded, as the dog has lost fully three-quarters of a pint of blood. I have just severed the medulla.
12:25	103.25	
12:30	103.75	
12:40	104	Breathing regular.
12:50	104.50	
1	104.75	
1:10	105.25	
1:30	105.50	Thermometer put into the abdominal cavity.
2	.....	Cardiometer connected with the femoral artery. Arterial pressure 75; upon galvanization of a sensitive nerve it fell to 50. The pneumogastric nerves were next cut; pressure after this was 45-55; on galvanization of a sensitive nerve the pressure rose to 65. The breathing was very much affected, and paralysis both of sensation and motion seemingly complete. Animal killed.

Autopsy.—Medulla oblongata divided at its junction with the pons. Cerebellum wounded.

EXPERIMENT 47.

A very powerful long-haired dog.

TIME.	RECT. TEMP.	REMARKS.
2:18 P. M.	106 ^o .8 F.	Dog has been struggling and fighting most violently, hence his high temperature.
2:19	.....	Section made.
2:25	107.8	
2:30	106.9	
2:35	107.0	
2:50	107.4	
3	107.9	Dog killed.

Autopsy.—Left side of the medulla separated from the pons, except the anterior fibres. Right side, superior one-quarter cut through.

EXPERIMENT 48.

A terrier bitch of moderate size and strength.

Time	Rect. Temp.	REMARKS
11:45 A. M.		
11:47	103.25 F.	Cut the medulla. Breathing at once ceased almost entirely, so that the dog was at one time thought to be dead, and artificial respiration, by compressing the body with the hand, was resorted to.
11:53	.....	Dog beginning to breathe voluntarily, conjunctiva not sensitive, complete paralysis of sensation and motion throughout the body.
11:54	103.50	Temp. of room 70°.
11:60	103.75	
12:15 P. M.	103.75	Dog shows no other signs of life than the slow, regular breathing.
12:30	103.75	
12:40	104.	
12:45	104.25	Breathing noisy, irregular.
12:55	104.75	General muscular rigidity, with frequent convulsions and tremor; both symptoms are much aggravated by any irritation of the surface. Legs stiffly extended, tail forcibly drawn down between them.
1:15	106.	Temp. of room 70°.
2:10	107.75	Thermometer is now in abdominal cavity (has been in the rectum). The dog has been vomiting freely.
2:15	.....	Arterial pressure 150-160; galvanization of a nerve caused it to fall to 120-130.
2:20	108.135	Cut the par vagum. Breathing at once almost suspended.
2:22	.....	Respiration only at very long intervals. Blood in arteries venous. On connecting a cardiometer tube with the femoral, the mercury rose to the top of the tube (205) and flowed over in abundance.
2:25	.....	There has been no breathing for some minutes. Heart has not ceased to beat.

Autopsy.—Knife has passed through the cerebellum, scraping the posterior surface of upper portion of medulla, and cutting it very obliquely at its junction with the pons.

In looking over the records of these experiments, it will be found that they appear very conclusive, in regard to the rise of temperature which follows division of the medulla high up. One of the most powerful means of lowering the temperature at our command is venesection, and yet, although the dog in Experiment 46 was almost bled to death, the temperature rose from the time the medulla was divided. In Experiment 47 the animal temperature was extraordinarily high, and yet the temperature began to rise at once after the operation. In Experiment 48 no bleeding of any moment occurred, and the elevation of temperature was therefore more marked than in the first trial. The rise commenced immediately after the division of the medulla, and amounted to almost five degrees, and was still increasing when the animal died. As the temperature of the surrounding air in both cases was not over seventy, the evidence is conclusive.

In neither case were the vaso-motor centres paralyzed. In the first experiment, after division of the par vagum, galvanization of a sensitive nerve was followed by a slight but distinct rise of the arterial pressure. The reason that this rise was so slight was probably the very small amount of blood in the vessels consequent upon the hemorrhage, so that contraction of the arteries was not followed by its usual effects.

In the smaller dog, the evidence that the general vaso-motor system was intact, was unimpeachable. At first, the galvanization of a sensitive nerve reduced the pressure, very decidedly, on account of its influence on the par vagum and the heart.

The amount of the arterial pressure was, however, sufficient to prove the integrity of the vaso-motor system, for if the vessels had all been dilated, the mercury in the tube of the manometer could certainly not have stood where it did. Whenever asphyxia is produced in the normal animal, an enormous rise of arterial pressure results, chiefly from vaso-motor spasm caused by the excess of carbonic acid in the blood. The great rise of pressure (from 120 to 205) which followed arrest of respiration in Experiment 48 is positive proof of the section having been made above the vaso-motor centre. The following experiment is confirmatory of the preceding one.

EXPERIMENT 49.

A stout young dog above medium size.

TIME.	RECT. TEMP.	REMARKS.
10:30 A. M.	103° 25 F.	
10:50	.....	Brain opened with slight hemorrhage.
10:55	104.12	
11:5	104.12	
11:20	104.37	
11:35	103.12	Medulla cut. Absolute paralysis of motion and of sensation at once developed.
11:37	103	
12 M.	103	
12:30 P. M.	103	Arterial pressure 120; on galvanizing the nerve the pressure fell at first but soon rose to 185, no movements except in muscles supplied by nerve were elicited.
1	101.75	
1:20	101	
1:25	.....	Dog put in a box at a temperature of 90°.
1:45	101.37	Temperature of box 102°.
2:30	104.25	Temperature of box 104.
2:45	104.50	Temperature of box 90.
3	105	Temperature of box 88.
3:30	106.50	Temperature of box 94.
4	107	Temperature of box 84.
4:30	107	Temperature of box 82.
4:40	107	Temperature of box 76.
5:30	107	Temperature of box 72.
8	106	Temperature of box 64.
8:30	105	Temperature of box 64.
9	105	Temperature of box 64.

Next morning the dog was found dead.

Autopsy.—Medulla was nearly severed obliquely, where it merged into the pons.

In this case, though there was a primary fall of temperature, the fever, when developed, was independent of the external heat, for whilst the latter was steadily falling from 104° to 72°, the animal heat rose from 104° to 107°. In this experiment the arterial pressure rose from 120 to 185, when a sensitive nerve was galvanised, and the vaso-motor system was therefore intact.

Upon dogs I have performed a number of other experiments similar to those just detailed, with a like result, but in a half dozen or more trials upon rabbits I have not once obtained a distinct permanent rise of temperature after section of the upper medulla. As examples of these experiments the following are submitted:—

EXPERIMENT 50.

A rabbit.

Time.	Rect. Temp.	REMARKS.
11:20 a. m.	.....	Skull opened.
11:25	103 F.	
11:29	.....	Section of brain made; most violent convulsions came on and lasted a few minutes.
11:30	103.5	
11:33	104	Animal quiet.
11:34	.....	Respiration ceased.
11:35	103.25	

Autopsy.—Wound of brain above the pons. One of the crura cerebri cut through entirely except a shred, the other crus wounded. A large clot at base of brain running into the fourth ventricle.

EXPERIMENT 51.

A rabbit.

Time.	Rect. Temp.	REMARKS.
12 m.	.....	Skull opened.
12:50 p. m.	105 F.	Rabbit purging.
12:8	.....	Brain operated upon.
12:10	105	
12:13	105.75	Temperature of room 70°.
12:21	105	
12:25	104.5	Rabbit purging.
12:28	104.5	
12:35	104	
12:45	104	
2:5	105.75	Rabbit lying in the sun, temperature of room 78°. Rabbit put in the shade.
2:22	105.75	
3:2	.....	Violent convulsions lasting a minute, followed by death.

Autopsy.—Incision nearly dividing pons and medulla at their junction, edge of the incision more than a millimetre from the Owsjannikow's space.

EXPERIMENT 52.

A rabbit.

Time.	Rect. Temp.	REMARKS.
4:28 p. m.	104.5 F.	
4:30	.....	Puncture of the left side of the brain through the skull.
4:33	104.75	Animal apparently completely paralyzed, not convulsed.
4:36	104.85	
4:41	104.75	
4:50	104.5	Violent persistent clonic spasm of the left side of the neck.
5:15	103	
5:40	102	
9	95	Animal died during the night.

Autopsy.—A clean incision running obliquely through the pons reaching above a point on its upper surface, below to within about a line of the lower surface.

It will be seen that these experiments, along with those of Bruck and Gantzer, show that it is an exceptional circumstance to get a rise of temperature in the rabbit when section is made to the medulla at its junction with the pons. I have also found that in the dog very frequently the rise does not occur, or is not permanent. This certainly in many and possibly in all cases is due to the formation of a clot in the

fourth ventricle, and consequent paralysis by pressure of the vaso-motor centres. The following experiment will serve as an example:—

EXPERIMENT 53.

A moderate sized dog.

TIME.	RECT. TEMP.	REMARKS
10:45 A. M.	.....	Opened the skull.
10:57	102°·5 F.	
11:6	.....	Cut the medulla.
11:10	102.65	Perfect paralysis; breathing nearly suspended.
11:12	102.76	
11:18	103	Breathing regular; entire paralysis.
11:27	102.87	
12:15 P. M.	101.75	
12:30	101.5	
12:45	101.25	
1	100.75	
1:30	100	
2	99.75	
3	97.25	
4:20	97.75	Galvanic current applied to the exposed sciatic nerve slows the pulse, blood pressure not decidedly affected.
4:40	.....	Par vagum cut.
4:45	.....	Current applied to freshly exposed femoral nerve, unless sufficiently violent to cause general tetanus, has no effect upon the blood pressure.
5:15	.....	Current applied to a freshly exposed sciatic nerve, result as before; under a very violent current the dog showed signs of feeling.
6:10	.. .....	Current again applied; no result.

Autopsy.—Section just at the junction of pons and medulla, leaving on each side a portion of tissue uncut, a fragment of bone lying upon the cerebellum and pressing it down upon the medulla. The whole of the fourth ventricle occupied with a firm clot pressing upon and separating all the parts.

The progress of this experiment is very instructive. In beginning, the vaso-motor centre was not implicated, and the bodily temperature began to rise. Subsequently a clot formed, and slowly annihilated by pressure the function of the vaso-motor centre. With the progressive vaso-motor paralysis the temperature of the body fell, at first slowly and then rapidly. When, as was proven by experimental test, the vaso-motor palsy was complete, the degree of bodily heat was far below the normal.

In searching for the reason that in rabbits separation of the medulla from the pons is so seldom followed by an increase of the animal temperature, paralysis of the vaso-motor centres by direct injury, shock, or hemorrhagic pressure at once suggests itself. The rabbit is so small an animal that the distance between the space assigned by Owsjannikow as containing the vaso-motor centre and the border of the pons cannot be more than a tenth of an inch. It is therefore very evident that to avoid wounding or influencing the vaso-motor centre, in dividing the medulla high up, is in the rabbit an exceedingly difficult and indeed almost impossible task.

In conclusion, the following propositions may be considered as expressing the demonstrations of the preceding experiments upon the effect of section of the medulla on animal temperature.

Injuries of the medulla, so situated as to paralyze the medullary vaso-motor centres, are followed by a very decided fall of animal temperature.

Section of the medulla at the line of its junction with the pons, in the dog usually leads to an elevation of animal temperature, if the medullary vaso-motor centres are not in any way compromised.

The rise and fall of animal temperature following sections of the medulla may be due to alterations of heat production or of heat dissipation. To determine this the following experiments have been performed.

The first series were undertaken to determine the effect of injuries which cause paralysis of the vaso-motor centres.

EXPERIMENT 54.

A large cur, weight 26.25 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:25 p. m.	70°.16	74° 8	72° 36	102°.92	828.057
12:40	69.32	75.47			
12:55	67.46	73.3			
1:10	69.44	73.76			
1:25	69.2	73.45	72.59	102.92	906.04
	69.12	74.16	0.23	0	77.983
	(mean)	69.12	(gain)		
		5.04			
		(gain)			

1:45 p. m.—Section made, followed by paralysis, which was complete, except that one leg was occasionally slightly moved. 1:50 p. m.—Rectal temperature 103° F.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:15 p. m.	70°.34	73°.68	71°.78		943.64
2:30	70.25	73.68			
2:45	70.04	74.12			
3	70.25	73.76			
3:15	70.97	74.66	72.41	94°.28	1023.074
	70.37	73.98	0.63		79.434
	(mean)	70.37	(gain)		
		3.61			
		(gain)			

3:30 p. m.—Animal still breathing well: the kymographion was connected with the carotid, the pneumogastrics cut and the sciatic exposed; galvanization of the sciatic had no influence upon blood pressure, although a very powerful current was used. The dog was killed some time later.

Autopsy.—The section was through the medulla, just below the point of the calamus. The right side was cut through completely, the left more than half through.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 77.983 at 74°.16—32° = 42.16 = t' . $V + (V \times t' \times 0.002035) = V'$.

$$V = \frac{77.983}{1.086} = 71.8. \quad W = \frac{1}{2} > 0.08073 = 5.8$$

Rise in temp. of air 5.04 = t . $Q = W \times t \times \text{sp. h.} = 5.8 \times 5.04 \times 0.2374 = 6.9397 = \text{heat given to air}$

Rise in temp. of water 0.23 \times 164.1414 = 37.7525 = heat given to calorimeter.

$$6.9397 = \text{heat given to air.}$$

Hourly dissipation of heat 44.6922

AFTER SECTION.

Quantity of air (V') = 79.434 at $73^{\circ}.98 - 32^{\circ} = 41.98 = t'$. $V + (V \times t' \times 0.002035) = V'$.

$$V = \frac{79.434}{1.085} = 73.2. \quad W = V' \times 0.08073 = 5.91$$

Rise in temp. of air $3.61 = t$. $Q = W \times t \times \text{sp. h.} = 5.91 \times 3.61 \times 0.2374 = 5.065 = \text{heat given to air.}$

Rise in temp. of water $0.63 \times 164.1414 = 103.4091 = \text{heat given to calorimeter.}$

5.065 = heat given to air.

Hourly dissipation of heat 108.4741

SUMMARY.

Hourly dissipation of heat after section 108.4741

Hourly dissipation of heat before section 44.6922

Gain in hourly dissipation of heat following section 63.7819

Heat Production.

BEFORE SECTION.

No change in bodily temperature.

Hourly heat dissipation = hourly heat production 44.6922.

AFTER SECTION.

Fall in temperature of animal in 85 minutes $8^{\circ}.72$.

Fall in temp. per hour $6.156 = t$. $W = 26.25$.

$Q = W \times t \times \text{sp. h.} = 26.25 \times 6.156 \times 0.75 = 121.1963^* = \text{heat drawn from reserve.}$

Heat drawn from reserve 121.1963

Heat dissipated hourly 108.4741

Heat lost from reserve over and above that accounted for 12.7222

SUMMARY.

Heat production before section 44.6922

Heat lost from reserve after section above that accounted for 12.7222

Difference in heat production before and after section 57.4144

EXPERIMENT 55.

A terrier bitch. Weight 16.25 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:50 P. M.	69 ^o .44	68 ^o .72	61 ^o .997	101 ^o .84	675.605
1:10	69.68	67.79			
1:30	65.48	66.68			
1:40	66.38	66.68			
1:50	.....	.....	63.1256	101.84	758.425
	<u>67.75</u>	<u>67.47</u>	<u>1.1286</u>	<u>0</u>	<u>82.82</u>
	67.47	(mean)	(gain)		
	<u>0.28</u>				
	(loss)				

2 P. M.—Section made. The trephine slipped and wounded the nerve centres. 2:3 P. M.—Rectal temperature, 104° ; 2:10 P. M., rectal temperature, $102^{\circ}.92$; 2:20 P. M., rectal temperature, $102^{\circ}.92$.

* This is probably excessive, because the cooling of the animal was almost certainly more rapid directly after the temperature in the rectum was taken than it was later.

Time	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter (cub. ft.)
2:35 p. m.	66.2	66.47	62.72		795.575
2:50	66.08	67.43			
3:5	65.96	67.12			
3:20	68.36	67.02			
3:35	64.76	68.09	63.50	100.13	860.32
	66.27 (mean)	67.23 66.27	0.78 (gain)		64.745
		0.96 (gain)			

3:55 p. m.—Carotid connected with the kymographion, the sciatic having been exposed, and pneumogastric cut.

Time. M. Sec.	ARTERIAL PRESS. (Millimetres.)	REMARKS.
0	195-200	
0 0	.....	Remaining pneumogastric cut.
	200-210	
2:50	190-197	Moderate galvanic irritation of the sciatic commenced.
3	195-200	
3:30	195-200	Irritation ceased.
4	195-200	
4:30	195-200	
5	194-202	
5:30	196-201	Very powerful galvanic current applied to the sciatic.
6:30	200-203	Irritation ceased. Muscular contractions caused by the current abundant sufficient to account for the slight rise of the arterial pressure.
7	200-203	

Autopsy.—Two wounds of medulla, each upon the right side, the left half being the more extensive, situated about four lines above the point of the calamus, and extending half-way to the centre. There was considerable effused blood in the brain, but no distinct spots.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V) = 82.82 at $67^{\circ}.47 - 32^{\circ} = 35.47 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{82.82}{1.072} = 77.3$. $W = V \times 0.08073 = 6.24$

Fall in temp. of air $0.28 = t$. $Q = W \times t \times \text{sp. h.} = 6.24 \times 0.28 \times 0.2374 = 0.4148 = \text{heat taken from air.}$

Rise in temp. of water $1.1286 \times 164.1414 = 185.25 = \text{heat given to calorimeter.}$

$0.4148 = \text{heat taken from air.}$

Heat dissipated in one hour 184.8352

AFTER SECTION.

Quantity of air (V) = 64.745 at $67^{\circ}.23 - 32^{\circ} = 35.23 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{64.745}{1.072} = 60.4$. $W = V \times 0.08073 = 4.88$

Rise in temp. of air $0.96 = t$. $Q = W \times t \times \text{sp. h.} = 4.88 \times 0.96 \times 0.2374 = 1.1122 = \text{heat given to calorimeter.}$

Rise in temp. of water $0.78 \times 164.1414 = 128.0303 = \text{heat given to calorimeter.}$

$1.1122 = \text{heat given to air.}$

Heat dissipated in one hour 129.1425

SUMMARY.

Hourly dissipation of heat before section 184.8352

Hourly dissipation of heat after section 129.1425

Hourly diminution of heat dissipation following section 55.6927

Heat Production

BEFORE SECTION

Loss of heat from bodily reserve none.

Hourly heat dissipation = hourly heat production 184.8352

AFTER SECTION.

Fall of bodily temperature in 1¼ hours 2.79, in 1 hour 2.232 = t.

$Q = W \times t \times \text{sp. h.} = 16.25 \times 2.232 \times 0.75 = 27.2025 = \text{loss of heat from reserve.}$

Hourly dissipation of heat	129.1425
Loss of heat from reserve	27.2025

<i>Hourly production of heat</i>	101.94
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SUMMARY.

Hourly production of heat before section	184.8352
Hourly production of heat after section	101.94

<i>Diminution of heat production following section</i>	82.8952
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When the medulla is injured in such a way as to paralyze the vaso-motor centres, thermic symptoms similar to those caused by section of the cord would naturally be looked for. In Experiment 54 such symptoms were actually present, the heat dissipation being primarily increased and the heat production diminished. On the other hand, in Experiment 55 the result was not altogether in accord with the preconception. Heat production certainly was diminished, but heat dissipation so far from being increased was actually lessened. The medulla was not, however, completely severed, one-half of it indeed being uninjured. It is, therefore, very probable that the vaso-motor paralysis was not complete, sufficient of the nerve fibres remaining intact to allow of some regulation of heat dissipation by the organism. That increased heat dissipation follows immediately upon complete vaso-motor palsy is very strongly indicated by the immediate and very rapid fall of bodily temperature which occurred in Experiments 44 and 45 when the knife was plunged into the vaso-motor centre.

From all the evidence it seems to me that we are justified in concluding that *wounds of the medulla so situated as to paralyze the vaso-motor centres cause decreased heat production with (certainly sometimes and probably always) primarily increased heat dissipation.*

The next series of experiments were directed to the determination of the effect upon calorification, of section of the medulla at its junction with the pons. The experiments are as follows:—

EXPERIMENT 56.

A terrier bitch. Weight 17.25 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
11:35 A. M.	71.0.9	73.0.1	74.0.4	102.0.2	378.79	0.4422	1.503
11:50	72.65	73.4					
12:5 P. M.	73	73.4					
12:20	73.4	73.45					
12:35	74.08	74.1					
12:50	75.2	74.5					
1:5	75.2	74.5	75.42	103.28	451.78	0.5076	1.5563
	73.63 (mean)	73.78 73.63	1.02 (gain)	1.08 (gain)	72.99 0.0654	0.0654	0.0533
		0.15 (gain)			73.0554		

1:25 P. M.—Medulla cut. Rectal temperature at once rose.

1:33 P. M.—Rectal temperature 104° . No apparent sensibility; breathing good; violent tremor; movements towards the right; very marked convergent downward strabismus, with constant oscillations of the eyeballs. Pupils widely dilated.

1:40 P. M.—Rectal temp. $103^{\circ}.64$. 1:51 P. M.—Temp. $103^{\circ}.64$. 2 P. M.—Temp. $103^{\circ}.8$. 2:15 P. M.—Temp. $103^{\circ}.8$. 2:30 P. M.—Temp. $103^{\circ}.9$.

Time	Air Temp. (Fah.)	Temp. (Fah.)	Box Temp. (Fah.)	RECT. TEMP. (Fah.)	GENERA METER (cub. ft.)	SAMPLE METER (cub. ft.)	AIR METER (cub. ft.)
2:45 P. M.	76°	$77^{\circ}.1$	75°	$103^{\circ}.9$	484.22	0.5101	1.6641
3	77.4	76.8					
3:15	78.44	77.18					
3:30	78.44	77.36					
3:45	78.3	77.44					
4	78	77.18					
4:15	.....	.....	76.34	102.92	556.74	0.5794	1.644
	78.1	77.18	1.34	0.98	72.52	0.0693	0.0809
	77.18	(mean)	(gain)	(loss)	0.0693		
	0.92				72.5893		
	(loss)						

5 P. M.—Rectal temperature $103^{\circ}.64$. Animal killed.

Autopsy.—Medulla at the right side where it joined the pons cut through except a thread. Left side about three-fourths cut through; no hemorrhage perceptible.

BEFORE SECTION.

Quantity of air (V') = 73.0554 at $73^{\circ}.78 - 32^{\circ} = 41.78 = t'$.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{73.0554}{1.085} = 67.3$. $W = V \times 0.08073 = 5.43$

Rise in temp. of air $0.15 = t$. $Q = W \times t \times \text{sp. h.} = 5.43 \times 0.15 \times 0.2374 = 0.1934 = \text{heat given to calorimeter.}$

Rise in temp. of water $1.02 \times 164.1414 = 167.4242 = \text{heat given to calorimeter.}$

$0.1934 = \text{heat given to air.}$

$167.6176 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$

Hourly dissipation of heat 111.7451

AFTER SECTION.

Quantity of air (V') = 72.5893 at $77^{\circ}.18 - 32^{\circ} = 45.18 = t'$.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{72.5893}{1.092} = 66.5$. $W = V \times 0.08073 = 5.4$

Fall in temp. of air $0.92 = t$. $Q = W \times t \times \text{sp. h.} = 5.4 \times 0.92 \times 0.2374 = 1.1794 = \text{heat taken from calorimeter.}$

Rise in temp. of water $1.34 \times 164.1414 = 219.9495 = \text{heat given to calorimeter.}$

$1.1794 = \text{heat taken from air.}$

$218.7701 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$

Hourly dissipation of heat 145.8468

SUMMARY.

Hourly dissipation of heat after section 145.8468

Hourly dissipation of heat before section 111.7451

Hourly increase in dissipation of heat following section 34.1017

Heat Production.

BEFORE SECTION.

Gain of bodily heat $1.08 = t$. $W = 17.25$.

$Q = W \times t \times \text{sp. h.} = 17.25 \times 1.08 \times 0.75 = 13.9725 = \text{heat gained by body in } 1\frac{1}{2} \text{ hours.}$

Hourly addition to heat reserve = 9.315

Hourly dissipation of heat 111.7451

Heat added hourly to reserve 9.315

Hourly heat production 121.0601

AFTER SECTION.

Fall of bodily temperature in 1½ hours 0.92, in 1 hour 0.61 = t.

$Q = W \times t \times \text{sp. h.} = 17.25 \times 0.61 \times 0.75 = 7.8934 = \text{hourly loss of heat from reserve.}$

Hourly dissipation of heat	145.8468
Hourly loss from heat reserve	7.8934
<i>Hourly heat production</i>	137.9534

SUMMARY

Heat production after section	137.9534
Heat production before section	121.0601

Hourly increase of heat production after section 16.8933

EXPERIMENT 57.

A dog. Weight 18.5 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
2:18 P. M.	79° 9	79° 8	78° 9.2	102° 56	653.86	0.5918	1.6445
2:33	79.6	79.7					
2:48	79.6	79.6					
3:3	79.2	79.6					
3:18	.....	.....	79.31	100.76	703.39	0.63965	1.7872
	79.57	79.67	0.39	1.8	49.53	0.04785	0.1427
	(mean)	79.57	(gain)	(loss)	0.0478		
		0.1			49.5778		
		(gain)					

3:26 P. M.—Pons cut. 3:29 P. M.—Rectal temperature, 101° 84.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)
4:18 P. M.	79° 9	79° 9	80° 7	101° 84	743.11	0.6399	1.7872
4:33	80.6	80.8					
4:48	80	80.7					
5:3	80	80.55					
5:18	79.5	80.24	81.49	101.12	790.865	0.6933	1.8916
	80	80.44	0.79	0.72	47.755	0.0534	0.1044
	(mean)	80	(gain)	(loss)	0.0534		
		0.44			47.8084		
		(gain)					

Post-mortem.—Medulla severed at its junction with the pons. A large clot of blood upon the pons.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V) = 49.5778 at 79° 67—32° = 47.67 = t.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{49.5778}{1.097} = 45.2$. $W = V \times 0.08073 = 3.65$

Rise in temp. of air 0.1 = t. $Q = W \times t \times \text{sp. h.} = 3.65 \times 0.1 \times 0.2374 = 0.087 = \text{heat given to air.}$

Rise in temp. of water 0.39 $\times 164.1414 = 64.0151 = \text{heat given to calorimeter.}$

0.087 = heat given to air.

Hourly dissipation of heat 64.1021

AFTER SECTION.

Quantity of air (V') = 47.8084 at $80^{\circ}.44 - 32^{\circ} = 48.44 = t'$.

$$V + (V \times t \times 0.002035) = V'. \quad V = \frac{47.8084}{1.091} = 43.5. \quad W = V \times 0.08073 = 3.5$$

Rise in temp. of air $0.44 = t$. $Q = W \times t \times \text{sp. h.} = 3.5 \times 0.44 \times 0.2374 = 0.3656 = \text{heat given to air}$

Rise in temp. of water $0.79 \times 164.1414 = 129.6717 = \text{heat given to calorimeter.}$

$0.3656 = \text{heat given to air.}$

Hourly dissipation of heat 130.0373

SUMMARY.

Heat dissipated hourly after section	130.0373
Heat dissipated hourly before section	64.1021

Hourly increase of heat dissipation following section 65.9352

Heat Production.

BEFORE SECTION.

Fall of temperature of body $1.8 = t$. $W = 18.5$

$Q = W \times t \times \text{sp. h.} = 18.5 \times 1.8 \times 0.75 = 24.975 = \text{heat lost from reserve in one hour.}$

Heat dissipated in 1 hour 64.1021

Heat lost from reserve 24.975

Hourly heat production 39.1271

AFTER SECTION.

Fall of temperature of body $0.72 = t$. $W = 18.5$

$Q = W \times t \times \text{sp. h.} = 18.5 \times 0.72 \times 0.75 = 9.99 = \text{heat lost from reserve in one hour.}$

Heat dissipated in 1 hour 130.0373

Heat lost from reserve 9.99

Hourly heat production 120.0473

SUMMARY.

Hourly production of heat after section	120.0473
Hourly production of heat before section	39.1271

Hourly increase of heat production following section 80.9202

EXPERIMENT 58.

A terrier. Weight 16.75 pounds.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. NUMBER (cub. ft.)
12:15 P. M.	58 ^o .61	64 ^o .49	62 ^o .36	101 ^o .84	416.03
12:30	59.14	65.96			
12:45	59.42	65.72			
1	59.73	66.08			
1:15	.....	.....	63.068	101.84	502.9
	59.22	65.56	0.708	0	80.7
	(mean)	59.22	(gain)		
		6.34	(gain)		

1:35 P. M.—Section made. 1:41—Rectal temperature $100^{\circ}.2$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:56 P. M.	64 ^o .22	67 ^o .22	62 ^o .24	.....	540.575
2:12	64.31	67.51			
2:30	64.04	67.51			
2:45	63.92	67.52			
2:56	61.58	67.12	63.032	102 ^o .2	602.672
	60.61	67.37	0.792	-----	62.097
	(mean)	60.61	(gain)		
		6.76			
		(gain)			

3 P. M.—Animal breathing quietly, completely paralyzed, but trembling violently all over. The sciatic exposed, and the carotid connected with the cardiometer.

TIME.	ARTERIAL PRESSURE. (Millimetres.)	REMARKS.
3:5 P. M.	90-100	
3:10	115-120	Galvanic current has been applied to the sciatic for half a minute, some not violent reflex contractions, much disturbance of respiration.
3:16	.....	Par vagum cut.
3:21	65-95	Much disturbance of respiration.
3:24	.....	Mild galvanic current applied to the sciatic.
3:26	120-125	Pressure has been steadily rising since the current was applied; there have been no general convulsive movements, but breathing has apparently been affected.
3:35	.....	Animal killed.

Autopsy.—Right half of medulla completely separated exactly at its junction with the pons, excepting a small band upon each side. Left half severed, except a film all across at the lower surface, and a band at the outer edge. No cerebral hemorrhage.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 86.87 at 65^o.56-32^o = 33.56 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{86.87}{1.0681} = 81.3. \quad W = V \times 0.08073 = 6.56$$

Rise in temp. of air 6.34 = t. Q = W × t × sp. h. = 6.56 × 6.34 × 0.2374 = 9.8735 = heat given to air.

Rise in temp. of water 0.708 × 164.1414 = 116.2121 = heat given to calorimeter.

9.8735 = heat given to air.

Hourly dissipation of heat 126.0856

AFTER SECTION.

Quantity of air (V') = 62.097 at 67^o.37-32^o = 35.37 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{62.097}{1.072} = 57.9. \quad W = V \times 0.08073 = 4.67$$

Rise in temp. of air 6.76 = t. Q = W × t × sp. h. = 4.67 × 6.76 × 0.2374 = 7.4945 = heat given to air.

Rise in temp. of water 0.792 × 164.1414 = 130 = heat given to calorimeter.

7.4945 = heat given to air.

Hourly dissipation of heat 137.4945

SUMMARY.

Hourly dissipation of heat before section 126.0856

Hourly dissipation of heat after section 137.4945

Hourly increase of heat dissipation following section 11.4089

Heat Production.

BEFORE SECTION.

No change in bodily temperature; hourly dissipation = hourly production of heat 126.0856

AFTER SECTION.

Rise of bodily temperature in 14 hours 2°, in 1 hour 1.6 = t. W = 16.75

$Q = W \times t \times \text{sp. h.} = 16.75 \times 1.6 \times 0.75 = 20.1 = \text{heat added to reserve.}$

Hourly dissipation of heat	137.4945
Hourly addition to heat reserve	20.1
<i>Hourly heat production</i>	<u>157.5945</u>

SUMMARY.

Hourly production of heat after section	157.5945
Hourly production of heat before section	<u>126.0856</u>
<i>Hourly increase of heat production following section</i>	<u>31.5089</u>

EXPERIMENT 59.

A mongrel Scotch terrier. Weight 15.75 pounds.

January 3.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER (cub. ft.)
12:56 P. M.	62.18	64.06	63.085	101.84	28.58
1:11	61.13	64.4			
1:26	61.13	64.18			
1:41	62.66	64.67			
1:56	63.77	65.03	63.319	101.84	<u>97.29</u>
	62.17 (mean)	64.47 62.17	0.234 (gain)	0	<u>68.71</u>
		2.3 (gain)			

2:15 P. M.—Section made followed at once by seemingly complete paralysis.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER (cub. ft.)
2:43 P. M.	64.4	65.84	62.6	100.5	107.5
2:58	61.63	64.4			
3:13	61.63	64.76			
3:28	61.43	65.12			
3:43	63.5	65.39	63.104	101.84	<u>180.45</u>
	62.52 (mean)	65.1 62.52	0.504 (gain)	1.34 (gain)	<u>72.95</u>
		2.58 (gain)			

Dog has been howling faintly in the box; shows evidences of sensibility in the body and hind legs slightly, although it is somewhat uncertain whether this is really the case, or whether the movements are reflex; some general tremors; head drawn forcibly to one side; respiration feeble.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER (cub. ft.)
4:37 P. M.	63.23	66.47	61.61	101.84	234.27
4:52	62.6	64.46			
5:7	62.14	64.1			
5:22	62.72	64.28			
5:37	62.72	64.46	62.24	103.1	<u>306.92</u>
	62.68 (mean)	64.75 62.68	0.63 (gain)	1.26 (gain)	<u>72.65</u>

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
8:56 P. M.	68 ^o .81	69 ^o .75	60 ^o .98	102 ^o .56	446.165
9:13	68	68.96			
9:28	67.46	68.45			
9:43	67.46	69.26			
9:58	67.64	68.45	61.98	101.84	521.56
	67.87 (mean)	68.97 67.87	1 (gain)	0.72 (loss)	75.395
		1.1 (gain)			

January 4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:25 P. M.	65 ^o .57	67 ^o .79	63 ^o .05	102 ^o .56	541.8
12:40	65.96	67.69			
12:55	67.04	69.17			
1:10	.....	.....	63.725	102.92	576.
	66.19 (mean)	68.22 66.19	0.675 (gain)	0.36 (gain)	34.2
		2.03 (gain)			

1:30 P. M.—Dog is conscious, with dulled but not destroyed sensibility in the body, and excessive hyperæsthesia of the head and upper neck, howling violently when these parts are touched. He can kick with all of his legs, but is unable to move his body. He was placed on the table, the thermometer introduced through an opening in the linea alba into the peritoneal cavity, and the sciatic exposed. The galvanic current employed was the full power of a Du Bois Reymond coil, with one large LeClanche cell.

TIME. M. Sec.	TEMPERATURE.	IRRITATION OF SCIATIC.
0	104 ^o .4 F.	
0:30	.....	Commenced.
1	104.5	
1:30	104.4	
2	104.3	
2:15	104.2	
2:45	104	
3:45	103.9	
4:15	103.8	Ceased.
5:15	103.8	
6:42	103.7	
9:45	103.7	
10:30	103.7	

Autopsy.—Section traversing entirely the medulla from side to side on its upper surface on a line with its junction with the pons, reaching half-way through, but leaving the lower part intact.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 68.71 at 64^o.47—32^o = 32.47 = t'.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{68.71}{1.066} = 64.4$. $W = V \times 0.08073 = 5.2$

Rise in temp. of air 2.3 = t. $Q = W \times t \times \text{sp. h.} = 5.2 \times 2.3 \times 0.2374 = 2.8393 = \text{heat units given to air}$

Rise in temp. of water 0.234 \times 164.1414 = 38.4091 = heat given to calorimeter.

2.8393 = heat given to air.

Total dissipation of heat in an hour 41.2484

AFTER SECTION.

1st Period—

Quantity of air (V') = 72.95 at $65^{\circ}.1 - 32^{\circ} = 33.1 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{72.95}{1.067} = 68.37. \quad W = V \times 0.08073 = 5.5$$

Rise in temp. of air $2.58 = t. \quad Q = W \times t \times \text{sp. h.} = 5.5 \times 2.58 \times 0.2374 = 3.3686 = \text{heat given to air.}$ Rise in temp. of water $0.504 \times 164.1414 = 82.7273 = \text{heat given to calorimeter.}$

3.3686 = heat given to air.

Hourly dissipation of heat 86.0959

2d Period—

Quantity of air (V') = 72.65 at $64^{\circ}.75 - 32^{\circ} = 32.75 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{72.65}{1.067} = 68.09. \quad W = V \times 0.08073 = 5.5$$

Rise in temp. of air $2.07 = t. \quad Q = W \times t \times \text{sp. h.} = 5.5 \times 2.07 \times 0.2374 = 2.7028 = \text{heat given to air.}$ Rise in temp. of water $0.63 \times 164.1414 = 103.4091 = \text{heat given to calorimeter.}$

2.7028 = heat given to air.

Heat dissipated in one hour 106.1119

3d Period—

Quantity of air (V') = 75.395 at $68^{\circ}.97 - 32^{\circ} = 36.97 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{75.395}{1.075} = 70. \quad W = V \times 0.08073 = 5.7$$

Rise in temp. of air $1.1 = t. \quad Q = W \times t \times \text{sp. h.} = 5.7 \times 1.1 \times 0.2374 = 1.4885 = \text{heat given to air.}$ Rise in temp. of water $1 \times 164.1414 = 164.1414 = \text{heat given to calorimeter.}$

1.4885 = heat given to air.

Hourly dissipation of heat 165.6299

4th Period—

Quantity of air (V') = 34.2 at $68^{\circ}.22 - 32^{\circ} = 36.22 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{34.2}{1.073} = 32. \quad W = V \times 0.08073 = 2.6$$

Rise in temp. of air $2.03 = t. \quad Q = W \times t \times \text{sp. h.} = 2.6 \times 2.03 \times 0.2374 = 1.2529 = \text{heat given to air.}$ Rise in temp. of water $0.675 \times 164.1414 = 110.7954 = \text{heat given to calorimeter.}$

1.2529 = heat given to air.

112.04 = heat dissipated in three-quarters of an hour.*Hourly dissipation of heat* 149.3977

SUMMARY.

Hourly heat dissipation before section	41.2484
Hourly heat dissipation after section:	
1st period	86.0959
2d period	106.1119
3d period	165.6299
4th period	149.3977

Heat Production.

BEFORE SECTION.

No change in the bodily temperature.

Hourly dissipation = hourly production of heat 41.2484

AFTER SECTION.

1st Period—

Rise of the bodily temperature $1.34 = t.$ $Q = W \times t \times \text{sp. h.} = 15.75 \times 1.34 \times 0.75 = 15.8286 = \text{heat added to reserve.}$

Hourly dissipation of heat 86.0959

Hourly addition to heat reserve 15.8286

Hourly production of heat 101.9245

2d Period—

Rise in animal temperature 1.26 = t.

$Q = W \times t \times \text{sp. h.} = 15.75 \times 1.26 \times 0.75 = 14.8837 = \text{heat added to reserve.}$

Hourly dissipation of heat	106.1119
Hourly addition to heat reserve	14.8837
<i>Hourly production of heat</i>	120.9956

3d Period—

Fall of animal temperature 0.72 = t.

$Q = W \times t \times \text{sp. h.} = 15.75 \times 0.72 \times 0.75 = 8.505 = \text{hourly loss from heat reserve.}$

Hourly dissipation of heat	165.6299
Hourly loss from heat reserve	8.505
<i>Hourly production of heat</i>	157.1249

4th Period—

Rise of animal temperature in three-quarters of an hour 0.36, in one hour 0.48 = t.

$Q = W \times t \times \text{sp. h.} = 15.75 \times 0.48 \times 0.75 = 5.67 = \text{heat added to reserve.}$

Hourly dissipation of heat	149.3977
Hourly addition to heat reserve	5.67
<i>Hourly production of heat</i>	155.0677

SUMMARY.

Hourly production of heat before section	41.2484
Hourly production of heat after section :	
1st period	101.9245
2d period	120.9956
3d period	157.1249
4th period	155.0677

In studying these experiments it is convenient to examine, first, the question of heat dissipation; secondly, that of heat production. The loss of bodily heat was increased by section in Experiments 56, 57, 58, 59. In regard to heat dissipation, section of the higher medulla therefore yields results similar to those caused by division of the spinal cord. In regard to heat production the case is different; it is remarkably diminished by section of the cord, but in all the experiments just detailed it was augmented. Thus in Experiment 56 the increase was about 27 per cent., in Experiment 57 about 67 per cent., in Experiment 58 about 12 per cent. In Experiment 59, which extended over two days with five distinct measurements, the increase at the different successive periods was respectively 77, 200, 300, 270 per cent. The reasons that in some instances the proportionate rise of heat production was much greater than in others are to be in part looked for in the imperfection of the section and in the effects of shock, or of slight bleeding, upon the vaso-motor centres. A point very worthy of notice is, that in several of these experiments no marked rise of the bodily temperature followed the section, the increase of heat dissipation being sufficient to counterbalance the increased production. It would seem, therefore, that the apparently exceptional cases, in which separation of the medulla from the pons without injury to the vaso-motor centres in the floor of the fourth ventricle is not followed by a rise of the bodily temperature, are not to be considered as really exceptional but only as instances in which heat dissipation is increased proportionately to or faster than heat production, so that no accumulation of heat in the body, *i. e.*, no rise of the bodily temperature occurs.

The results of our whole study as to the effects of separation of the medulla from the pons upon thermogenesis may be formulated as follows: *Section of the medulla at its junction with the pons is followed by increased heat dissipation and increased heat production, the increased dissipation usually not keeping pace with the increased production, so that the bodily temperature rises.*

The question which naturally arises at this stage of our investigation is as to the cause of the phenomena which follow superior medullary section. In regard to the heat dissipation, it is apparently simply the result of the increased heat production, a warmer body naturally giving off more heat than a cooler one. More than this, the vaso-motor system being intact, *i. e.*, the normal mechanism for cooling the body being preserved, it is inevitable that the living animal organism, which is producing heat more rapidly than normal, should endeavor to cool its body as rapidly as possible so as to get rid of the excess of heat.

Increased heat production being then the cause of the increased heat dissipation, the problem presents itself—what is the cause of the increased heat production?

Various explanations have been offered to account for the rise of bodily temperature which follows the separation of the medulla from the pons. One set of investigators believe that it is due to irritation of the vaso-motor centres. It is, however, a general guiding principle in making deductions that section of a nerve induces abolition of function and that the symptoms which follow such section are paralytic unless clearly proved to be of other nature. Heidenhain, who has especially advocated the irritation theory, states that he was led to his conclusion by noting that the rabbits, upon which Bruck and Günter experimented, showed symptoms of irritation of the medulla in that their breathing was exceedingly rapid. Acting upon this, he suggested that the effect of puncture should be tried, and accordingly Bruck and Günter instituted such experiments. (*Pflüger's Archiv*, Bd. iii. p. 579.) The temperature rose more uniformly than in the previous experiments in which section was practised. It was found that two or more punctures were more effectual than a single one, and that the effect was still more pronounced, if two of the lance-shaped needles were plunged in at once, and allowed to remain. (Am sichersten darf man auf die Temperatur-Steigerung rechnen, wenn man zwei Nadeln in einer Ebene, die ungefähr 1 mm. vor dem tuberculären interparietale liegt, jederseits 2 mm. von der Median-Ebene in das Gehirn senkt und dieselben liegen lässt.)

It is evident that in the experiment of Bruck and Günter, the nerve centres were actually wounded, and I see no reason for disbelieving the possibility of this wound affecting the conducting power of the nerve fibres, especially as it is plain that the deeper and longer the wound, *i. e.*, the more numerous the needles, the greater was the rise in temperature. The paralytic effect of plunging a lance-shaped needle into a nerve centre certainly reaches, at least for a time, beyond the obvious wound, and the effect of leaving a needle in must be to increase this paralysis by pressure. The reason the rise was obtained more frequently after the puncture than after the section of the medulla, seems to me to depend upon the circumstance that in the former case the vaso-motor centres were not so apt to be involved as in the latter. (See page 61.)

The experiments of Bruck and Günter do not prove then what has been claimed for them. On the other hand, in the numerous experiments which I have made I have very rarely seen any symptom of irritation other than the rise of temperature produced by the section. On the other hand, I have seen the rise of temperature occur when the shock to the respiratory centres has been so great as to paralyze them and suspend breathing. How could the section under these circumstances stimulate the vaso-motor centres which lie so close to the respiratory centre. Again, I have seen the rise of temperature persist for more than twenty-four hours, and have never seen it, when once established, subside so long as the animal survived, unless by the formation of a clot the vaso-motor centre of the medulla was paralyzed. Such is not the history of irritation. I have so often seen this persistent rise of temperature with no signs of irritation, with no apparent disturbance of the circulation or respiration, that I am strongly inclined to believe it to be paralytic in its origin, due to the removal of some force.

Reasoning from rise of temperature in the present case is, for obvious reasons, uncertain in its results, but an examination of the calorimetrical experiments will I believe disprove the correctness of the irritation theory. Taking up the experiments of the last series *seriatim*, it will be seen that in Experiment 56, so far as can be judged from the blood pressure, no vaso-motor spasm existed, the pressure was not high, and galvanization of a nerve increased it nearly one-third by inducing a vaso-motor spasm. Such a rise could hardly have occurred if great vaso-motor irritation, with genuine vaso-motor spasm, had existed before the galvanization of the sciatic. In Experiment 57 there was nothing especially bearing upon the subject under discussion. The same may be said of Experiment 58. Experiment 59, however, furnishes very conclusive evidence. Irritation produced by a section must be greatest immediately after section, and would be expected to disappear in a few hours. Yet in this case the effect upon heat production steadily increased for some hours, and was *much more decided nearly twenty-four hours* after section than it was in the *hour immediately following* section. Thus before the operation, the hourly yield was 41.2484; after the operation, the first hour it was 101.9245; the third hour it was 120.9956; the seventh hour it was 157.1249; and the twenty-third hour, although the dog had been without food and was much exhausted, it was 155.0677. This one experiment is itself sufficient to throw grave doubt upon the irritation theory. As I have in this paper given all the experiments as they were performed, I here append the following, which at first seemed contradictory in its results to those previously performed, but in which the autopsy proved that the medulla was not severed. The chief value of the experiment is in showing that wounds of the cerebellum have little effect on the thermic functions of the body.

EXPERIMENT 60.

A large long-haired Pomeranian dog. Weight 24 lbs.

January 9.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER (cub. ft.)
2:6 P. M.	66 ^o .92	65 ^o .03	59 ^o .1	.....	.....
2:20	67.46	64.31	.....	102 ^o .56	5.63
2:35	67.55	64.22			
2:45	67.73	64.58			
2:6	63.23	64.76	60.3	104	78.3
	66.58	64.58	1.2	1.44	72.67
	64.58	(mean)	(gain)	(gain)	
	2				
	(loss)				

Section 3:20 P. M. 3:35 P. M.—Rectal temperature 104^o 36.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER (cub. ft.)
3:47 P. M.	67 ^o .76	61 ^o .57	55 ^o .2	.....	127
4	67.76	62.75			
4:15	67.28	62.75			
4:30	66.8	62.65			
4:47	.....	.....	56.85	100 ^o	213
	67.4	62.43	1.65		86
	62.43	(mean)	(gain)		
	4.97				
	(loss)				

Consciousness and respiration good. Movement is, however, restricted to kicking in the air: and the feet seemingly moved alike. The animal is perfectly powerless to move his body.

January 10. 11:44 A. M.—Rectal temperature 106^o.16. Dog has been lying by a hot stove.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GENERAL METER (cub. ft.)
11:59 A. M.	75 ^o .11	69 ^o .64	61 ^o .5	.....	236.2
12:14 P. M.	69.44	66.8			
12:29	68.24	66.8			
12:50	66.47	66.29			
12:59	.....	.....	62.7	104 ^o .36	324
	69.81	67.38	1.2		87.8
	67.38	(mean)	(gain)		
	2.43				
	(loss)				

2 P. M.—Dog can get up upon all four legs; holds them wide apart; if he stands he sways to and fro an instant, and then tumbles over; sits most of the time on his haunches, but moves occasionally all about the room; can wag his tail.

Autopsy.—Middle cerebellum cut clear across at its lower portion, entirely through the roof of the fourth ventricle. Medulla not wounded. Pons with a punctured wound on its right side a line in breadth and extending half through.

Heat Dissipation.

BEFORE SECTION.

Quantity of air 72.67 at 64^o.58 — 32^o = 32.58.

$$V + (V \times t \times 0.002035) = V' \quad V = \frac{72.67}{1.066} = 68.2 \quad W > 0.08073 = 5.5$$

Fall in temp. of air 2. $Q = W \times t \times \text{sp. h.} = 5.5 \times 2 \times 0.2374 = 2.6114 = \text{heat taken from air}$ Rise in temp. of water 1.2 $\times 164.1414 = 196.9697 = \text{heat given to calorimeter.}$

$$2.6114 = \text{heat taken from air.}$$

Hourly dissipation of heat 194.3583

AFTER SECTION.

1st Period—

Quantity of air (V') = 86 at $62^{\circ}.43 - 32^{\circ} = 30.43 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{86}{1.062} = 81. \quad W = V \times 0.08073 = 6.54$$

Fall in temp. of air $4.97 = t$. $Q = W \times t \times \text{sp. h.} = 6.54 \times 4.97 \times 0.2374 = 7.7164 = \text{heat taken from air.}$

Rise in temp. of water $1.65 \times 164.1414 = 270.8333 = \text{heat given to calorimeter.}$

$7.7164 = \text{heat taken from air.}$

Hourly dissipation of heat $\underline{263.1169}$

2d Period—

Quantity of air (V') = 87.8 at $67^{\circ}.38 - 32^{\circ} = 35.38 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{87.8}{1.072} = 82. \quad W = V \times 0.08073 = 6.6$$

Fall in temp. of air $2.43 = t$. $Q = W \times t \times \text{sp. h.} = 6.6 \times 2.43 \times 0.2374 = 3.8074 = \text{heat taken from air.}$

Rise in temp. of water $1.2 \times 164.1414 = 196.9697 = \text{heat given to calorimeter.}$

$3.8074 = \text{heat taken from air.}$

Hourly dissipation of heat $\underline{193.1623}$

SUMMARY.

Before section, hourly dissipation of heat	194.3583
After section, hourly dissipation of heat.	1st period 263.1169
	2d period 193.1623

Heat Production.

BEFORE SECTION.

Hourly rise of animal temperature $1.44 = t$.

$Q = W \times t \times \text{sp. h.} = 24 \times 1.44 \times 0.75 = 25.92 = \text{gain of heat reserve.}$

Hourly dissipation of heat 194.3583

Hourly gain of heat reserve 25.92

Hourly heat production $\underline{220.2783}$

AFTER SECTION.

1st Period—

Fall of animal temperature in $1\frac{1}{4}$ hours 4.36 , in one hour $3.49 = t$.

$Q = W \times t \times \text{sp. h.} = 24 \times 3.49 \times 0.75 = 62.82 = \text{heat lost from reserve.}$

Hourly dissipation of heat 263.1169

Hourly loss from heat reserve 62.82

Hourly heat production $\underline{200.2969}$

2d Period—

Fall of animal temperature in $1\frac{1}{4}$ hours 1.8 , in 1 hour $1.44 = t$.

$Q = W \times t \times \text{sp. h.} = 24 \times 1.44 \times 0.75 = 25.92 = \text{heat lost from reserve.}$

Hourly dissipation of heat 193.1623

Hourly loss of heat from reserve 25.92

Hourly production of animal heat $\underline{167.2423}$

SUMMARY.

Hourly production of heat before section	220.2783
Hourly production of heat after section:	1st period 200.2969
	2d period 167.2423

If nerve fibres, whose paralysis is either directly or indirectly capable of acting upon the bodily temperature, pass down the medulla, it would, *a priori*, be probable

that by slight wounds we should be able to irritate them, and cause a lessening of the heat production. It is plain that if this can be done the irritation theory must be abandoned. It would be the height of absurdity to maintain any other than a paralytic theory, when complete section destroys and slight wounds or irritation increase a function. In Experiment 60 a slight wound of the pons was followed by an immediate slight reduction of the hourly heat production, but I do not desire to attach too much importance to this, and have performed the following experiments:—

EXPERIMENT 61.

A dog, weight 21.5 pounds.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:9 P. M.	67 ^o .64	70 ^o .16	64 ^o .28	101 ^o .84	179.52
12:24	65.84	69.84			
12:39	64.88	67.9			
12:54	65	66.92			
1:9	.....	.....	64.94	102.20	254.095
	65.84	68.7	0.66	0.36	74.575
	(mean)	65.84	(gain)	(gain)	
		2.86			
		(gain)			

1:20 P. M.—Puncture made in the medulla; 1:25 P. M. animal can move the front legs, but the hind legs seem to be paralyzed; conscious. 1:31 P. M.—Rectal temperature 103^o.64.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:46 P. M.	68 ^o .45	69 ^o .94	65 ^o .39	.....	291.55
2:1	68.81	70.34			
2:16	68.72	70.9			
2:31	68.9	69.85			
2:46	68.81	69.85	66.20	100 ^o .76	369.51
	68.74	70.18	0.81		77.96
	(mean)	68.74	(gain)		
		1.44			
		(gain)			

Animal has recovered the power of moving the hind legs.

Autopsy.—Only wound of the brain, a minute puncture in the upper surface of the medulla, in its centre and at the end of the fourth ventricle. Considerable effused blood about the medulla.

Heat Dissipation.

BEFORE PUNCTURE.

Quantity of air (V') = 74.575 at 68^o.7—32^o = 36.7 = t' .

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{74.575}{1.075} = 69.37$. $W = V \times 0.08073 = 5.6$

Rise in temp. of air 2.86 = t . $Q = W \times t \times \text{sp. h.} = 5.6 \times 2.86 \times 0.2374 = 3.8022 = \text{heat given to calorimeter.}$

Rise in temp. of water 0.66 \times 164.1414 = 108.3333 = heat given to calorimeter.

3.8022 = heat given to air.

Hourly dissipation of heat 112.1355

AFTER PUNCTURE.

Quantity of air (V') = 77.96 at $70^{\circ}.18 - 32^{\circ} = 38.18 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{77.96}{1.078} = 72.3. \quad W = V \times 0.08073 = 5.84$$

Rise in temp. of air $1.44 = t$. $Q = W \times t \times \text{sp. h.} = 5.84 \times 1.44 \times 0.2374 = 1.9964 = \text{heat given to air.}$

Rise in temp. of water $0.81 \times 164.1414 = 132.9545 = \text{heat given to calorimeter.}$

$1.9964 = \text{heat given to air.}$

Hourly dissipation of heat $\underline{134.9509}$

Heat Production.

BEFORE SECTION.

Rise of animal temperature $0.36 = t$.

$$Q = W \times t \times \text{sp. h.} = 21.5 \times 0.36 \times 0.75 = 5.805 = \text{heat added to reserve.}$$

Hourly dissipation of heat 112.1355

Hourly gain of heat reserve 5.805

Hourly production of heat $\underline{117.9405}$

AFTER SECTION.

Fall of animal temperature in $1\frac{1}{4}$ hours 2.88 , in 1 hour $2.304 = t$.

$$Q = W \times t \times \text{sp. h.} = 21.5 \times 2.304 \times 0.75 = 37.152 = \text{heat lost from reserve.}$$

Hourly dissipation of heat 134.9509

Hourly loss from heat reserve 37.152

Hourly production of heat $\underline{97.7989}$

SUMMARY.

Hourly production of heat before puncture 117.9405

Hourly production of heat after puncture 97.7989

Diminution of heat production following puncture $\underline{20.1416}$

EXPERIMENT 62.

A Scotch terrier, weight 18.5 pounds.

January 7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:55 P. M.	55°	59°45	59°24	102°92	639
2:16	55.2	59.18			
2:25	56	59.63			
2:40	56.4	59.95			
2:55	58.8	60.44	60.36	102.2	719.29
	56.28	59.73	1.12	0.72	80.29
	(mean)	56.28	(gain)	(loss)	
		3.45			
		(gain)			

3:15 P. M.—Section made; 3:20 P. M. dog has some power of motion, kicking legs in air.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:37 P. M.	57°4	60°16	60°1	101°84	734
3:52	55.1	60.13			
4:7	56	60.56			
4:22	55.8	60.23			
4:37	57.5	60.33	60.68	99.24	797.25
	56.36	60.28	0.58	2.6	63.25
	(mean)	56.36	(gain)	(loss)	
		3.92			
		(gain)			

January 8.—Dog has violent rolling movements, apparently the result of voluntary effort—these are always from left to right—body rolling over and over. Left side apparently as powerful as ever, right side very decidedly paralyzed, but dog can still move legs feebly, sensibility also very dull. Left side hyperæsthetic. Right eye anæsthetic; inflammatory changes have commenced in the ear. Consciousness and respiration perfect.

TIME.	AIR TEMP. (Fah.)	TUNE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METEOR. (cub. ft.)
1:33 P. M.	62.24	63.41	61.52	102.92	892
1:45	61.4	63.32			
2:10	61.8	63.68			
2:25	61.7	63.68			
2:33	63.23	64.04	62.36	102.92	922
	62.08 (mean)	63.63 62.08	0.84 (gain)	0	70
		1.55 (gain)			

3 P. M.—Dog killed:

Autopsy.—Large wound of cerebellum. Medulla only wounded in the outer third of the right side on the line of its junction with the pons: here it is divided.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V') = 80.29 at $59^{\circ}.73 - 32^{\circ} = 27.73 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{80.29}{1.056} = 76$. $W = V \times 0.08073 = 6.14$

Rise in temp. of air $3.45 = t$. $Q = W \times t \times \text{sp. h.} = 6.14 \times 3.45 \times 0.2374 = 5.0288 = \text{heat given to air}$

Rise in temp. of water $1.12 \times 164.1414 = 183.8384 = \text{heat given to calorimeter.}$

5.0288 = heat given to air.

Hourly dissipation of heat 188.8672

AFTER SECTION.

1st Period—

Quantity of air (V') = 63.25 at $60^{\circ}.28 - 32^{\circ} = 28.28 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{63.25}{1.058} = 59.8$. $W = V \times 0.08073 = 4.8$

Rise in temp. of air $3.92 = t$. $Q = W \times t \times \text{sp. h.} = 4.8 \times 3.92 \times 0.2374 = 4.466 = \text{heat given to air.}$

Rise in temp. of water $0.58 \times 164.1414 = 95.2020 = \text{heat given to calorimeter.}$

4.466 = heat given to air.

Hourly dissipation of heat 99.668

2d Period—

Quantity of air (V') = 70 at $63^{\circ}.63 - 32^{\circ} = 31^{\circ}.63 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{70}{1.064} = 65.8$. $W = V \times 0.08073 = 5.3$

Rise in temp. of air $1.55 = t$. $Q = W \times t \times \text{sp. h.} = 5.3 \times 1.55 \times 0.2374 = 1.9502 = \text{heat given to air.}$

Rise in temp. of water $0.81 \times 164.1414 = 137.8787 = \text{heat given to calorimeter.}$

1.9502 = heat given to air.

Hourly dissipation of heat 139.8289

SUMMARY.

Hourly dissipation of heat before section	188.8672
Hourly dissipation of heat after section: 1st period	99.668
2d period	139.8289

Heat Production.

BEFORE SECTION.

Fall of animal temperature $0.72 = t$.

$$Q = W \times t \times \text{sp. h.} = 18.5 \times 0.72 \times 0.75 = 9.99 = \text{heat lost from reserve.}$$

Heat dissipated in one hour	188.8672
Heat lost in one hour from reserve	9.99

<i>Total production of heat in one hour</i>	178.8772
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AFTER SECTION.

1st Period—

Fall of animal temperature $2.6 = t$.

$$Q = W \times t \times \text{sp. h.} = 18.5 \times 2.6 \times 0.75 = 36.07 = \text{heat lost from reserve.}$$

Heat dissipated in one hour	99.668
Heat lost in one hour from reserve	36.075

<i>Hourly production of heat</i>	63.593
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2d Period—

No alteration of animal temperature.

Hourly dissipation and therefore production of heat 139.8289

SUMMARY.

Hourly production of heat before section	178.8772
Hourly production of heat after section :	
1st period	63.593
2d period	139.8289

In the first of these experiments the markedly increased heat dissipation strongly indicates a partial vaso-motor palsy produced by effused blood. It is therefore possible that the diminished heat production had its origin in this cause and not in any irritation of inhibitory nerve fibres. Experiment 61 is a much more decisive one. In it, directly after the wound and at a time when there were very marked symptoms of motor irritation, both heat production and heat dissipation were enormously reduced. It will be remembered that in vaso-motor palsy, heat dissipation is at first increased, so that the fact that the heat dissipation fell from 188.8672 units per hour to 99.668 units per hour proves that there was no vaso-motor palsy. Indeed it would seem that no conceivable vaso-motor condition could account for the symptoms. The wound was a small one situated high up, *i. e.* at a distance from the vaso-motor centre, and could not have caused vaso-motor palsy. Those who hold the irritation theory and explain the *increased* production of heat which is produced by section of the medulla where it joins the pons, cannot invoke the same irritation to account for the extraordinarily *diminished* heat production (from 178.8772 to 63.593 units) caused by the slight wound at the position of section in the other cases. In Experiment 59, after division of the medulla the heat production steadily increased for hours, so that twenty-four hours after division of the medulla the hourly rate was nearly four times what it was before section, although during the first hours of section it was only twice as great as the norm. Mechanical irritation naturally subsides rapidly in its effects, instead of increasing in this way. This is very plainly shown by the experiment last recorded. At first, heat production was lessened about two-thirds by the puncture, but in twenty-four hours it had increased almost to what it was before section—so nearly, indeed, that the difference, amounting only to about one-

fifth, can readily be accounted for by the exhaustion following the injury, and especially by the prolonged deprivation of food. Taking together all the facts which have been heretofore brought forward and apparently proven in this memoir, I can arrive at no other conclusion than that the rise of bodily temperature, and of heat production following separation of the pons from the medulla, is paralytic and due to the removal of some active force.

Tscheschin, led by the rise of the bodily temperature which he had noticed after separation of the medulla from the pons, proposed the theory that there is in the brain, somewhere above the pons, a nerve centre whose function it is directly to inhibit or repress the chemical movements of the body, *i. e.* the production of animal heat, and which has been called the inhibitory heat centre. It must be clearly understood that this theory involves the exercise of a controlling influence of the nervous system upon the nutrition of the body. There are physiologists who deny the possibility of such control. It would seem, however, that such denial is opposed to many well established physiological facts. The performance of function is certainly associated with or dependent upon nutritive changes, and production of contraction in a muscular fibre by nerve force must be by the exertion of a direct influence upon its nutrition.

The influence of the nervous system upon disease, *i. e.* upon perverted nutrition, appears frequently to be a direct one—the disappearance of warts, the subsidence of inflammation, and the cure of chills, under the spells of the so-called magnetic physicians, as well as the success of tractors and of metallotherapy—all bear witness to the same fact. I have personal knowledge of two cases in which milk secreted in a previously healthy woman directly after a severe fright, produced immediately violent convulsions in the child, in one case ending almost at once fatally. Every one must have seen violent chorea produced by sudden emotion. Even the grave nutritive disorder chlorosis seems at times to owe its origin to a similar cause. I have seen a case in which a boy violently throwing a ball felt something yield in the arm, the sensation being followed at once by numbness, and in a few hours by a copious eruption of small herpetic vesicles all over the region of the distribution of the median nerve. The curious phenomena of ordinary herpes zoster, the trophic changes often associated with neuralgia or paralysis of the fifth pair of nerves, the various peripheral changes following spinal diseases cannot be explained upon the idea of a vaso-motor production. Charcot and his pupils have by their labors shed much light upon this subject. It is only necessary to mention their observations on infantile palsy, on acute decubitus, on the changes in the joints in locomotor ataxy, and on amyotrophic paralysis, all of which afford proof of the profound structural alterations which may occur under the influence of spinal disease.

To examine the clinical and pathological evidence upon this point would carry us too far beyond the subject directly in hand to be proper to the occasion. It is only necessary to reiterate the fact that various sorts of nutritive changes—changes of kind as well as of degree of growth—are traceable to disease of the nervous system, and to call attention to the very able paper of M. Landouzy, on this subject, in the *Revue Mensuelle de Médecine et de Chirurgie*, January, 1878.

For reasons just assigned it seems to me that there is no inherent absurdity in the inhibitory heat centre theory. Its correctness is however certainly not proven by any facts as yet adduced. It is probable that the bulk, at least, of the animal heat is developed in the muscles, and it is possible that the so-called general vaso-motor centre of the medulla is only the centre of the abdominal circulation. As is well known, the bloodvessels of the abdomen, if perfectly relaxed, are sufficient to hold almost all the blood of the body. It is conceivable then that they may dominate the arterial pressure; so that a vaso-motor centre for the muscular system may exist higher up in the brain than the medulla, and yet not reveal itself by changes in the arterial pressure, just as the addition of a hundred men to an army of 100,000, or of a gill of water to a hogshead full would not be noticed. If such a muscular centre did exist, section of the medulla at the junction with the pons would quicken the muscular circulation most markedly and might thereby materially increase the amount of heat production.

The determination of the comparative probability of the two theories must be left to a later portion of this paper, after it has been shown that there are high up in the brain certain centres evidently connected in some way with the production of animal heat.

For the present we can only conclude that the rise of bodily temperature following separation of the pons from the cord is due either to paralysis of an inhibitory heat centre or of a muscular vaso-motor centre.

Although the higher centre, whatever its nature may be, which dominates animal heat production is very powerful, it is evident that the thermic activities of the organism must be very greatly affected by the circulation and the respiration: that cutting off the materials of growth and the oxygen required for the life processes must exercise a dominant influence, and that an increased supply of these agents must also produce a decisive effect. The following experiment is of interest as showing the very great power of defective respiration in preventing the increased heat production which otherwise would have followed the operation performed.

EXPERIMENT 63.

A dog		Weight about 30 lbs							
TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	RECT. TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(cub. ft.)
12:16 P. M.	80° 88	81° 68	79° 8	102° 2	925.44	21.21835	02.9418	133.9062	126.23
12:31	80.5	81.9							
12:46	80.86	82.04							
1:1	81.22	82.04	80.52	102.2	995.218	21.2495	02.9868	133.93275	126.2505
	80.86	81.91	0.72	0	69.778	0.03115	0.045	0.02655	0.0205
	(mean)	80.86	(gain)		0.03115				
		1.05			69.80915				
		(gain)							

1:45 P. M.—Section made. Respiration at once ceased. Artificial respiration was kept up about half an hour, when imperfect respiration came on. From the beginning the temperature of the rectum rose slowly and steadily. At 3 P. M. respiration very slow, only four a minute; lips, etc., cyanotic. Rectal temperature 106°.7 F.

Time	Air Temp.	Temp.	Box Temp.	Rect. Temp.	GENERAL METER.	SAMPLE METER.	Air Meter.	SAMPLE Meter.	Air Meter.
	(Fah.)	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(cub. ft.)
3:18 p. m.	84.7	83.7	82.56	106.7	171.225	21.3493	2.9858	133.92375	126.3385
3:23	84.35	83.95							
3:38	84.15	82.04	82.76	105.8	204.839	21.3916	3.0651	133.95702	126.3385
	84.4	83.23	0.2	0.9	33.614	0.0423	0.0793	0.03327	0.02285
	83.23	(mean)	(gain)	(loss)	0.0423				
	1.17				33.6563				
	(loss)								

A second part of the water taken out of box breathing as before, and very carefully filtered through a filter paper placed on the neck of the bottle at the border of the piston. Given nearly the same result.

Heat Dissipation.

BEFORE SECTION.

Quantity of air (V) = 69.80915 at 81° 91 - 32° = 49.91 = v'.
 $V + (V \times v' \times 0.002035) = V'$. $V' = \frac{69.80915}{1.1016} = 63.3$. $W = V \times 0.08073 = 63.4 \times 0.08073 = 5.1$
 Rise in temp. of air 1.05 = t. $Q = W \times t \times \text{sp. h.} = 5.1 \times 19.5 \times 0.2374 = 1.2713$
 Rise in temp. of water 0.72 $\times 164.1414 = 118.1818 = \text{heat given to calorimeter.}$
 Quotient for box 2241 $\times 0.02655 = 59.4985 = \text{moisture leaving box.}$
 Quotient for air 1551.3 $\times 0.0205 = 31.8016 = \text{moisture entering box.}$
 $27.6969 = \text{moisture vaporized in box.}$
 $27.6969 = 4.4111 \text{ heat expended in vaporization.}$
 6.2789
 $1.2713 = \text{heat given to air.}$
 $4.4111 = \text{heat expended in vaporization}$
 $118.1818 = \text{heat given to water.}$

Hourly dissipation of heat 123.8642

AFTER SECTION.

Quantity of air (V) = 33.6563 at 83° 23 - 32° = 51.23 = v'.
 $V + (V \times v' \times 0.002035) = V'$. $V' = \frac{33.6563}{1.104} = 30.5$. $W = V \times 0.08073 = 2.46$.
 Fall in temp. of air 1.17 = t. $Q = W \times t \times \text{sp. h.} = 2.46 \times 1.17 \times 0.2374 = 0.6832 = \text{heat taken from air.}$
 Rise in temp. of water 0.2 $\times 164.1414 = 32.8283 = \text{heat given to water.}$
 Quotient for box 795 $\times 0.03327 = 26.4496 = \text{moisture leaving box.}$
 Quotient for air 425 $\times 0.02695 = 11.4537 = \text{moisture entering box.}$
 $14.9959 = \text{moisture vaporized in box.}$
 $14.9959 = 2.3883 = \text{heat expended in vaporization.}$
 6.2789
 $32.8283 = \text{heat given to water.}$
 $2.3883 = \text{heat expended in vaporization.}$
 34.2166
 $0.6832 = \text{heat taken from air.}$
 $33.5334 = \text{total dissipation of heat in half an hour.}$

Hourly dissipation of heat 67.0668

SUMMARY.

Hourly dissipation of heat before section 123.8642
 Hourly dissipation of heat after section 67.0668
Decrease in hourly dissipation of heat 56.7974

Heat Production.

BEFORE SECTION.

No determination of reserve heat.
Heat dissipation, = heat production 123.8642

AFTER SECTION.

Fall of animal temperature $0.9 = t$. $W = 30$.
 $Q = W \times t \times \text{sp. h.} = 30 \times 0.9 \times 0.75 = 20.25 = \text{lessened amount of reserved heat.}$

Heat dissipation	67.0626
Heat drawn from reserve	20.25
<i>Hourly production of heat</i>	46.8126

SUMMARY.

Hourly production of heat before section	123.8642
Hourly production of heat after section	46.8126
<i>Hourly decrease in production of heat</i>	77.0516

In looking over the summary of this experiment it will be seen that, although there was section of the medulla at its junction with the pons, yet the hourly rate of heat production was decreased from 123.8642 units to 46.8126 units. This extraordinary result is readily accounted for by the state of the respiration. The rate of the breathing was reduced to four or five acts per minute, and the intensely cyanotic lips and mouth of the unconscious animal showed the lack of oxygen. This experiment is of further interest on account of the great and rapid rise of the bodily temperature which followed the operation notwithstanding the diminished heat production. It affords a striking example of the fact that the temperature register is no index of the amount of heat production. It is also important as indicating that retention of heat follows vaso-motor spasm. Vaso-motor spasm, it is well known, is one of the phenomena of asphyxia, and must have been highly developed when the first rise of temperature occurred. That excessive heat retention was the cause of the rise of temperature is very evident, and is also directly proven. As the stimulation lasted and the relaxation of fatigue began to be developed, the temperature began to fall, but even at this time heat dissipation was at an hourly rate of 67.0626 instead of 123.8642. The difference of course had much of its causation in the diminished heat production; yet if the avenues of escape had been open, the bodily temperature would have rapidly fallen to below the normal point instead of remaining as it did over 3.5 degrees above normal. How the results of this experiment could be explained by, or indeed made concordant with, the irritation theory it is hard to understand. That the vaso-motor as well as the respiratory system largely dominates heat production is abundantly shown by my experiments upon the cord. After section of the cord there is of course paralysis of the fibres which are cut when the medulla is separated from the pons. This is however more than counterbalanced by the vaso-motor palsy, for diminished heat production is always the result of cord section.

The fact that the production of animal heat is influenced by some centres situated in or above the pons Varolii, and also that it is in some degree independent of

changes in the general arterial pressure, is corroborated by the results of irritation of a peripheral nerve.

In 1870, P. Heidenhain announced (*Pflüger's Archiv*, p. 504) that when a sensitive nerve is stimulated, a fall of temperature occurs simultaneously with the rise of the blood pressure. I shall not attempt to follow this memoir closely, but shall simply state the results of experiments, the conclusions drawn, and the evident reasons there are for not allowing the justice of the deductions made.

The experimental facts which were reached are as follows:—

1st. Irritation of a sensitive nerve causes a rise in blood pressure but a fall in temperature.

2d. This fall occurs in the posterior part of the body even after the circulation has been cut off by forcible compression of the aorta.

3d. When, in animals which have been thrown into a high fever by the injection of putrid matters, a sensitive nerve is stimulated, a rise of blood pressure occurs as in the normal condition, but *no change of temperature*.

Dr. Heidenhain believes that when the blood pressure rises the blood current moves more rapidly, and that the fall of temperature is due to the surface blood being returned more quickly to the internal organs and thereby cooling them more rapidly than normal. It seems scarcely necessary to point out that if the blood is returned more rapidly to the interior, it of necessity remains upon the exterior for a shorter period, and is cooled less than normal. It makes no difference whether a quart of fluid cooled one-tenth of a degree, or a pint cooled two-tenths of a degree is returned in a given time, so far as the general temperature is concerned. Moreover it has been distinctly proven in an earlier part of this memoir, that vasomotor paralysis, not spasm, favors rapid dissipation of heat. Either the second or the third of Heidenhain's asserted experimental facts seems, to my mind, entirely sufficient to prove the incorrectness of his theory; for if the fall of temperature occurs in a part which is deprived of its blood, or if it does not occur in fever although the nerve irritation has its usual effect upon the blood pressure, how can alterations in the blood pressure be the cause of the fall? The improbability of Heidenhain's theory is further shown by the circumstance that in some of his experiments the temperature fell steadily after galvanization of a nerve though the animals were wrapped in wool. On the whole, the proof appears to be very strong that the fall of temperature which follows galvanization of a sensitive nerve is not due to an increased dissipation of heat from the body owing to changes in the circulation.

The work of Heidenhain has been reviewed and extended by Dr. F. Kögel (*Pflüger's Archiv*, 1871, Bd. iv.), who found that the fall of temperature did not always occur when the nerve was irritated, although the blood pressure always rose, and also that the temperature usually remained at the minimum point for a long time after the withdrawal of the stimulus, although the blood pressure returned at once to the normal point.

The experiments and results of Heidenhain were, indeed, not entirely novel. The same ground appears to have been covered by Mantigazza. Where his memoir

is published I am unable to say, but his results and conclusions, as quoted without reference, by Redard (*Archives Générales*, 6^e Série, t. xix. p. 35), are as follows:—

1. Intense pain transmitted by spinal nerves and the skin causes a rapid fall of temperature, which in the rabbit amounts to from 0°.68 C. to 2°.48 C.; the mean being 1°.27 C. (= 2°.29 F.)

2. The temperature falls perceptibly during the first minute, and arrives at its maximum in from ten to twelve minutes.

3. The lowered temperature may last for an hour and a half.

4. The fall is most marked when the pain does not give origin to muscular spasms.

5. The same phenomena occur in man.

6. The grave abatement of temperature produced by a pain lasting ten minutes would appear to be dependent upon an alteration of the chemical actions of the body, and not merely to an indirect influence exerted upon the vaso-motor nerves.

In order to clearly determine the truth concerning the influence of irritation upon a sensitive nerve, I have performed a number of experiments, some of which are repetitions of those of earlier observers. The records of these experiments are as follows:—

EXPERIMENT 64.

A young pup Crural and axillary nerves exposed, and thermometer placed in peritoneal cavity.

MIN. SEC.	TEMP.	REMARKS.
0	101°.25 F.	Intense current to the brachial plexus; violent cries and struggles.
1:30	101.5	
2:30	100.75	Current withdrawn.
4	100.75	
4:30	100.62	
5:30	100.5	
7	100.37	
9	100.37	Current reapplied.
10	100.37	
11	100.25	Current broken.
13	100.12	
17	100	
19	99.83	
21	99.75	
22	99.61	
24	99.5	Current reapplied.
25	99.5	
26	99.5	
27	99.37	Current broken.
29	99.25	
67	99	
97	100	
127	100	Animal killed.

EXPERIMENT 65.

A stout tomcat. The animal was closely wrapped up in flannels, many folds around the body and legs. Thermometer in the peritoneal cavity.

Mis. Sec.	Temp.	REMARKS.
0	101.61 F.	
5	101.5	Brachial nerves cut down upon and exposed since last note.
6	.....	Intense current applied to the nerves.
7	101.37	Violent cries and struggles.
8	101.5	Current interrupted.
20	101.61	
25	101.5	
26	.....	Current applied.
26:30	101.8.	Violent struggles and cries.
27	101.5	
28	101.67	Current broken.
30	101.5	
33	101.5	
35	101.5	Cat killed.

EXPERIMENT 66.

An adult rabbit. Under chloroform the axillary nerves were exposed, and a thermometer inserted through a small opening in the linea alba into the peritoneal cavity.

Mis. Sec.	Temp.	REMARKS.
0	102.75 F.	
2	102.75	Current applied to the nerve; violent struggles and cries.
3:30	102.75	Temperature of room 83°. Current broken.
4:30	102.87	
5	102.61	
7	102.61	
8	102.37	
10	102.37	
13	102.25	
15	102.13	
18	102	
19	101.87	Current applied; struggles and cries as before.
20	102	Current broken.
21	102	
22	101.75	
26	101.61	
29	101.5	
32	101.37	

EXPERIMENT 67.

An adult rabbit; prepared as in previous experiments, except that the crural nerve was used.

Mis. Sec.	Temp.	REMARKS.
0	103.25 F.	
2	103.25	Current applied to nerve.
2:30	103.75	Violent struggles and cries; current broken.
4	103.5	
10	102.75	Rabbit quiet.
12	102.5	
14	102.75	
15	102	
17	101.5	

MIN. SEC.	TEMP.	REMARKS.
21:30	101.25	Anæsthesia has been induced and the opposite crural nerve exposed, which was used throughout the rest of the experiment.
22	101.5	Current applied.
22:30	101.5	Current broken.
23:30	101.62	Rabbit squealing and struggling.
25	101.62	Current applied, giving rise to violent struggles and cries.
26	101.75	Current broken.
27	101.75	
29	101.5	
32	101.13	
35	100.87	
40	100.25	
47	99.62	
49	99.5	Rabbit killed.

An examination of these records will show that rarely did the temperature fall whilst the current was being applied, and that in several cases there was even a perceptible rise, amounting to from an eighth to a half of a degree. This rise I believe to have been due to the rise of blood pressure and to the violent muscular exertion which the pain caused. It certainly occurred at the period at which the blood pressure was increased. In many experiments upon the effects of irritation of a sensitive nerve on the arterial pressure, I have found that if the rise occur it is immediate, and that in a very brief time after the cessation of the irritation the arterial pressure becomes normal. In all of my experiments, here reported, the fall of temperature did not fairly commence until after the period of disturbance of the circulation had passed by; in most cases it was very persistent and progressively increased for many minutes. In Experiment 67 the fall amounted to three degrees and three-quarters, and did not reach its maximum until twenty-three minutes after the last irritation of the sensitive nerve. It is therefore highly improbable that the fall of temperature is due to disturbances of the circulation, since, at the time of the fall of temperature, the circulation is not profoundly affected. The time of the fall and its permanence indicate that *the fall of temperature which results from the irritation of a sensitive nerve, is independent of the state of the circulation as measured by the arterial pressure.*

If this proposition be correct, and if, as has already been rendered probable, there is above the medulla a centre which has the power of directly or indirectly inhibiting heat production, it is reasonable to expect that, after section of the medulla at the border of the pons, galvanization of a sensitive nerve will fail to affect the temperature. Further, if such galvanization does fail to affect the temperature, it is evident that a heat-controlling centre of some kind, situated above the pons, must exist, since the general circulation and respiration are affected as in the normal animal. Such is the reasoning, and in order to test what the fact may be, the following experiments were performed.

EXPERIMENT 68.

A stout young dog. Medulla, as demonstrated at autopsy, nearly cut through at its junction with the pons.

TIME.	TEMP.	REMARKS.
1 P. M.	101° 75 F.	Galvanization of a sensitive nerve with an intense Faradic current for half a minute had no perceptible effect on the bodily temperature. Dog watched many minutes.

EXPERIMENT 69.

A stout terrier. Medulla oblongata found at the autopsy to be very nearly severed from the pons.

Time.	Temp.	REMARKS.
2:40 p. m.	107.75 F.	A very intense Faradic current passed for one minute through the <i>axillary nerves</i> , had no influence on the bodily temperature. Animal watched many minutes.

EXPERIMENT 70.

A powerful dog. Medulla oblongata separated from the pons, as proven by the autopsy.

Time.	Temp.	REMARKS.
1:30 p. m.	105.25 F.	Galvanization of a large sensitive nerve with a very strong Faradic current for one and a half minutes had no perceptible effect on the temperature. Animal watched many minutes.

EXPERIMENT 71.*

A cur. The medulla had been separated from the pons and the temperature had risen to 106.9

Min. Sec.	Temp.	REMARKS.
1	105.9	Applied a very powerful Faradic current to the sciatic nerve.
1:45	106	
2	106	
15	106	
30	106	
45	106	
3	106	
15	106	
45	106	
5:15	106.1	
6	106.2	
7	106.2	Current increased to the whole force of the Du Bois Reymond coil.
8	106.1	
9	106.1	
10	106.1	Current stopped.
Waited 5 minutes, and then reapplied the current with the full force of the Du Bois Reymond coil		
1	106.4	Current applied; full force of the Du Bois Reymond coil.
15	106.2	
1:45	106.2	
2	106.2	
3	106.1	
4	106.2	Current stopped.
5	106.2	
6	106.2	
10	106.2	

The current applied with the full coil was so exceedingly powerful as to produce violent general muscular tetanus.

It will be seen that these experiments are very uniform in their results and very decisive. Every care was practised to have the nerve fresh and uninjured, and the animal watched. In two of the experiments the effect of the current upon the

* This experiment was performed in the presence of Prof. Harrison Allen and Demonstrators Reichert and Smith, of the Physiological Laboratory of the University of Pennsylvania.

blood pressure was studied and found to be normal. In one experiment, which has been previously reported (see Experiment 59), stimulation of the nerve had a very decided effect upon the bodily temperature; the result is however not contradictory, for, at the autopsy, the section of the medulla was found to be partial; and it is probable that enough of the fibres remained intact to make the powerful stimulation felt.

The results of these experiments are seemingly different from those of similar experiments made by R. Heidenhain (*Pflüger's Archiv*, Bd. iii. p. 510). That observer states that in a number of instances he has found that irritation of a sensitive nerve, after separation of the pons from the medulla, is followed by a fall of temperature. On examining the record of the single detailed experiment, I find, however, that the fall took place solely during the application of the galvanism to the nerve, and amounted at such times only to from 0.05 to 0.1 of a degree C. (0.09 to 0.18 F.). Indeed, throughout the experiment, the temperature really rose, so that at the end it was decidedly higher during the periods of nerve excitement than it was before the nerve had been irritated at all; and at the close, when the nerve was not stimulated, the bodily heat was 0.2 C. (0.36 F.) higher than at first. This very slight fall of temperature, occurring during the period of stimulation, is something very different from the profound fall, that we have been discussing, which occurs some time after the stimulation. This slight, evanescent alteration of temperature—which also occurred in Experiment 71 of my own series between the 7th and 10th minute—is very probably due to alterations in the respiration or circulation. The experiments of Heidenhain, therefore, corroborate rather than contradict those whose records have just been given.

In conclusion the experiments seem to establish the proposition that *galvanization of a sensitive nerve produces a fall of the bodily temperature by acting upon some nervous centre situated either in or above the pons.*

The existence of some centre in or above the pons directly or indirectly controlling heat production having been established, attention naturally directs itself towards the discovery of the seat of that centre. Mechanical destruction of the pons being evidently not practicable without involving other vital portions of the brain, I have tried to accomplish the result by means of caustic injections. The experiments performed are as follows:—

EXPERIMENT 72.

A dog. Weight 14 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
12:39 P. M.	58° 64	67° 02	66° 2	103° 1	959.1	
12:54	59.04	66.8				
1:9	65.21	67.23				
1:24	65.21	67.23				
1:39	66.29	67.59	66.371	103.1	1045	
	62.88	67.17	0.171	0	85.9	
	(mean)	62.88	(gain)			
		4.29				
		(gain)				

2 P. M.—Three minims of strong aqua ammonia were thrown by means of a hypodermic syringe into the pons. Most violent tetanus was at once developed, and continued about twenty minutes when breathing recommenced, life having been sustained by artificial respiration. 2:40 P. M.—Dog relaxed. Rectal temperature $99^{\circ}.32$ F.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GAS. METER. (cub. ft.)	REMARKS
2:54 P. M.	65.96	68 ^o .54	68 ^o .27	1076	Animal in constant motion in the box.
3:9	65.66	69.26				
3:24	65.21	69.26				
3:39	68.9	68.72				
3:54	67.46	69.75	68.625	101 ^o .48	1146	
	66.64 (mean)	69.11 66.64	0.355 (gain)		70	
		2.47 (gain)				

4 P. M.—Animal breathing slowly and deeply; relaxed but with fibrillary contractions of the muscles. Died during the evening or night.

Autopsy.—Cerebellum very widely destroyed. Upper one-fourth of the pons disintegrated. Medulla not injured.

Heat Dissipation.

BEFORE INJECTION.

Quantity of air (V') = 85.9 at $67^{\circ}.17 - 32^{\circ} = 35.17 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{85.9}{1.071} = 80.2$. $W = V \times 0.08073 = 6.47$

Rise in temp. of air $4.29 = t$. $Q = W \times t \times \text{sp. h.} = 6.47 \times 4.29 \times 0.2374 = 6.5893 = \text{heat given to air}$

Rise in temp. of water $0.171 \times 164.1414 = 28.0682 = \text{heat given to calorimeter}$.

6.5893 = heat given to air.

Hourly dissipation of heat 34.6575

AFTER INJECTION.

Quantity of air (V') = 70 at $69^{\circ}.11 - 32^{\circ} = 37.11 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{70}{1.0755} = 65.1$. $W = V \times 0.08073 = 5.25$

Rise in temp. of air $2.47 = t$. $Q = W \times t \times \text{sp. h.} = 5.25 \times 2.47 \times 0.2374 = 3.0805 = \text{heat given to air}$.

Rise in temp. of water $0.355 \times 164.1414 = 58.2702 = \text{heat given to calorimeter}$.

3.0805 = heat given to air.

Hourly dissipation of heat 61.3507

SUMMARY.

Hourly dissipation of heat after injection 61.3507

Hourly dissipation of heat before injection 34.6575

Hourly increase of heat following injection 26.6932

Heat Production.

BEFORE INJECTION.

No change in heat reserve.

Hourly dissipation of heat = hourly production 34.6575

AFTER INJECTION.

Rise of animal temp. in $1\frac{1}{2}$ hours 2.16, in 1 hour 1.728 = t .

$Q = W \times t \times \text{sp. h.} = 14 \times 1.728 \times 0.75 = 18.144 = \text{hourly gain of heat reserve}$.

61.3507 = hourly dissipation of heat.

Hourly production of heat 79.4947

SUMMARY.

Hourly production of heat after injection 79.4947
 Hourly production of heat before injection 34.6575

Hourly increase of heat production following injection 44.8372

EXPERIMENT 73.

A dog. Weight 16 lbs.
 February 6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:50 A. M.	67 ^o .55	71 ^o .59	70 ^o .07	102 ^o .2	170.65
12:05 P. M.	68.99	70.64			
12:20	68.99	70.64			
12:35	68.81	70.52			
12:50	68.99	70.06	70.358	102.92	253.12
	68.67	70.69	0.288	0.72	82.47
	(mean)	68.67	(gain)	(gain)	
		2.02			
		(gain)			

1:12 P. M.—Injected five drops of a 20 per cent. solution of chromic acid into the pons.

1:19 P. M.—Rectal temperature 103^o.64. Some rigidity of muscles, most marked on the left side.

General palsy; sensations blunted.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:41 P. M.	69 ^o .44	71 ^o .84	70 ^o .079	.....	270.4
1:56	68.12	70.43			
2:11	68.12	70.34			
2:26	67.76	70.34			
2:41	67.98	69.96	70.52	.....	351.4
	68.28	70.58	0.441	.....	81
	(mean)	68.28	(gain)		
		2.3			
		(gain)			

2:5 P. M.—Rectal temperature 101^o.23.

February 7. 10:50 A. M.—Dog has been lying by a warm fire. Rectal temperature 102^o.56.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:1 A. M.	.....	.....	68 ^o .72	.....	367.15
11:16	65 ^o .48	69 ^o .20			
11:31	65.84	69.17			
12:1 P. M.	65.84	69.17	68.99	.....	441.
	65.72	69.18	0.27	.....	73.85
	(mean)	65.72	(gain)		
		3.46			
		(gain)			

12:20 P. M.—Sensation seemingly perfect; the dog can kick well with all his legs, but cannot get up on them. Rectal temperature 100^o.48. Dog killed.

Autopsy.—Complete destruction of the left cerebellar lobe and peduncle; upper superficial portion of the pons completely destroyed.

Heat Dissipation.

First Period—

Quantity of air (V') = 82.47 at 70^o.69 — 32^o = 38.69 = t'.

V + (V × t' × 0.002035) = V'. V = $\frac{82.47}{1.079}$ = 76.4. W = V × 0.08073 = 6.17.

Rise in temp. of air 2.02 = t. Q = W × t × sp. h. = 6.17 × 2.02 × 0.2374 = 2.9588 = heat given to air.

Rise in temp. of water 0.288 × 164.1414 = 47.2727 = heat given to calorimeter.

2.9588 = heat given to air.

Heat dissipated in an hour 50.2315

*Second Period—*Quantity of air (V') = 81 at $70^{\circ}.58 - 32^{\circ} = 38.58 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{81}{1.0785} = 75.1. \quad W = V \times 0.08073 = 6.06$$

Rise in temp. of air $2.3 = t. \quad Q = W \times t \times \text{sp. h.} = 6.06 \times 2.3 \times 0.2374 = 3.3089 = \text{heat given to air.}$ Rise in temp. of water $0.441 \times 164.1414 = 72.3864 = \text{heat given to calorimeter.}$ $3.3089 = \text{heat given to air.}$ *Hourly dissipation of heat* 75.6953*Third Period—*Quantity of air (V') = 73.85 at $69^{\circ}.18 - 32^{\circ} = 37.18 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{73.85}{1.0714} = 68.6. \quad W = V \times 0.08073 = 5.54.$$

Rise in temp. of air $3.46 = t. \quad Q = W \times t \times \text{sp. h.} = 5.54 \times 3.46 \times 0.2374 = 4.5245 = \text{heat given to air.}$ Rise in temp. of water $0.27 \times 164.1414 = 44.3181 = \text{heat given to calorimeter.}$ $4.5245 = \text{heat given to air.}$ *Hourly dissipation of heat* 48.8426

SUMMARY.

Hourly heat dissipation. First period	50.2315
Second period	75.6953
Third period	48.8426
<i>Gain of heat dissipation in second period</i>	25.4638
<i>Loss of heat dissipation in third period</i>	1.3889

*Heat Production.**First Period—*Rise of bodily temperature $0.72 = t.$

$$Q = W \times t \times \text{sp. h.} = 16 \times 0.72 \times 0.75 = 8.64 = \text{heat added to reserve.}$$

 $50.2315 = \text{dissipation of heat.}$ *Hourly production of heat* 58.8715*Second Period—*Fall of bodily temperature in 92 minutes 2.41; in one hour 1.572 = $t.$

$$Q = W \times t \times \text{sp. h.} = 16 \times 1.572 \times 0.75 = 18.864 = \text{heat lost from reserve.}$$

Dissipation of heat 75.6953

Loss from heat reserve 18.864

Hourly production of heat 56.8313*Third Period—*Fall of bodily temperature in 90 minutes 2.08; in one hour 1.3867 = $t.$

$$Q = W \times t \times \text{sp. h.} = 16 \times 1.3867 \times 0.75 = 16.6404 = \text{loss from heat reserve in one hour.}$$

Dissipation of heat 48.8426

Loss from heat reserve 16.6404

Hourly production of heat 32.2022

SUMMARY.

Production of heat in the hour. First period	58.8715
Second period	56.8313
Third period	32.2022
<i>Loss of heat production in second period</i>	2.0402
<i>Loss of heat production in third period</i>	26.6693

In studying the first of these experiments (Experiment 72) the fall of the bodily temperature immediately following the injection at once attracts attention. This

may fairly be attributed to the complete suspension of respiration; the tightly contracted muscle allowing only sufficient artificial respiration to maintain life. It must of course be remembered that it was essential not to injure the animal, and that consequently artificial respiration was limited to external manipulation. After respiration was re-established the bodily temperature began to rise. The hourly rate of heat production at this time was 79.4947 instead of 34.6575—a remarkable difference. This experiment apparently confirms the results of medullary section, showing that the inhibitory centre is situated at least as high up as the pons.

The next experiment was continued longer, and gave results less readily explained than those just discussed. Immediately after the injection, as well as later, the heat production was found to be much reduced. The autopsy showed a complete destruction of the left cerebellar lobe and peduncle, as well as of the upper portion of the pons. So extensive a lesion may well be expected to cause vaso-motor disturbance, and it has been abundantly proven by the effects of section of the cord that the action of the higher heat-centre is dominated by the vaso-motor system; indeed the effects upon heat dissipation and production, in the experiment, were exactly such as follow section of the cord. The production of vaso-motor palsy seems to me the most plausible explanation of the phenomena noticed. A possible explanation is also afforded by the supposition that the heat-controlling fibres or centres in the pons escaped, the pons having in truth been only partially destroyed. The difficulty of exactly locating the lesion, multiplied as it is by the fact that two injections are of necessity required in the upper brain (one for each side), has deterred me from making many of these injection experiments; the following are all that I have performed:—

EXPERIMENT 74.

A small dog. Weight 12 lbs.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:10 A. M.	68°.24	73°.66	90.89	102°.94	503
11:30	69.32	72.68			
11:50	70.52	73.25			
12:10 P.	72.05	73.45	70.07	102.38	567
	70.03 (mean)	73.26 70.03	0.18 (gain)	0.54 (loss)	64
		3.23 (gain)			

1 P. M.—Injection of strong water of ammonia.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub ft.)
2:55 A. M.	68°.72	72°.08	70°.736	100°.9	606
3:10	66.29	70.76			
3:25	66.29	70.43			
3:40	70.07	71.15			
3:55	71.36	72.08	70.928	100.9	671
	68.55 (mean)	71.3 68.55	0.192 (gain)		65
		2.75 (gain)			

4 P. M.—Dog killed. Left corpus striatum the only part of the brain injured—it totally destroyed

Heat Dissipation.

BEFORE INJECTION.

Quantity of air (V') = 64 at $73^{\circ}.26 - 32^{\circ} = 41.26 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{64}{1.08} = 59.04$. $W = V \times 0.08073 = 4.8$ Rise in temp. of air $3.23 = t$. $Q = W \times t \times \text{sp. h.} = 4.8 \times 3.23 \times 0.2374 = 3.6806 = \text{heat given to air.}$ Rise in temp. of water $0.18 \times 164.1414 = 29.5454 = \text{heat given to calorimeter.}$ $3.6806 = \text{heat given to air.}$ *Hourly dissipation of heat* 33.226

AFTER INJECTION.

Quantity of air (V') = 65 at $71^{\circ}.3 - 32^{\circ} = 39.3 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{65}{1.08} = 60.2$. $W = V \times 0.08073 = 4.86$ Rise in temp. of air $2.75 = t$. $Q = W \times t \times \text{sp. h.} = 4.86 \times 2.75 \times 0.2374 = 3.1728 = \text{heat given to air.}$ Rise in temp. of water $0.192 \times 164.1414 = 31.5152 = \text{heat given to calorimeter.}$ $3.1728 = \text{heat given to air.}$ *Hourly dissipation of heat* 34.688

SUMMARY.

Hourly dissipation of heat after injection 34.688

Hourly dissipation of heat before injection 33.226

Hourly increase of heat dissipation following injection 1.462*Heat Production.*

BEFORE INJECTION.

Fall of bodily temperature $0.54 = t'$. $Q = W \times t' \times \text{sp. h.} = 12 \times 0.54 \times 0.75 = 4.86 = \text{hourly loss from heat reserve.}$

Hourly dissipation of heat 33.226

Loss from heat reserve 4.86

Hourly production of heat 28.366

AFTER INJECTION

No change of bodily temperature.

Hourly dissipation, = hourly production of heat 34.688

SUMMARY.

Hourly production of heat after injection 34.688

Hourly production of heat before injection 28.366

Gain of heat production following injection 6.322

EXPERIMENT 75.

A large dog, weight 36 pounds.

TIME.	AIR TEMP. (Fah.)	TEMP. TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METRE. (cub. ft.)
1:8 P. M.	65 ^o .21	70 ^o .21	65 ^o .165	102 ^o .92	707
1:23	64.13	70.88			
1:38	64.4	70.25			
1:54	64.22	70.25			
2:8	64.88	70.16	66.62	103.28	791.5
	64.57	70.35	1.455	0.36	84.5
	(mean)	64.57	(gain)	(gain)	
		5.78			
		(gain)			

2:30 P. M.—Strong aqua ammonia injected into the left brain. Head immediately flexed to the right, no movements. 2:36 P. M.—Rectal temperature, 103°.1.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:56 P. M.	64°.4	68°.54	65°.255	.....	844
3:11	63.73	68.98			
3:26	63.32	68.72			
3:41	63.23	68.27			
3:56	63.92	68.54	66.56	97°.52	926
	63.72	68.61	1.305		82
	mean)	63.72	(gain)		
		4.89	(gain)		

4:15 P. M.—The feet are very cold. Incoördinate movements of front feet. 9 P. M.—Animal gradually dying.

Autopsy.—Destruction of a large portion of the left optic thalamus, also of the cerebral convolution immediately over this, also of all of the deeper portions of the entire left hemisphere.

Heat Dissipation.

BEFORE INJECTION.

Quantity of air (V) = 84.5 at 70°.35—32° = 38°.35 = t'.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{84.5}{1.078} = 78.3$. $W = V \times 0.08073 = 6.3$
 Rise in temp. of air 5.78 = t. $Q = W \times t \times \text{sp. h.} = 6.3 \times 5.78 \times 0.2374 = 8.6447 = \text{heat given to air.}$
 Rise in temp. of water 1.455 $\times 164.1414 = 238.8257 = \text{heat given to calorimeter.}$
 8.6447 = heat given to air.

Hourly dissipation of heat 247.4704

AFTER INJECTION.

Quantity of air (V) = 82 at 68°.61—32° = 36.61 = t'. $V + (V \times t' \times 0.002035) = V'$.
 $V = \frac{82}{1.074} = 76.3$. $W = V \times 0.08073 = 6.16$
 Rise in temp. of air 4.89 = t. $Q = W \times t \times \text{sp. h.} = 6.16 \times 4.89 \times 0.2374 = 7.1511 = \text{heat given to air.}$
 Rise in temp. of water 1.305 $\times 164.1414 = 214.2045 = \text{heat given to calorimeter.}$
 7.1511 = heat given to air.

Hourly dissipation of heat 221.3556

SUMMARY.

Hourly dissipation of heat before injection	247.4704
Hourly dissipation of heat after injection	221.3556
<i>Diminution of heat dissipation following injection</i>	26.1148

Heat Production.

BEFORE INJECTION.

Rise of bodily temperature 0.36 = t.
 $Q = W \times t \times \text{sp. h.} = 36 \times 0.36 \times 0.75 = 9.72 = \text{heat added to reserve.}$
 Hourly dissipation of heat 247.4704
 Hourly gain from heat reserve 9.72
Hourly production of heat 257.1904

AFTER INJECTION.

Fall of animal temperature in 1½ hours 5.58, in 1 hour 4.185 = t.

$Q = W \times t \times \text{sp. h.} = 36 \times 4.185 \times 0.75 = 112.995 = \text{heat lost from reserve.}$

Hourly dissipation of heat 221.3556

Hourly loss from heat reserve 112.995

Hourly production of heat 108.3606

SUMMARY

Hourly production of heat before injection 257.1904

Hourly production of heat after injection 108.3606

Diminution of hourly production of heat following injection 148.8298

These experiments do not require extended comment. The first would seem to indicate that in the dog the corpus striatum is connected either directly or by conduction with the function of heat production. The small size of the dog and the consequently minute amount of heat dissipated increases, however, greatly the chances of error, and not very much confidence can be put in the single experiment.

The great diminution of heat production which followed the operation in the second experiment was probably due to shock, *i. e.*, vaso-motor palsy, caused by the destruction of nearly a whole cerebral hemisphere.

The only conclusion to be drawn is that the method employed is a doubtful one, and that no decided light has been thus far thrown upon the position of the inhibitory heat centre by its employment.

Eulenburg and Landois reported in *Virchow's Archiv*, Bd. lxxviii., p. 245, a series of experiments upon the effect of destruction of the cerebral cortex on the temperature of the feet of dogs. They found that when a certain region in the neighborhood of the sulcus cruciatus was destroyed either by means of a hot iron or by chemical reagents, almost immediately the temperature of the opposite extremities rose. They assert that in some cases the difference between the feet of the two sides amounted to 13° C. (23° F.), and that occasionally it was only 1° 5 C. (2° 7 F.). They located the exact position of this region as being bordered anteriorly by the sulcus cruciatus, and extending to the fourth primitive convolution embracing especially a "hackenförmig" gyrus which appears to correspond to the gyrus postfrontalis (Owen) in man and apes. They also state that they were able to separate the region presiding over the front from that governing the hinder extremities, the focus for the front legs lying somewhat more forward and in immediate proximity to the distal end of the sulcus cruciatus. Eulenburg and Landois further discovered that when the region was irritated with a galvanic current the paws grew cooler. The duration of the elevation of temperature after destruction of the cerebral temperature varied. In most cases the increased warmth was perceptible for a long time, in some instances for three months; but in some dogs it disappeared after two or three days. Other portions of the cerebral surface than those already spoken of were destroyed without perceptible thermic effect.

This research of Landois and Eulenburg is in accord with that of Prof. L. Hitzig (*Centralblatt für die Med. Wissenschaft.*, 1876, p. 323), so that the main facts must be considered as almost established. Led by these corroborated statements

of Landois and Eulenburg I have made the following experiments to determine whether destruction of the region indicated by them has any influence upon the general heat production.

EXPERIMENT 76.

A dog. Weight 16 lbs.

12:45 P. M.—Rectal temperature 103°.5.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
1:1 P	73°·94	76°·16	71°·156	138.82	
1:16	73.94	75.08			
1:31	74.39	75.47			
1:46	74.6	75.38			
2:1	75.08	75.47			
2:16	72.73	74.37			
2:31	74.6	75.2	72.203	273.45	
	74.18	75.3	1.047	134.63	
	(mean)	74.18	(gain)		
		1.12			
		(gain)			

2:45 P. M.—Rect. temp. 102°.9. 3:5 P. M.—Brain burnt with a hot iron. 3:35 P. M.—Rect. temp. 101°.7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
3:53 P. M.	77°·36	76°·47	70°·295	284.26	
4:8	75.8	74.3			
4:23	75.65	74.84			
4:38	74.72	74.21			About $\frac{1}{2}$ gallon of water was found in the inner box.
4:53	74.3	74.21			
5:8	73.64	73.84			
5:23	73.94	73.66	71.6	419.	
	75.06	74.5	1.305	134.74	
	74.5	(mean)	(gain)		
	0.56				
	(loss)				

5:35 P. M.—Rect. temp. 103°. Loss of tactile sense very marked on each side.

11:45 A. M.—Rectal temperature 104°.8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
12:19 P. M.	72°·78	73°·88	70°·448	581.1	
12:34	72.2	73.65			
12:49	71.96	73.55			
1:4	71.96	73.35			
1:19	71.78	73.45			A leak in the top of the box caused the whole stratum of sawdust on the lid to be wet through, causing much loss of heat, and making this observation somewhat unreliable.
1:34	71.87	73.65			
1:49	71.96	73.88			
2:9	71.96	73.66			
2:19	.....	.....	71.69	732.655	
	72.06	73.63	1.242	151.555	
	(mean)	72.06	(gain)		
		1.57			
		(gain)			

2:30 P. M.—Rectal temperature 104°.8.

Time	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	GEN. METER (cub. ft.)	REMARKS.
3:12 p. m.	73°·4	71°·39	71°·24	778·68	
3:22	73·4	73·88			
3:42	73·52	74·12			
5:37	73·4	74·12			
4:12	73·94	74·21	71·897	848·14	
	73·53	73·54	0·657	69·46	
		73·53			
		0·01			

4:15 p. m.—Rectal temperature 105°·4. The dog eats well; can walk well, but the tactile sense in the paws seems almost abolished.

Autopsy.—Right side: Wound through the gray matter about one-third of an inch in diameter, involving the outer part of the sulcus cruciatus, and the first, second, and third convolutions. Left side: Wound posterior to sulcus, involving the whole brain beyond the first convolution which escaped, reaching in depth nearly to the ventricle.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 134.63 at 75°·3 — 32° = 43.3 = t' .

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{134.63}{1.088} = 123.74$. $W = V \times 0.08073 = 9.99$.

Rise in temp. of air 1.12 = t . $Q = W \cdot t \times \text{sp. h.} = 9.99 \times 1.12 \times 0.2374 = 2.6562 = \text{heat given to air.}$

Rise in temp. of water 1.047 \times 130.859 = 137.0094 = heat given to calorimeter.

2.6562 = heat given to air.

139.6656 = heat dissipated in 1½ hours.

Hourly dissipation of heat 93.1104

AFTER OPERATION.

First Period—

Quantity of air (V') = 134.74 at 74°·5 — 32° = 32.5 = t' .

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{134.74}{1.066} = 126.4$. $W = V \times 0.08073 = 10.2$

Fall in temp. of air = 0.56 = t . $Q = W \times t \times \text{sp. h.} = 10.2 \times 0.56 \times 0.2374 = 1.356 = \text{heat taken from air.}$

Rise in temp. of water 1.305 \times 130.859 = 170.771 = heat given to calorimeter.

1.356 = heat taken from air.

169.415 = heat dissipated in 1½ hours.

Hourly dissipation of heat 112.9453

Second Period—

Quantity of air (V') = 151.555 at 73°·63 — 32° = 41.63 = t' .

$V + (V \times t' \times 0.002034) = V'$. $V = \frac{151.555}{1.085} = 139.7$. $W = V \times 0.08073 = 11.28$.

Rise in temp. of air 1.57 = t . $Q = W \times t \times \text{sp. h.} = 11.28 \times 1.57 \times 0.2374 = 4.043 = \text{heat given to air.}$

Rise in temp. of water $1.242 \times 130.859 = 162.5269 =$ heat given to calorimeter.
 $4.043 =$ heat given to air.

 $166.5699 =$ heat dissipated in 2 hours.
Hourly dissipation of heat 83.2849

Third Period—

Quantity of air (V') = 69.46 at $73^{\circ}.54 - 32^{\circ} = 41.54 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{69.46}{1.085} = 64$. $W = V \times 0.08073 = 5.17$.
Rise in temp. of air $0.01 = t$. $Q = W \times t \times \text{sp. h.} = 5.17 \times 0.01 \times 0.2374 = 0.0042 =$ heat given to air.
Rise in temp. of water $0.657 \times 130.859 = 85.9743 =$ heat given to calorimeter.
 $0.0042 =$ heat given to air.

Heat dissipated in one hour 85.9786

SUMMARY.

Hourly dissipation of heat before operation		93.1104
Hourly dissipation of heat after operation.	First period	112.9453
	Second period	83.2849
	Third period	85.9786
<i>Gain in dissipation of heat during first period after operation</i>		19.8349
	<i>Loss of same second period</i>	9.8255
	<i>Loss of same third period</i>	7.1318

Heat Production.

BEFORE OPERATION.

Fall of bodily temperature in 2 hours 0.6, in 1 hour 0.3 = t .
 $Q = W \times t \times \text{sp. h.} = 16 \times 0.3 \times 0.75 = 3.6 =$ heat taken from reserve.
 $93.1104 =$ hourly dissipation of heat.

Hourly heat production 89.5104

AFTER OPERATION.

First Period—

Rise of bodily temperature in 2 hours 1.3, in 1 hour 0.65 = t .
 $Q = W \times t \times \text{sp. h.} = 16 \times 0.65 \times 0.75 = 7.8 =$ heat added to reserve.
 $112.9453 =$ hourly dissipation of heat.

Hourly production of heat 120.7453

Second Period—

No change in bodily temperature, hourly dissipation = *hourly production of heat* 83.2849

Third Period—

Rise of bodily temperature in $1\frac{3}{4}$ hours 0.6, in 1 hour 0.343 = t .
 $Q = W \times t \times \text{sp. h.} = 16 \times 0.343 \times 0.75 = 4.116 =$ heat added to reserve.
 $85.9786 =$ hourly dissipation of heat.

Hourly production of heat 90.0946

SUMMARY.

Hourly production of heat before operation		89.5104
Hourly production of heat after operation.	First period	120.7453
	Second period	83.2849
	Third period	90.0946
<i>Hourly gain in heat production immediately following operation</i>		31.2349
<i>Hourly loss of heat production, second period, following operation</i>		6.2255
<i>Hourly gain of heat production, third period, following operation</i>		0.5842

EXPERIMENT 77.

A dog. Weight 16 pounds.

April 1, 1:45 P. M.—Rectal temperature $104^{\circ}.1$

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:55 P. M.	70 ^o .88	73 ^o .98	69 ^o .98	.....	687.91
2:10	69.92	73.45			
2:25	70.04	71.84			
2:40	70.34	71.6			
2:55	70.34	72.08			
3:10	71.96	73.14	70.43	104 ^o .1	839.5
	70.58 (mean)	72.68 70.58	0.45 (gain)		151.59
		2.1 (gain)			

3:20 P. M.—Rectal temperature, $104^{\circ}.1$. 3:30 P. M.—Brain operated on.

3:45 P. M.—Rectal temperature, $104^{\circ}.6$. Animal not fully recovered from anaesthetics.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:5 P. M.	74 ^o .21	75 ^o .92	71 ^o.	.....	890.6
4:20	73.4	75.38			
4:35	73.4	74.96			
4:50	73.3	74.	.....	.....	1001.3
5:5	.....	.....	71.48		
	73.58 (mean)	75.06 73.58	0.48 (gain)		110.7
		1.48 (gain)			

5:15 P. M.—Rectal temperature, $102^{\circ}.4$.

April 2.—Dog in good condition; but the scalp wound suppurating and some brain matter escaping. He has had nothing to eat since the operation.

12 M.—Rectal temperature $103^{\circ}.3$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:19 P. M.	70 ^o .04	71 ^o .6	68 ^o .18	.....	104.03
12:34	69.2	71.06			
12:49	69.32	70.97			
1:1	69.32	70.97			
1:19	69.4	71.06			
1:34	70.34	71.42	68.765	.....	210.71
	69.6 (mean)	71.18 69.6	0.585 (gain)		106.68
		1.58 (gain)			

1:45 P. M.—Rectal temperature $103^{\circ}.9$.

April 3.—Animal killed.

Autopsy.—Brain: Right side; a small deep lacerated wound reaching nearly to the ventricle, and situated at the extreme outer edge of the second convolution nearly half-way back from the front. Left side; a large lacerated pulpified wound, chiefly occupying the third convolution, but to some extent involving the outer edge of the second, reaching about half-way to the ventricle. (See Fig. 2.)



Heat dissipated in 1 hour	63.6426
Heat added to reserve	4.116
<i>Hourly production of heat</i>	<u>67.7586</u>

SUMMARY.

Hourly production of heat before operation	51.616
Hourly production of heat after operation. 1st period	47.9833
2d period	67.7586
<i>Loss of hourly production of heat immediately following operation</i>	3.6327
<i>Gain of hourly production of heat subsequent day after operation</i>	16.1426

EXPERIMENT 78.

A dog. Weight 16.5 pounds.

April 22, 11:50 A. M.—Rectal temperature 102° .7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:3 P. M.	73° .09	75° .47	74° .129	756.4
12:20	72.73	75.2		
12:35	72.63	74.84		
12:51	72.47	74.84		
1:5	72.73	75.68		
1:18	72.42	74.3	74.504	870.64
	<u>72.68</u>	<u>75.05</u>	<u>0.375</u>	<u>114.24</u>
	(mean)	72.68	(gain)	
		<u>2.37</u>		
		(gain)		

1:20 P. M.—Rectal temperature 103° .6. 2 P. M.—Brain washed out freely through trepan openings over Hitzig's region.

April 23, 12:20 P. M.—Rectal temperature 103° .6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:32 P. M.	64° .76	72° .32	70° .34	933.78
12:47	69.55	71.51		
1:2	70.43	72.08		
1:17	70.04	72.86		
1:32	70.04	72.77		
1:47	72.32	74.03		
2:2	71.78	73.66	71.24	1063.696
	<u>69.84</u>	<u>72.75</u>	<u>0.9</u>	<u>129.916</u>
	(mean)	69.84	(gain)	
		<u>2.91</u>		
		(gain)		

2:10 P. M.—Rectal temperature 103° .

April 25.—Dog beginning to eat.

April 27.—Dog able to walk some.

May 3.—Dog killed. Right side of brain; a very large wound, involving 1, 2, 3, 4 primitive convolutions, running across the sulcus cruciatus and extending into the ventricles. Left side; wound about one-third of an inch posterior to the sulcus cruciatus, involving 1, 2, 3 convolutions, and extending into the ventricles. (See Fig. 3.)



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 114.24 at $75^{\circ}.05 - 32^{\circ} = 43.05 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{114.24}{1.088} = 105. \quad W = V \times 0.08073 = 8.48$$

Rise in temp. of air $2.37 = t$. $Q = W \times t \times \text{sp. h.} = 8.48 \times 2.37 \times 0.2374 = 4.7688 = \text{heat given to air.}$

Rise in temp. of water $0.375 \times 130.859 = 49.0721 = \text{heat given to calorimeter.}$

4.7688 = heat given to air.

53.8409 = heat dissipated in $1\frac{1}{4}$ hours.

Hourly dissipation of heat 43.0727

DAY FOLLOWING OPERATION.

Quantity of air (V') = 129.916 at $72^{\circ}.75 - 32^{\circ} = 40.75 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{129.916}{1.083} = 120. \quad W = V \times 0.08073 = 9.69$$

Rise in temp. of air $2.91 = t$. $Q = W \times t \times \text{sp. h.} = 9.69 \times 2.91 \times 0.2374 = 6.6942 = \text{heat given to air.}$

Rise in temp. of water $0.9 \times 130.859 = 117.7731 = \text{heat given to calorimeter.}$

6.6942 = heat given to air.

124.4673 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 82.9782

SUMMARY.

Hourly dissipation of heat before operation 43.0727

Hourly dissipation of heat day following operation 82.9782

Gain in hourly dissipation of heat 39.9055

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in $1\frac{1}{4}$ hours $0^{\circ}.9$, in 1 hour $0.72 = t$.

$Q = W \times t \times \text{sp. h.} = 16.5 \times 0.72 \times 0.75 = 8.91 = \text{heat added to reserve.}$

Heat dissipated in 1 hour 43.0727

Heat added to reserve 8.91

Hourly production of heat 51.9827

AFTER OPERATION.

Fall of bodily temperature in $1\frac{1}{2}$ hours $0^{\circ}.6$, in 1 hour $0.4 = t$.

$Q = W \times t \times \text{sp. h.} = 16.5 \times 0.4 \times 0.75 = 4.95 = \text{heat taken from reserve.}$

Heat dissipated in 1 hour 82.9782

Heat taken from reserve 4.95

Hourly production of heat 78.0282

SUMMARY.

Hourly production of heat day after operation 78.0282

Hourly production of heat day before operation 51.9827

Gain of hourly heat production following operation 26.0455

EXPERIMENT 79.

A dog. Weight 18.25 pounds.

March 21.—Dog fed about 10 A. M. 11:15 A. M.—Rectal temperature 103° 8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:30 A. M.	.....	.....	67° 55	269.59
11:45	.....	.....
12 M.	60° 2	68° 12		
12:15 P. M.	63.32	68.		
12:30	59.7	67.88	68.636	333.15
	61.07	68	1.086	63.56
	(mean)	61.07	(gain)	
		6.93		
		(gain)		

12:40 P. M.—Rectal temperature 103° 4. 1 P. M.—Brain operated upon. 1:10 P. M.—Rectal temperature 101° 6. 1:15 P. M.—Rectal temperature 103°. Dog has a very distinct loss of tactile sense on each side, with marked sprawling movements, and the rooster tread or gait.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:19 P. M.	64° 67	70° 09	67° 01	420.72
1:34	64.13	69.53		
2:4	62.6	69.08		
2:19	61.9	68.36	68.252	454.5
	63.32	69.26	1.242	33.78
	(mean)	63.32	(gain)	
		5.94		
		(gain)		

2:30 P. M.—Rectal temperature 102° 5.

March 22.—The dog has not had any food since 10 A. M., March 21.

3:39 P. M.—Rectal temperature 102° 7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:50 P. M.	66° 2	69° 62	67° 271	503.7
4:5	64.22	69.08		
4:20	64.04	69.08		
4:35	64.31	67.76		
4:50	64.22	68.54	68.135	542.
	64.6	68.8	0.864	38.3
	(mean)	64.6	(gain)	
		4.2		
		(gain)		

4:54 P. M.—Rectal temperature 103°.

Animal died during the night. Autopsy.—Right side of the brain uninjured; region of the left sulcus cruciatus destroyed; also the whole corpus callosum.

BEFORE OPERATION.

Quantity of air (V) = 63.56 at 68° — 32° = 36 = t'.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{63.56}{1.073} = 59.2$. $W = V \times 0.08073 = 4.78$

Rise in temp. of air 6.93 = t. $Q = W \times t \times \text{sp. h.} = 4.78 \times 6.93 \times 0.2374 = 7.864 = \text{heat given to air}$

Rise in temp. of water 1.086 \times 130.859 = 142.1129 = heat given to calorimeter.

Hourly dissipation of heat 149.9769

AFTER OPERATION.

First Period—

Quantity of air (V') = 33.78 at $69^{\circ}.26 - 32^{\circ} = 37.26 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{33.78}{1.076} = 31.4$. $W = V \times 0.08073 = 2.53$
 Rise in temp. of air $5.94 = t$. $Q = W \times t \times \text{sp. h.} = 2.53 \times 5.94 \times 0.2374 = 3.5677 = \text{heat given to air.}$
 Rise in temp. of water $1.242 \times 130.859 = 162.5268 = \text{heat given to calorimeter.}$
 $3.5677 = \text{heat given to air.}$

Heat dissipated in one hour 166.0945

Second Period—

Quantity of air (V') = 38.3 at $68^{\circ}.8 - 32^{\circ} = 36.8 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{38.3}{1.075} = 35.6$. $W = V \times 0.08073 = 2.87$
 Rise in temp. of air $4.2 = t$. $Q = W \times t \times \text{sp. h.} = 2.87 \times 4.2 \times 0.2374 = 2.8682 = \text{heat given to air.}$
 Rise in temp. of water $0.864 \times 130.859 = 113.0622 = \text{heat given to calorimeter.}$
 $2.8682 = \text{heat given to air.}$

Hourly dissipation of heat 115.9304

SUMMARY.

Hourly dissipation of heat before operation	149.9769
Hourly dissipation of heat after operation: First period	166.0945
Second period	115.9304
<i>Gain in hourly dissipation of heat during first period after operation</i>	16.1176
<i>Loss in hourly dissipation of heat during second period after operation</i>	34.0465

Heat Production.

BEFORE OPERATION.

Fall of animal temperature in $1\frac{1}{2}$ hours $0^{\circ}.4$, in 1 hour $0.267 = t$.
 $Q = W \times t \times \text{sp. h.} = 18.25 \times 0.267 \times 0.75 = 3.6555 = \text{heat taken from reserve.}$
 $149.9769 = \text{heat dissipated in one hour.}$
 $3.6555 = \text{heat taken from reserve.}$

Hourly production of heat 146.3214

AFTER OPERATION.

First Period—

Fall of animal temperature in $1\frac{1}{2}$ hours $0^{\circ}.5$, in 1 hour $0.334 = t$.
 $Q = W \times t \times \text{sp. h.} = 18.25 \times 0.334 \times 0.75 = 4.5716 = \text{heat taken from reserve.}$
 $166.0945 = \text{hourly dissipation of heat.}$
 $4.5716 = \text{heat taken from reserve.}$

Hourly production of heat 161.5229

Second Period—

Rise of animal temperature in $1\frac{1}{4}$ hours $0^{\circ}.3$, in 1 hour $0.24 = t$.
 $Q = W \times t \times \text{sp. h.} = 18.25 \times 0.24 \times 0.75 = 3.275 = \text{heat added to reserve.}$
 $115.9304 = \text{hourly dissipation of heat.}$
 $3.275 = \text{heat added to reserve.}$

Hourly production of heat 119.2054

SUMMARY.

Hourly production of heat before operation	146.3214
Hourly production of heat after operation: First period	161.5229
Second period	119.2054
<i>Gain in heat production during first period after operation</i>	15.2015
<i>Loss of heat production during second period after operation</i>	27.116

EXPERIMENT 80.

A dog. Weight 10.5 pounds.

April 5. 11:20 A. M.—Rectal temperature $104^{\circ}.2$.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:55 A. M.	64 ^o .22	71 ^o .12	71 ^o .24	542.72
12:10 P. M.	67.55	72.5		
12:25	67.64	72.5		
12:40	67.04	72.41		
12:55	67.55	72.68	71.69	672
	66.8	72.24	0.45	129.28
	(mean)	66.8	(gain)	
		5.44		
		(gain)		

1:10 P. M.—Rectal temperature $104^{\circ}.9$. 1:20 P. M.—Brain operated on during other process.

1:30 P. M.—Rectal temperature $102^{\circ}.25$.

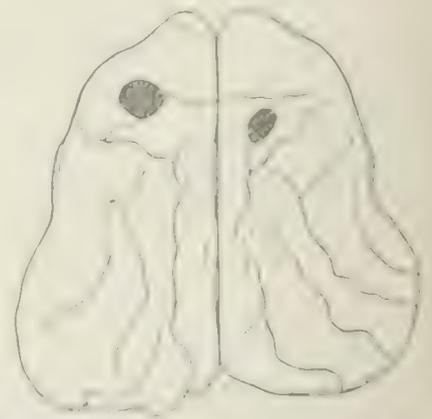
TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:48 P. M.	68.81	69 ^o .44	67 ^o .55	712
2:3	67.55	68.72		
2:18	67.16	68.72		
2:33	67.64	69.8		
2:48	68	69.44	68.48	809.22
	67.83	69.22	0.93	97.22
	(mean)	67.83	(gain)	
		1.39		
		(gain)		

3 P. M.—Rectal temperature $103^{\circ}.25$.

April 8.—Symptoms of loss of tactile sense, decided in all four extremities, but most marked anteriorly. Dog killed.

Autopsy.—Brain with very many secondary convolutions obscuring primary. Two large wounds: left side, situated upon the sulcus cruciatus, involving first and second convolutions, extending through the gray matter. Right side; wound involving the first convolution about one-fourth of an inch posterior to the sulcus, and extending two-thirds through the gray matter.

Fig. 4.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 129.28 at $72^{\circ}.24 - 32^{\circ} = 40.24 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{129.28}{1.082} = 119.5$ $W = V \times 0.08073 = 9.61$

Rise in temp. of air $5.44 = t$. $Q = W \times t \times \text{sp. h.} = 9.61 \times 5.44 \times 0.2374 = 12.4109$ heat given to air.

Rise in temp. of water $0.45 \times 130.859 = 58.8865 = \text{heat given to calorimeter.}$

$12.4109 = \text{heat given to air.}$

Hourly dissipation of heat 71.2974

AFTER OPERATION.

Quantity of air (V') = 97.22 at $69^{\circ}.22 - 32^{\circ} = 37.22 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{97.22}{1.076} = 90.3$. $Q = V \times 0.08073 = 7.3$

Rise in temp. of air $1.39 = t$. $Q = W \times t \times \text{sp. h.} = 7.3 \times 1.39 \times 0.2374 = 2.4089 = \text{heat given to air.}$

Rise in temp. of water $0.93 \times 130.859 = 121.6989 = \text{heat given to calorimeter.}$

$2.4089 = \text{heat given to air.}$

Hourly dissipation of heat $\underline{124.1078}$

SUMMARY.

Hourly dissipation of heat before operation 71.2974

Hourly dissipation of heat after operation $\underline{124.1078}$

Hourly gain of dissipation of heat following operation $\underline{52.8104}$

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in $1\frac{1}{2}$ hours $0^{\circ}.7$, in 1 hour $0.382 = t$.

$Q = W \times t \times \text{sp. h.} = 10.5 \times 0.382 \times 0.75 = 3.0082 = \text{heat added to reserve.}$

$3.0082 = \text{heat added to reserve.}$

$71.2974 = \text{heat dissipated hourly.}$

Hourly heat production $\underline{74.3056}$

AFTER OPERATION.

Rise of bodily temperature in $1\frac{1}{2}$ hours 1° , in 1 hour $0.666 = t$.

$Q = W \times t \times \text{sp. h.} = 10.5 \times 0.666 \times 0.75 = 5.25 = \text{heat added to reserve.}$

$5.25 = \text{heat added to reserve.}$

$124.1078 = \text{heat dissipated hourly.}$

Hourly heat production $\underline{129.3578}$

SUMMARY.

Hourly heat production after operation 129.3578

Hourly heat production before operation $\underline{74.3056}$

Hourly increase of heat production following operation $\underline{55.0522}$

EXPERIMENT 81.

A cur. Weight 16 lbs.

March 26. 12:35 P. M.—Rectal temperature $103^{\circ}.9$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:42 P. M.	67 ^o .04	72 ^o .68	70 ^o .25	806.1
1:2	66.38	72.68		
1:17	66.29	71.24		
1:32	68.24	71.06		
1:47	69.44	71.72		
2:2	69.32	71.72		
2:12	70.12	71.96	70.989	1001.84
	68.12	71.87	0.739	195.74
	(mean)	68.12	(gain)	
		3.75		
		(gain)		

2:20 P. M.—Rectal temperature $103^{\circ}.9$. 2:45 P. M.—Brain operated on with a cataract needle through trephine openings in the skull.

3 P. M.—Rectal temperature 104°.5.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:23 P. M.	71.96	73.35	71°	1058.6
3:38	71.15	73.35		
3:53	71.03	73.04		
4:20	70.52	73.04		
4:35	69.88	73.45		
4:53	70.88	73.55	71.97	1218.74
	70.9 (mean)	73.3 70.9	0.97 (gain)	160.14
		2.4 (gain)		

5 P. M.—Rectal temperature 104°.5. 5:30 P. M.—Dog fed.

March 27. 11:45 A. M.—Rectal temperature 104°.9.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:7 P. M.	71° 73	73° 88	72° 05	286.61
12:20	70.97	73.66		
12:35	70.88	73.14		
12:50	70.43	73.04		
1:7	70.64	73.04		
1:22	70.16	72.86		
1:37	71.24	73.55	73.058	408.79
	70.86 (mean)	73.31 70.86	1.008 (gain)	122.18
		2.45 (gain)		

1:45 P. M.—Rectal temperature 105°.4. Dog at times has a sprawling gait, but the tactile sense is not distinct. 5:30 P. M.—Dog fed.

March 28. 12:40 P. M.—Rectal temperature 105°.5.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:45 P. M.	60° 2	65° 39	64° 31	434.35
1	61.7	66.08		
1:15	64.22	67.13		
1:30	65	67.43		
1:45	63.68	66.8		
2	67.64	68.27		
2:15	70.16	68.72	65.408	587.04
	64.66 (mean)	67.12 64.66	1.098 (gain)	152.69
		2.46 (gain)		

2:25 P. M.—Rectal temperature 105°.5.

Dog killed March 28. *Autopsy*.—Two orifices in the skull—one directly over the median sinus, a piece of bone pushed down on the brain, but no wound of the brain. One orifice in the neighborhood of Hitzig's region of the right hemisphere. Here a deep lacerated wound of brain, situated in the second primitive convolution, about half an inch posterior to the sulcus cruciatus, and reaching almost to the corpus striatum.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 195.74 at $71^{\circ}.87 - 32^{\circ} = 39.87 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{195.74}{1.081} = 181.1$. $W = V \times 0.08073 = 14.62$
 Rise in temp. of air $3.75 = t$. $Q = W \times t \times \text{sp. h.} = 14.62 \times 3.75 \times 0.2374 = 12.9976 = \text{heat given to air.}$
 Rise in temp. of water $0.739 \times 130.859 = 96.7048 = \text{heat given to calorimeter.}$
 $12.9976 = \text{heat given to air.}$

 $109.7024 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 73.1349

AFTER OPERATION.

First Period—

Quantity of air (V') = 160.14 at $73^{\circ}.3 - 32^{\circ} = 41.3 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{160.14}{1.084} = 147.7$. $W = V \times 0.08073 = 11.9$
 Rise in temp. of air $2.4 = t$. $Q = W \times t \times \text{sp. h.} = 11.9 \times 2.4 \times 0.2374 = 6.7801 = \text{heat given to air.}$
 Rise in temp. of water $0.97 \times 130.859 = 126.9332 = \text{heat given to calorimeter.}$
 $6.7801 = \text{heat given to air.}$

 $133.7133 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 89.1422

Second Period—

Quantity of air (V') = 122.18 at $73^{\circ}.31 - 32^{\circ} = 41.31 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{122.18}{1.084} = 112.7$. $W = V \times 0.08073 = 9.1$
 Rise in temp. of air $2.45 = t$. $Q = W \times t \times \text{sp. h.} = 9.1 \times 2.45 \times 0.2374 = 5.2928 = \text{heat given to air.}$
 Rise in temp. of water $1.098 \times 130.859 = 143.6832 = \text{heat given to calorimeter.}$
 $5.2928 = \text{heat given to air.}$

 $137.1987 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 91.4658

Third Period—

Quantity of air (V') = 152.69 at $67^{\circ}.12 - 32^{\circ} = 35.12 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{152.69}{1.071} = 142.6$. $W = V \times 0.08073 = 11.5$
 Rise in temp. of air $2.46 = t$. $Q = W \times t \times \text{sp. h.} = 11.5 \times 2.46 \times 0.2374 = 6.716 = \text{heat given to air.}$
 Rise in temp. of water $1.098 \times 130.859 = 143.6832 = \text{heat given to calorimeter.}$
 $6.716 = \text{heat given to air.}$

 $150.3992 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 100.2661

SUMMARY.

Hourly dissipation of heat before operation	73.1349
Hourly dissipation of heat after operation:	
First period	89.1422
Second period	91.4658
Third period	100.2661
<i>Gain of heat dissipation following operation:</i>	
First period	16.0073
Second period	18.3309
Third period	27.1312

Heat Production.

BEFORE OPERATION.

No change of bodily temperature, hourly heat dissipation = *hourly heat production* 73.1349

AFTER OPERATION.

First Period—No change of bodily temperature.Hourly dissipation of heat = *hourly production of heat* 89.1422*Second Period*—Rise of bodily temperature in 2 hours $0^{\circ}.5$, in 1 hour $0.25 = t$. $Q = W \times t \times \text{sp. h.} = 16 \times 0.25 \times 0.75 = 3$ = heat added to reserve.

91.4658 = heat dissipated hourly.

Hourly production of heat 91.4658*Third Period*—No change of bodily temperature.Hourly dissipation of heat = *hourly production of heat* 100.2661

SUMMARY.

Hourly production of heat before operation		73.1349
Hourly production of heat after operation:	First period	89.1422
	Second period	91.4658
	Third period	100.2661
<i>Gain of hourly production of heat following operation:</i>	<i>First period</i>	16.0073
	<i>Second period</i>	18.3309
	<i>Third period</i>	27.1312

EXPERIMENT 82.

A large dog. Weight 47.8 pounds.

April 30, 12:30 P. M.—Rectal temperature $103^{\circ}.4$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:44 P. M.	63 ^o .92	70 ^o .25	68 ^o .99	256.52
12:59	64.58	71.33		
1:14	65	71.6		
1:29	64.58	71.42		
1:45	64.22	71.33		
1:59	65.12	71.33		
2:14	67.16	71.33		
2:29	67.48	71.24	70.59	335.47
	65.25	71.23	1.8	78.95
	(mean)	65.25	(gain)	
		5.98		
		(gain)		

2:45 P. M.—Rectal temperature $104^{\circ}.7$. 3:15 P. M.—Brain injured. 3:50 P. M.—Rectal temperature $102^{\circ}.9$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:17 P. M.	70 ^o .06	73 ^o .88	68 ^o .64	396.4
4:32	70.16	73.24		
4:47	70.16	73.35		
5:2	70.04	73.66		
5:17	70.34	73.66		
5:32	71.33	73.56	70.52	448.26
	70.35	73.56	1.88	51.86
	(mean)	70.35	(gain)	
		3.21		
		(gain)		

5:35 P. M.—Rectal temperature $103^{\circ}.8$.

Autopsy.—Both sides of brain symmetrically wounded, along the whole length of the corpus callosum extending a little in front of it and one-quarter of an inch posteriorly, and passing into the ventricles.

EXPERIMENT 83.

A cur dog. Weight 15.25 pounds.

11:25 P. M.—Rectal temperature 101°.2. Paw temperature 92°.8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:39 A. M.	.....	.....	65°.39	116.32
11:45	65°.75	67°.69		
12 M.	67.28	67.69		
12:15 P. M.	67.55	68		
12:30	67.76	68.18		
12:45	68.12	68.27		
1	68.12	68.27		
1:15	69.36	68.63		
1:30	69.20	68.84		
1:39	.....	.....	67.16	233.35
	67.9	68.2	1.77	117.03
	(mean)	67.9	(gain)	
		0.3		
		(gain)		

1:45 P. M.—Rectal temperature 101°.6.

1:50 P. M.—Brain operated on mechanically.

2:25 P. M.—Rectal temperature 101°.6.

Paw temperature 97°.4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:34 P. M.	.....	.....	67°.46	238
2:45	69°.71	70°.34		
3	70.77	70.43		
3:15	70.34	70.61		
3:30	70.52	70.61		
4	69.36	71.15		
4:15	70.43	70.97		
4:34	.....	.....	68.927	341
	70.19	70.69	1.467	103
	(mean)	70.19	(gain)	
		0.5		
		(gain)		

4:49 P. M.—Rectal temperature 101°.4

Autopsy.—Left wound small, but very deep, piercing the second convolution about four lines posterior to the sulcus cruciatus and extending into the ventricle. Right wound involving the third convolution only, nearly corresponding in anterior position to the other wound. (Fig. 6.)



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V) = 117.03 at 68°.2 - 32° = 36.2 = t'.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{117.03}{1.0074} = 109$. $W = V \times 0.08073 = 8.8$

Rise in temp. of air 0.3 = t. $Q = W \times t \times \text{sp. h.} = 8.8 \times 0.3 \times 0.2374 = 0.6267 = \text{heat taken from air}$

Rise in temp. of water 1.77 $\times 130.859 = 231.6204 = \text{heat given to calorimeter.}$

0.6267 = heat given to air.

232.2471 = heat dissipated in 2 hours.

Hourly dissipation of heat 116.1236

Time.	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gas. Measur. (cub. ft.)
3:46 p.	.....	.....	65° 876	102°	856
3:50	63° 8	68			
4:5	64.76	68			
4:20	64.88	68			
4:35	65.30	67.16			
4:50	65.84	67.16			
5:5	.....	.....	
5:16	.....	.....	67.1	102.2	951.8
	64.91 (mean)	67.66 64.91	1.224 (gain)	0.2	95.8
		2.65 (gain)			

June 13.

Time.	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gas. Measur. (cub. ft.)
1:10 p.	.....	.....	63° 545	102.2	963.87
1:15	67° 88	66.8			
1:30	67.76	66.8			
1:45	66.08	66.92			
2	68.24	67.13			
2:15	69.53	67.69			
2:30	69.44	67.69			
2:45	70.25	57.9			
3:10	.....	.....	65.435	102.8	1085.28
	68.45 67.28	67.28 (mean)	1.89 (gain)	0.6 (gain)	121.41
	1.17 (loss)				

There is no palsy and no loss of tactile sense.

Autopsy.—Right side of brain: large wound reaching clear through to the ventricle, involving the whole of second and third convolutions, and to some extent, the third and fourth, situated about half-way between the sulcus cruciatus and the posterior brain margin. Left side: wound almost two-thirds the way from the sulcus to the posterior margin, involving the third convolution and part of the fourth and second, reaching nearly to the ventricle. (Fig. 7.)



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 122.84 at $66^\circ - 32^\circ = 34.6 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{122.84}{1.07} = 114.8$. $W = V \times 0.08073 = 9.27$

Rise in temp. of air $2.3 = t$. $Q = W \times t \times \text{sp. h.} = 9.27 \times 2.3 \times 0.2374 = 5.0616 = \text{heat given to air}$

Rise in temp. of water $1.98 \times 130.8539 = 259.1006 = \text{heat given to calorimeter.}$

$5.0616 = \text{heat given to air.}$

$264.1622 = \text{heat dissipated in two hours.}$

Hourly dissipation of heat 132.0811

AFTER OPERATION.

1st Period—

Quantity of air (V') = 95.8 at $67^{\circ}.66 - 32^{\circ} = 35.66 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{95.8}{1.072} = 89.4. \quad W = V \times 0.08073 = 7.21$$

Rise in temp. of air $2.65 = t$. $Q = W \times t \times \text{sp. h.} = 7.21 \times 2.65 \times 0.2374 = 4.7733 = \text{heat given to air.}$

Rise in temp. of water $1.224 \times 130.8589 = 160.1713 = \text{heat given to calorimeter.}$

4.7733 = heat given to air.

164.9446 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 109.9631

2d Period—

Quantity of air (V') = 121.41 at $67^{\circ}.28 - 32^{\circ} = 35.28 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{121.41}{1.072} = 113. \quad W = V \times 0.08073 = 9.1$$

Fall in temp. of air $1.17 = t$. $Q = W \times t \times \text{sp. h.} = 9.1 \times 1.17 \times 0.2374 = 2.5276 = \text{heat taken from air.}$

Rise in temp. of water $1.89 \times 130.8589 = 247.3233 = \text{heat given to calorimeter.}$

2.5276 = heat taken from air.

244.7957 = heat dissipated in 2 hours.

Hourly dissipation of heat 122.3978

SUMMARY.

Hourly dissipation of heat before operation	132.0811
Hourly dissipation of heat after operation:	
First period	109.9631
Second period	122.3978
Loss of heat dissipation following operation:	
First period	22.118
Second period	9.6833

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 2 hours 0.6, in 1 hour 0.3 = t .

$Q = W \times t \times \text{sp. h.} = 14.5 \times 0.3 \times 0.75 = 3.2625 = \text{heat added to reserve.}$

132.0811 = hourly dissipation of heat.

3.2625 = hourly addition to heat reserve.

Hourly production of heat 135.3436

AFTER OPERATION.

1st Period—

Rise of bodily temperature in $1\frac{1}{2}$ hours 0.2, in 1 hour 0.13 = t .

$Q = W \times t \times \text{sp. h.} = 14.5 \times 0.13 \times 0.75 = 1.4137 = \text{heat added to reserve.}$

109.9631 = hourly dissipation of heat.

1.4137 = hourly addition to heat reserve.

Hourly production of heat 111.3768

2d Period—

Rise of bodily temperature in 2 hours 0.6, in 1 hour 0.3 = t .

$Q = W \times t \times \text{sp. h.} = 14.5 \times 0.3 \times 0.75 = 3.2625 = \text{heat added to reserve.}$

122.3978 = hourly dissipation of heat.

3.2625 = hourly addition to heat reserve.

Hourly production of heat 125.6603

SUMMARY.

Hourly production of heat before operation	135.3436
Hourly production of heat after operation:	
First period	111.3768
Second period	125.6603
Loss of heat production following operation:	
First period	23.9668
Second period	9.6833

EXPERIMENT 85.

A dog. Weight 14 pounds.

June 10.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:27 A. M.	62 ^o .96	68 ^o	65 ^o .192	103 ^o	840.5
11:42	62.96	67.8			
11:57	64.76	67.8			
12:12 P. M.	65.12	67.8			
12:27	65.39	68			
12:42	65.36	67.69			
12:57	65.21	68			
1:12	65.66	67.79			
1:27	65.21	68			
1:42	65.75	68.27			
1:57	.....	.....	68.216	103.6	1003.
	64.84 (mean)	67.91 64.84	3.024 (gain)	0.6 (gain)	162.5
		3.07 (gain)			

2:20 P. M.—Temperature of the hind paw 99^o. 2:30 P. M.—Both sides of brain operated on with white hot iron. 2:50 P. M.—Rectal temperature 102^o.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:2 P. M.	.....	.....	67 ^o .796	.....	1067
3:17	62 ^o .77	69.95			
3:32	64.76	70.06			
3:47	65.66	69.95			
4:2	65.75	71.24			
4:17	65.6	71.06			
4:32	65.75	70.97			
4:47	65.96	70.88			
5:2	.....	.....	69.71	102 ^o .20	1196
	65.18 (mean)	70.59 65.18	1.914 (gain)		129
		5.41 (gain)			

Fig. 8.



Jan. 11. Temperature of right hind paw 93^o.6; left paw lower than my thermometer will register; no distinct loss of tactile sense. Animal killed.

Autopsy.—Two very large wounds: one on the right side about a half inch posterior to the sulcus cruciatus, involving the second and third convolutions, barely touching the extreme outer part of first. On the left side a similar wound, so situated that its border comes to within a quarter of an inch of the extreme outer end of the sulcus cruciatus. Both wounds reaching to the ventricles.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V) = 162.5 at 67^o.91 — 32^o = 35.91 = t'.

$V + (V \times t' \times 0.002035) = V'$. $V' = \frac{162.5}{1.07} = 152$. $W = V \times 0.08073 = 12.3$

Rise in temp. of air 3.07 = t. $Q = W \times t \times \text{sp. h.} = 12.3 \times 3.07 \times 0.2374 = 8.9645 = \text{heat given to air}$

Rise in temp. of water 3.024 \times 130.859 = 395.7176 = heat given to calorimeter.

8.9645 = heat given to air.

404.6821 = heat dissipation in 2½ hours.

Hourly dissipation of heat 161.8728

AFTER OPERATION.

Quantity of air (V') = 129 at $70^{\circ}.58 - 32^{\circ} = 38.58 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{129}{1.079} = 110.3. \quad W = V \times 0.08073 = 8.9$$

Rise in temp. of air $5.41 = t$. $Q = W \times t \times \text{sp. h.} = 8.9 \times 5.41 \times 0.2374 = 11.4318 = \text{heat given to air.}$

Rise in temp. of water $1.914 \times 130.859 = 250.4641 = \text{heat given to calorimeter.}$

$$\frac{11.4318}{261.8959} = \text{heat given to air.}$$

261.8959 = heat dissipated in 2 hours.

Hourly dissipation of heat 130.9479

SUMMARY.

Hourly dissipation before operation	161.8728
Hourly dissipation after operation	130.9479
<i>Loss of heat dissipation following operation</i>	<i>30.9249</i>

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 2 hours $0^{\circ}.6$, in 1 hour $0.3 = t$.

$Q = W \times t \times \text{sp. h.} = 14 \times 0.3 \times 0.75 = 3.15 = \text{heat added to reserve.}$

$$\frac{161.8728}{3.15} = \text{hourly dissipation of heat.}$$

Hourly production of heat 165.0228

AFTER OPERATION.

No change in bodily temperature.

Hourly heat dissipation = *hourly heat production* 130.9479

SUMMARY.

Hourly production of heat before operation	165.0228
Hourly production of heat after operation	130.9479
<i>Loss in hourly heat production following operation</i>	<i>34.0749</i>

EXPERIMENT 86.

A small black and tan terrier. Weight 8.3 pounds.

June 12.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:58 P. M.	.....	.....	63 ^o .05	102 ^o .4	684
1	61 ^o	66 ^o .8			
1:15	63.04	66.8			
1:30	65.12	66.8			
1:45	65.48	66.92			
2	65.39	67.01			
2:15	65.39	67.01			
2:28	.....	.....	64.76	102.8	797
	64.22	66.89	1.71	0.4	113
	(mean)	64.22	(gain)	(gain)	
		2.67			
		(gain)			

2:45 P. M.—Brain operated on; centres mechanically destroyed.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GAS. METER. (cub. ft.)
3:28 p. m.	.....	.....	65 ^o .48	101.3	801
3:50	63 ^o .8	68 ^o .36			
4:5	64.76	68.27			
4:20	64.88	68.18			
4:35	65.3	68.18			
4:50	65.84	68.9			
5:8	.....	.....	67.568	101.5	930
	64.92 (mean)	68.38 64.92	2.088 (gain)	0.2 (gain)	129
		3.46 (gain)			

June 13.—Tactile sense completely abolished in all the paws.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GAS. METER. (cub. ft.)
1:10 p. m.	.....	.....	63.338	101 ^o .5	541.2
1:15	66 ^o .08	68 ^o .48			
2:30	67.88	68.27			
1:45	67.76	68.6			
2	68.24	68.81			
2:15	69.53	69.35			
2:30	69.44	69.44			
2:45	70.25	70.16			
3:10	.....	.....	66.14	99.5	669.5
	68.45 (mean)	69.01 68.45	2.802 (gain)	2 (loss)	128.3
		0.56 (gain)			

Autopsy.—Right side: wound involving the sulcus cruciatus in whole of second convolution, and also involving to some extent first and third convolutions, extending down into ventricles. Left side: a similar wound situated somewhat nearer the middle line, so as to involve very largely the first convolution.

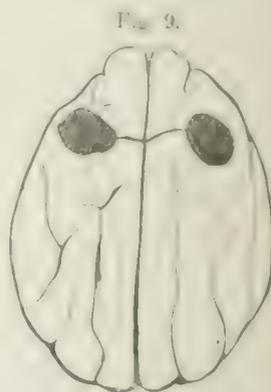


Fig. 9.

BEFORE OPERATION.

Quantity of air (V') = 113 at $66^{\circ}.89 - 32^{\circ} = 34.89 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{113}{1.071} = 105.5$. $W = V \times 0.08073 = 8.52$

Rise in temp. of air $2.67 = t$. $Q = W \times t \times \text{sp. h.} = 8.52 \times 2.67 \times 0.2374 = 5.4005 = \text{heat given to air}$

Rise in temp. of water $1.71 \times 79.5436 = 136.0195 = \text{heat given to calorimeter.}$

5.4005 = heat given to air.

141.42 = heat dissipated in 1½ hours.

Hourly dissipation of heat 94.28

AFTER OPERATION

Quantity of air (V) = 129 at $68^{\circ}.38 - 32^{\circ} = 36.38 = t'$. $V + (V \times t' \times 0.002035) = V'$.

$$V = \frac{129}{1.074} = 120. \quad W = V \times 0.08073 = 9.7$$

Rise in temp of air $3.46 = t$. $Q = W \times t \times \text{sp. h.} = 3.46 \times 0.2374 \times 0.75 = 0.6161 = \text{heat given to air.}$

Rise in temp. of water $2.088 \times 79.5436 = 166.087 = \text{heat given to calorimeter.}$

0.6161 = heat given to air.

166.7031 = heat dissipated in $1\frac{1}{2}$ hours.

Hourly dissipation of heat 111.1354

Second Period—

Quantity of air (V') = 128.3 at $69^{\circ}.01 - 32^{\circ} = 37.01 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{128.3}{1.075} = 119.3. \quad W = V \times 0.08073 = 9.63$$

Rise in temp. of air $0.56 = t$. $Q = W \times t \times \text{sp. h.} = 9.63 \times 0.56 \times 0.2374 = 1.2802 = \text{heat given to air.}$

Rise in temp. of water $2.802 \times 79.5436 = 222.8812 = \text{heat given to calorimeter.}$

1.2802 = heat given to air.

224.1614 = heat dissipated in 2 hours.

Hourly dissipation of heat 112.0807

SUMMARY.

Hourly heat dissipation before operation	94.28
Hourly heat dissipation after operation : First period	111.1354
Second period	112.0807

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in $1\frac{1}{2}$ hours $0^{\circ}.4$, in 1 hour $0.2666 = t$.

$Q = W \times t \times \text{sp. h.} = 8.3 \times 0.2666 \times 0.75 = 1.66 = \text{heat added hourly to reserve.}$

94.28 = hourly dissipation of heat.

1.66 = hourly addition to reserve.

Hourly heat production 95.94

AFTER OPERATION.

First Period—

Rise of bodily temperature in $1\frac{1}{2}$ hours $0^{\circ}.2$, in 1 hour $0.1333 = t$.

$Q = W \times t \times \text{sp. h.} = 8.3 \times 0.1333 \times 0.75 = 0.83 = \text{heat added hourly to reserve.}$

111.1354 = hourly dissipation of heat.

0.83 = hourly addition to reserve.

Hourly heat production 111.9654

Second period—

Fall of bodily temperature in 2 hours 2° , in 1 hour $1 = t$.

$Q = W \times t \times \text{sp. h.} = 8.3 \times 1 \times 0.75 = 6.225 = \text{heat lost from reserve.}$

112.0807 = heat dissipated hourly.

6.225 = heat hourly lost from reserve.

Hourly heat production 105.8557

SUMMARY.

Hourly heat production before operation	95.94
Hourly heat production after operation : First period	111.9654
Second period	105.8557
Gain in heat production following operation : First period	16.0254
Second period	9.9157

EXPERIMENT 87.

A cur. Weight 11.5 pounds.

Time.	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
11:10 a. m.	.....	.....	65°.21	103°	123.5
11:25	67° .37	68° .6			
11:45	65.75	68.99			
12 m.	67.28	68.99			
12:15 p. m.	67.55	69.08			
12:30	67.76	69.26			
12:40	.....	.....	67.478	102.4	263
	67.14	68.98	2.268	0.6	139.5
	(mean)	67.14	(gain)	(loss)	
		1.84			
		(gain)			

1 P. M.—Brain operated on; mechanical destruction of cortex.

Time.	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
2:18 p. m.	.....	.....	67 .664	101 .8	315.4
2:35	69° .62	70 .79			
2:45	69.71	71.48			
3	70.07	71.6			
3:15	70.34	71.87			
3:30	70.52	71.87			
3:48	.....	.....	69.665	104	460.2
	70.05	71.52	2.004	2.2	144.8
	(mean)	70.05	(gain)	(gain)	
		1.47			
		(gain)			

Autopsy.—Right wound of brain small, penetrating through the gray matter, involving only the third convolution near the posterior part of the middle third. Left wound large, involving both the second and third convolutions situated correspondingly to the other brain wound. (Fig. 10.)

Fig. 10.

*Heat Dissipation.*

BEFORE OPERATION.

Quantity of air (V) = 139.5 at 68° .98 — 32° = 36.98 = t' . $V + (V \times t' \times 0.002035) = V'$. $V = \frac{139.5}{1.075} = 130$. $W = V \times 0.08073 = 10.5$ Rise in temp. of air 1.84 = t . $Q = W \times t \times \text{sp. h.} = 10.5 \times 1.84 \times 0.2374 = 4.5866 = \text{heat given to air}$ Rise in temp. of water 2.268 \times 79.5436 = 180.4049 = heat given to calorimeter.

4.5866 = heat given to air.

184.9915 = heat dissipated in 1½ hours.

Hourly dissipation of heat 123.3277

Time.	Air Temp. (Fah.)	True Temp. (Fah.)	Box Temp. (Fah.)	Rect. Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:40 P. M.	.....	.....	71 ^o .6	101 ^o .1	560
4	74.3	76.01			
4:15	74.39	76.28			
4:30	75.11	76.37			
4:45	75.32	76.64			
5	75.44	76.82			
5:15	75.44	76.82			
5:30	75.44	76.82			
5:46	.....	.....	74.12	102.8	674
	75.06 (mean)	76.54 75.06	2.52 (gain)	1.7 (gain)	114
		1.48 (gain)			

Autopsy.—Wound of left cerebrum very large and very deep, involving first, second, and third convolutions, in the region of the sulcus cruciatus. Wound of right cerebrum small, extending through the gray matter and involving the third and fourth convolutions situated antero-posteriorly near the centre of the brain.

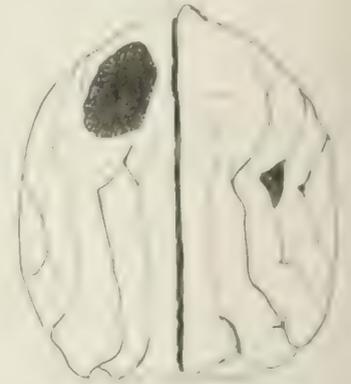


Fig. 11.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 116.6 at $74^{\circ}.04 - 32^{\circ} = 42.04 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{116.6}{1.085} = 107.5$. $W = V \times 0.08073 = 8.68$

Fall in temp. of air $0.65 = t$. $Q = W \times t \times \text{sp. h.} = 8.68 \times 0.65 \times 0.2374 = 1.3394 = \text{heat taken from air.}$

Rise in temp. of water $2.655 \times 130.8589 = 347.4304 = \text{heat given to calorimeter.}$

1.3394 = heat taken from air.

346.091 = heat dissipated in 2 hours.

Hourly dissipation of heat 173.0455

AFTER OPERATION.

Quantity of air (V') = 114 at $76^{\circ}.54 - 32^{\circ} = 44.54 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{114}{1.09} = 104.6$. $W = V \times 0.08073 = 8.44$

Rise in temp. of air $1.48 = t$. $Q = W \times t \times \text{sp. h.} = 8.44 \times 1.48 \times 0.2374 = 2.9654 = \text{heat given to air.}$

Rise in temp. of water $2.52 \times 130.8589 = 329.7644 = \text{heat given to calorimeter.}$

2.9654 = heat given to air.

332.7298 = heat dissipated in 2 hours.

Hourly dissipation of heat 166.3649

Heat Production.

BEFORE OPERATION.

Fall of bodily temperature in 2 hours $0^{\circ}.4$, in one hour $0.2 = t$.

$Q = W \times t \times \text{sp. h.} = 32.75 \times 0.2 \times 0.75 = 4.9125 = \text{heat taken from reserve.}$

173.0455 = hourly dissipation of heat.

4.9125 = heat taken from reserve.

Hourly production of heat 168.133

AFTER OPERATION.

Rise of bodily temperature in 2 hours $1^{\circ}.7$, in one hour $0.85 = t$.

$Q = W \times t \times \text{sp. h.} = 32.75 \times 0.85 \times 0.75 = 20.8781 = \text{heat added to reserve.}$

$166.3649 = \text{heat dissipation in an hour.}$

$20.8781 = \text{heat added to reserve.}$

Hourly production of heat 187.243

SUMMARY.

Hourly production of heat after operation 187.243

Hourly production of heat before operation 168.133

Hourly gain of heat production following operation 19.11

EXPERIMENT 89.

A cur. Weight 20 pounds.

June 20, 12:50 P. M.—Rectal temperature 103° .

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:12 P. M.	.....	.....	67 ^o .76	1021
1:20	73 ^o .19	70 ^o .64		
1:35	73.85	70.97		
1:50	74.48	71.6		
2:5	73.94	71.42		
2:20	74.6	71.72		
2:40	.....	.....	68.81	1291
	74.01	71.27	1.05	270
	71.27	(mean)	(gain)	
	2.74			
	(loss)			

2:50 P. M.—Rectal temperature 103° .

3 P. M.—Brain operated on mechanically; violent hemorrhage, stopped by plugging the orifice.

3:40 P. M.—Rectal temperature 102° .

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:45 P. M.	.....	.....	69 ^o .416	266
4	73 ^o .94	70 ^o .06		
4:15	76.37	72.59		
4:30	76.16	72.77		
4:45	76.04	72.42		
5	75.44	72.5		
5:15	.....	.....	70.268	438
	75.59	72.07	0.852	172
	72.07	(mean)	(gain)	
	3.52			
	(loss)			

5:25 P. M.—Rectal temperature $102^{\circ}.4$.

Autopsy, June 21.—Very large hernia cerebri. On opening the skull: the left hemisphere with its surface destroyed over the anterior third, everywhere through the gray matter, and much of the space throughout almost the whole depth. Right hemisphere; a large deep wound extending anteriorly nearly to the extreme outer part of the sulcus cruciatus, involving the second and third convolutions. Base of the brain and all the furrows of the upper surface filled with dense hard blood clots.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V) = 270 at $71^{\circ}.27 - 32^{\circ} = 39.27 = t$. $V + (V \times t \times 0.002035) = V'$. $V = \frac{270}{1.08} = 250$. $W = V \times 0.08073 = 20.2$ Fall in temp. of air $2.74 = t$. $Q = W \times t \times \text{sp. h.} = 20.2 \times 2.74 \times 0.2374 = 13.14 = \text{heat taken from air}$ Rise in temp. of water $1.05 \times 130.8589 = 137.4018 = \text{heat given to calorimeter.}$

13.14 = heat taken from air.

124.2618 = heat dissipated in $1\frac{1}{2}$ hours.*Hourly dissipation of heat* 82.8412

AFTER OPERATION.

Quantity of air (V) = 172 at $72^{\circ}.07 - 32^{\circ} = 40.07 = t$. $V + (V \times t \times 0.002035) = V'$. $V = \frac{172}{1.082} = 159$. $W = V \times 0.08073 = 12.84$.Fall in temp. of air $3.52 = t$. $Q = W \times t \times \text{sp. h.} = 12.84 \times 3.52 \times 0.2374 = 10.7345 = \text{heat taken from air}$ Rise in temp. of water $0.852 \times 130.8589 = 111.4918 = \text{heat given to calorimeter.}$

10.7345 = heat taken from air.

100.7573 = heat dissipated in $1\frac{1}{2}$ hours.*Hourly dissipation of heat* 67.1716

SUMMARY.

Hourly dissipation of heat before operation 82.8412

Hourly dissipation of heat after operation 67.1716

Hourly loss of heat dissipation following operation 15.6696*Heat Production.*

BEFORE OPERATION.

No change of bodily temperature, hourly dissipation = *hourly production of heat* 82.8412.

AFTER OPERATION.

Rise of bodily temperature in $1\frac{1}{2}$ hours $0^{\circ}.4$, in 1 hour $0.2667 = t$. $Q = W \times t \times \text{sp. h.} = 20 \times 0.2667 \times 0.75 = 4 = \text{heat added to reserve.}$

67.1716 = hourly dissipation of heat.

4 = hourly addition to heat reserve

Hourly production of heat 71.1716

SUMMARY.

Hourly production of heat before operation 82.8412

Hourly production of heat after operation 71.1716

Hourly loss of heat production following operation 11.6696

EXPERIMENT 90.

A dog. Weight 10 pounds.

11:25 A. M.—Rectal temperature $102^{\circ}.2$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:32 A. M.	.....	.....	66°.902	708
11:40	70°.88	71.		
11:55	71.51	71.96		
12:10 P. M.	71.87	72.41		
	.....	.....	68.342	804
	71.42	72.11	1.44	96
	(mean)	71.42	(gain)	
		0.69		

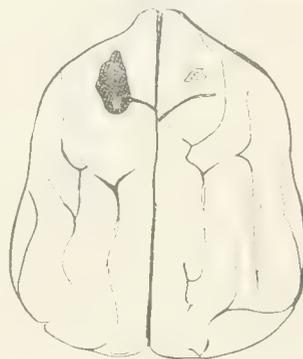
12:40 P. M.—Rectal temperature 102°.10. 12:50 P. M.—Brain operated on.
 2:46 P. M.—Rectal temperature 102°.4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:56 P. M.	.....	.....	69°.44	810.2
3:3	74°.72	74°.84		
3:18	75.2	75.2		
3:28	75.02	75.08		
3:45	74.84	75.47		
3:50	.....	.....	71.161	918
	74.94	75.15	1.721	97.8
	(mean)	74.94	(gain)	
		0.21		
		(gain)		

4 P. M.—Rectal temperature 102°.

Autopsy.—Large wound involving the second and third convolutions in the neighborhood of the sulcus cruciatus. Least possible scratch on the anterior left hemisphere, some distance in front of sulcus cruciatus.

Fig. 12.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 96 at 72°.11 — 32° = 40.11 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{96}{1.08} = 89. \quad W = V \times 0.08073 = 7.18$$

Rise in temp. of air 0.69 = t. $Q = W \times t \times \text{sp. h.} = 7.18 \times 0.69 \times 0.2374 = 1.1761 = \text{heat given to air.}$

Rise in temp. of water $1.44 \times 79.5436 = 114.5434 = \text{heat given to calorimeter.}$

1.1761 = heat given to air.

Hourly dissipation of heat 115.7195

AFTER OPERATION.

Quantity of air (V') = 97.8 at 75°.15 — 32° = 43.15 = t'.

$$V + (V \times t \times 0.002035) = V'. \quad V = \frac{97.8}{1.087} = 90. \quad W = V \times 0.08073 = 7.26.$$

Rise in temp. of air 0.21 = t. $Q = W \times t \times \text{sp. h.} = 7.26 \times 0.21 \times 0.2374 = 0.3619 = \text{heat given to air.}$

Rise in temp. of water $1.721 \times 79.5436 = 136.8952 = \text{heat given to calorimeter.}$

0.3619 = heat given to air.

Hourly dissipation of heat 137.2571

SUMMARY.

Hourly dissipation of heat before operation 115.7195

Hourly dissipation of heat after operation 137.2571

Hourly loss of heat dissipation following operation 21.5376

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in an hour 0.1 = t.

$Q = W \times t \times \text{sp. h.} = 10 \times 0.1 \times 0.75 = 0.75 = \text{heat added to reserve.}$

115.7195 = heat dissipation in an hour.

Hourly production of heat 116.4695

AFTER OPERATION.

Fall of bodily temperature in 1½ hours 0.4, in 1 hour 0.32 = t.

$Q = W \times t \times \text{sp. h.} = 10 \times 0.32 \times 0.75 = 2.4 = \text{heat taken from reserve.}$

137.2571 = heat dissipated hourly.

Heat produced hourly 134.8571

SUMMARY.

Hourly production of heat before operation 116.4695

Hourly production of heat after operation 134.8571

Hourly increase of heat production following operation 18.3876

EXPERIMENT 91.

A bitch. Weight 20.75 pounds.

June 26. 11:20 A. M.—Rectal temperature 102° 5.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER.
11:30 A. M.	.....	.....	72.37	102° 5	106
11:50	75° 92	74° 3			
12:5 P. M.	75.65	74.84			
12:20	75.74	74.75			
12:30	.....	.....	73.04	.....	242
	75.77	74.63	0.67		106
	74.63	(mean)	(gain)		
	1.14				
	(loss)				

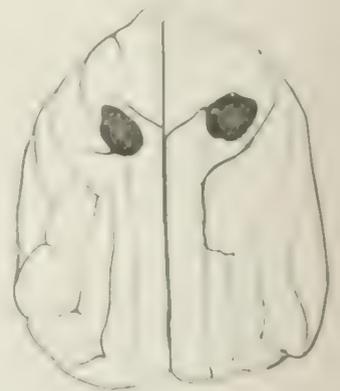
12:40 P. M.—Rectal temperature 102° 5. 12:50 P. M.—Brain exposed. 3:10 P. M.—Dressing of Hitzig's region with hot iron, both sides.

3:25 P. M.—Rectal temperature 101° 4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER.
3:37 P. M.	.....	.....	74.12	.....	438
3:52	79° 76	77.36			
4:7	80.12	77.45			
4:22	79.76	77.54			
4:37	79.76	77.54	75.12	.....	504.2
	79.85	77.47	1		95.2
	77.47	(mean)	(gain)		
	2.38				
	(loss)				

4:45 P. M.—Rectal temperature 102° 6.

FIG. 13.



Autopsy.—Extensive wound of the first convolution on each side of the brain just posterior to the sulcus cruciatus. (Fig. 13.)

1:15 p. m.—Rectal temperature 102°.4.

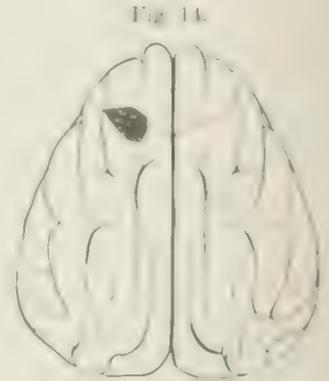
1:20 p. m.—Brain exposed. 2 p. m.—Brain wounded mechanically on one side.

2:5 p. m.—Rectal temperature 101°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:13 p. m.	.....	.....	73°.10	1035
2:30	77°.63	79°.07		
2:45	78.44	79.07		
3:30	79.43	80		
3:43	.....	.....	74.93	1150
	78.5	79.38	1.83	115
	(mean)	78.5	(gain)	
		0.88		
		(gain)		

2:50 p. m.—Rectal temperature 102°.6.

Autopsy.—Only one side of the brain injured. Wound passing through the gray matter, involving the first and second convolutions anterior and posterior to the sulcus cruciatus.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V) = 119 at 76°.87 — 32° = 44.87 = t'.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{119}{1.09} = 109$. $W = V \times 0.08073 = 8.8$

Rise in temp. of air 0.66 = t. $Q = W \times t \times \text{sp. h.} = 0.66 \times 8.8 \times 0.2374 = 1.3788 = \text{heat given to air.}$

Rise in temp. of water 1.624 \times 79.5436 = 129.1794 = heat given to calorimeter.

1.3788 = heat given to air.

130.5582 = heat dissipated in 1½ hours

Hourly dissipation of heat 87.0388

AFTER OPERATION.

Quantity of air (V) = 115 at 79°.38 — 32° = 47.38 = t'.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{115}{1.096} = 105$. $W = V \times 0.08073 = 8.5$

Rise in temp. of air 0.88 = t. $Q = W \times t \times \text{sp. h.} = 8.5 \times 0.88 \times 0.2374 = 1.7757 = \text{heat given to air.}$

Rise in temp. of water 1.83 \times 79.5436 = 145.5655 = heat given to calorimeter.

1.7757 = heat given to air.

147.3412 = heat dissipated in 1½ hours.

Hourly dissipation of heat 98.2275

SUMMARY.

Hourly dissipation of heat before operation 87.0388

Hourly dissipation of heat after operation 98.2275

Hourly gain of heat dissipation following operation 11.1887

Heat Production.

BEFORE OPERATION.

Fall of bodily temperature in $1\frac{3}{4}$ hours $1^{\circ}.1$, in 1 hour $0.6286 = t$.

$$Q = W \times t \times \text{sp. h.} = 11.2 \times 0.6286 \times 0.75 = 5.2802 = \text{hourly loss from heat reserve.}$$

$$87.0388 = \text{hourly dissipation of heat.}$$

$$5.2802 = \text{loss from heat reserve.}$$

$$\text{Hourly production of heat } 81.7586$$

AFTER OPERATION.

Rise of bodily temperature in $1\frac{3}{4}$ hours $1^{\circ}.4$, in 1 hour $0.8 = t$.

$$Q = W \times t \times \text{sp. h.} = 11.2 \times 0.8 \times 0.75 = 6.72 = \text{heat added to reserve.}$$

$$6.72 = \text{hourly addition to heat reserve.}$$

$$98.2275 = \text{hourly heat dissipation.}$$

$$\text{Hourly production of heat } 104.9475$$

SUMMARY.

Hourly production of heat before operation	81.7586
Hourly production of heat after operation	104.9475
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Hourly gain of heat production following operation	23.1889

EXPERIMENT 93.

A dog. Weight 15 pounds.

12 M.—Rectal temperature 105° .

TIME.	AIR TEMP. (Fah.)	TUBE TEMP (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:12 P. M.	64 ^o .67	64 ^o .94	60 ^o .03	692
12:27	64.76	65.30		
12:42	67.16	67.28		
12:57	65.48	66.68		
1:12	64.76	66.68		
1:27	65.6	67.01		
1:42	65.3	67.37		
1:57	64.67	67.55		
2:12	64.22	68.09		
2:27	64.13	68.36		
2:42	64.13	68.36		
2:57	63.80	68		
3:12	66.08	68.60	65.03	835.5
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	64.98	67.25	5	143.5
	(mean)	64.98	(gain)	(gain)
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		2.27		
		(gain)		

3:20 P. M.—Rectal temperature 105° . 3:30 P. M.—Operated on.

4:4 P. M.—Rectal temperature $102^{\circ}.8$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:20 P. M.	65 ^o .72	66 ^o .29	63 ^o .25	883
4:35	65.94	66.56		
4:50	64.58	66.68		
5:5	65.39	67.19		
5:20	66.08	67.46		
5:35	67.76	67.64		
5:50	68.81	68.09	65.30	952
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	66.32	67.13	2.05	69
	(mean)	66.32	(gain)	
		<hr style="width: 20%; margin-left: auto; margin-right: auto;"/>		
		0.81		
		(gain)		

6:4 P. M.—Rectal temperature $103^{\circ}.8$. Dog killed.

Autopsy.—Wound of the left hemisphere: immediately in front of the sulcus cruciatus, not wounding the gray matter of the first convolution posterior to the sulcus at all, or the white matter below it, just scraping the front of the sulcus. Right hemisphere: the gray matter at the distal end of the sulcus, and beyond it destroyed.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 143.5 at $67^{\circ}.25 - 32^{\circ} = 35.25 = t$.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{143.5}{1.072} = 133.8$. $W = V \times 0.08073 = 10.8$

Rise in temp. of air $2.27 = t$. $Q = W \times t \times \text{sp. h.} = 10.8 \times 2.27 \times 0.2374 = 5.8201 = \text{heat given to air}$

Rise in temp. of water $5 \times 130.8589 = 654.2945 = \text{heat given to calorimeter.}$

$5.8201 = \text{heat given to air.}$

$660.1146 = \text{heat dissipated in 3 hours.}$

Hourly dissipation of heat 220.0382

AFTER OPERATION.

Quantity of air (V') = 69 at $67^{\circ}.13 - 32^{\circ} = 35.13 = t$.

$V + (V \times t \times 0.002035) = V'$. $V = \frac{69}{1.071} = 64.4$. $W = V \times 0.08073 = 5.2$

Rise in temp. of air $0.81 = t$. $Q = W \times t \times \text{sp. h.} = 5.2 \times 0.81 \times 0.2374 = 0.9999 = \text{heat given to air}$

Rise in temp. of water $2.05 \times 130.8589 = 268.2607 = \text{heat given to calorimeter.}$

$0.9999 = \text{heat given to air.}$

$269.2606 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$

Hourly dissipation of heat 179.5071

SUMMARY.

Hourly dissipation of heat before operation	220.0382
Hourly dissipation of heat after operation	179.5071
<i>Hourly loss of heat dissipation following operation</i>	<u>40.5311</u>

Heat Production.

BEFORE OPERATION.

No change of temperature of body.

Hourly dissipation = *hourly production of heat* 220.0382

AFTER OPERATION.

Rise of bodily temperature in 1 hour $0.5 = t$.

$Q = W \times t \times \text{sp. h.} = 15 \times 0.5 \times 0.75 = 5.625 = \text{heat added to reserve.}$

$179.5071 = \text{hourly dissipation of heat.}$

Hourly production of heat 185.1321

SUMMARY.

Hourly production of heat before operation	220.0382
Hourly production of heat after operation	185.1321
<i>Hourly loss of heat production following operation</i>	<u>34.9061</u>

EXPERIMENT 94.

A long-haired Scotch terrier. Weight 13.5 pounds.

0:30 A. M.—Rectal temperature, 103° 7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
10:53 A. M.	69° 92	69° 56	64° 4	462.5
11:8	66.38	67.76		
11:23	65.81	67.28		
11:38	65.81	67.28		
11:53	66.56	67.28		
12:8 P. M.	66.68	67.64		
12:23	66.8	67.76		
12:38	66.92	67.37		
12:53	67.04	67.76		
1:8	67.28	68.36		
1:23	67.55	68.48	66.22	594.5
	66.89 (mean)	67.87 66.89	1.82 (gain)	132 (gain)
		0.98 (gain)		

1:30 P. M.—Rectal temperature, 103° 9 1:45 P. M.—Operation.

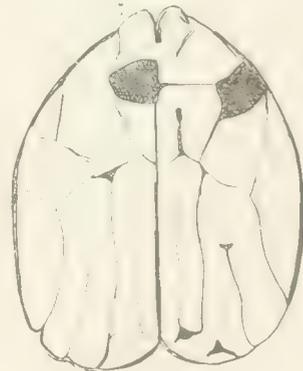
2:42 P. M.—Rectal temperature, 102° 7.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:58 P. M.	69° 98	69° 08	65° 03	540.5
3:13	70.04	68.98		
3:28	69.92	69.08		
3:43	69.62	69.2		
3:58	69.32	69.2		
4:13	69.32	69.32		
4:28	68.36	69.32		
4:43	70.28	69.89		
4:58	71.78	69.89		
5:13	73.13	70.43		
5:28	73.22	71.87	67.09	661
	70.45 69.66	69.66 (mean)	2.06 (gain)	120.5 (gain)
		0.79 (loss)		

5:42 P. M.—Rectal temperature 102° 9.

Autopsy.—Brain: Left side, first convolution destroyed at the sulcus cruciatus. Right side, second convolution destroyed in similar situation; first convolution slightly wounded.

Fig. 16.



Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 132 at $67^{\circ}.87 - 32^{\circ} = 35.87 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{132}{1.073} = 123$. $W = V \times 0.08073 = 9.93$.

Rise in temp. of air $0.98 = t$. $Q = W \times t \times \text{sp. h.} = 9.93 \times 0.98 \times 0.2374 = 2.3102 = \text{heat given to air.}$

Rise in temp. of water $1.82 \times 130.858 = 238.1616 = \text{heat given to calorimeter.}$

2.3102 = heat given to air.

240.4718 = heat dissipated in $2\frac{1}{2}$ hours.

Hourly dissipation of heat 96.1487

AFTER OPERATION.

Quantity of air (V') = 120.5 at $69^{\circ}.66 - 32^{\circ} = 37.66 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{120.5}{1.077} = 112$. $W = V \times 0.08073 = 9.04$

Fall in temp. of air $0.79 = t$. $Q = W \times t \times 0.2374 = 1.6954 = \text{heat taken from reserve.}$

Rise in temp. of water $2.06 \times 130.858 = 269.5675 = \text{heat given to calorimeter.}$

1.6954 = heat taken from air.

267.8721 = heat dissipated in $2\frac{1}{2}$ hours.

Hourly dissipation of heat 107.1488

SUMMARY.

Hourly dissipation of heat after operation 107.1488

Hourly dissipation of heat before operation 96.1487

Gain in hourly heat dissipation following operation 11.0001

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 3 hours $0^{\circ}.2$, in 1 hour $0.066 = t$.

$Q = W \times t \times \text{sp. h.} = 13.5 \times 0.066 \times 0.75 = 0.668 = \text{heat added hourly to reserve.}$

96.1487 = hourly dissipation of heat.

0.668 = heat added to reserve hourly.

Hourly heat production 96.8167

AFTER OPERATION.

Rise of bodily temperature in 3 hours $0^{\circ}.2$, in 1 hour $0.066 = t$.

$Q = W \times t \times \text{sp. h.} = 13.5 \times 0.066 \times 0.75 = 0.668 = \text{heat added to reserve.}$

0.668 = hourly addition of heat to reserve.

107.1488 = hourly dissipation of heat.

Hourly production of heat 107.8168

SUMMARY.

Hourly heat production after operation 107.8168

Hourly heat production before operation 96.8167

Hourly gain of heat production after operation 11.0001

EXPERIMENT 95.

A terrier. Weight 14 pounds.

November 25, 1:45 P. M.—Rectal temperature 103° .4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
1:59 P. M.	68° .36	69° .32	59° .9	319.25	
2:14	64.04	66.68			
2:29	64.31	65.21			
2:44	66.47	66.47			
2:59	65	66.08			
3:14	64.58	65.6			
3:29	64.13	65.48			
3:44	65.39	66.08			
3:59	66.47	66.38			
4:14	65.96	66.56	.....	.....	Dog quiet throughout experiment.
4:29	65.72	67.1			
4:44	64.88	68.18			
4:59	65.72	67.55	63.41	438.5	
	65.46 (mean)	66.67 65.46	3.51 (gain)	119.25	
		1.21 (gain)			

5:15 P. M.—Rectal temperature 104° .1.

5:45 P. M.—Dog operated on. 6:10 P. M.—Rectal temperature 104° .93.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
6:13 P. M.	62° .6	65° .96	60° .35	463.75	Dog quiet.
6:28	63.32	66.8	.....	.....	Dog quiet.
6:43	64.31	66.92	.....	.....	Dog whining.
6:58	65.72	67.28	.....	.....	Dog quiet.
7:13	65.39	67.64	.....	.....	Dog restless.
7:28	65.6	68.27	.....	.....	Dog quiet.
7:43	64.4	67.55	.....	.....	Dog quiet.
8:5	66.47	68.09	.....	.....	Dog quiet.
8:13	.....	.....	63.7	568.2	Dog quiet.
	64.73 (mean)	67.31 64.73	3.35 (gain)	104.45	
		2.58 (gain)			

8:25 P. M.—Rectal temperature 102° .8.

9 P. M.—Rectal temperature 102° .8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
9:13 P. M.	68° .9	67° .01	61° .72	614	Dog quiet.
9:35	58.7	64.52	.....	.....	Dog quiet.
9:53	64.76	65.21	.....	.....	Dog quiet.
10:13	65.48	66.08	.....	.....	Dog howling.
10:35	64.40	66.08	.....	.....	Dog howling.
10:55	64.67	66.29	.....	.....	Dog quiet.
11:15	62.1	66.29	.....	.....	Dog quiet.
11:35	61.9	65.21	.....	.....	Dog quiet.
12:13	.....	.....	64.13	897.65	Dog quiet.
	63.86 (mean)	65.83 63.86	2.41 (gain)	283.65	
		1.97 (gain)			

November 26, 12:30 A. M.—Rectal temperature 102° .5.

1:30 A. M.—Rectal temperature 102° .8.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
2:18 A. M.	69.58	68.09	64.13	229	
2:45	70.64	69.56			
3:5	69.3	65.6			
3:25	69.2	68.48			
3:38	69.86	68.98			
4	67.04	67.88			
4:18	.....	.....	
	67.81	68.1	1.14	1.28	
	(mean)	67.81			
		0.29			
		(gain)			

4:30 A. M.—Rectal temperature 102°.5.

6:43 A. M.—Rectal temperature 103°.3.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)	REMARKS.
7:3 A. M.	68.36	67°.46	64°.22	227	
7:18	67.64	67.76			
7:33	66.47	68.09			
7:48	67.16	68.18			
8:3	67.28	68.27			
8:18	66.92	68.18			
8:33	66.8	68.27			
8:48	66.68	68.18			
9:3	67.76	68.27	65.39	223	
	67.23	68.07	1.17	96	
	(mean)	67.23	(gain)		
		0.84			
		(gain)			

9:13 A. M.—Rectal temperature 102°.9.

Heat Dissipation.

BEFORE OPERATION.

Quantity of air (V') = 119.25 at 66°.67 - 32° = 34.67 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{119.25}{1.07} = 111.45, \quad W = V \times 0.08073 = 9$$

Rise in temp. of air 1.21 = t. Q = W × t × sp. h. = 9 × 1.21 × 0.2374 = 2.5853 = heat given to air.

Rise in temp. of water 3.51 × 130.8589 = 459.3147 = heat given to calorimeter.

$$2.5853 = \text{heat given to air.}$$

$$461.9 = \text{heat dissipated in 3 hours.}$$

$$\text{Hourly dissipation of heat } 153.63$$

AFTER OPERATION.

First Period—

Quantity of air (V') = 104.45 at 67°.31 - 32° = 35.31 = t'.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{104.45}{1.072} = 97.44, \quad W = V \times 0.08073 = 7.866$$

Rise in temp. of air 2.58 = t. Q = W × t × sp. h. = 7.866 × 2.58 × 0.2374 = 4.8179 = heat given to air.

Rise in temp. of water 3.35 × 130.8589 = 438.3773 = heat given to calorimeter.

$$4.8179 = \text{heat given to air.}$$

$$443.1952 = \text{heat dissipated in 2 hours.}$$

$$\text{Hourly dissipation of heat } 221.5976$$

Second Period—

Quantity of air (V') = 283.65 at $65^{\circ}.83 - 32^{\circ} = 33.83 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{283.65}{1.069} = 265.34. \quad W = V \times 0.08073 = 2.14$$

Rise in temp. of air $1.97 = t$. $Q = W \times t \times \text{sp. h.} = 2.14 \times 1.97 \times 0.2374 = 10.0083 = \text{heat given to air.}$

Rise in temp. of water $2.41 \times 130.8589 = 315.3726 = \text{heat given to calorimeter.}$

10.0083 = heat given to air.

325.3809 = heat dissipated in 3 hours.

Hourly dissipation of heat 108.4603

Third Period—

Quantity of air (V') = 158 at $68^{\circ}.1 - 32^{\circ} = 36.1 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{158}{1.073} = 147.2. \quad W = V \times 0.08073 = 11.9$$

Rise in temp. of air $0.29 = t$. $Q = W \times t \times \text{sp. h.} = 11.9 \times 0.29 \times 0.2374 = 0.8193 = \text{heat given to air.}$

Rise in temp. of water $1.1 \times 130.8589 = 143.9448 = \text{heat given to calorimeter.}$

0.8193 = heat given to air.

144.7641 = heat dissipated in 2 hours.

Hourly dissipation of heat 72.382

Fourth Period—

Quantity of air (V') = 96 at $68^{\circ}.07 - 32^{\circ} = 36.07 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{96}{1.073} = 89.4. \quad W = V \times 0.08073 = 7.2$$

Rise in temp. of air $0.84 = t$. $Q = W \times t \times \text{sp. h.} = 7.2 \times 0.84 \times 0.2374 = 1.4357 = \text{heat given to air.}$

Rise in temp. of water $1.17 \times 130.8589 = 153.1049 = \text{heat given to calorimeter.}$

1.4357 = heat given to air.

154.5406 = heat dissipated in 2 hours.

Hourly dissipation of heat 77.2703

SUMMARY.

Hourly dissipation of heat before operation		153.63
Hourly dissipation of heat after operation:	First period	221.5976
	Second period	108.4603
	Third period	72.382
	Fourth period	77.2703
<i>Gain of hourly dissipation of heat after operation:</i>	<i>First period</i>	67.9676
<i>Loss of hourly dissipation of heat after operation:</i>	<i>Second period</i>	45.1697
	<i>Third period</i>	81.248
	<i>Fourth period</i>	76.3597

Heat Production.

BEFORE OPERATION.

Rise of bodily temperature in 1 hour $0.2 = t$.

$$Q = W \times t \times \text{sp. h.} = 14 \times 0.2 \times 0.75 = 2.1 = \text{heat added to reserve.}$$

153.63 = hourly dissipation of heat.

2.1 = hourly addition to heat reserve.

Hourly production of heat 155.73

AFTER OPERATION.

First Period—

Fall of bodily temperature in 1 hour $0^{\circ}.8 = t$.

$$Q = W \times t \times \text{sp. h.} = 14 \times 0.8 \times 0.75 = 8.4 = \text{heat taken from reserve.}$$

221.5976 = hourly dissipation of heat.

8.4 = hourly loss from heat reserve.

Hourly production of heat 230.044

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Second Period—

Fall of bodily temperature in 1 hour 0.086 = t.

 $Q = W \times t \times \text{sp. h.} = 14 \times 0.086 \times 0.75 = 0.903 = \text{heat taken from reserve.}$

108.4603 = hourly dissipation of heat.

0.903 = hourly loss from heat reserve.

Hourly production of heat 107.5573*Third Period—*

Fall of bodily temperature in 1 hour 0.1 = t.

 $Q = W \times t \times \text{sp. h.} = 14 \times 0.1 \times 0.75 = 1.05 = \text{heat taken from reserve.}$

72.382 = hourly dissipation of heat.

1.05 = hourly loss from heat reserve.

Hourly production of heat 71.332*Fourth Period—*

Fall of bodily temperature in 1 hour 0.18 = t.

 $Q = W \times t \times \text{sp. h.} = 14 \times 0.18 \times 0.75 = 1.89 = \text{heat taken from reserve.}$

77.2703 = hourly dissipation of heat.

1.89 = hourly loss from heat reserve.

Hourly production of heat 75.3803

SUMMARY.

Hourly production of heat before operation	155.73
Hourly production of heat after operation:	
First period	230.044
Second period	107.5573
Third period	71.332
Fourth period	75.3803
<i>Gain of hourly production of heat after operation:</i>	<i>First period</i> 74.314
<i>Loss of hourly production of heat after operation:</i>	<i>Second period</i> 48.1727
	<i>Third period</i> 84.398
	<i>Fourth period</i> 80.3497

In studying the results of these experiments the comparison is most readily made by means of tabulated statements. Of these three are appended: the first, including experiments in which both first convolutions were involved; the second, cases in which only one first convolution was involved; third, experiments in which other portions of the brain were alone wounded. The figures given under the headings of first day and second day express the hourly rate of heat production.

TABLE I.—BOTH FIRST CONVOLUTIONS INVOLVED.

EAR	FIRST DAY.		SECOND DAY.		REMARKS.
	Before Operation.	After Operation.	First Period.	Second Period.	
76	89.5104	120.7453	83.2849	90.0946	
80	74.3056	129.3578			
82	160.0696	217.592			
86	95.94	111.9654	105.8557	.....	Wounds very deep and large
91	85.5401	140.9665			make much shock.
95	155.73	230.044	107.5573	.....	Periods follow one another.

TABLE II.—ONE FIRST CONVOLUTION INVOLVED.

EXP.	FIRST DAY.		SECOND DAY.		REMARKS.
	Before Operation.	After Operation.	First Period.	Second Period.	
78	51.9827	.....	78.0282		
79	146.3214	161.5229	119.2054	.....	Left Hitzig's destroyed; also corpus callosum.
81	73.1349	89.1422	91.4658	100.2661	The only wound of brain was so far back as scarcely to be in Hitzig's region.
88	168.133	187.243			
89	82.8412	71.1716	.....	.....	A great deal of bleeding with brain-clots all over base, may account for different results.
90	116.4695	134.8571			
92	81.7586	104.9475			
94	96.8167	107.8168			

TABLE III.—WOUNDS NOT INVOLVING FIRST CONVOLUTION.

EXP.	FIRST DAY.		SECOND DAY.		REMARKS.
	Before Operation.	After Operation.	Before Operation.	After Operation.	
77	51.616	47.9833	67.7586		
83	118.4111	95.2983			
84	135.3436	111.3768	125.6603		
85	165.0228	130.9479			
87	119.8777	121.2737			
93	220.0382	185.1321			

In looking over these tables it will be seen that there are fourteen experiments in which one or both of the first convolutions were injured immediately behind the sulcus cruciatus, and six experiments in which other portions of the brain were alone affected. In not one of the latter was there any increase of heat production worthy of notice immediately following the brain injury, whilst in thirteen of the fourteen experiments, compromising the so-called "Hitzig's region," there was a decided increase in the yield of heat. In the exceptional experiment a large sinus was wounded, and the blood clotting upon all parts of the brain must have greatly disturbed all the results, affecting profoundly by pressure both the vaso-motor and respiratory functions; the exceptional result is therefore very well accounted for. Of the thirteen consonant experiments, in seven there was one, and in six there were both of the first convolutions injured. In the latter set, the increase of heat production was, reading the experiments as they are arranged in the table, about 35, 74, 36, 27, 65, and 47 per cent.; in the experiments in which only one centre was injured, the increased production of heat was, reading as before, but omitting the first experiment because no study was made after the operation until the next day, 10, 22, 11, 15, 30, and 12 per cent. The average increase in the heat production was therefore 47 per cent. when both sides of the brain were affected, and 17 per cent. when only one side was compromised. When to this relation is added the fact that in twenty experiments the results were uniform, except in one instance in which the brain was deluged with blood from a wounded sinus, it is difficult to resist believing that in the dog *destruction of the brain region known as the first cerebral convolution posterior to and in the vicinity of the sulcus cruciatus is followed by an increase in heat production.* It may be noted that in several of the experiments, in which other portions of the brain than Hitzig's region were destroyed, there was a very decided fall in the rate of heat production.

A plausible explanation of this fall is to be found in the supposition that in these instances the wounds of the brain were sufficiently near the Hitzig's region to irritate it. In order to determine whether such irritation would diminish heat production, two experiments were performed. A properly located opening was made in the skull of the dog by a trephine, and the brain membranes carefully dissected off; the orifice was then filled with salt, which was held in its place by a pledget of lint, over which the scalp wound was closed by sewing. The experiments are as follows:—

EXPERIMENT 96.

A dog. Weight 22 pounds. 11:20 A. M.—Rectal temperature $102^{\circ}.5$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:32	...	...	70 ^o .34	492
12:45	72 ^o .42	73 ^o .04		
12	73.3	73.04		
12:15 P. M.	73.64	72.5		
12:32	73.94	73.14	71.42	604
	73.32	72.93	1.08	112
	72.93	(mean)	(gain)	
	0.39 (loss)			

12:45 P. M.—Rectal temperature $102^{\circ}.5$. 1 P. M.—Brain exposed. 1:55 P. M.—Dry salt put on Hitzig's regions.

2 P. M.—Rectal temperature $102^{\circ}.4$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:16 P. M.	74.72	74.57	71.69	615
2:35	74.02	74.66		
2:50	75.56	75.08		
3:5	76.16	74.75		
3:20	76.16	75.29		
3:35	75.92	74.57	72.905	750
	75.42	74.82	1.215	130
	74.82	(mean)	(gain)	
	0.6 (loss)			

4 P. M.—Rectal temperature $102^{\circ}.6$.

Autopsy.—The regions salted comprised the first and second convolutions of each hemisphere for some distance on both sides of the sulcus cruciatus; arachnoid much injected.

Heat Dissipation.

BEFORE IRRITATION.

Quantity of air (V') = 112 at $72.93^{\circ} - 32^{\circ} = 40.93 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{112}{1.083} = 103.4$. $W = V \times 0.08073 = 8.35$

Fall in temp. of air $0.39 = t$. $Q = W \times t \times \text{sp. h.} = 8.35 \times 0.39 \times 0.2374 = 0.7731 = \text{heat taken from air.}$

Rise in temp. of water $1.08 \times 130.8589 = 141.3276 = \text{heat given to calorimeter.}$

$0.7731 = \text{heat taken from air.}$

Heat dissipated in one hour 140.5545

AFTER IRRITATION.

Quantity of air (V) = 135 at $74^{\circ}.82 - 32^{\circ} = 42.82 = t$.
 $V + (V \times t \times 0.002035) = V'$. $V = \frac{135}{1.087} = 124.2$. $W = V \times 0.08073 = 10.03$
 Fall in temp. of air $0.6 = t$. $Q = W \times t \times \text{sp. h.} = 10.03 \times 0.6 \times 0.2374 = 1.4287 = \text{heat taken from air.}$
 Rise in temp. of water $1.215 \times 130.8589 = 158.9936 = \text{heat given to calorimeter.}$
 $1.4287 = \text{heat taken from air.}$

$157.5649 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$

Hourly dissipation of heat 105.0433

SUMMARY.

Heat dissipated before irritation 140.5545
 Heat dissipated after irritation 105.0433

Hourly loss of heat dissipation following irritation 35.5112

Heat Production.

BEFORE IRRITATION.

No change of bodily temperature.
 Heat dissipated in an hour = *hourly production of heat* 140.5545

AFTER IRRITATION.

Rise of bodily temperature in 2 hours $0^{\circ}.2$, in 1 hour $0.1 = t$.
 $Q = W \times t \times \text{sp. h.} = 22 \times 0.1 \times 0.75 = 1.65 = \text{heat added in an hour to reserve.}$
 $105.0433 = \text{heat dissipated in an hour.}$

Hourly production of heat 106.6933

SUMMARY.

Hourly heat production before irritation 140.5545
 Hourly heat production after irritation 106.6933

Hourly diminution of heat production following irritation 33.8612

EXPERIMENT 97.

A bitch. Weight 29.5 pounds. 11 A. M.—Rectal temperature 103° .

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	RECT. TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:16 A. M.	.....	.....	67 ^o .46	104 ^o .8	784.3
11:40	70 ^o .88	71 ^o .51			
11:55	71.51	73.24			
12:10 P. M.	71.87	73.45			
12:16	.....	.....	69.32	104.8	886.6
	71.42 (mean)	72.73 71.42	1.86 (gain)		102.3
		1.31 (gain)			

12:25 P. M.—Rectal temperature 103° . 1 P. M.—Brain exposed; on opening brain trephine slipped into brain.

2 P. M.—Salt put on the brain. 2:25 P. M.—Rectal temperature 104° .

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
2:32 P. M.	.....	.....	70 ^o .88	905.4
2:48	74 ^o .84	74 ^o .21		
3:3	74.72	74.48		
3:18	75.2	74.48		
3:28	75.02	74.57	72.26	984
	74.95 74.43	74.43 (mean)	1.38 (gain)	78.6
	0.52 (loss)			

3:40 P. M.—Rectal temperature 104° S.

3:43 P. M.—Hitzig's region destroyed with a knife.

TIME.	AIR TEMP. (Fah.)	TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:55 P. M.	.....	.....	72° 5	1008
4:10	75° 44	76° 28		
4:25	76° 04	76° 16		
4:55	76° 16	77° 36	74° 21	1111.45
	75.88	76.6	1.71	103.45
	(mean)	75.88	(gain)	
		0.72		
		(gain)		

5 P. M.—Rectal temperature 104°.

Autopsy.—Extreme right anterior lobe of brain cut to pieces; wound not extending to within one-quarter inch of sulcus cruciatus. Small wound of second and third convolution in sulcus of same side, extending to ventricle.

Heat Dissipation.

BEFORE IRRITATION.

Quantity of air (V') = 102.3 at 72° 73 — 32° = 40.73 = t' .
$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{102.3}{1.086} = 94.4. \quad W = V \times 0.08073 = 7.62$$
Rise in temp. of air 1.31 = t . $Q = W \times t \times \text{sp. h.} = 7.62 \times 1.31 \times 0.2374 = 2.3698 = \text{heat given to air.}$ Rise in temp. of water 1.86 \times 130.8589 = 243.3975 = heat given to calorimeter.

2.3698 = heat given to air.

Hourly dissipation of heat = 245.7673

AFTER IRRITATION.

First Period—

Quantity of air (V') = 78.6 at 74° 43 — 32° = 42.43 = t' .
$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{78.6}{1.086} = 72.3. \quad W = V \times 0.08073 = 5.84$$
Fall in temp. of air 0.52 = t . $Q = W \times t \times \text{sp. h.} = 0.52 \times 5.84 \times 0.2374 = 0.7209 = \text{heat taken from air.}$ Rise in temp. of water 1.38 \times 130.8589 = 180.5852 = heat given to calorimeter.

0.7209 = heat taken from air.

Hourly dissipation of heat = 179.8643

Second Period—

Quantity of air (V') = 103.45 at 76° 6 — 32° = 44.6 = t' .
$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{103.45}{1.09} = 95. \quad W = V \times 0.08073 = 7.67$$
Rise in temp. of air 0.72 = t . $Q = W \times t \times \text{sp. h.} = 7.67 \times 0.72 \times 0.2374 = 1.3110 = \text{heat given to air.}$ Rise in temp. of water 1.71 \times 130.8589 = 223.7687 = heat given to calorimeter.

1.3110 = heat given to air.

Hourly dissipation of heat = 225.0797

SUMMARY.

Hourly dissipation of heat before irritation	245.7673
Hourly dissipation of heat after irritation: First period	179.8643
Second period	225.0797

Heat Production.

BEFORE IRRITATION.

No change of bodily temperature.

Hourly dissipation = hourly production of heat 245.7673

AFTER IRRITATION.

First Period—

Rise of temperature of body in $1\frac{1}{2}$ hours $0^{\circ}.8$, in 1 hour $0^{\circ}.64 = t'$.

$$Q = W \times t' \times \text{sp. h.} = 20.5 \times 0.64 \times 0.75 = 9.84 = \text{heat added to reserve.}$$

$$179.8643 = \text{heat dissipated hourly}$$

$$\text{Hourly production of heat } \underline{189.7043}$$

Second Period—

Fall of temperature in $1\frac{1}{2}$ hours $0^{\circ}.8$, in 1 hour $0^{\circ}.6 = t'$.

$$Q = W \times t' \times \text{sp. h.} = 20.5 \times 0.6 \times 0.75 = 9.225 = \text{heat taken from reserve.}$$

$$225.0797 = \text{heat hourly dissipated.}$$

$$9.225 = \text{heat taken from reserve.}$$

$$\text{Hourly production of heat } \underline{215.8547}$$

SUMMARY.

Hourly production before irritation	245.7673
Hourly production during irritation	189.7043
Hourly production after destruction	215.8547

The first of these experiments is a simple one, performed in the manner already indicated. It will be noted that during the period of irritation there was a decided reduction in the hourly production of heat amounting to 22 per cent. In the second experiment the diminution in the rate of heat production following the salting was curiously enough also 22 per cent. There was in the second experiment an attempt to destroy the centres after the period of irritation; neither of them, however, was destroyed. The rise of heat production that followed the operation was distinct, but did not equal the previous fall, the whole amount of heat produced not being as great as before the skull was opened. Probably there was in this case during the last calorimetrical observation paresis of one centre, and irritation of the other.

The experiments which have just been detailed are in accord with those previously reported, in which the brain was locally destroyed. The results of the entire series, comprising 22 consecutive concordant experiments, are summed up in the following proposition:—

Destruction of the first cerebral convolution in the dog posterior to and in the vicinity of the sulcus cruciatus is followed at once by a very decided increase of heat production, whilst after irritation of the same nervous tract there is a decided decrease of heat production.

Whatever may be the exact nature of the proven relation between the region of the brain under discussion and thermogenesis, there is one very important point which is not absolutely determined by my experiments, namely, as to the permanency of the effects induced. There are three experiments bearing upon the subject, in which only one convolution was wounded; in two of these trials the increase of heat production was seemingly maintained twenty-four hours after the operation, but in the third it was not kept up. There are also three experiments in which the two centres were involved; in only one of these is there any show of permanency in the increased heat production. In the most thoroughly watched of the experiments the early formation of an intra-ventricular clot may have

been the cause of the sudden check of heat production. Further elaborate experimentation can alone determine positively how permanent the influence of the brain region noted upon heat production is, but the drift of the evidence at present is to indicate that the effect is temporary, and that the first convolution does not contain the centres which preside over calorification, but is in some way connected with these centres so as to exert an influence upon them.

The probabilities are that the calorific centres are situated in the pons, and that the power of the first convolution depends upon habitual co-action. Thus, volition may habitually use the upper cortex spoken of in starting the machinery of muscular movement, and along with this machinery, or even as a necessary part of it, that of heat production may also be moved.

The conclusion just reached is in a measure related to the vexed question of cerebral localization. It may therefore be allowable to speak of the matter in a little more detail. All of the functions of the nervous centres are, in some of the lower forms of life, concentrated in a single cell, and as the scale of life is ascended the nervous system becomes more and more complex by the differentiation of its parts for the more complete performance of functional acts. It is evident that anatomical and functional differentiation must have at least some relation with one another, and that finally one act must be performed solely by one part. It seems inconceivable that a complex mechanism like the human cerebro-spinal axis should work harmoniously in any other way than that certain parts should perform certain acts. This localization of function it will be seen is not the result of an original rigid formation of the mechanism, but is probably acquired by habitual use for the species, and certainly also to some extent for the individual. All parts of the nervous system possess theoretically at least more or less of the original power which resided in the primordial nerve cell, and enabled it to perform various diverse acts. It is consequently perfectly conceivable that when one cell is disabled in the more complex mechanism another should gradually take on its function: Every physiologist who believes in a respiratory or a vaso-motor centre, if logical, believes also in the principle underlying cerebral localization. With the view of the matter just put forth it is evident that degrees of localization must exist. In the dog the speech centre, so far as is known, is not differentiated; in man it is strictly so. In the same way in the dog the motor centres of the cortex cerebri seem to have reached only the stage of habitual action, so that when one part of a convolution is removed another can replace it, whilst in the man the motor functions of the cortex appear to be differentiated beyond the stage of habitual action, and one part to be no longer able to replace another: consequently destructions which produce only evanescent results in the dog cause in the man permanent paralyses.

Having found that there is an apparent connection between the cerebral cortex and the thermic functions of the body, I have attempted to discover whether light could be thrown upon the truth or falsity of the theories of heat regulation heretofore discussed. It will be remembered that the conclusion was reached that there is either a general vaso-motor centre for the muscular system, situated above the medulla, which acts independently of the medullary vaso-motor centres, or else that there is in the pons or above it an inhibitory heat centre. It is hardly pos-

sible that the action of the cortical centres upon thermogenesis is merely that of a local vaso-motor influence; the action must involve the whole muscular system, and it would seem probable that it should be able to make itself perceived by an effect upon the blood pressure. To determine whether the vaso-motor system of the muscles is capable of modifying arterial pressure at all, the following experiments were performed. In them a curarized dog, with splanchnics and pneumogastriacs cut, had his sciatic nerve irritated by a faradic current. Section of the splanchnics is believed to cause complete vaso-motor palsy of the abdominal vessels, and the question was whether after such palsy the contraction of the remaining arterioles of the body produced by irritating a sensitive nerve would be able to make an impression upon the arterial pressure.

EXPERIMENT 98.

A dog. Curari given; artificial respiration; pneumogastriacs cut; left splanchnic (as shown by autopsy) completely severed above the diaphragm; right splanchnic divided except a corner of the sheath with possibly some nerve fibres remaining in it; sciatic nerve exposed.

TIME. Sec.	ARTERIAL PRESSURE. (Millimetres.)	IRRITATION.	REMARKS.
0	30	.....
1	30	Current applied.	
4	37	.....
6	44	.....
12	52	.....
15	53	.....
18	52	Current broken.	
22	40	.....	Fig. 4, Plate IV, represents the tracing of this Experiment; I represents the point at which the circuit was closed; O, that at which it was broken.
30	37	.....
36	29	.....

EXPERIMENT 99.

A dog. Curari given; artificial respiration; par vagum divided; sciatic nerve exposed. Wound of the brain: right side, the first convolution, outer part of the sulcus cruciatus; left side, wound entirely in advance of the left sulcus cruciatus.

TIME. Sec.	ARTERIAL PRESSURE. (Millimetres.)	IRRITATION.	REMARKS.
0	45-35	Current applied.	
2	82-62	.....	Disturbance of respiration very marked, but no struggles.
4	78-58	.....
14	68-55	Current broken.	
21	45-37	.....

More curari given and splanchnics cut, as shown by the autopsy, just below the last rib.

TIME. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	18	.....
36	18	.....	Perfectly steady pressure since last note.
37	...	Current applied.	
41	20	.....
43	21	.....
46	23	.....
49	24	.....
53	26	.....
56	29	.....
60	28	.....
64	28	Current broken.	
67	26	.....
71	24	.....
75	21	.....

TIME. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	18	.....	Pressure has been steady for many seconds.
1	...	Current applied.	
7	20	.....
12	24	.....
15	24	Current broken.	Pressure has been steady.
20	24	.....
24	19	.....

EXPERIMENT 100.

A dog. Par vagum cut; artificial respiration; woorari given; carotid artery used; spleen cut, as proved by autopsy, as they entered the crura of the diaphragm; sciatic exposed.

TIME. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	28	.....
2	28	Current applied.	
3	32	.....
10	33	.....
15	33	.....
30	33	.....
33	32	Current broken.	Fig. 3, Plate IV. represents the tracing of the arterial pressure.
36	29	.....
33	27	.....

TIME. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION	REMARKS.
0	28	.....
6	29	.....
12	...	Current applied.	
15	35	.....
24	36	.....
28	42	.....
37	42	Current broken.	Steady pressure since last note.
39	43	.....
42	35	.....
44	32	.....

TIME. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	27	Current applied.	
2	32	.....

EXPERIMENT 101.

A dog. Curari given; artificial respiration; vagi divided; splanchnics cut just above the diaphragm, as shown by autopsy; sciatic nerve exposed. Some hemorrhage occurred during the operation and further lowered the blood pressure.

TIME. Sec.	ARTERIAL PRESSURE. (Millimetres.)	IRRITATION.	REMARKS.
0	11	.....
10	11	Current applied.	
15	15	.....
20	20	.....
25	26	.....
30	24	.....
35	24	Current broken.	
40	18	.....
45	16	.....
50	15	.....
55	13	.....

TIME. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	11	Current applied.	Fig. 1, Plate IV. represents the tracing of this Experiment.
5	17	.....
10	20	.....
30	24	.....
40	26	Current broken.	
45	22	.....
50	18	.....
60	14	.....

Detailed discussion of these experiments is not necessary; they prove that, although the influence of the splanchnics upon the force of the blood current is very great, after their section irritation of a sensitive nerve is still capable of producing a rise in the arterial pressure, and that consequently the arterioles, other than those of the abdomen, play at least some part in the determination of the blood pressure.

With this knowledge the next step in the investigation was to discover whether either irritation or destruction of the special region of the brain cortex, which is connected with the thermic functions of the body, has any influence upon the arterial pressure.

EXPERIMENT 102.

This dog had been used in the second fever experiment, but except for some embolic (?) lameness seemed well. Curari given; artificial respiration; femoral artery used; trephine opening upon each side over the Hitzig's centre; vagi not cut.

TIME. H. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
2:48 P. M.	215-220	
2:49	215-230	
2:49:10	215-225	Brain surface in Hitzig's regions mechanically destroyed.
2:49:20	205-220	

* In the experiments marked with an asterisk, the scale of the instrument with which the pressures were taken was an arbitrary one; the numbers therefore represent units, whose exact value I am not now able to give. As each experiment is a relative one and complete in itself, this omission does not affect the conclusions to be drawn from the series.

TIME.	ARTERIAL PRESSURE.*	REMARKS.
11 M. Sec.		
2:49:35	210-220	
2:49:50	215-225	
2:50	220-230	
2:50:15	215-235	
2:50:30	210-220	
2:50:50	220-230	Brain washed out very freely in mass.
2:51	215-225	
2:51:30	220-230	
2:52	215-225	
2:52:30	210-230	
2:53	215-225	
2:53:30	205-215	
2:55	210-220	Artificial respiration stopped.
	195-200	
2:56	200-210	Some respiratory movements.
	210-215	
2:57	220-225	No respiration.
2:58	227-50	
	227-50	Clot formed.
3	240-250	Clot cleaned out.
	255	
3: 1	255-260	
3: 1:30	245-250	Animal killed.

Autopsy.—The upper anterior third of the brain washed away so as to uncover freely the ventricles.

EXPERIMENT 103.

A dog. Artificial breathing, and curari used; a trephine opening over the sulcus cruciatus on each side.

TIME.	ARTERIAL PRESSURE.*	REMARKS.
11 M. Sec.		
3:12 P. M.	230-240	
3:12:30	225-235	
3:13	230-240	Metallic wires connected with battery (Du Bois Reymond's apparatus, one large Grenet cell) inserted in immediate neighbourhood of the sulcus cruciatus; mild current sent through.
3:13:5	220-230	Muscular twitchings about the head very decided.
3:13:10	225-235	Current broken.
3:13:20	210-235	The full force of the coil applied; violent tetanus of the anterior part of the body.
3:14	250	Current broken.
3:14:30	235-245	
3:15	220-235	
3:17	220-240	
3:18	210-225	
3:18:40	220-240	Mechanical destruction of the anterior part of the brain induced; general muscular movements induced.
3:19	210-260	
3:19:10	230-240	
3:19:20	210-250	
3:19:35	220-230	Animal quiet; voluntary breathing re-established.
3:19:50	220-235	
3:20	220-240	
3:20:10	210-230	
3:20:25	230-240	
3:20:35	220-240	
3:20:45	220-235	
3:21	210-225	A stream of water forced into the brain through one trephine opening and out the other.
	200-210	

TIME. H. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
	210-230	
	220-230	
3:22	220-230	
	215-225	
	210-220	
	210-225	
3:23	210-220	

Autopsy.—Right side of brain: the whole region near the sulcus cruciatus washed away; the ventricles uncovered. Left side of brain: the same region gone excepting in its extreme outer portion.

In studying these experiments, it will be observed that they were performed upon dogs with the vagi uncut. In the first of the two, the Hitzig's region was destroyed mechanically without the arterial pressure being affected at all, it remaining steady from 215-230, rising and falling within narrow limits. One minute and forty seconds later, a strong stream of water was forced into one trephine opening and through to the other carrying out with it masses of brain. The effect of this procedure was remarkably little. There was no fall of the arterial pressure whatever for five minutes, and then the diminution was so slight and temporary that probably it had its source in some other cause than the operation. Some minutes later, artificial respiration being suspended, an enormous rise of the arterial pressure occurred, showing that the general vaso-motor system was intact.

In the second experiment, a mild electrical current sent through both Hitzig's regions produced no rise of pressure whatever. Later, a very powerful current produced a decided rise of pressure, to account for which, the violent tetanus of the anterior part of the body seemed itself sufficient. At 3:18:40 P. M., the surface of the Hitzig's cerebral region was mechanically destroyed. The muscular movements induced caused some momentary derangement of the circulation. In twenty seconds, however, the arterial pressure had returned to the place whence it started at 3:12 P. M., *i. e.*, from 225-240. It did not vary decisively from this until 3:21 P. M., when a stream of water was forced violently into the brain, producing great destruction. After this there was a very slight fall of pressure, the mercury descending to 210-230; a fall remarkably small considering the extent of the injury and the probability of the occurrence of severe shock.

It will be seen that these experiments are in accord, and warrant the following conclusion: that when the vagi are uncut, neither the application of galvanic currents to nor the mechanical destruction of Hitzig's region has any decided influence upon the blood pressure.

There was a distinct slowing of the pulse produced by the application of the galvanic current; which, of course, indicates an excitation of the pneumogastries. Now, it is well known, that galvanization of a sensitive nerve in the dog with the vagi uncut often fails to induce rise of the arterial pressure—although it induces vaso-motor spasm—because it inhibits the cardiac action by stimulating the pneumogastric centres. As such an influence was manifest in the case under consideration, the following experiments were performed upon dogs with cut vagi:—

EXPERIMENT 104.

A very large dog. Curari given; artificial respiration; femoral artery used; par vagum cut; trephine opening on each side over Hitzig's region.

TIME.	ARTERIAL PRESSURE.*	REMARKS.
H. M. Sec		
11:18	A. M. 200-210	
11:19	200-210	
11:20		A very strong faradic current sent through the brain, the wires being inserted in the gray matter of Hitzig's regions.
11:20:15		General tetanus.
11:20:30		General tetanus.
11:21		General tetanus.
11:21:15		General tetanus.
11:21:20	... ..	Current interrupted.
11:22		
11:23		Animal lost about two fluidounces of blood.
11:23:45		More curari given.
11:25		
11:25:15		
11:25:30		A mild but decided current sent through the brain.
11:25:50		
11:26	.....	Very powerful current employed; no tetanus.
11:26:30		
11:26:45		Tracing Fig. 4, Plate II. represents the arterial pressure at the points marked thereon.
11:28:30	.....	Current interrupted.
11:29		
11:29:30		
11:30		
11:30:30		Dura mater, etc., irritated by insertion of nozzle of syringe.
11:31:15	... ..	Water forced in so as to destroy the brain.
11:31:30		
11:32		
11:32:15		
11:32:30		
11:33		
11:33:30		
11:34		
11:34:30		Animal pithed. At the autopsy Hitzig's region found to have been destroyed upon both sides of the brain.

EXPERIMENT 105.

A moderate sized dog. Conditions as in the last Experiment, except that the vagi were not cut in the beginning of the Experiment.

TIME.	ARTERIAL PRESSURE.*	REMARKS.
M. Sec.		
1:2	205-210	
1:25	205-210	
4:33	205-215	
5:40	200	A very decided current sent through the brain.
6	225-235	
6:42	235	General tremblings.
6:50		
6:30		Current broken.
7		Vagi cut.
8		
8:5		
8:45		

TIME.	ARTERIAL PRESSURE.*	REMARKS.
M. Sec.		
9	250-260	Instrument plunged into the brain.
9:5	260-270	} All this time the brain is being operated upon.
9:6	260-270	
9:10	270-280	
9:20	270-280	
9:26	230	
9:36	240	At this moment, water forced into the brain, washing out masses of it.
10	260-270	Work on brain ceased.
10:15	260-270	
10:30	250-260	
11	250-255	Animal pithed. At autopsy upper surface of the anterior lobes of the brain found disorganized.

EXPERIMENT 106.

A dog. Curari employed, with artificial respiration; femoral artery; two trephine openings made over the Hitzig's region, and galvanic needles inserted into the brain.

TIME.	ARTERIAL PRESSURE.*	REMARKS.
M. Sec.		
10	230-240	
10:20	240-250	
10:50	250-260	Weak current applied to the brain.
11	230-240	
11:15	240-250	
11:30	240-250	
11:40	.....	Current broken.
11:50	225-233	
13	230-235	
13:30	.....	Weak current applied to the brain.
13:40	230-235	
13:50	225-230	
14	.....	Current broken.
14:30	220-230	
15:35	220-225	

TIME.	ARTERIAL PRESSURE.*	REMARKS.
H. M. Sec.		
1:28:10 P. M.	210-215	
1:28:30	210-215	Weak current applied to the brain.
1:28:40	210-215	Fig. 3, Plate V. represents the tracing from 1:28:30 to 1:28:50.
1:28:50	.....	Current broken.
1:28:55	210-215	
1:29:30	210-220	Strong current to the brain. Fig. 6, Plate II. represents the tracing from 29:30 to 30.
1:29:50	220-225	Some struggles.
1:30	.....	Current broken. Fig. 5, Plate II. represents the tracing of arterial pressure needle from 1:31:45 to 1:32:10.
1:31:50	210-215	One side of the brain destroyed with a needle.
1:31:55	.....	Other side of the brain destroyed with a needle
1:32	210-215	
1:32:20	220	
1:32:40	210-225	
1:35	.....	Brain broken up afresh with the handle of a scalpel.
1:35:50	220-225	
1:36	220-225	
1:36:20	225-230	
1:37:10	220-225	
1:37:20	225-230	

TIME. H. M. Sec.	ARTERIAL PRESSURE.*	REMARKS.
1:47:50	210-215	
1:48	210-215	
1:49	210-215	
1:50	200-210	
1:51	210-215	
1:52	210-215	Animal killed.

Autopsy.—Right and left side of the brain destroyed to the ventricles over a large surface involving the first, second, and third convolutions, and reaching to the sulcus cruciatus in front.

In the first of these experiments (Experiment 104) the very powerful current (the full force of the apparatus) applied in the beginning to the Hitzig's region, produced general tetanus with rise of the blood pressure. This was at 11:20 A. M. More curari having been given, sufficient to entirely paralyze voluntary movements, a mild current, but one sufficient to be very painful to the tongue, was applied to the brain at 11:25:30 A. M. This failed to produce rise of pressure, as is shown in the tracing Plate II. Fig. 4. This current was certainly sufficiently powerful to have violently affected the blood pressure, if it had been applied to a sensitive nerve. At 11:26 A. M. the current was increased to the full power of the coil, with the sudden rise of pressure, that is depicted in the tracing. Later on in the experiment, the nozzle of a syringe was forced into the brain, and a stream of water driven forcibly in. At once the blood pressure rose from 200-220 up to 350-400, and maintained itself at 280-290 for four minutes, till the lower brain was broken up with a pithing instrument.

In the next experiment (Experiment 105) a very decided current, sent through the brain before section of the vagi, caused an immediate rise of pressure, which may have been due to the general muscular tetanic tremblings. After the vagi were cut, the pressure stood at 230-235. When an instrument was plunged into one of the Hitzig's regions and the brain destroyed, the mercury at once rose to 250-260, and the brain being still worked with, the pressure was maintained for some seconds at 270-280; on ceasing the operation the mercury fell to 240. Water was now forced into the brain, bringing away large masses of it; the mercury immediately rose to 260 and 270, and although only ten or fifteen seconds were occupied with the process the pressure maintained itself at 250-255 for more than a minute, when the experiment was brought to an end.

The last experiment of the series (Experiment 106) is in accord with the others. A mild, but decided, faradic current applied to the Hitzig's region had no decided effect upon the blood pressure. This was tried three times; at 1:10:50, at 1:13:30, and at 1:28:30. At the first application there was apparently in the beginning a rise of pressure; but as this did not continue in this case, and did not occur at all in the other instances, it was probably due to some accidental extraneous momentary cause. A powerful current was applied to the brain at 1:20:30, and produced a slight rise, which may have been due to the violent struggles; this rise is seen in the tracing Plate II. Fig. 6. The lack of the effect in the final trial is well shown in the tracing Plate V. Fig. 3. Destruction of the Hitzig's region did not have as much effect as in the preceding experiment, but produced

at first some slight rise in the pressure, as is shown in the tracing (Plate II. Fig. 5). The arterial pressure was watched for nearly twenty minutes after the destruction of the brain and suffered no notable fall; showing that nothing comparable to a governing vaso-motor centre had been destroyed.

The experiments of the series are on the whole so closely concordant that further repetition has seemed unnecessary. They appear to establish the following conclusions: *After section of the vagi, in the curarized animal, mild irritation of the Hitzig's region has no influence upon the blood pressure; but the application of powerful galvanic currents or of great mechanical violence produces a more or less marked elevation of the arterial pressure, which probably is due not to irritation of the Hitzig's region itself, but to irritation of the trigeminal nerve twigs in the dura mater, by diffusion of the electric current or of the excessive mechanical force.* Total destruction of the Hitzig's region in both sides of the brain does not abate the blood pressure.*

The conclusions, just reached, would seem to show that neither irritation nor destruction of the first cerebral convolution in the dog is able distinctly to affect the arterial pressure when the par vagum is cut and the splanchnic nerves are entire.

Such experiments are however not entirely satisfactory. It is conceivable that a vaso-motor centre, controlling the bloodvessels in the muscles, may exist in the upper cerebrum and give no unmistakable sign of its presence when it is destroyed, because it is so overshadowed by the abdominal vaso-motor system; just as the addition of an individual dollar could not be perceived in a heap of coin. To sift the matter as closely as possible, several further series of experiments were undertaken. In the first of these, a sensitive nerve was galvanized, after section of the splanchnics and destruction of Hitzig's region in the cerebral cortex. It has already been shown that when the Hitzig's region is intact and the splanchnics are divided, galvanization of the sciatic causes a decided rise of the arterial pressure; now if this rise does not occur after destruction of the Hitzig's centre, such centre must obviously have a vaso-motor value; on the other hand, if the rise occur after as before the destruction of the cerebral cortex, the vaso-motor value of the latter must be null or exceedingly unimportant.

In the second series of experiments Hitzig's region was destroyed after section of the splanchnics, and the effect upon the arterial system noted.

If, after removal of the disturbing influence of the powerful abdominal circulation, the Hitzig's cortex is unable to sensibly influence the arterial pressure, *i. e.*, the vaso-motor condition of the extra-abdominal bloodvessels, the ascribing of a dominant vaso-motor power to it seems more than gratuitous. The experiments are as follows:—

* I have frequently noted signs of extreme pain when working with brain membranes never any when the brain itself was alone disturbed.

EXPERIMENT 107.

A dog. Morphia and curari employed, with artificial respiration; vagi cut; carotid and splanchnics exposed; Hitzig's region destroyed.

TIME. Sec.	ART. PRESS. (Millimetres.)	IRRITATION.	REMARKS.
0	38	Current applied.	The splanchnics not cut; arterial pressure has been steady some minutes; Faradic current used.
3	48		
5	58		
7	64		
10	71	.....	Tracing Fig. 1, Plate III.; the first + marks the beginning the second + the ending of the irritation.
12	69	Current broken.	
14	63		
16	60		
19	56		
22	54		
28	46		

Splanchnics cut.

TIME. Sec.	ART. PRESS. (Millimetres.)	IRRITATION.	REMARKS.
0	17	Current applied.	Arterial pressure has been steady for some time; Faradic current used.
3	19		
5	20		
9	22		
12	25		
14	28		
16	29		
21	29		
28	28	Current broken.	Fig. 2, Plate III.; I marks the beginning of irritation at 0 sec. the + the ending of irritation at 28 sec.
32	24		
43	21		
49	20		
53	18		

EXPERIMENT 108.

A dog. Curari employed, with artificial respiration; pneumogastrics and splanchnics cut; skull opened, but brain not injured.

TIME. M:Sec.	ART. PRESS. (Millimetres.)	IRRITATION.	REMARKS.
0	24-33		
0:6	32		
0:11	31		
0:25	30		
0:29	33		
0:38	33		
1	33	Current applied.	Strong Faradic current; no movements of the muscles voluntary to the nerve.
1:7	35		
1:16	35		
1:25	35	Current broken.	The upper tracing, Fig. 3, Plate III., represents this experiment, the first cross belongs to the upper tracing, and marks 1 minute when the irritation of the sciatic began.
1:34	35		Asphyxia produced.
1:42	45		Artificial respiration resumed. See Plate IV, Fig. 2.
1:50	35		
2	...	.....	Brain operated on, and Hitzig's region on both sides destroyed, as was afterwards proven by the autopsy.
4	29		
4:10	20		

TIME. M. Sec.	ART. PRESS. (Millimetres.)	IRRITATION.	REMARKS.
4:20	29	.....
4:25	30	.....
4:27	29	.....
6	30	.....
6:5	30	.....
6:15	30	Current applied.	Faradic current of the same strength as previously employed.
6:20	34	.....	The lower tracing of Fig. 3, Plate III. represents the experiment,
6:22	35	.....	the second + belongs to it and marks the beginning of irritation.
6:28	38	.....
6:32	40	.....	A kink in the tube of artificial respiration apparatus momentarily
6:34	45	.....	interfered with the supply of air, causing partial asphyxia.
6:39	38	.....
6:49	35	Current broken.	
7:8	33	.....	Asphyxia produced.
7:10	42	.....
7:20	44	.....
7:22	44	.....	Animal killed.

In the first of these two experiments, the brain cortex having been destroyed mechanically and the par vagum cut, the arterial pressure rose, on galvanization of the sciatic nerve, from 38 to 69 millimetres. After section of the splanchnics the pressure rose from 17 to 29 millimetres on irritation of the sciatic, showing that destruction of the cerebral cortex and of the splanchnics does not produce complete vaso-motor palsy. The comparative effects of irritation before and after section of the splanchnics are well shown in Plate III., Figs. 1 and 2. The second experiment was even more conclusive in its evidence. The steady arterial pressure, after section of the splanchnics, was 31 to 33 millimetres. On galvanization of the sciatic it rose in seven seconds to 35, and on production of asphyxia to 45. The brain was then operated on, the Hitzig's cortex of both hemispheres being removed, and on one side the ventricles being freely opened. The arterial pressure at first fell to 29, but afterwards rose to 31. The sciatic was irritated with a Faradic current of the same strength as before, and in seven seconds the pressure rose to 35, and on asphyxia being induced increased still further to 45 (see Fig. 3, Plate III.). It is evident that in this case destruction of the cortex cerebri had no effect upon the arterial pressure after the removal of the dominant influence of the abdominal circulation, and it would seem as though vaso-motor influence must be excluded from the explanation of the effects of wounds of this portion of the cortex upon heat production.

The opinion has already been expressed that the centre which directly controls the production of animal heat is not in the cortex, consequently the fact that the cortex has no vaso-motor action whilst it indicates the truth of the theory of a direct nervous inhibition of heat production can hardly be considered to establish it. Not knowing exactly in what region of the brain the sought-for calorific centre, if it exists, is located, it is not possible to experiment directly upon the effects of its destruction, but plainly the direct facts can be indirectly discovered by studying the effect upon blood pressure of the galvanization of a sensitive nerve after section of the medulla at its junction with the pons and of the splanchnics, since such section removes the body from the influence of said calorific centre. The following experiment is in such direction.

EXPERIMENT 109.

A dog. The medulla cut; pneumogastric severed; artificial respiration employed; wocain administered; carotid artery and sciatic nerve used.

Time. M. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	50	.....
10	50	Galvanic.	Strong Faradic current.
13	75	.....
15	80	.....
18	98	.....
20	103	.....
23	113	.....
26	120	.....	Needle of manometer now rose above the top of the registering drum, and the pressure could no longer be recorded. Plate V. Fig. 1, represents the tracing of the arterial pressure of this experiment, + corresponding to beginning of irritation at 10 seconds, ++ to cessation of irritation.

4:20 P. M.—The splanchnics divided.

Time. M. Sec.	ARTERIAL PRESSURE (Millimetres.)	IRRITATION.	REMARKS.
0	35	.....	Pressure has been steady for some minutes.
10	35	Began.	Strong Faradic current.
13	43	.....
15	46	.....
18	49	.....
30	54	.....
36	47	.....	Plate V. Fig. 2, represents the tracing of this experiment, + corresponding to beginning of irritation at 19 seconds, ++ to its cessation at 44 seconds.
41	43	Ceased.	
49	37	.....
52	35	.....
1	35	.....	Asphyxia produced.
1:5	44	.....
1:8	48	.....	After this the pressure did not rise any more.

Autopsy.—The splanchnics cut below the last ribs, just as they are entering the diaphragm. The medulla completely separated from the pons; only one pneumogastric severed in the neck.

This experiment certainly shows that, *after separation of the medulla from the pons and after section of the splanchnics, the arterial pressure still rises, when asphyxia occurs or a sensitive nerve is irritated*: a comparison of this rise with that which occurs when the splanchnics only are divided will show that it is as great as the latter. It must therefore be allowed that there is no vaso-motor centre above that of the medulla, which is able to impress the arterial pressure even when the splanchnics are divided and the dominating power of the abdominal circulation withdrawn. I have also made a series of experiments upon venous pressure, hoping to be able to determine in this way the effect of injuries of the nerve centres upon the blood supply of muscles. No technical difficulties of much importance were met with, the proneness to blood coagulation being overcome by the use of a *saturated* solution of carbonate of sodium; but it was found that the local conditions of the arteries of a part affect very little the venous pressure, the latter being dominated by the general venous pressure and by the muscular condition of the part under study: thus in a number of experiments, section of the

sciatic nerve in the dog had no demonstrable effect upon the blood pressure of the corresponding femoral vein. This method of investigating the matter under consideration led to no result; this is, however, not of vital importance, for it seems scarcely conceivable, that a vaso-motor centre, whose paralysis was followed by dilatation of all the muscular arterioles and whose influence upon heat production should be as great as is required by the facts of the case, should not impress, in any way, the arterial pressure, even after withdrawal of the influence of the abdominal circulation. It seems to me about as nearly demonstrated as it can be that the centre in the medulla dominates the vessels in every part of the body, and consequently that the rise of the heat production following section of the medulla is not due to an influence exerted upon the circulation, but directly upon the heat making function. The theory that teaches the existence of a nerve centre in the pons or in the brain above it, which by a direct action inhibits the production of animal heat, seems therefore to be most in accord with all the evidence bearing upon the matter, and I am myself disposed to adopt it as at least very probable.

It is a matter of much interest to decide as to the location in man of the centres which control the production of heat. I do not believe that it is right to apply rigidly to man, rules of localizations discovered in the cerebral hemispheres of the lower animals. The differentiation, anatomical and functional, is so much greater in the human than in the canine brain, that diversity of anatomical localization is very probable. In determining the seat of caloric inhibition in man a great difficulty offers itself. No human calorimetrical observations have been made at all, and if we judge from a rise of bodily temperature vaso-motor disturbance may be readily mistaken for an increased heat production. It is possible, however, that close observation of apoplectic and traumatic brain cases, aided by cautious reasoning, may, in the future, enable us to trace out the course of the heat fibres, and rather with the desire of giving an impulse to the observation of cases than with the expectation of deciding the question, a brief discussion of the present evidence is here entered upon.

Evidently the first point to direct attention to is in regard to the pons Varolii and the optic thalamus.

Bastian states that in apoplexy of the pons, if the life of the patient be prolonged, "the temperature of both sides of the body steadily rises, till at the time of death it may have attained 109° or even 110°." (*Paralysis from Brain Disease*, p. 220.) He also asserts that after hemorrhage into the optic thalamus the paralyzed limb may be for many weeks or months "one and a half or even two degrees" hotter than the sound limb. Limbs paralyzed by hemorrhage in the corpus striatum, or its neighborhood, are said also to be slightly but temporarily hotter than the sound limb. Upon what or how many cases Dr. Bastian rests these generalizations I do not know. Hemorrhage confined to the optic thalamus is rare. The only case I have a reference to is that reported by Dr. Remy (*Bull. Soc. de Anat.*, Paris, 1875, 3 ser. x. p. 158). In this the original attack came on early in October, 1874, but the subject did not come under observation until the ninth of November. The temperatures as taken in this case were—

Nov. 9. Right hand 32°.9 C., left 36°; right elbow 34°.9, left 35°.3; right axilla 37°.1, left 37°.3.

Dec. 1. Right axilla 37°.0 C., left 37°.2; right elbow 35°.6, left 35°.8.

Hemorrhage limited to the pons is comparatively very frequent, and I have looked up a number of references, with the results shown in the tabulated statements.

CASES WITH FEVER DEVELOPED.

Nunneley.	Trans. Lond. Path. Soc., xi. p. 11.	Head at first alone hot; later whole surface.
Alexander.	Lancet, 1875, i. p. 722.	Cross paralysis. Fever only slight, not developed for some hours. Temperature for a while 101°.4 F. in right, 102°.2 in left axilla. Clot occupying the right lower half of the pons not extending beyond the median line.
Johnson.	British Med Journ., 1877, i. p. 13.	Temperature 1° higher in popliteal space of paralyzed side, lower on sound side; not stated how long this lasted. Cross paralysis. No autopsy.
Lepine.	L'Union Med., 1876, i. p. 961.	Rise of temperature slight and developed slowly; only partial left hemiplegia with muscular contraction. Head rotated towards paralyzed side. Very small clot in right side, about equal distance from front and rear of pons, a little to right of median line.
Rendu.	Bull. Soc. Anat., 1875, p. 75.	Cross paralysis; slight rise of temperature slowly developed; no immediate rise of temperature in paralyzed side; no sugar or albumen in urine; a large clot in median extending into left cerebral peduncle which it almost entirely occupies; also into fourth ventricle, but only affects summit of ventricle; maximum lesion on left side of ventricle, almost the whole upper third of which is destroyed.
Huchard.	Bull. Soc. Anat., 1868, p. 143.	One hour after attack temperature of right side 36° C., left side 35°.4; right side paralyzed in 1½ hours after the attack. Large clot in left side of pons.

CASES IN WHICH TEMPERATURE WAS NORMAL OR BELOW NORMAL.

Weber.	Tr. Med. Chirurg. Soc., xliv. p. 153.	Tumor. In section of pons on level with origin of fifth nerve, in lower or anterior part of left half close to periphery, a round tumor half an inch in diameter; softening extended to floor of fourth ventricle and to the right.
Weber.	Ibid.	Tumor, almost identical with last.
Weber.	Ibid.	Softening of pons in centre of superior part nearest cornu cerebri.
Telédano.	Bull. Soc. Anat., 1875, p. 670.	Temperature 39° C. Considerable hemorrhage into centre of pons, which was softened and disorganized. Fatty degeneration of surrounding parts.
Pinard.	Bull. Soc. Anat., 1871, p. 37.	Temperature 36°.5 C. Pupils widely dilated. Very large clot occupying anterior part of pons, and breaking into third ventricle; death in three hours.
Brown.	Journ. Mental Science, xxi. (1875-6) p. 256.	

CASES IN WHICH THERE IS NO MENTION OF TEMPERATURE.

Bristowe.	Trans. Lond. Path. Soc., xi. p. 11.
Ogle.	Trans. Lond. Path. Soc., xi. p. 11.
Ogle.	Trans. Lond. Path. Soc., i. p. 15.
Broadbent.	Trans. Lond. Path. Soc., xii. p. 16.
Morrison.	Trans. Lond. Path. Soc., i. p. 36.
Peacock.	Trans. Lond. Path. Soc., i. p. 36.
Barlow.	Trans. Lond. Path. Soc., iv. p. 28.
Browne.	London Lancet, 1875, i. p. 196.
Spanton.	London Lancet, 1875, i. p. 609.
Hernpath.	London Lancet, 1848, ii. p. 72.

Russell.	British Med. Journal, 1868, ii. p. 611.
Harkass.	British Med. Journal, 1868, i. p. 426.
Weber.	British Med. Journal, 1877, i. p. 13.
Wilks.	Med. Times and Gaz., 1863, i. p. 214.
Brown-Séguard.	Med. Times and Gaz., 1863, i. p. 213.
Brown-Séguard.	Med. Times and Gaz., 1862, i. p. 429.
Henrich.	Bull. Soc. Anat., 1874, p. 35.
Senac.	Bull. Soc. Anat., 1850, p. 208.
Desnos.	L'Union Méd., 1873, xv. p. 435.
Paris.	Journal de la Physiologie, 1860, p. 717.
Fenwick.	Canada Med. and Surg. Journal, 1876, iv. p. 121.
Lemaire.	Bull. Soc. Anat., 1863. xxxviii. p. 281.

It is probable in the majority of cases in which no mention is made of the temperature, no marked deviation from normal existed. The only conclusion which it seems to me can be drawn is that further and closer observation is needed before we can come to any positive conclusion as to the location of the heat-controlling centre in man, but that its probable situation is in the pons.

CHAPTER III.

THE THERMIC PHENOMENA OF FEVER.

In the present chapter the chief object of research is the determination of whether the rise of temperature in fever is due to an increased production of heat, or whether it is owing simply to retention of heat? Of course, the problem is a very old one, although not as yet settled. In the various attempts to work it out various methods have been used. These methods may all be classed as either deductive or directly experimental. The deductive attempts have consisted in calculating from the amount of food and tissue-waste in health and fever, the amount of heat which is generated. It is plain that this is more demonstrative than *a priori* reasoning, but it is not as convincing as direct experimentation. Later on, the subject may be considered from this point of view, but at present I shall examine solely the experimental evidence at hand.

The evidence hitherto brought forward consists of experiments made upon man and upon animals. The two most important studies upon man are those of Prof. Liebermeister (*Beobachtungen und Versuche über die anwendung des Kalten Wassers bei Fieberhaften Krankheiten*, Leipzig, 1868) and of E. Leyden (*Deutsches Archiv*, Bd. III.).

Liebermeister's plan consisted in comparing the effects produced by normal and feverish individuals in raising the temperature of cold baths of known quantity and temperature. Several difficulties are in the way of this method; some of these Prof. Liebermeister perceived and overcame more or less completely. It was found that the body cools down very unequally in the bath, the limbs falling much more rapidly than the trunk. This source of error was, to some extent, done away with by beginning the data for the subsequent calculation, after the patient had already been some time in the bath; *i. e.*, after the extremities had already been, in great part cooled. Prof. Liebermeister considers the specific heat of the body at 0.83, which is perhaps a little high; but, in relative experiments, error from such source must in great part disappear. Allowance in all of the experiments was made for the spontaneous cooling of the bath in a way which appears perfectly fair; the basis of this allowance was obtained by permitting, after the removal of the body, the bath to cool for a period of time equal to that during which the body had been in it.

Liebermeister made fourteen experiments upon fever cases, and compared the results with those obtained by König upon healthy men. The conclusion arrived at is,—that when baths of the same temperature are employed, “without exception, the loss of heat in the fever patient is greater than in the well person.”

This evidence is very important, but there is one underlying possible fallacy which prevents it from being considered conclusive. According to Liebermeister himself, heat production, both in health and disease, is profoundly affected by the heat

loss. In this way, both in the fevered and in the healthy individual, the cold bath greatly stimulates heat production.

Now it is plainly to be expected that the degree of this stimulation will be in direct proportion to the difference between the temperature of the animal or man and the external cold. The bath of uniform temperature, such as was used by Liebermeister, is not uniform in its relations to the fevered and non-fevered man. Take for example, a bath of 90°; to the normal individual it is a tepid bath only 8°·5 lower than his own temperature, to the patient with a temperature of 106° it is a cool bath 16° below his own temperature. Important, then, as the research of Liebermeister is, the most that can be fairly claimed for it is that it indicates increased heat production as present in fever.

Leyden's experiments were upon a very different plan. He encased a limb of a patient in a calorimeter, similar in its general idea to that employed in the present research by myself, but of course entirely different in the plan of its construction (*Deutsche Archiv*, Bd. III. p. 282). The details of these experiments, and of the form and construction of the calorimeter, may be found in the paper quoted (or in English, in Dr. Burdon Sanderson's article "On the Process of Fever," *Reports of the Medical Officer of the Privy Council*, No. VI., 1875). I shall not recite them.

Prof. Leyden, in his first series of experiments with the legs naked (*op. cit.*, p. 288), found in three healthy men the average heat dissipation of the limb per hour was 0.165 French units; in four fever observations (three cases) it was 0.319. Moreover, in two of the fever patients, comparative studies were made: thus, in No. 4, when the bodily temperature was 40°·2 C. the hourly heat discharge was 0.33; when the bodily temperature was 39°·8 C., the hourly heat discharge was 0.245; in No. 6, when the bodily temperature was 39°·8 C., the hourly heat discharge was 30; when the bodily temperature was 36°·7 C., the hourly heat discharge was 0.14. A series of observations was made upon a case of relapsing fever. The more important of these observations are tabulated in the following table; in the preparation of which I have used the tabulated résumé prepared by Burdon Sanderson:—

CASE I—RELAPSING FEVER.

No.	DATE.	INCREMENT OF TEMPERATURE IN CALORIMETER.				REMARKS.
		TEMP. OF WARD. (Cent.)	TEMP. OF PATIENT. (Cent.)	PULSE.	TEMPERATURE IN CALORIMETER. (Cent.)	
1	Oct. 22	18°·6	40°·2	108	0°·21	Extremities undressed. Weight 150 pounds.
2	Oct. 23	18.1	37.1	76	0.18	Moderate amount of sweat under hose.
3	Oct. 24	18.3	37.3	76	0.20	Distinct sweat under hose.
4	Oct. 25	17.75	37.2	72	0.14	Damp under hose.
5	Oct. 26	18.4	37.1	60	0.1	
6	{ Nov. 2 morning }	19.35	39	88	0.155	
7	{ Nov. 2 afternoon }	19.5	40.2	96	0.201	
8	Nov. 3	18.5	39.2	88	0.14	
9	Nov. 4	18.75	37.9	92	0.21	Much sweat, bodily temperature during operation fell to 37° C.
10	{ Nov. 5 11:30-12:30 }	18.25	39.9	104	0.11	A decided chill during this observation.
11	{ Nov. 5 1-1:30 }	18.25	39.8	...	0.12	
12	Nov. 6	18	37.2	76	0.14	
13	Nov. 7	18.1	36.7	60	0.1	

CASE II.—RELAPSING FEVER.

No.	DATE	TEMP. OF WARD. (Cent.)	TEMP. OF PATIENT. (Cent.)	PULSE.	INCREMENT OF TEMPERATURE IN CALORIMETER. (Cent.)	REMARKS.
			39°·8	108	0°·16	Male, <i>æt.</i> 18, weight 101 pounds. The numbers bracketed relate to a period of observation of 5 hours, during which the bodily temperature was gradually sinking. The patient was sweating the whole time; most profusely during the middle hour, when the surface loss was greatest.
			36·7	88	0·19	
1	Nov. 14	20°·5	.....	...	0·24	
		(mean)	37·2	64	0·16	
			37	...	0·15	
2	Nov. 15	20·5	36·8	64	0·075	Observations 2 to 6 were made on different days during the <i>non-febrile</i> intervals. Each observation lasted 2 hours, of which the mean result is given in each case.
3	Nov. 16	20·3	36·5	68	0·20	
4	Nov. 17	20·5	36·5	64	0·06	
5	Nov. 18	20	36·5	68	0·1	
6	Nov. 19	20	36·5	68	0·1	
7	Nov. 20	19·6	40·6	106	0·145		Observations 7 and 8 were made at 11 A. M. and 6 P. M. of the first day of the relapse. Excessive thirst, very dry skin.
8	Nov. 21	19·4	40·4	108	0·145	
9	Nov. 22	19·4	39	110	0·142	Observation 9 was continued for four hours, viz. from noon to 4 P. M. During the whole time the skin was hot and dry.
10	Nov. 23	.....	40·5	...	0·1	Observation 10 lasted 2 hours, skin being hot and dry.
11	Nov. 23	.....	.....	...	...	Observation lasted 5:45 to 7:45 P. M. Sweating came on during it, and continued all the evening.
12	Nov. 23	.....	.....	...	...	Taken at 8:15 P. M.

CASE III.—RELAPSING FEVER.

No.	DATE	TEMP. OF WARD. (Cent.)	TEMP. OF PATIENT. (Cent.)	PULSE.	INCREMENT OF TEMPERATURE IN CALORIMETER. (Cent.)	REMARKS.
1	Oct. 29	18°·8	40°	120	0°·19	Male, weight 96 pounds.
2	Oct. 29	18·1	40·5	124	0·14	Observations 2 and 3 followed at intervals of half an hour, during which a rigor occurred.
3	Oct. 29	18·1	.....	...	0·18	
4	Oct. 30	18·5	40·3	124	0·15	Observations 5 and 6 were made during the relapse at 12:5 and 1:45 P. M. of the same day. During observation 5, patient had had a rigor, and the skin was hot and dry. At 1:15 P. M. sweating came on and continued during the period of observation.
5	Oct. 31	19·7	41·4	120	0·13	
6	Oct. 31	19·8	39·5	...	0·2	
7	Oct. 31	19·9	36·1	80	0·06	Observation 7 was made at 5:35 P. M. of the same day.
8	Nov. 8	17·5	37·3	80	0·105	Observation 8 at mid-day, when convalescence was established.

CASE IV.—PNEUMONIA.

No.	DATE	TEMP. OF WARD. (Cent.)	TEMP. OF PATIENT. (Cent.)	PULSE.	INCREMENT OF TEMPERATURE IN CALORIMETER. (Cent.)	REMARKS.
1	Jan. 7	18°·8	40°	100	0°·192	Male, <i>æt.</i> 19, weight 101 pounds. Observation 1 made at mid-day; skin moist.
2	Jan. 8	18·8	39·2-37·2	92-76	0·26	Observation 2 made at 6:30 P. M., general perspiration.
3	Jan. 11	18·6	37·1	...	0·105	Convalescence.

CASE V.—PNEUMONIA.

No.	DATE.	TEMP. OF WARD. (Cent.)	TEMP. OF PATIENT. (Cent.)	PULSE.	INCREMENT OF		REMARKS.
					TEMPERATURE IN CALORIMETER. (Cent.)		
1	Jan. 11	19 ^o .5	39 ^o .7-40 ^o .5	100	0 ^o .14		Male, æt. 30, weight 130 pounds.
2	Jan. 12	19.9	40.3	100	0.175		
3	Jan. 13	19.5	39.3-38.4	100	0.225		
	Jan. 14	19.5	40.2	108	0.23		
	Jan. 20	17	normal	normal	0.11		

The conclusions drawn by Leyden from his experiments are: The dissipation of heat is increased in fever, both when the bodily temperature is constant, when it is increasing, and when it is diminishing; consequently there is without doubt increased heat production in fever. In the highest fever the rate of giving off of heat is almost double the normal standard. Heat dissipation reaches its maximum in critical periods when the temperature is rapidly falling; under these circumstances it may be three times as rapid as normal. This rapid critical dissipation occurs with profuse sweating, whilst in fever with rising temperature there is no perceptible production of water even under an impermeable cloth. (Während bei ansteigendem Fieber überhaupt keine Wasser Production selbst unter einer imperspirabeln Decke nachweisbar ist.) In epicritical states the heat dissipation sinks below normal.

Prof. Sanderson objects to these conclusions of Leyden. I quote from him *in extenso* (p. 56).

"The careful study of Professor Leyden's results has led me to an interpretation which differs materially from that which he has embodied in his main conclusion. He admits, throughout, the great importance of visible perspiration, *i. e.*, of the secretion of watery fluid by the sweat glands as a condition favoring the discharge of heat from the skin. He points out that in all those of his experiments in which the heating of the calorimetric water was most rapid, the result could be connected with rapid cooling of the accessible parts of the body, and with profuse sweating. But he finds there were cases in which, notwithstanding the dryness of the skin, the fevered body parted with its heat to the calorimeter with a rapidity which could not possibly be accounted for as the mere result of the greater heat of the surface. In looking through the cases I am unable to find a single instance in which, the state of the skin being noted, it was found that, in the absence of perspiration, the loss from the surface was considerably in excess. This being so I am compelled to associate increased discharge from the surface not with pyrexia, but with sweating, for while on the one hand I find instances in which the patient was in high fever, with only an average of heat loss, I find in the same patient on another day a very active discharge of heat from the surface, but no fever.

"In so far as can be shown that the increased rate at which the fever patient's heat was communicated from the limb to the calorimeter in which it was inclosed is dependent on sweating, the result is of little value or significance as an index of increased production of heat in the living tissues. Under the condition of the experiment, *i. e.*, when a limb is inclosed in an air-tight chamber, the air which occupies the space between the cutaneous surface and that of the chamber soon becomes saturated with moisture. As soon as this state of things is established there is no further loss of heat by the conversion of sweat into vapor; the effect of sweating therefore resolves itself into the mere abstraction of the limb to a certain quantity of watery liquid of which the whole of the heat goes into the calorimeter. So far as the body of the patient is concerned, the process is attended with the loss of a certain quantity of water, and manifests itself in a corresponding loss of weight, but so far as relates to the chemical processes by which heat is produced, it fails to afford any information. If for every gramme of water sweated out at the surface, it were the law of the animal economy that an equal quantity of cold water should be ingested, then it might be said with truth

that for every gramme discharged a quantity must be generated in the body sufficient to warm a gramme of water from the ordinary temperature to that of the blood. So far from this being the case, the loss of water is, as a rule, supplied in the diet of fever by liquid, of which the temperature is as high as, or higher than, that which it has to acquire in order to be discharged, in which case it is obvious that the water, as it actually leaves the body cooler than it entered it, must (in so far as it has any appreciable action on the temperature of the body) tend rather to favor the accumulation of heat than to promote its discharge."

I have given this long extract because I am not able to fully see the force of the objection urged by Dr. Sanderson, and do not wish to misrepresent him. The question is simply whether more heat is or is not given off during fever. It makes no difference how the heat is taken out of the body. If it goes from the body in any way at all, it is dissipated—which is the sum of the whole matter. Further, it is well known that cold and not hot drinks are generally used in fever. The amount of heat carried into the system even by hot drinks is proportionally trifling, and I conceive that Dr. Sanderson's idea of the amount of heat carried out by water which escapes vaporization is an exaggeration. Moreover Dr. Leyden very positively asserts that there was increased dissipation in fever cases when there was no transpiration and when there was ascending temperature.

A more plausible objection to Dr. Leyden's method is that it is perfectly conceivable that in fever such alterations of circulation may occur as to change the relation between the limbs and the trunk in regard to the dissipation of heat.

It might also be urged that the experiments were all in the daytime, and that it may be the dissipation of heat is diminished at night. It is difficult to determine how much of force there is in these objections. It does certainly seem a fair conclusion that the investigations of Liebermeister and Leyden, whilst not actually demonstrative, in their accordance corroborate very strongly the theory which teaches that in fever the rate of heat production is beyond its norm.

Prof. Senator has made a very elaborate study in regard to febrile thermogenesis in dogs (*Untersuchungen über die Fieberhaften Process und seine Behandlung*, Berlin, 1873). His experiments were made with a calorimeter similar in its general idea to that employed by myself. The dog to be used was, previous to the experiment, kept fed regularly once a day with a determinate amount of food. From eighteen to twenty-six hours after the last meal he was placed in the calorimeter for a period of from one to four hours. Upon this observation was based the calculation of heat dissipation for the "first hunger day." Twenty-four hours later, no food having been given, an observation was taken for the "second hunger day." After fever had been produced by septic injections, a parallel series of observations was performed, sometimes for two, sometimes for three days. The results of these experiments are summed up in the following table, which I have modified from the article of Prof. Sanderson. It will be noticed that in this table, under the head of "first day," are comprised the "first hunger day" (normal), and the "first fever day" (fever); under that of second day, the "second hunger day" (normal), and the "second fever day" (fever).

OBSERVATION 1.—Weight of animal 11 pounds 10 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	{ Normal.	39 ^o .0	13.32	12:58 P. M.—1:58 P. M	
	{ Fever.	39.3	12.46	12:55	1:55
2d day	{ Normal.	39.0	11.50	12:25	1:25
	{ Fever.	40.3	11.58	12:43	1:43

OBSERVATION 2.—Weight 16 pounds 4 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	{ Normal.	39 ^o .1	15.67	12:7 P. M.—1:7 P. M.	
	{ Fever.	39.4	15.29	12:29	1:29
2d day	{ Normal.	39.1	17.32	12:23	1:23
	{ Fever.	40.3	15.57	12:39	1:39

OBSERVATION 3.—Weight 16 pounds.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	{ Normal.	39 ^o .0	12.64	12:26 P. M.—1:26 P. M.	
	{ Fever.	39.6	9.91	1:5	2:5
2d day	{ Normal.	38.8	11.87	12:36	1:36
	{ Fever.	40.7	14.52	12:25	1:25
3d day	Fever.	40.7	11.87	12:30	1:30

OBSERVATION 4.—Weight 10 pounds 10 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	{ Normal.	39 ^o .3	8.67	12:37 P. M.—1:37 P. M.	
	{ Fever.	39.5	9.52	12:57	1:51
2d day	{ Normal.	39.3	10.24	12:24	1:24
	{ Fever.	40.7	11.86	12:34	1:34
3d day	Fever.	39.6	9.43	12:37	1:37

OBSERVATION 5.—Weight 9 pounds 9 oz.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	{ Normal.	38 ^o .9	12.31	10:2 A. M.—	
	{ Fever.	39.7-40.3	11.97	10:25	2:25 P. M.
2d day	{ Normal.	38.9	12.67	9:40	1:40
	{ Fever.	41.0	15.22	10:6	2:6

OBSERVATION 6.—Weight 24 pounds.

		RECT. TEMP. (Cent.)	HEAT PRODUCTION. (French units.)	TIME OF OBSERVATION.	
1st day	{ Normal.	39 ^o .0	24.18	11:31 A. M.—1:31 P. M.	
	{ Fever.	39.2	25.40	10:55	1:55
2d day	{ Normal.	39.0	24.48	11:31	2:31
	{ Fever.	40.0	23.59	11:39	2:39

OBSERVATION 7.—Weight 12 pounds 9 oz.

		RECT. TEMP.				HEAT PRODUCTION.				TIME OF OBSERVATION.			
		Morn.		Aftern.		Morn.		Aftern.		Morning.		Evening.	
		(Cent.)	(Cent.)	(Fr. U.)	(Fr. U.)	(Fr. U.)	(Fr. U.)	(Fr. U.)	(Fr. U.)				
1st day	{ Normal.	38 ^o .8	38 ^o .8	15.94	16.20	10:2	A. M.—1:2	P. M.—5:16	P. M.—6:16	P. M.			
	{ Fever.	38.7	40.7	15.34	17.44	10:11	1:11	4:50	5:50				
2d day	{ Normal.	38.8	38.6	16.47	17.06	10:15	1:15	5:20	6:20				
	{ Fever.	40.0	40.0	15.48	19.50	10:27	1:27	4:42	5:52				
3d day	Fever.	40.4	39.9	17.41	15.57	11:54	1:54	4:31	5:31				

The conclusions which Senator draws from his own experiments, and the investigations of Liebermeister and Leyden are: that the dissipation of heat is during the chill of early fever lessened, not increased; but that it is increased during the height of the fever, sometimes as much as 70-75 per cent., and still more at the critical febrile decline.

I think a close study of the table, just given, will hardly bear out this conclusion as being fairly derivable from it. I shall not, however, discuss this in detail, because the method of experimentation of Senator seems to me open to such fallacies as to rob it of much of its authoritativeness. The rhythm of animal thermometry, especially in septic disease, indicates a corresponding rhythm in heat production. Now, it is most probable, that in septic fever this rhythm is very different from what it is in the normal state. Hence, comparisons of the fever and normal heat product, made over an hour or so in the twenty-four hours, must yield doubtful results. The comparison should be made for the whole day. For this and other reasons, which it is not necessary to discuss in detail, it has seemed to me that the experiments of Senator are an insufficient basis for answering the question as to heat production in fever.

For the purpose, if possible, of finally solving this first problem in the nature of fever, the following experiments were undertaken:—

EXPERIMENT 110.

A male adult cur. Weight 17.5 pounds.

August 2.

1:15 p. m.—Ate one pound of raw liver, lungs, and heart of sheep.

Time.	Air TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	Wt. of Feces
2:35 p. m.	76.64	79.88	77.24	1088.793	21.5867	3.2613	78.4195	1.0000
2:50	76.54	80.33						
3:5	76.44	80.33						
3:20	76.34	81.05						
3:35	76.34	80.72						
3:50	76.28	81.32						
4:5	76.15	82.64						
4:20	76.28	82.76						
4:35	76.15	82.16						
4:50	76.15	81.86						
5:15	76.05	82.4						
5:30	76.05	82.9						
5:45	76.05	82.83						
6	75.92	82.64						
6:15	75.83	82.98						
6:30	75.83	83.05						
6:45	75.83	83.4						
7	75.73	83.64						
7:15	75.73	83.48						
7:30	75.32	82.98	82.4	1413.085	21.867	3.509	78.5825	1.0000
	76.08	82.16	5.16	324.292	0.2803	0.2477	0.163	0.0000
	(mean)	76.08	(gain)	0.2803			(gain)	
		6.08		324.5723				
		(gain)						

7:35 p. m.—Rectal temperature 39° C. (102.2 F.).

August 2 and 3.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
8:57 P. M.	77° 9	81° 9	80°	517.311	21.869	3.505	78.5825	134.2315
9:12	77.36	82.16						
9:27	77.54	82.04						
9:42	77.36	82.16						
9:57	77.9	82.04						
10:12	77.36	81.68						
10:27	77.18	82.62						
10:42	76.64	82.16						
10:57	77.36	81.86						
11:12	77.45	82.62						
11:27	77.45	82.62						
11:42	77.54	83.12						
11:57	77.42	82.98						
12:12 A. M.	77.45	83.96						
12:27	77.45	83.57						
12:42	77.45	83.05						
12:57	77	83.24						
1:12	77.09	83.24						
1:27	77.36	82.98						
1:42	77.45	83.05						
1:57	77.36	82.98	82.4	1041.725	22.188	3.7005	78.731	134.3448
	77.38	82.67	2.4	524.414	0.319	0.1955	0.1485	0.1133
	(mean)	77.38	(gain)	0.319			(gain)	(gain)
				524.733				
				5.29				
				(gain)				

August 3.

1:57 A. M.—Rectal temperature 39° 13 C. (102° 43 F.).

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
3:30 A. M.	77° 45	81° 05	80° 6	81.828	22.1883	103.7033	78.731	134.3448
3:45	77.27	81.05						
4	77.09	80.72						
4:15	75.55	80.72						
4:30	76.04	80.51						
4:45	75.92	80.24						
5	75.11	80.12						
5:15	75.29	80						
5:30	75.47	84.42						
5:45	75.29	80.33						
6	75.83	81.05						
6:15	76.37	80.72						
6:30	76.55	80.72						
6:45	76.55	81.68						
7	76.64	81.59						
7:15	75.97	81.01						
7:30	76.04	81.05						
7:45	76.28	82.16						
8	76.28	82.76						
8:15	76.28	82.98						
8:30	76.04	83.05	82.04	410.085	22.3395	103.8605	78.7948	134.4352
	76.15	81.33	1.44	328.257	0.1512	0.1572	0.0638	0.0904
	(mean)	76.15	(gain)	0.1512			(gain)	(gain)
				328.4082				
				5.18				
				(gain)				

8:30 A. M.—Rectal temperature 39° 38 C. (102° 89 F.).

9:30 A. M.—Dog ate one-quarter of a pound of raw liver. Received no further food, but allowed to stay out of box until evening.

August 3.

6:16 p. m.—Barometer 29.9. Rectal temperature 40°.12 C. (104°.2 F.).

Time	Air Temp. (Fah.)	Temp. (Fah.)	Box Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	Air Meter. (cub. ft.)	SAMPLE COLUMBIMETER. (cub. ft.)	Air COLUMBIMETER. (cub. ft.)
6:16 p. m.	82°	82°.64	79°.94	493.185	22.3328	3.8573	150.4602	134.3643
6:31	81.59	82.52						
6:46	81.32	82.04						
7:01	80.69	82.68						
7:16	80.36	81.59						
7:31	80.36	81.59						
7:46	80.36	81.68						
8:01	80.12	81.68						
8:15	79.43	81.59						
8:30	79.43	82.16						
8:45	78.8	81.95						
9:00	79.25	81.95						
9:15	77.99	82.04						
9:30	78.32	81.68						
9:45	77.63	81.77						
10:00	77.18	81.77						
10:15	76.76	81.5						
11:30	76.35	81.41						
11:45	76.37	81.32						
11:00	76.28	81.77						
11:16	77.45	81.86	81.95	864.335	22.6127	4.0523	150.3315	134.3647
	78.95	81.86	2.01	371.15	0.2799	0.195	0.1713	0.2799
	(mean)	78.95	(gain)	0.2799			(gain)	(gain)
		2.91		371.4299				
		(gain)						

11:16 p. m.—Barometer 29.9. Rectal temperature 39°.5 C. (103°.1 F.).

August 4.

Time	Air Temp. (Fah.)	Temp. (Fah.)	Box Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	Air Meter. (cub. ft.)	SAMPLE COLUMBIMETER. (cub. ft.)	Air COLUMBIMETER. (cub. ft.)
12:10 a. m.	78°.20	81°.59	80°.51	912.46	22.6132	4.0545	150.3315	134.3647
12:25	77.72	81.59						
12:40	77.18	81.41						
12:55	77.81	81.41						
1:10	77.9	81.68						
1:25	78.32	81.68						
1:40	78.08	81.68						
1:55	77.99	81.59						
2:10	77.45	81.41						
2:25	77.45	81.5						
2:55	77.09	81.5						
3:10	76.55	81.41						
3:40	76.2	81.05						
3:55	75.44	81.23						
4:10	75.32	81.04						
4:25	75.2	80.96						
4:40	75.2	81.05						
4:55	74.6	80.72						
5:10	73.94	80	81.59	1291.545	22.7407	4.0582	150.3315	134.3648
	76.72	81.29	1.08	379.085	0.1275	0.2837	0.0000	0.2837
	(mean)	76.72	(gain)	0.1275			(gain)	(gain)
		4.57		379.2125				
		(gain)						

5:10 a. m.—Barometer 29.9. Rectal temperature 39°.5 C. (103°.1 F.).

August 4.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
6:23 A. M.	74 ^o .6	79 ^o .43	79 ^o .61	360.045	22.7407	104.3382	150.3554	134.6288
6:38	74.12	79.52						
6:53	73.85	79.16						
7:8	73.1	79.04						
7:23	73.4	79.64						
7:38	73.85	80.51						
7:53	73.64	80.6						
8:8	74.94	80.72						
8:23	74.3	81.23						
8:38	74.3	81.23						
8:53	74.39	81.41						
9:8	74.12	81.41						
9:23	74.03	81.41						
9:38	74.3	81.59						
9:53	74.5	80.96						
10:8	74.39	81.05						
10:23	74.6	82.04						
10:38	74.6	80.84						
10:53	74.72	79.48						
11:8	74.6	78.53						
11:23	74.88	80	81.41	733.035	22.9434	104.5807	150.4543	134.7362
	74.23	80.47	1.8	372.99	0.2027	0.2425	0.0989	0.1074
	(mean)	74.23	(gain)	0.2027			(gain)	(gain)
		6.24		373.1927				
		(gain)						

11:23 A. M.—Barometer 29.95. Rectal temperature 39° C. (102° 2 F.)

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
1:30 P. M.	76 ^o .73	78 ^o .53	77 ^o .52	796.22	22.9438	104.5815	150.4543	134.7362
1:45	76.55	78.53						
2	76.55	78.8						
2:15	77.	79.16						
2:30	77.36	79.43						
2:45	77.54	79.43						
3	77.54	79.43						
3:15	77.45	79.64						
3:30	77.90	80.	78.56	944.96	23.1158	104.7018	150.5445	134.7868
	77.18	79.22	1.04	148.74	0.172	0.1203	0.0902	0.0506
	(mean)	77.18	(gain)	0.172			(gain)	(gain)
		2.04		148.912				
		(gain)						

3:30 P. M.—Barometer 30. Rectal temperature 39° C. (102° 2 F.).

August 6.

1:37 p. m.—Barometer 30 Rectal temperature 39° C. (102.2 F.).

Time	Air TEMP. (Fah.)	TEMP. TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	WATER
1:37 p.m.	78.72	79.04	77.9	34.197	23.1051	104.7075	150.5472	1.34
1:52	78.8	80.33						
2:7	79.24	80.24						
2:22	79.93	80.96						
3:37	79.84	81.05						
2:52	80.68	81.8						
3:7	80.6	82.57						
3:22	81.45	81.68						
3:37	81.64	80.51						
3:52	79.45	81.68						
4:7	80.88	82.52						
4:22	80.88	82.92						
4:37	80.6	82.76						
4:52	80.6	83.24						
5:7	80.6	83.75						
5:22	80.6	83.75						
5:37	80.57	83.65						
5:52	80.51	83.48						
6:7	80.6	83.05						
6:22	80.69	83.2						
6:37	80.69	83.05	81.77	370.427	23.4053	105.063	150.7518	1.34
	80.37 (mean)	82.14 80.37	3.87 (gain)	336.23 0.3002	0.3002	0.3555	0.2046 (gain)	0.002
		1.77 (gain)		336.5302				

6:37 p. m.—Barometer 29.9. Rectal temperature 40° C. (104° F.).

August 6 and 7.

8:9 p. m.—Barometer 29.9. Rectal temperature 40° C. (104° F.).

Time	Air TEMP. (Fah.)	TEMP. TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	WATER
8:9 p.m.	80.48	81.79	79.52	427.65	23.4053	105.0645	150.7518	1.34
8:24	79.88	81.32						
8:39	79.52	80.96						
8:54	79.25	81.68						
9:9	78.92	81.59						
9:24	78.56	82.04						
9:39	78.44	82.77						
9:54	77.99	81.59						
10:9	77.9	81.41						
10:24	77.72	79.88						
10:39	77.54	81.68						
10:54	77.09	81.5						
11:9	76.64	81.77						
11:24	77.27	81.77						
11:39	77.18	81.77						
11:54	76.55	81.68						
12:9 a. m.	76.16	81.59						
12:24	76.16	81.41						
12:39	76.04	81.68						
12:54	75.92	81.59						
1:9	75.92	81.59	81.72	766.782	23.6728	105.3185	150.8641	1.34
	77.67 (mean)	81.57 77.67	2.2 (gain)	339.132 0.2675	0.2675	0.254	0.1123 (gain)	0.002
		3.9 (gain)		339.3995				

1:9 a. m.—Barometer 29.9. Rectal temperature 40°.37 C. (104°.67 F.).

August 7.

2:58 p. m.—Barometer 29.9. Rectal temperature 40°.37 C. (104°.67 F.).

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
2:58 P. M.	76°.01	81°.23	80°.55	825.125	23.6728	105.3185	150.8641	135.04
3:13	75.92	80.96						
3:28	75.56	80.84						
3:43	75.2	80.84						
3:58	74.72	81.05						
4:13	74.6	80.84						
4:28	74.21	82.32						
4:43	74.3	80.96						
4:58	73.88	80.84						
5:13	73.88	80.6						
5:28	74.3	80.84						
5:43	74.3	80.96						
5:58	74.6	81.05						
6:13	74.72	81.32						
6:28	74.6	81.23						
6:43	74.6	80.96						
7:13	74.48	81.05						
7:28	75.65	81.14						
7:43	75.44	80.96						
7:58	75.83	81.5	81.71	1241.543	23.8268	105.4373	150.9462	135.0875
	74.89	81.07	1.16	416.418	0.154	0.1188	0.0821	0.0475
	(mean)	74.89	(gain)	0.154			(gain)	(gain)
		6.18		416.572				
		(gain)						

7:58 p. m.—Barometer 29.89. Rectal temperature 40° C. (104° F.).

6:27 p. m.—Barometer 29.8. Rectal temperature 41°.125 C. (106°.02 F.).

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
6:27 P. M.	80°.48	81°.54	78°.845	379.913	23.8248	105.434	126.4666	110.394
6:42	80.48	81.14						
6:57	80.24	81.05						
7:12	80.	80.96						
7:27	80.12	81.05						
7:42	79.04	81.77						
7:57	78.92	82.16						
8:12	78.80	82.90						
8:27	78.68	82.91						
8:57	78.44	82.64						
9:12	77.9	82.52						
9:27	77.9	82.98						
9:42	78.08	83.36						
9:57	77.9	83.05						
10:12	77.81	83.12						
10:27	77.72	83.12						
10:42	77.45	83.36						
10:57	77.9	83.24						
11:12	77.98	83.36						
11:27	77.54	83.36	82.88	708.518	24.031	105.5903	126.5968	110.9652
	78.66	82.48	4.035	328.605	0.2062	0.1563	0.1302	0.0742
	(mean)	78.66	(gain)	0.2062			(gain)	(gain)
		3.82		328.8112				
		(gain)						

11:27 p. m.—Barometer 29.82. Rectal temperature 41° C. (105°.8 F.).

August 8.

1:4 A. M.—Barometer 28.82. Rectal temperature 41°.625 C. (106°.92 F.).

Time.	Air TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE COLUMEN (cub. ft.)	AIR COLUMEN (cub. ft.)
1:4 A. M.	79°.64	82°.28	79°.88	754.086	24.0307	105.5913	126.8808	111.6884
1:19	78.56	81.59						
1:40	77.36	81.68						
1:49	77.09	81.5						
2:4	77.18	81.68						
2:19	7.36	81.68						
2:34	77.63	82.16						
2:49	77.81	82.52						
3:4	77.72	82.16						
3:19	77.36	82.4						
3:34	77.45	82.76						
3:49	77.45	82.4						
4:4	77.36	82.52						
4:19	77.27	82.16						
4:34	76.76	82.04						
4:49	77.18	81.59						
5:4	77.18	81.68						
5:19	76.88	81.86						
5:34	77.	82.28						
5:49	76.37	82.16						
6:4	75.56	82.04	82.16	1059.62	24.1681	105.7322	126.8821	111.47
	77.34 (mean)	82.06 77.34	2.28 (gain)	305.534 0.1374	0.1374	0.1409	0.0004 (mean)	0.0004 (mean)
		4.72 (gain)		305.6714				

6:4 P. M.—Barometer 29.92. Rectal temperature 40° C. (104° F.).

7:42 P. M.—Rectal temperature 40°.5 C. (104°.9 F.).

Time.	Air TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE COLUMEN (cub. ft.)	AIR COLUMEN (cub. ft.)
7:42 A. M.	77°.99	80°.24	79°.52	1102.809	24.1694	105.7308	126.8824	111.47
8:12	78.2	80.51						
8:27	78.2	80.6						
8:42	78.56	80.84						
8:57	78.92	80.6						
9:12	79.16	80.96						
9:27	79.25	81.14						
9:42	79.52	81.23						
9:57	79.88	81.05						
10:12	80.36	81.23						
10:27	80.36	81.5						
10:32	80.24	81.5						
10:47	80.6	81.5						
11:2	80.6	81.5						
11:17	80.69	81.5						
11:37	81.41	81.68						
11:52	81.08	81.68						
12:7 P. M.	80.96	81.59						
12:22	81.08	81.68						
12:38	81.2	81.95						
12:42	.....	.....	81.555	1418.082	24.5001	106.0573	126.8885	111.7884
	79.84 (mean)	81.19 79.84	2.035 (gain)	315.273 0.3307	0.3307	0.3265	0.0004 (mean)	0.0004 (mean)
		1.35 (gain)		315.6037				

12:42 P. M.—Rectal temperature 40°.5 C. (104°.9 F.).

Heat Dissipation.

First Period—

Quantity of air (V') = 324.5723 at $82^{\circ}.16 - 32^{\circ} = 50.16 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{324.5723}{1.102} = 294.5$. $W = V \times 0.08073 = 23.8$

Rise in temp. of air 6.08 = t . $Q = W \times t \times \text{sp. h.} = 23.8 \times 6.08 \times 0.2374 = 34.3527$ heat given to air.

Quotient for box $1157 \times 0.163 = 188.591 =$ moisture leaving box.

Quotient for air $1310 \times 0.1305 = 170.955 =$ moisture entering box.

17.636 = moisture vaporized in box.

$\frac{17.636}{6.2789} = 2.8088 =$ heat expended in vaporization.

Rise in temp. of water $5.16 \times 164.1414 = 846.9696 =$ heat given to calorimeter.

34.3527 = heat given to air.

2.8088 = heat expended in vaporization.

884.1311 = heat dissipated in 5 hours.

Hourly dissipation of heat 176.8262

Second Period—

Quantity of air (V') = 524.733 at $82^{\circ}.67 - 32^{\circ} = 50.67 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{524.733}{1.103} = 475$. $W = V \times 0.08073 = 38.35$

Rise in temp. of air 5.29 = t . $Q = W \times t \times \text{sp. h.} = 38.35 \times 5.29 \times 0.2374 = 48.1617 =$ heat given to air.

Quotient for box $1645 \times 0.1485 = 244.2825 =$ moisture leaving box.

Quotient for air $2684 \times 0.1133 = 304.0972 =$ moisture entering box.

59.8147 = moisture condensed in box.

$\frac{59.8147}{6.2789} = 9.5262 =$ heat gained from condensation.

Rise in temp. of water $2.4 \times 164.1414 = 393.9394 =$ heat given to calorimeter.

48.1617 = heat given to air.

442.1011

9.5262 = heat gained from condensation.

432.5749 = heat dissipated in 5 hours.

Hourly dissipation of heat 86.515

Third Period—

Quantity of air (V') = 328.4082 at $81^{\circ}.33 - 32^{\circ} = 49.33 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{328.4082}{1.1} = 298.5$. $W = V \times 0.08073 = 24.1$

Rise in temp. of air 5.18 = t . $Q = W \times t \times \text{sp. h.} = 24.1 \times 5.18 \times 0.2374 = 29.6365 =$ heat given to air.

Quotient for box $2172 \times 0.0638 = 138.5736 =$ moisture leaving box.

Quotient for air $2089 \times 0.0904 = 188.8456 =$ moisture entering box.

50.272 = moisture condensed in box.

$\frac{50.272}{6.2789} = 8.0065 =$ heat gained from condensation.

Rise in temp. of water $1.44 \times 164.1414 = 236.3636 =$ heat given to calorimeter.

29.6365 = heat given to air.

266.0001

8.0064 = heat gained from condensation.

257.9937 = heat dissipated in 5 hours.

Hourly dissipation of heat 51.5987

*Fourth Period—*Quantity of air (V') = 371.4299 at $81^{\circ}.86 - 32^{\circ} = 49.86 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{371.4299}{1.1} = 337.6. \quad W = V \times 0.08073 = 27.2$$

Rise in temp. of air $2.91 = t$. $Q = W \times t \times \text{sp. h.} = 27.2 \times 2.91 \times 0.2374 = 18.7902 = \text{heat given to air.}$ Quotient for box $1327 \times 0.1713 = 227.3151 = \text{moisture leaving box.}$ Quotient for air $1904.6 \times 0.1204 = 229.3138 = \text{moisture entering box.}$ $1.9987 = \text{moisture condensed in box.}$ $1.9987 = 0.3181 = \text{heat gained from condensation.}$

6.2789

Rise in temp. of water $2.01 \times 164.1414 = 329.9242 = \text{heat given to calorimeter.}$ $18.7902 = \text{heat given to air.}$ 348.7144 $0.3181 = \text{heat gained from condensation.}$ $348.3963 = \text{heat dissipated in 5 hours.}$ *Hourly dissipation of heat* $\frac{348.3963}{5} = 69.6793$ *Fifth Period—*Quantity of air (V') = 379.2125 at $81^{\circ}.29 - 32^{\circ} = 49.29 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{379.2125}{1.1} = 344.5. \quad W = V \times 0.08073 = 27.8$$

Rise in temp. of air $4.57 = t$. $Q = W \times t \times \text{sp. h.} = 27.8 \times 4.57 \times 0.2374 = 30.1607 = \text{heat given to air.}$ Quotient for box $2976.3 \times 0.0239 = 71.1336 = \text{moisture leaving box.}$ Quotient for air $1337.6 \times 0.0741 = 99.1458 = \text{moisture entering box.}$ $28.0122 = \text{moisture condensed in box.}$ $28.0122 = 4.4613 = \text{heat gained from condensation.}$

6.2789

Rise in temp. of water $1.08 \times 164.1414 = 177.2727 = \text{heat given to calorimeter.}$ $30.1607 = \text{heat given to air.}$ 207.4334 $4.4613 = \text{heat gained from condensation.}$ $202.9721 = \text{heat dissipated in 5 hours.}$ *Hourly dissipation of heat* $\frac{202.9721}{5} = 40.5944$ *Sixth Period—*Quantity of air (V') = 373.1927 at $80^{\circ}.47 - 32^{\circ} = 48.47 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{373.1927}{1.099} = 340. \quad W = V \times 0.08073 = 27.4$$

Rise in temp. of air $6.24 = t$. $Q = W \times t \times \text{sp. h.} = 27.4 \times 6.24 \times 0.2374 = 40.5897 = \text{heat given to air.}$ Quotient for box $1841.1 \times 0.0989 = 182.0848 = \text{moisture leaving box.}$ Quotient for air $1216.5 \times 0.1074 = 164.278 = \text{moisture entering box.}$ $17.8068 = \text{moisture vaporized in box.}$ $17.8068 = 2.836 = \text{heat expended in vaporization.}$

6.2789

Rise in temp. of water $1.8 \times 164.1414 = 295.4545 = \text{heat given to calorimeter.}$ $40.5897 = \text{heat given to air.}$ $2.836 = \text{heat expended in vaporization.}$ $338.8802 = \text{heat dissipated in 5 hours.}$ *Hourly dissipation of heat* $\frac{338.8802}{5} = 67.776$ *Seventh Period—*Quantity of air (V') = 148.912 at $79^{\circ}.22 - 32^{\circ} = 47.22 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{148.912}{1.0961} = 135.9. \quad W = V \times 0.08073 = 10.97$$

Rise in temp. of air $2.04 = t$. $Q = W \times t \times \text{sp. h.} = 10.97 \times 2.04 \times 0.2374 = 5.3173 = \text{heat given to air.}$

Quotient for box $865.8 \times 0.0902 = 78.0952 =$ moisture leaving box.

Quotient for air $1237.8 \times 0.0506 = 62.6327 =$ moisture entering box.

$15.4625 =$ moisture vaporized in box.

$\frac{15.4625}{6.2789} = 2.4629 =$ heat expended in vaporization.

Rise in temp. of water $1.04 \times 164.1414 = 170.7071 =$ heat given to calorimeter.

$5.3173 =$ heat given to air.

$2.4629 =$ heat expended in vaporization.

$178.4873 =$ heat dissipated in 2 hours.

Hourly dissipation of heat 89.2437

Eighth Period—

Quantity of air (V') = 336.5302 at $82^{\circ}.14 - 32^{\circ} = 50.14 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{336.5302}{1.102} = 305.4$. $W = V \times 0.08073 = 24.6$

Rise in temp. of air $1.77 = t$. $Q = W \times t \times \text{sp. h.} = 24.6 \times 1.77 \times 0.2374 = 10.3369 =$ heat given to air.

Quotient for box $1121 \times 0.2046 = 229.3566 =$ moisture leaving box.

Quotient for air $949.8 \times 0.1612 = 153.5919 =$ moisture entering box.

$76.7647 =$ moisture vaporized in box.

$\frac{76.7647}{6.2789} = 12.2258 =$ heat expended in vaporization.

Rise in temp. of water $3.87 \times 164.1414 = 635.2272 =$ heat given to water.

$10.3369 =$ heat given to air.

$12.2258 =$ heat expended in vaporization.

$657.7899 =$ dissipation of heat in 5 hours.

Hourly dissipation of heat 131.558

Ninth Period—

Quantity of air (V') = 339.3995 at $81^{\circ}.57 - 32^{\circ} = 49.57 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{339.3995}{1.1} = 308.5$. $W = V \times 0.08073 = 24.9$

Rise in temp. of air $3.9 = t$. $Q = W \times t \times \text{sp. h.} = 24.9 \times 3.9 \times 0.2374 = 23.0539 =$ heat given to air.

Quotient for box $1231.4 \times 0.1123 = 138.2862 =$ moisture leaving box.

Quotient for air $1336.2 \times 0.092 = 122.9302 =$ moisture entering box.

$15.356 =$ moisture vaporized in box.

$\frac{15.356}{6.2789} = 2.4615 =$ heat expended in vaporization.

Rise in temp. of water $2.2 \times 164.1414 = 361.1111 =$ heat given to water.

$23.0539 =$ heat given to air.

$2.4615 =$ heat expended in vaporization.

$386.6265 =$ dissipation of heat in 5 hours.

Hourly dissipation of heat 77.3253

Tenth Period—

Quantity of air (V') = 416.572 at $81^{\circ}.07 - 32^{\circ} = 49.07 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{416.572}{1.1} = 378.7$. $W = V \times 0.08073 = 30.6$

Rise in temp. of air $6.18 = t$. $Q = W \times t \times \text{sp. h.} = 30.6 \times 6.18 \times 0.2374 = 44.8942 =$ heat given to air.

Quotient for box $2705 \times 0.0821 = 222.0805 =$ moisture leaving box.

Quotient for air $3506.5 \times 0.0475 = 166.5588 =$ moisture entering box.

$55.5217 =$ moisture vaporized in box.

$\frac{55.5217}{6.2789} = 8.8426 =$ heat expended in vaporization.

Rise in temp. of water $1.16 \times 164.1414 = 190.404 =$ heat given to water.
 $44.8912 =$ heat given to air.
 $8.8426 =$ heat expended in vaporization.

 $244.1408 =$ dissipation of heat in 5 hours.
Hourly dissipation of heat 48.881

Eleventh Period—

Quantity of air (V') = 328.8112 at $82.48^\circ - 32^\circ = 50.48 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{328.8112}{1.103} = 298.1$. $W = V \times 0.08073 = 24.07$
Rise in temp. of air $3.82 = t$. $Q = W \times t \times \text{sp. h.} = 24.07 \times 3.82 \times 0.2374 = 21.8283 =$ heat given to air.
Quotient for box $1591.6 \times 0.1302 = 207.6169 =$ moisture leaving box.
Quotient for air $2103.1 \times 0.0742 = 156.05 =$ moisture entering box.

 $51.5669 =$ moisture vaporized in box.
 $6.2789 = 8.2127 =$ heat expended in vaporization.
Rise in temp. of water $4.035 \times 164.1414 = 662.3105 =$ heat given to water.
 $21.8283 =$ heat given to air.
 $8.2127 =$ heat expended in vaporization.

 $692.3515 =$ dissipation of heat in 5 hours.
Hourly dissipation of heat 138.4703

Twelfth Period—

Quantity of air (V') = 305.6714 at $82^\circ.06 - 32^\circ = 50.06 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{305.6714}{1.102} = 277.4$. $W = V \times 0.08073 = 22.3$
Rise in temp. of air $4.72 = t$. $Q = W \times t \times \text{sp. h.} = 22.3 \times 4.72 \times 0.2374 = 24.9878 =$ heat given to air.
Quotient for box $2224.7 \times 0.0853 = 189.7669 =$ moisture leaving box.
Quotient for air $2169.4 \times 0.1306 = 283.3236 =$ moisture entering box.

 $93.5567 =$ moisture condensed in box.
 $6.2789 = 14.9 =$ heat gained from condensation.
Rise in temp. of water $2.28 \times 164.1414 = 374.2424 =$ heat given to water.
 $24.9878 =$ heat given to air.

 $399.2302 =$ heat gained from condensation.

 $384.3302 =$ dissipation of heat in 5 hours.
Hourly dissipation of heat 76.866

Thirteenth Period—

Quantity of air (V') = 315.6037 at $81^\circ.19 - 32^\circ = 49.19 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{315.6037}{1.101} = 287$. $W = V \times 0.08073 = 23.3$
Rise in temp. of air $1.35 = t$. $Q = W \times t \times \text{sp. h.} = 23.3 \times 1.35 \times 0.2374 = 7.4674 =$ heat given to air.
Quotient for box $954.3 \times 0.2064 = 196.9675 =$ moisture leaving box.
Quotient for air $966.6 \times 0.0883 = 85.3508 =$ moisture entering box.

 $111.6167 =$ moisture vaporized in box.
 $6.2789 = 17.7769 =$ heat expended in vaporization.
Rise in temp. of water $2.035 \times 164.1414 = 334.0278 =$ heat given to water.
 $7.4674 =$ heat given to air.
 $17.7769 =$ heat expended in vaporization.

 $359.2721 =$ dissipation of heat in 5 hours.
Hourly dissipation of heat 71.8544

Heat Production.

First Period—

No change of bodily temperature.

Heat dissipated hourly = *hourly production of heat* 176.8262

Second Period—

Rise of bodily temperature in 5 hours 0°.1806, in 1 hour 0.036 = t.

$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.036 \times 0.75 = 0.4725 = \text{heat added to reserve.}$
 86.515 = hourly dissipation of heat.
 0.4725 = hourly addition to heat reserve.

Hourly production of heat 86.9875

Third Period—

Rise of bodily temperature in 5 hours 0°.3515, in 1 hour 0.0703 = t.

$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.0703 \times 0.75 = 0.9227 = \text{heat added to reserve.}$
 51.5987 = hourly dissipation of heat.
 0.9227 = hourly addition to heat reserve.

Hourly production of heat 52.5214

Fourth Period—

Fall of bodily temperature in 5 hours 1°.1, in 1 hour 0.22 = t.

$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.22 \times 0.75 = 2.8875 = \text{heat taken from reserve.}$
 69.6793 = hourly dissipation of heat.
 2.8875 = hourly loss from heat reserve.

Hourly production of heat 66.8918

Fifth Period—

No change of bodily temperature.

Heat dissipated hourly = *hourly production of heat* 40.5944

Sixth Period—

Fall of bodily temperature in 5 hours 0°.724, in 1 hour 0.145 = t.

$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.145 \times 0.75 = 1.9031 = \text{heat taken from reserve.}$
 67.776 = hourly dissipation of heat.
 1.9031 = hourly loss from heat reserve.

Hourly production of heat 65.8729

Seventh Period—

No change of bodily temperature.

Heat dissipated hourly = *hourly production of heat* 89.2437

Eighth Period—

Rise of bodily temperature in 5 hours 1°.8, in 1 hour 0.36 = t.

$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.36 \times 0.75 = 4.725 = \text{heat added to reserve.}$
 131.558 = hourly dissipation of heat.
 4.725 = hourly addition to reserve.

Hourly production of heat 136.283

Ninth Period—

Rise of bodily temperature in 5 hours 0°.67, in 1 hour 0.134 = t.

$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.134 \times 0.75 = 1.7588 = \text{heat added to reserve.}$
 77.3253 = hourly dissipation of heat.
 1.7588 = hourly addition to reserve.

Hourly production of heat 79.0841

*Tenth Period—*Fall of bodily temperature in 5 hours $0^{\circ}.67$, in 1 hour $0^{\circ}.134 = t$.

$$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.134 \times 0.75 = 1.7588 = \text{heat taken from reserve.}$$

$$48.8281 = \text{hourly dissipation of heat.}$$

$$1.7588 = \text{heat taken from reserve.}$$

Hourly production of heat 47.0693*Eleventh Period—*Fall of bodily temperature in 5 hours $0^{\circ}.4$, in 1 hour $0^{\circ}.08 = t$.

$$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.08 \times 0.75 = 1.05 = \text{heat taken from reserve.}$$

$$138.4703 = \text{hourly dissipation of heat.}$$

$$1.05 = \text{heat taken from reserve.}$$

Hourly production of heat 137.4203*Twelfth Period—*Fall of bodily temperature in 5 hours $2^{\circ}.92$, in 1 hour $0.584 = t$.

$$Q = W \times t \times \text{sp. h.} = 17.5 \times 0.584 \times 0.75 = 7.665 = \text{heat taken from reserve.}$$

$$76.866 = \text{hourly dissipation of heat.}$$

$$7.665 = \text{heat taken from reserve.}$$

Hourly production of heat 69.201*Thirteenth Period—*

No change of bodily temperature.

Heat dissipated hourly = *hourly production of heat* 71.8544

RECAPITULATION.

DATE.	TIME.	HOURLY HEAT DISSIPATION.	HOURLY HEAT PRODUCTION.	RECT. TEMP. (Fah.)	REMARKS.
First day.	(2:35 P. M. to 7:35 P. M.	176.8262	176.8262	102.2	Ate just before go-
Aug. 2, 2:30 P. M. to	8:57 P. M. to 1:57 A. M.	86.515	86.9875	102.2 to 102.43	ing in, one pound
Aug. 3, 2:30 P. M.	(3:30 A. M. to 8:30 A. M.	51.5987	52.5214	102.43 to 102.89	of raw liver.
Second day.	(6:16 P. M. to 11:16 P. M.	69.6793	66.6627	102.89 to 103.1	Ate at 9:30 A. M.
Aug. 3, 3:30 P. M. to	12:10 A. M. to 5:10 A. M.	40.5944	40.5944	103.1	$\frac{1}{2}$ of lb. of raw
Aug. 4, 3:30 P. M.	(6:23 A. M. to 11:23 A. M.	67.776	65.8729	103.1 to 102.2	liver; no further
	1:30 A. M. to 3:30 P. M.	89.2437	89.2437	102.2	food.
Third day.	(1:37 P. M. to 6:37 P. M.	131.558	136.283	102.2 to 104	
Aug. 6, 1:30 P. M. to	8:9 P. M. to 1:9 A. M.	77.3253	79.0841	104 to 104.67	
Aug. 7, 1:30 P. M.	(2:58 A. M. to 7:58 A. M.	48.8281	47.0693	104.67 to 104	
Fourth day.	(6:27 P. M. to 11:27 P. M.	138.4703	137.4203	106.02 to 105.8	
Aug. 7, 2 P. M. to	1:4 A. M. to 6:4 A. M.	76.866	69.201	106.92 to 104	
Aug. 8, 2 P. M.	(7:42 A. M. to 12:42 P. M.	71.8544	71.8544	104.9	

SUMMARY.

	TIME IN CALORIMETER.	AVERAGE HOURLY HEAT DISSIPATION.	AVERAGE HOURLY HEAT PRODUCTION.	EXTREMES OF RECT. TEMP. (Fah.)	AVERAGE RECT. TEMP.
First day.	15 hours.	104.9799	105.445	102.2 to 103.1	102.56
Second day.	17 hours.	62.8668	61.4198	104.2 to 102.2	103.20
Third day.	15 hours.	85.9028	87.4787	102.2 to 104.67	103.42
Fourth day.	15 hours.	95.7302	92.8252	104 to 106.92	105.42

EXPERIMENT 111.

A long-haired cur. Weight 39 pounds; has had no food since April 8, 6 p. m., when he ate one pound of liver.

April 9.

12:33 p. m.—Rectal temperature 102°.85.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.	REMARKS.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)	
1:20 P. M.	70°	69°85	68°	910.575	27.99	108.5515	65.6517	58.6281	Howling.
1:35	67.37	70.88	.....	.....	.....	.....	.....	.....	Howling.
1:50	68.36	70.43	.....	.....	.....	.....	.....	.....	Howling
2:5	68.36	69.95	.....	.....	.....	.....	.....	.....
2:20	68.52	70.64	.....	.....	.....	.....	.....	.....
2:35	67.28	70.64	.....	.....	.....	.....	.....	.....
2:50	67.16	70.25	.....	.....	.....	.....	.....	.....
3:5	65.75	70.25	.....	.....	.....	.....	.....	.....	Quiet.
3:20	66.47	70.43	.....	.....	.....	.....	.....	.....	Quiet.
3:35	65.30	69.85	.....	.....	.....	.....	.....	.....	Whining.
3:50	62.96	69.26	.....	.....	.....	.....	.....	.....	Whining.
4:5	66.47	71.06	.....	.....	.....	.....	.....	.....	Whining, very uneasy.
4:20	68.54	71.6	.....	.....	.....	.....	.....	.....	Whining.
4:35	66.68	70.88	.....	.....	.....	.....	.....	.....	Quiet.
4:50	66.56	70.76	.....	.....	.....	.....	.....	.....	Whining.
5:5	66.38	71.15	.....	.....	.....	.....	.....	.....	Quiet.
5:20	66.2	71.51	.....	.....	.....	.....	.....	.....	Quiet.
5:35	65.48	70.34	.....	.....	.....	.....	.....	.....	Whining, very uneasy.
5:50	65.66	71.51	.....	.....	.....	.....	.....	.....	Whining.
6:5	65.77	71.06	.....	.....	.....	.....	.....	.....	Whining.
6:20	67.04	72.32	71.96	1425.59	28.2286	108.6992	65.74	58.6542	Whining.
	66.77	70.695	3.96	515.015	0.2386	0.1477	0.0883	0.0261	
	(mean)	66.77	(gain)	0.2386			(gain)	(gain)	
		3.92		515.2536					
		(gain)							

6:35 p. m.—Rectal temperature 104°.7. 6:40 p. m.—Dog ate one and a half pounds of raw liver.

April 9 and 10.

7:37 p. m.—Rectal temperature 103°.9.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.	REMARKS.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)	
7:37 P. M.	64°31	68°24	68°45	469.176	28.229	8.7995	65.74	58.6542	Whining.
8:7	65.56	70.25	.....	.....	.....	.....	.....	.....	Quiet.
8:22	65.88	69.64	.....	.....	.....	.....	.....	.....	Whining.
8:37	65.56	69.64	.....	.....	.....	.....	.....	.....	Quiet.
8:52	65.48	69.35	.....	.....	.....	.....	.....	.....	Quiet.
9:7	65.39	68.96	.....	.....	.....	.....	.....	.....	Whining.
9:22	65.66	68.72	.....	.....	.....	.....	.....	.....	Quiet.
9:37	65.66	68.96	.....	.....	.....	.....	.....	.....	Quiet.
9:52	65.75	70.06	.....	.....	.....	.....	.....	.....	Whining.
10:7	65.96	69.64	.....	.....	.....	.....	.....	.....	Quiet.
10:22	66.08	69.64	.....	.....	.....	.....	.....	.....	Quiet.
10:37	66.38	69.74	.....	.....	.....	.....	.....	.....	Quiet.
10:52	66.47	69.84	.....	.....	.....	.....	.....	.....	Quiet.
11:7	66.38	69.94	.....	.....	.....	.....	.....	.....	Quiet.
11:22	66.8	69.96	.....	.....	.....	.....	.....	.....	Quiet.
11:37	66.38	70.16	.....	.....	.....	.....	.....	.....	Whining.
11:52	66.68	69.54	.....	.....	.....	.....	.....	.....	Whining.
12:5 A. M.	66.68	70.43	.....	.....	.....	.....	.....	.....	Whining.
12:22	68.81	72.77	.....	.....	.....	.....	.....	.....	Whining.
12:37	69.92	71.06	71.58	938.815	28.4905	8.9585	65.8413	58.6876	Quiet.
	66.29	69.83	3.13	469.639	0.2615	0.159	0.1013	0.0334	
	(mean)	66.29	(gain)	0.2615			(gain)	(gain)	
		3.54		469.9005					
		(gain)							

12:37 A. M.—Rectal temperature 104°.4.

April 10.

1:45 A. M.—Rectal temperature 103°.9.

Time	Air Temp.	Tube Temp.	Box Temp.	General Meter.	Sample Meter.	Air Meter.	Sample Calcium Tube.	Air Calcium Tube.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
2:20 A. M.	66.29	69.64	68.7	1036.07	28.49165	8.9572	65.8413	58.6876
2:35	66.08	69.64	.....	.....	.....	.....	.....	.....
2:50	65.39	69.64	.....	.....	.....	.....	.....	.....
3:5	67.04	70.61	.....	.....	.....	.....	.....	.....
3:20	67.16	70.79	.....	.....	.....	.....	.....	.....
3:35	68.24	70.88	.....	.....	.....	.....	.....	.....
3:50	68.81	70.61	.....	.....	.....	.....	.....	.....
4:5	68.9	72.32	.....	.....	.....	.....	.....	.....
4:20	68.99	71.42	.....	.....	.....	.....	.....	.....
4:35	69.52	71.42	.....	.....	.....	.....	.....	.....
4:50	69.53	72.08	.....	.....	.....	.....	.....	.....
5:5	69.53	71.72	.....	.....	.....	.....	.....	.....
5:20	68.99	71.33	.....	.....	.....	.....	.....	.....
6:35	69.08	70.43	.....	.....	.....	.....	.....	.....
6:50	69.08	70.52	.....	.....	.....	.....	.....	.....
6:5	69.2	70.76	.....	.....	.....	.....	.....	.....
6:20	69.08	71.96	.....	.....	.....	.....	.....	.....
6:35	68.99	72.95	.....	.....	.....	.....	.....	.....
6:50	69.08	72.32	.....	.....	.....	.....	.....	.....
7:5	69.2	73.04	.....	.....	.....	.....	.....	.....
7:20	69.88	72.77	72.68	127.81	28.6683	.....	.....	.....
	68.42	71.28	3.98	491.74	0.17665	0.1103	0.0735	0.0628
	(mean)	68.42	(gain)	0.1766			.....	.....
		2.86		491.9166				
		(gain)						

7:30 A. M.—Rectal temperature 105°.

8:30 A. M.—Ate one-half a pound of raw liver.

9:55 A. M.—Rectal temperature 103°.1.

10:25 A. M.—Barometer 30.13.

Time	Air Temp.	Tube Temp.	Box Temp.	General Meter.	Sample Meter.	Air Meter.	Sample Calcium Tube.	Air Calcium Tube.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
10:25 A. M.	66.68	68.36	67.64	613.265	28.6727	7.074	.....	.....
10:40	66.92	68.63	.....	.....	.....	.....	.....	.....
10:55	66.29	68.84	.....	.....	.....	.....	.....	.....
11:10	67.46	69.08	.....	.....	.....	.....	.....	.....
11:25	67.55	69.26	.....	.....	.....	.....	.....	.....
11:40	67.37	66.96	.....	.....	.....	.....	.....	.....
11:55	67.55	69.75	.....	.....	.....	.....	.....	.....
12:10 P. M.	67.64	70.06	.....	.....	.....	.....	.....	.....
12:25	67.04	69.96	69.44	813.98	28.7403	8.00375	.....	.....
	67.17	68.99	1.8	200.715	0.0676	0.92975	.....	.....
	(mean)	67.17	(gain)	0.0676			(gain)	(gain)
		1.82		200.7826				
		(gain)						

12:30 P. M.—Rectal temperature 104°.2.

April 10.

2:50 P. M.—Injected in external jugular vein twenty minims of foul pus mixed with water.

3:10 P. M.—Rectal temperature 104° 7. Barometer 30.09.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS.
3:10 P. M.	70° 64	71° 24	67° 88	867.115	28.7325	9.5745	65.9375	58.7171	Whining.
3:55	65.30	69.26	.....	.....	.....	.....	.....	.....	Quiet.
4:10	68.54	69.95	.....	.....	.....	.....	.....	.....	Quiet.
4:25	69.08	70.05	.....	.....	.....	.....	.....	.....	Quiet.
4:40	69.53	70.34	.....	.....	.....	.....	.....	.....	Quiet.
4:55	69.37	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:10	69.79	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:25	69.53	70.34	.....	.....	.....	.....	.....	.....	Quiet.
5:40	69.53	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:55	68.8	70.43	.....	.....	.....	.....	.....	.....	Quiet.
6:10	69.62	70.43	.....	.....	.....	.....	.....	.....	Whining.
6:25	68.99	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:40	68.45	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:55	67.57	70.76	.....	.....	.....	.....	.....	.....	Quiet.
7:10	68.63	70.88	.....	.....	.....	.....	.....	.....	Quiet.
7:25	69.2	70.97	.....	.....	.....	.....	.....	.....	Quiet.
7:40	69.53	71.6	.....	.....	.....	.....	.....	.....	Quiet.
7:55	69.44	71.24	.....	.....	.....	.....	.....	.....	Quiet.
8:10	68.9	71.24	.....	.....	.....	.....	.....	.....	Quiet.
8:25	68.81	71.33	.....	.....	.....	.....	.....	.....	Quiet.
8:40	70.52	71.92	71.24	1370.365	28.9554	9.7727	66.0253	58.7716	Quiet.
	69.04	70.67	3.36	503.25	0.2229	0.1982	0.0878	0.0545	
	(mean)	69.04	(gain)	0.2229			(gain)	(gain)	
		1.63		503.4729					
		(gain)							

8:45 P. M.—Rectal temperature 103° 9.

9:5 P. M.—Dog ate one-half of a pound of raw liver.

April 10 and 11.

10 P. M.—Rectal temperature 103° 9. 10:30 P. M.—Barometer 30.04.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS.
10:45 P. M.	71° 42	70° 64	68° 225	444.30	28.9467	9.773	64.6339	63.8221	Whining.
11	70.52	70.88	.....	.....	.....	.....	.....	.....	Quiet.
11:15	70.25	70.64	.....	.....	.....	.....	.....	.....	Quiet.
11:30	70	70.64	.....	.....	.....	.....	.....	.....	Quiet.
11:45	69.88	71.06	.....	.....	.....	.....	.....	.....	Quiet.
12	69.7	70.97	.....	.....	.....	.....	.....	.....	Quiet.
12:15 A. M.	69.61	70.96	.....	.....	.....	.....	.....	.....	Quiet.
12:30	69.32	72.32	.....	.....	.....	.....	.....	.....	Quiet.
12:45	69.61	71.84	.....	.....	.....	.....	.....	.....	Quiet.
1	70.16	71.96	.....	.....	.....	.....	.....	.....	Quiet.
1:15	70.04	72.32	.....	.....	.....	.....	.....	.....	Quiet.
1:30	69.92	71.6	.....	.....	.....	.....	.....	.....	Quiet.
1:45	69.92	71.6	.....	.....	.....	.....	.....	.....	Quiet.
2	70.52	72.41	.....	.....	.....	.....	.....	.....	Quiet.
2:15	68.8	72.23	.....	.....	.....	.....	.....	.....	Quiet.
2:30	70	72.5	.....	.....	.....	.....	.....	.....	Quiet.
2:45	69.71	72.32	.....	.....	.....	.....	.....	.....	Quiet.
3	69.80	72.68	.....	.....	.....	.....	.....	.....	Quiet.
3:15	70.16	72.92	.....	.....	.....	.....	.....	.....	Quiet.
3:30	70.04	73.04	.....	.....	.....	.....	.....	.....	Quiet.
3:45	71.76	72.8	72.32	931.316	29.3596	10.0946	64.8162	63.9169	Quiet.
	70.05	72.25	4.095	487.016	0.4129	0.3216	0.1823	0.0948	
	(mean)	70.05	(gain)	0.4129			(gain)	(gain)	
		2.2		487.4289					
		(gain)							

4 A. M.—Rectal temperature 105°.

5 A. M.—Rectal temperature 104°.

April 11

5 A. M.—Barometer 29.9. Rectal temperature 104° 8.

Time.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS
5:30 A. M.	70° 66	71° 42	68.6	976.1929	29.3929	10.098	64.8162	63.9169	Quart.
5:45	70.43	70.43	.....	.....	.....	.....	.....	.....	Quart.
6	70.64	70.64	.....	.....	.....	.....	.....	.....	Quart.
6:15	70.52	70.76	.....	.....	.....	.....	.....	.....	Quart.
6:30	70.43	70.88	.....	.....	.....	.....	.....	.....	Quart.
6:45	70.76	70.97	.....	.....	.....	.....	.....	.....	Quart.
7	70.52	70.97	.....	.....	.....	.....	.....	.....	Quart.
7:15	69.35	70.64	.....	.....	.....	.....	.....	.....	W. 1/2 p. 1/2
7:30	69.79	71.06	.....	.....	.....	.....	.....	.....	Quart.
7:45	69.79	70.97	.....	.....	.....	.....	.....	.....	Quart.
8	70.25	71.24	.....	.....	.....	.....	.....	.....	Quart.
8:15	70.52	71.51	.....	.....	.....	.....	.....	.....	Quart.
8:30	70.16	71.33	.....	.....	.....	.....	.....	.....	Quart.
8:45	69.32	70.43	.....	.....	.....	.....	.....	.....	Quart.
9	70.43	71.84	.....	.....	.....	.....	.....	.....	Quart.
9:15	70.	71.84	.....	.....	.....	.....	.....	.....	W. 1/2 p. 1/2
9:30	69.36	71.42	.....	.....	.....	.....	.....	.....	Quart.
9:45	67.76	71.48	.....	.....	.....	.....	.....	.....	Quart.
10	66.20	71.15	.....	.....	.....	.....	.....	.....	Quart.
10:15	67.57	71.30	.....	.....	.....	.....	.....	.....	Quart.
10:30	68.54	72.08	72.068	1475.34	29.5917	10.354	64.88	63.9924	Quart.
	69.62 (mean)	71.17 69.62	3.468 (gain)	499.1471 01.988	0.1988	0.256	0.0638 (gain)	0.0755 (gain)	
		1.55 (gain)		499.3459					

10:45 A. M.—Rectal temperature 105° 4. 11 A. M.—Dog ate half a pound of raw liver eagerly.

11:20 A. M.—20 minims of stale pus injected into the jugular vein.

11:34 P. M.—Rectal temperature 107°.

12:31 P. M.—Rectal temperature 107°.

Time.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)	REMARKS
12:31 P. M.	70° 34	70° 25	68°	683.09	29.5904	10.3513	64.8895	63.9924	Quart.
12:45	70.64	71.72	.....	.....	.....	.....	.....	.....	Quart.
1	70.88	71.06	.....	.....	.....	.....	.....	.....	Quart.
1:15	70.56	71.42	.....	.....	.....	.....	.....	.....	Quart.
1:30	70.97	71.06	.....	.....	.....	.....	.....	.....	W. 1/2 p. 1/2
1:45	71.6	71.15	.....	.....	.....	.....	.....	.....	Quart.
2	71.69	71.41	.....	.....	.....	.....	.....	.....	Quart.
2:15	72.2	72.32	.....	.....	.....	.....	.....	.....	Quart.
2:30	72.2	72.5	.....	.....	.....	.....	.....	.....	Quart.
2:45	70.87	72.5	.....	.....	.....	.....	.....	.....	Quart.
3	72.83	73.04	.....	.....	.....	.....	.....	.....	Quart.
3:15	72.52	72.95	.....	.....	.....	.....	.....	.....	Quart.
3:30	72.63	73.35	.....	.....	.....	.....	.....	.....	Quart.
3:45	72.42	73.04	.....	.....	.....	.....	.....	.....	Quart.
4	72.32	72.95	.....	.....	.....	.....	.....	.....	Quart.
4:15	72.20	73.24	.....	.....	.....	.....	.....	.....	Quart.
4:30	71.87	73.45	.....	.....	.....	.....	.....	.....	Quart.
4:45	71.87	73.14	.....	.....	.....	.....	.....	.....	Quart.
5	72.32	73.66	.....	.....	.....	.....	.....	.....	Quart.
5:15	72.52	74.21	.....	.....	.....	.....	.....	.....	Quart.
5:31	83.3	74.	72.68	1066.59	29.903	10.5424	65.0275	64.0525	Quart.
	72.33 (mean)	72.49 72.33	4.68 (gain)	383.5 0.3126	0.3126	0.1911	0.138 (gain)	0.0601 (gain)	
		0.16 (gain)		383.8126					

5:40 P. M.—Rectal temperature 104° 15.

April 11.

6:30 P. M.—Barometer 29.67. Rectal temperature 104°.15.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.	REMARKS.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)	
7:2 A. M.	73°.8	71°24	67°76	144.	29.9091	10.5434	65.0275	64.0525	Quiet.
7:15	72.93	71.33	.....	.....	.....	.....	.....	.....	Quiet.
7:30	72.72	71.51	.....	.....	.....	.....	.....	.....	Quiet.
7:45	72.08	71.33	.....	.....	.....	.....	.....	.....	Quiet.
8	72.32	71.42	.....	.....	.....	.....	.....	.....	Quiet.
8:15	71.15	71.6	.....	.....	.....	.....	.....	.....	Quiet.
8:30	70.64	71.51	.....	.....	.....	.....	.....	.....	Quiet.
8:45	71.06	72.5	.....	.....	.....	.....	.....	.....	Quiet.
9	70.52	72.32	.....	.....	.....	.....	.....	.....	Quiet.
9:15	69.88	72.59	.....	.....	.....	.....	.....	.....	Quiet.
9:30	68.	72.8	.....	.....	.....	.....	.....	.....	Quiet.
9:45	68.	73.04	.....	.....	.....	.....	.....	.....	Quiet.
10	67.86	71.96	.....	.....	.....	.....	.....	.....	Quiet.
10:15	65.84	72.77	.....	.....	.....	.....	.....	.....	Quiet.
10:30	66.2	71.96	.....	.....	.....	.....	.....	.....	Quiet.
10:45	65.3	72.59	.....	.....	.....	.....	.....	.....	Quiet.
11	66.47	72.2	.....	.....	.....	.....	.....	.....	Quiet.
11:15	65.75	71.72	.....	.....	.....	.....	.....	.....	Quiet.
11:30	63.32	71.72	.....	.....	.....	.....	.....	.....	Quiet.
11:45	64.22	71.8	.....	.....	.....	.....	.....	.....	Quiet.
12:02 P. M.	65.3	72.86	72.32	618.302	30.1382	10.654	65.107	64.0947	Quiet.
	68.73	72.04	4.56	474.302	0.2291	0.1106	0.0795	0.0422	
	(mean)	68.73	(gain)	0.2291			(gain)	(gain)	
		3.31		474.5311					
		(gain)							

12:17 P. M.—Rectal temperature 105°.15.

April 12.

12:52 P. M.—Rectal temperature 105°.1.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.	REMARKS.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)	
1:41 P. M.	66°.98	69°.95	68°.09	737.27	30.1376	10.6525	65.1070	64.0947	Quiet.
1:56	67.64	69.95	.....	.....	.....	.....	.....	.....	Quiet.
2:11	67.64	71.12	.....	.....	.....	.....	.....	.....	Quiet.
2:26	67.04	70.43	.....	.....	.....	.....	.....	.....	Quiet.
2:56	67.37	70.25	.....	.....	.....	.....	.....	.....	Quiet.
3:11	68.81	70.97	.....	.....	.....	.....	.....	.....	Quiet.
3:26	68.89	71.42	.....	.....	.....	.....	.....	.....	Quiet.
3:41	69.44	71.42	.....	.....	.....	.....	.....	.....	Quiet.
3:56	64.4	69.96	.....	.....	.....	.....	.....	.....	Quiet.
4:11	64.13	69.75	.....	.....	.....	.....	.....	.....	Quiet.
4:26	64.76	69.54	.....	.....	.....	.....	.....	.....	Quiet.
4:41	64.31	69.75	.....	.....	.....	.....	.....	.....	Quiet.
4:56	63.32	69.44	.....	.....	.....	.....	.....	.....	Quiet.
5:11	65.96	70.43	.....	.....	.....	.....	.....	.....	Quiet.
5:26	66.68	70.25	.....	.....	.....	.....	.....	.....	Quiet.
5:41	66.8	70.43	.....	.....	.....	.....	.....	.....	Quiet.
5:56	67.04	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:11	66.56	71.24	.....	.....	.....	.....	.....	.....	Quiet.
6:26	66.38	70.64	.....	.....	.....	.....	.....	.....	Quiet.
6:41	66.08	70.34	71.78	1309.64	30.2641	10.7448	65.1475	64.1166	Quiet.
	66.47	70.40	2.98	572.37	0.1265	0.0923	0.0405	0.0219	
	(mean)	66.47	(gain)	0.1265			(gain)	(gain)	
		3.93		572.4965					
		(gain)							

6:50 P. M.—Rectal temperature 104°.6.

April 12.

9:30 A. M.—Rectal temperature 105°.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	Air Meter. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)
9:42 A. M.	63.41	67 ^o .79	67 ^o .513	285.41	30.264	10.7448	65.1475
9:57	64.76	68.18					
10:12	64.31	68.					
10:27	64.76	68.36					
10:42	65.12	68.63					
10:57	64.49	69.08					
11:12	64.88	68.84					
11:27	65.3	69.35					
11:42	65.48	69.35					
11:57	65.21	69.54					
12:12 P. M.	65.57	69.54					
12:27	65.84	69.54					
12:42	65.96	69.65					
12:57	66.2	69.54	69.68	583.625	30.49136	10.8205	65.23
	65.09	68.95	2.167	298.215	0.22736	0.0757	0.0825
	(mean)	65.09	(gain)	0.2273			(gain)
		3.86		298.4423			
		(gain)					

1:10 P. M.—Rectal temperature 104^o.8.

April 13.

9 A. M.—Dog seems very ill; walks with great difficulty, and refuses to eat.

9 A. M.—Rectal temperature 105^o.85.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	GEN. METER. (cub. ft.)
10:18 A. M.	62.6	67 ^o .59	65 ^o .6	639.24
10:30	60.6	66.68		
10:45	63.05	66.68		
11	64.09	67.33		
11:15	64.64	67.69		
11:30	65.21	68.45		
11:45	65.57	68.53		
12 M	65.84	68.27		
12:15 P. M.	66.36	68.96		
12:30	66.8	69.08		
12:45	65.48	68.		
1	65.84	68.45		
1:15	65.84	68.45		
1:30	65.96	69.08		
1:45	66.08	68.96		
2	66.56	69.44		
2:15	66.6	69.35		
2:30	67.37	69.85		
2:45	67.55	70.16		
3	68.12	70.16		
3:18	68.36	70.25	69.32	1070.694
	65.64	68.64	3.72	431.454
	(mean)	65.64	(gain)	
		3		
		(gain)		

3:25 P. M.—Rectal temperature 105^o.85.

April 13.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:35 P. M.	69.2	69.44	66.29	105.3
4:45	68.63	68.96		
5	68.54	69.17		
5:15	68.18	69.17		
5:30	67.46	69.08		
5:45	67.28	69.26		
6	66.8	69.26		
6:15	67.1	69.44		
6:30	66.56	69.55		
6:45	66.47	69.85		
7	66.29	69.85		
7:15	66.38	69.85		
7:30	66.29	69.75		
7:45	65.96	69.85		
8	65.57	69.85		
8:15	65.96	70.25		
8:30	65.57	70.06		
8:45	64.22	69.64		
9	66.08	71.43		
9:15	67.46	71.15		
9:35	67.64	71.15	70.565	536.741
	66.83	69.81	4.275	431.441
	(mean)	66.83	(gain)	
		2.98		
		(gain)		

9:45 P. M.—Rectal temperature 105°.4.

April 13 and 14.

10:30 P. M.—Rectal temperature 105°.4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
11 P. M.	62.4	67.79	65.96	590.555
11:15	64.96	67.23		
11:30	64.09	67.79		
11:45	62.24	67.32		
12	62	67.02		
12:15 A. M.	63.23	68		
12:30	63.63	68.45		
12:45	63.41	68.45		
1	62.6	68.18		
1:15	62.36	68.09		
1:30	62.14	68.27		
1:45	61.8	68		
2	66.38	68.09		
2:15	61.5	68.27		
2:30	62.72	69.17		
2:45	62.36	69.08		
3	62.84	68.45		
3:15	62.24	68.45		
3:30	62.48	68.45		
3:45	62.1	68.54		
4	63.23	68.84	69.845	1041.48
	62.89	68.19	3.885	450.925
	(mean)	62.89	(gain)	
		5.3		
		(gain)		

4:15 A. M.—Rectal temperature 105°.

April 14.

4:45 A. M.—Rectal temperature 104°.9.

Time.	Air Temp. (Fah.)	Temp. Temp. (Fah.)	Box Temp. (Fah.)	Gas. Meter. (cub. ft.)
5:7 A.M.	65.03	69.2	66.2	1091
5:15	64.31	68.36		
5:30	64.04	68.09		
5:45	63.32	68		
6	62.36	67.8		
6:15	62.15	67.49		
6:30	62.06	68.27		
6:45	61.7	68		
7	61.75	69.44		
7:15	61.7	67.23		
7:30	62.6	65.48		
7:45	61.7	66.92		
8	61.5	66.47		
8:15	60.7	66.68		
8:30	61.6	66.47		
8:45	61.4	67.33		
9	61.3	67.23		
9:30	61.1	67.79		
9:45	61.8	68.18		
10:7	61.1	68	69.89	1506.5
	62.16	67.62	3.69	415.5
	(mean)	62.16		
		5.46		
		(gain)		

10:15 A. M.—Rectal temperature 104°.9.

April 16.—Dog alive and apparently better; eats; very lame.

*Heat Dissipation.**First Period—*Quantity of air (V') = 515.2536 at 70°.69 — 32° = 38.69 = t' . $V + (V \times t' \times 0.002035) = V'$. $V = \frac{515.2536}{1.079} = 477.4$. $W = V \times 0.08073 = 38.6$ Rise in temp. of air 3.92 = t . $Q = W \times t \times \text{sp. h.} = 38.6 \times 3.92 \times 0.2374 = 35.92 = \text{heat given to a.r.}$ Quotient for box $2159 \times 0.0883 = 190.6397 = \text{moisture leaving box.}$ Quotient for air $3488 \times 0.0261 = 91.0368 = \text{moisture entering box.}$

99.6029 = moisture vaporized in box.

 $\frac{99.6029}{6.2789} = 15.86 = \text{heat expended in vaporization.}$ Rise in temp. of water $3.96 \times 164.1414 = 650 = \text{heat given to calorimeter.}$

35.92 = heat given to air.

15.86 = heat expended in vaporization.

701.78 = heat dissipated in 5 hours.

Hourly dissipation of heat 140.36*Second Period—*Quantity of air (V') = 469.9 at 69°.83 — 32° = 37.83 = t' . $V + (V \times t' \times 0.002035) = V'$. $V = \frac{469.9}{1.077} = 436.3$. $W = V \times 0.08073 = 35.22$ Rise in temp. of air 3.54 = t . $Q = W \times t \times \text{sp. h.} = 35.22 \times 3.54 \times 0.2374 = 29.5987 = \text{heat given to a.r.}$ Quotient for box $1797 \times 0.1013 = 182.0361 = \text{moisture leaving box.}$ Quotient for air $2955 \times 0.0334 = 98.697 = \text{moisture entering box.}$

83.3391 = moisture vaporized in box.

 $\frac{83.3391}{6.2789} = 13.2744 = \text{heat expended in vaporization.}$ Rise in temp. of water $3.13 \times 164.1414 = 513.7626 = \text{heat given to calorimeter.}$

29.5987 = heat given to air.

13.2744 = heat expended in vaporization.

556.6357 = heat dissipated in 5 hours.

Hourly dissipation of heat 111.3271

Third Period—

Quantity of air (V') = 491.9166 at $71^{\circ}.28 - 32^{\circ} = 39.28 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{491.9166}{1.08} = 455.478$. $W = V \times 0.08073 = 36.77$
 Rise in temp. of air $2.86 = t$. $Q = W \times t \times \text{sp. h.} = 36.77 \times 2.86 \times 0.2374 = 24.9655 = \text{heat given to air.}$
 Quotient for box $2403 \times 0.0715 = 171.8145 = \text{moisture leaving box.}$
 Quotient for air $3847.5 \times 0.0238 = 91.5905 = \text{moisture entering box.}$
 $\frac{80.224}{6.2789} = 12.774 = \text{heat expended in vaporization.}$
 $80.224 = \text{moisture vaporized in box.}$
 Rise in temp. of water $3.98 \times 164.1414 = 653.283 = \text{heat given to calorimeter.}$
 $24.9655 = \text{heat given to air.}$
 $12.774 = \text{heat expended in vaporization.}$
 $691.0225 = \text{heat dissipated in 5 hours.}$
Hourly dissipation of heat 138.2045

Fourth Period—

Quantity of air (V') = 200.7826 at $68^{\circ}.99 - 32^{\circ} = 36.99 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{200.7826}{1.075} = 186.7$. $W = V \times 0.08073 = 15.07$
 Rise in temp. of air $1.82 = t$. $Q = W \times t \times \text{sp. h.} = 15.07 \times 1.82 \times 0.2374 = 6.511 = \text{heat given to air.}$
 Quotient for box } Meter incorrectly read.
 Quotient for air }
 Rise in temp. of water $1.8 \times 164.1414 = 295.4545 = \text{heat given to calorimeter.}$
 $6.511 = \text{heat given to air.}$
 $4.5 = \text{heat expended in vaporization.}^*$
 $306.4655 = \text{heat dissipated in 2 hours.}$
Hourly dissipation of heat 153.2327

Fifth Period—

Quantity of air (V') = 503.4729 at $70^{\circ}.67 - 32^{\circ} = 38.67 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{503.4729}{1.079} = 466.6$. $W = V \times 0.08073 = 37.67$.
 Rise in temp. of air $1.63 = t$. $Q = W \times t \times \text{sp. h.} = 37.67 \times 1.63 \times 0.2374 = 14.5768 = \text{heat given to air.}$
 Quotient for box $2258.7 \times 0.0878 = 198.3139 = \text{moisture leaving box.}$
 Quotient for air $2540.2 \times 0.0545 = 138.4409 = \text{moisture entering box.}$
 $59.8730 = \text{moisture vaporized in box.}$
 $\frac{59.8730}{6.2789} = 9.534 = \text{heat expended in vaporization.}$
 Rise in temp. of water $3.36 \times 164.1414 = 551.5151 = \text{heat given to calorimeter.}$
 $14.5768 = \text{heat given to air.}$
 $9.534 = \text{heat expended in vaporization.}$
 $575.6259 = \text{heat dissipated in 5 hours.}$
Hourly dissipation of heat 115.1252

Sixth Period—

Quantity of air (V') = 487.4289 at $72^{\circ}.25 - 32^{\circ} = 40.25 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{487.4289}{1.08} = 451.32$. $W = V \times 0.08073 = 36.43$
 Rise in temp. of air $2.2 = t$. $Q = W \times t \times \text{sp. h.} = 36.4 \times 2.2 \times 0.2374 = 19.03 = \text{heat given to air.}$
 Quotient for box $1180.5 \times 0.1823 = 215.205 = \text{moisture leaving box.}$
 Quotient for air $1415.6 \times 0.0948 = 134.199 = \text{moisture entering box.}$
 $81.006 = \text{moisture vaporized in box.}$
 $\frac{81.006}{6.2789} = 12.89 = \text{heat expended in vaporization.}$
 Rise in temp. of water $4.095 \times 164.1414 = 672.159 = \text{heat given to calorimeter.}$
 $19.03 = \text{heat given to air.}$
 $12.89 = \text{heat expended in vaporization.}$
 $704.079 = \text{heat dissipated in 5 hours.}$
Hourly dissipation of heat 140.816

* In a case of accident like this, the heat gain or loss connected with moisture is estimated.

*Seventh Period—*Quantity of air (V') = 499.3459 at $71^{\circ}.17 - 32^{\circ} = 39.17 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{499.3459}{1.08} = 462.3$. $W = V \times 0.08073 = 37.32$ Rise in temp. of air $1.55 = t$. $Q = W \times t \times \text{sp. h.} = 37.32 \times 1.55 \times 0.2374 = 13.7326 = \text{heat given to air}$ Quotient for box $2511.8 \times 0.0638 = 160.25 = \text{moisture leaving box.}$ Quotient for air $1950.6 \times 0.0755 = 147.27 = \text{moisture entering box.}$

12.98 = moisture vaporized in box. $\frac{12.98}{6.2789} = 2.067 = \text{heat expended in vaporization.}$ Rise in temp. of water $3.468 \times 164.1414 = 569.2424 = \text{heat given to calorimeter.}$

13.7326 = heat given to air.

2.067 = heat given to vapor.

585.0420 = heat dissipated in 5 hours.*Hourly dissipation of heat* 117.0084*Eighth Period—*Quantity of air (V') = 383.8126 at $72^{\circ}.49 - 32^{\circ} = 40.49 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{383.8126}{1.082} = 354.7$. $W = V \times 0.08073 = 28.63$ Rise in temp. of air $0.16 = t$. $Q = W \times t \times \text{sp. h.} = 28.63 \times 0.16 \times 0.2374 = 1.0875 = \text{heat given to air.}$ Quotient for box $1227.8 \times 0.138 = 169.437 = \text{moisture leaving box.}$ Quotient for air $2008.4 \times 0.0601 = 120.7048 = \text{moisture entering box.}$

48.7322 = moisture vaporized in box. $\frac{48.7322}{6.2789} = 7.759 = \text{heat expended in vaporization.}$ Rise in temp. of water $4.68 \times 164.1414 = 768.1817 = \text{heat given to calorimeter.}$

1.0875 = heat given to air.

7.759 = heat expended in vaporization.

777.0282 = heat dissipated in 5 hours.*Hourly dissipation of heat* 155.4056*Ninth Period—*Quantity of air (V') = 474.5311 at $72^{\circ}.04 - 32^{\circ} = 40.04 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{474.5311}{1.08} = 439.38$. $W = V \times 0.08073 = 35.47$ Rise in temp. of air $3.31 = t$. $Q = W \times t \times \text{sp. h.} = 35.47 \times 3.31 \times 0.2374 = 27.87 = \text{heat given to air.}$ Quotient for box $2071.3 \times 0.0795 = 164.6683 = \text{moisture leaving box.}$ Quotient for air $4290.5 \times 0.0422 = 181.0591 = \text{moisture entering box.}$

16.3908 = moisture condensed in box. $\frac{16.3908}{6.2789} = 2.61 = \text{heat gained from condensation.}$ Rise in temp. of water $4.56 \times 164.1414 = 748.4848 = \text{heat given to calorimeter.}$

27.87 = heat given to air.

776.3548

2.61 = heat gained from condensation.

773.7448 = heat dissipated in 5 hours.*Hourly dissipation of heat* 154.7489*Tenth Period—*Quantity of air (V') = 572.4965 at $70^{\circ}.4 - 32^{\circ} = 38.4 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{572.4965}{1.078} = 531$. $W = V \times 0.08073 = 42.87$ Rise in temp. of air $3.93 = t$. $Q = W \times t \times \text{sp. h.} = 42.87 \times 3.93 \times 0.2374 = 40 = \text{heat given to air.}$

*Fifteenth Period—*Quantity of air (V') = 415.5 at $67^{\circ}.62 - 32^{\circ} = 35.62 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{415.5}{1.072} = 387.6. \quad W = V \times 0.08073 = 31.2909$$

Rise in temp. of air $5.46 = t$. $Q = W \times t \times \text{sp. h.} = 31.2909 \times 5.46 \times 0.2374 = 40.5582 = \text{heat given to air}$ Rise in temp. of water $3.69 \times 164.1414 = 605.6817 = \text{heat given to calorimeter.}$ $40.5582 = \text{heat given to air.}$ $646.2399 = \text{heat dissipated in 5 hours.}$ *Hourly dissipation of heat* 129.2479*Heat Production.**First Period—*Rise of bodily temperature in 5 hours $1^{\circ}.625$, in 1 hour $0.325 = t$. $Q = W \times t \times \text{sp. h.} = 39 \times 0.325 \times 0.75 = 9.50625 = \text{heat added to reserve.}$ $140.36 = \text{hourly dissipation of heat.}$ $9.50625 = \text{hourly addition to heat reserve.}$ *Hourly production of heat* 149.87*Second Period—*Rise of bodily temperature in 5 hours $0^{\circ}.5$, in 1 hour $0.1 = t$. $Q = W \times t \times \text{sp. h.} = 39 \times 0.1 \times 0.75 = 2.925 = \text{heat added to reserve.}$ $111.3271 = \text{hourly dissipation of heat.}$ $2.925 = \text{hourly addition to heat reserve.}$ *Hourly production of heat* 114.2521*Third Period—*Rise of bodily temperature in 5 hours $0^{\circ}.9565$, in 1 hour $0.1913 = t$. $Q = W \times t \times \text{sp. h.} = 39 \times 0.1913 \times 0.75 = 5.5575 = \text{heat added to reserve.}$ $138.2045 = \text{hourly dissipation of heat.}$ $5.5575 = \text{hourly addition to heat reserve.}$ *Hourly production of heat* 143.762*Fourth Period—*Rise of bodily temperature in 2 hours $0^{\circ}.85$, in 1 hour $0.43 = t$. $Q = W \times t \times \text{sp. h.} = 39 \times 0.43 \times 0.75 = 12.58 = \text{heat added to reserve.}$ $153.2327 = \text{hourly dissipation of heat.}$ $12.58 = \text{hourly addition to heat reserve.}$ *Hourly production of heat* 165.8127*Fifth Period—*Fall of bodily temperature in 5 hours $0^{\circ}.7165$, in 1 hour $0.14 = t$. $Q = W \times t \times \text{sp. h.} = 39 \times 0.14 \times 0.75 = 4.095 = \text{heat taken from reserve.}$ $115.1252 = \text{hourly dissipation of heat.}$ $4.095 = \text{hourly loss from heat reserve.}$ *Hourly production of heat* 111.0302*Sixth Period—*Rise of bodily temperature in 5 hours $0^{\circ}.915$, in 1 hour $0.18 = t$. $Q = W \times t \times \text{sp. h.} = 39 \times 0.18 \times 0.75 = 5.265 = \text{heat added to reserve.}$ $140.816 = \text{hourly dissipation of heat.}$ $5.265 = \text{hourly addition to heat reserve.}$ *Hourly production of heat* 146.081

RECAPITULATION.

	TIME.	HEAT DISSIPATION.	HEAT PRODUCTION.	RECT. TEMP. (Fah.)	REMARKS.
First day.	1:20 P. M. to 6:20 P. M.	140.36	149.87	102 ^o .85 to 104 ^o .7	No food since 6 P. M. day before
April 9, 1 P. M. to	7:37 P. M. to 12:37 A. M.	111.3271	114.2521	103.9 to 104.4	
April 10, 1 P. M.	2:20 A. M. to 7:20 A. M.	138.2045	143.762	103.9 to 105	Had 1½ lbs. food
	10:25 A. M. to 12:25 P. M.	153.2327	165.8127	103.1 to 104.2	liver at 6:40 A. M.
At 2:50 P. M.—20 minims of foul pus injected into jugular vein.					
Second day.	3:40 P. M. to 8:40 P. M.	115.1252	111.0302	104.7 to 103.9	
April 10, 3:30 P. M. to	10:15 P. M. to 3:15 A. M.	140.816	146.081	103.9 to 105.	Dog ate 1½ lbs
April 11, 3:30 P. M.	5:30 A. M. to 10:30 A. M.	117.0084	120.1966	104.8 to 105.4	liver at 9:5 A. M.
	12:30 P. M. to 3:30 P. M.	155.4056	139.5748	107 to 104.15	
11:20 P. M.—20 minims of pus injected. Dog ate ½ lb. of beef at 1 P. M.					
Third day.	3:30 P. M. to 5:30 P. M.*	155.4056	139.5748	107 to 104.15	
April 11, 3:30 P. M. to	7:2 P. M. to 12:2 A. M.	154.7489	159.8091	104.15 to 105.15	
April 12, 3:30 P. M.	1:41 A. M. to 6:41 A. M.	107.3396	104.9119	105.1 to 104.6	
	9:42 A. M. to 12:42 P. M.	117.946	116.337	105 to 104.8	
Fourth day.	10:18 A. M. to 3:18 P. M.	126.7412	126.7412	105.85	Dog very sick & refuses food
April 13, 10 A. M. to	4:35 P. M. to 9:35 P. M.	144.9167	142.84	105.85 to 105.4	
April 14, 10 A. M.	11 P. M. to 4 A. M.	136.066	134.194	105.4 to 105	
	5:7 A. M. to 10:71 A. M.	129.2479	129.2479	104.9	

SUMMARY.

	TIME IN CALORIMETER.	AVERAGE HOURLY HEAT DISSIPATION.	AVERAGE HOURLY HEAT PRODUCTION.	EXTREMES OF RECT. TEMP. (Fah.)	AVERAGE RECT. TEMP. (Fah.)
First day.	17 hours.	132.7014	139.4733	102 ^o .85 to 105 ^o	104.07
Second day.	18 hours.	129.498	128.0702	103.9 to 105.4	104.54
Third day.	15 hours.	131.5025	130.1177	104.15 to 107	104.89
Fourth day.	20 hours.	134.243	133.256	104.9 to 105.85	105.39

EXPERIMENT 112.

A dog. Weight 19 pounds. Had been fed in the morning.

May 10. 12:13 P. M.—Rectal temperature 103^o.3.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:13 A. M.	68 ^o .36	71 ^o .96	69 ^o .56	753.38
12:28	67.28	71.84		
12:43	67.55	72.2		
12:58	67.55	71.96		
1:13	68.24	71.24		
1:28	67.76	71.96		
1:43	68.72	71.72		
1:58	68.81	71.84		
2:13	69.08	72.08		
2:28	69.02	72.41		
2:43	69.62	72.5		
2:58	69.8	72.86		
3:13	69.44	72.5		
3:28	69.71	72.86		
3:43	70.04	72.95		
3:58	70.16	73.14		
4:13	70.43	73.45		
4:28	71.56	73.66	72.23	1088.65
	69.06 (mean)	72.79 69.06	2.67 (gain)	335.27
		3.73 (gain)		

4:28 P. M.—Rectal temperature 102^o.5.

4:57 P. M.—Rectal temperature 103^o.4.

* This period was obtained by taking average of period from 12:30 P. M. to 3:30 P. M.

May 10.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
5:11 P. M.	72° 53	74° 3	71° 36	104.88
5:26	71.51	74.3		
5:41	71.84	73.76		
5:56	71.72	74.12		
6:11	71.84	74.12		
6:26	72.6	74.12		
6:41	71.24	73.45		
6:56	70.52	74.21		
7:11	70.25	74.12		
7:26	70.25	74.21		
7:41	69.92	73.45		
7:56	69.71	73.45		
8:11	69.62	73.55		
8:26	68.72	73.45		
8:41	68.72	73.35		
8:56	68.8	73.35		
9:11	68.9	73.25		
9:26	67.76	72.95		
9:41	68.36	73.33		
9:56	68.72	73.55		
10:11	69.20	73.55	73.445	445.52
	70.13	73.71	2.085	340.64
	(mean)	70.13	(gain)	
		3.58		
		(gain)		

10:30 P. M.—Rectal temperature 103° 3.

May 10 and 11.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
11:3 P. M.	65° 64	70° 64	71° 0	510.695
11:18	65.96	71.72		
11:33	65.21	72.5		
11:48	64.13	71.6		
12:3 A. M.	65	72.2		
12:18	64.67	71.72		
12:33	65	72.32		
12:48	64.67	72.59		
1:3	64.4	72.08		
1:18	64.4	72.8		
1:33	65.12	72.59		
1:48	65.12	72.68		
2:3	66.68	72.95		
2:18	68.36	73.88		
2:33	69.33	74.39		
2:48	68.99	73.66		
3:3	67.28	72.77		
3:18	67.28	72.86		
3:33	67.37	72.95		
3:48	68.36	73.04		
4:3	68.81	73.04	73.418	859.55
	66.275	72.62	2.418	348.855
	(mean)	66.275	(gain)	
		6.345		
		(gain)		

4:15 A. M.—Rectal temperature 102° 8.

May 11.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
5 A. M.	67.76	71 ^o .06	70.592	906.50
5:15	65.66	71.06		
5:30	69.29	71.24		
5:45	65.39	71.15		
6	64.22	70.43		
6:15	64.22	70.43		
6:30	62.15	69.75		
6:45	62.15	69.44		
7	62.15	69.54		
7:15	62.15	70.25		
7:30	63.68	70.97		
7:45	63.92	70.06		
8	63.32	70.43		
8:15	63.05	70.43		
8:30	62.87	70.31		
8:45	62.87	70.06		
9	63.05	69.96		
9:15	63.23	70.52		
9:30	63.5	70.43		
9:45	63.41	70.97		
10	63.68	69.65	72.725	1251.7
	63.89 (mean)	70.44 63.89	2.133 (gain)	345.15
		6.55 (gain)		

10:24 A. M.—Rectal temperature 102^o.8.4:20 P. M.—Rectal temperature 103^o.7.

4:30 P. M.—Twenty minims of putrid blood (six days old) injected into the jugular vein.

4:35 P. M.—Dog vomiting.

4:50 P. M.—Rectal temperature 104^o.3.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:57 P. M.	65 ^o .66	65 ^o .96	66 ^o .056	261.7
5:12	66.38	66.68		
5:27	68.54	68.63		
5:42	67.76	68		
5:57	66.26	68.47	66.92	339.45
	66.92 (mean)	67.55 66.92	0.864 (gain)	77.75
		0.63 (gain)		

6:5 P. M.—Rectal temperature 102^o.6

May 11.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
6:21 P. M.	65 ^o .66	.....	66 ^o .29	364.65
6:36	62.24	67.33		
6:51	62.6	67.13		
7:5	63.32	66.56		
7:20	63.05	66.8		
7:35	63.14	66.92		
7:50	62.48	67.33		
8:5	62.24	67.33		
8:20	61.7	67.33		
8:35	61.6	67.04		
8:50	61.4	66.8		
9:5	61.4	66.68		
9:20	61.3	67.79		
9:35	59.7	67.13		
9:50	62.1	66.37		
10:5	62.1	67.43		
10:20	62.2	67.49		
10:35	62.2	67.59		
10:50	62.15	67.59		
11:15	63.68	67.8		
11:21	.....	68	68.48	719.1
	62.31 (mean)	67.22 62.31	2.19 (gain)	354.45
		4.91 (gain)		

11:30 P. M.—Rectal temperature 104^o.3.

May 12.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:13 A. M.	63 ^o .23	65 ^o .03	66 ^o .965	734.8
12:30	63.8	66.38		
12:45	64.31	67.79		
1	63.23	67.49		
1:15	64.88	68.45		
1:30	65	68.45		
1:45	65.48	68.63		
2	65.66	69.35		
2:15	65.84	69.65		
2:30	66.2	69.95		
2:45	66.29	69.45		
3	66.08	69.95		
3:15	65.98	70.25		
3:30	65.86	69.85		
3:45	66.08	69.54		
4	66.08	69.64		
4:15	66.29	69.85		
4:30	66.29	69.75		
4:45	66.2	69.75		
5	66.08	69.75		
5:13	64.67	68.75	69.26	1060
	65.41 (mean)	68.9 65.41	2.295 (gain)	325.2
		3.49 (gain)		

5:30 A. M.—Rectal temperature 104^o.

May 12

6 A. M.—Rectal temperature 104° 5.

TIME.	AIR TEMP. (Fah.)	TRNE TEMP. (Fah.)	Box TEMP. (Fah.)	GEN. METER. (cu. ft.)
6:18 A. M.	66.29	69° 08	66° 56	113.4
6:30	66.38	68.63		
6:45	67.9	65.96		
7	62.	67.43		
7:15	62.2	67.23		
7:30	62.	66.56		
7:45	61.7	66.47		
8	61.8	66.8		
8:15	61.9	66.8		
8:30	61.4	66.38		
8:45	61.9	66.08		
9	60.5	66.08		
9:15	60.3	66.64		
9:30	60.3	66.56		
9:45	60.3	66.47		
10	60.3	66.65		
10:15	60.4	66.92		
10:30	60.4	66.84		
10:45	61.	67.59		
11	61.1	67.02		
11:18	.....	.....	68.225	449.72
	62.00 (mean)	66.91 62.00	1.665 (gain)	336.02
		4.91 (gain)		

11:30 A. M.—Rectal temperature 104° 3. Dog refuses to eat.

TIME.	AIR TEMP. (Fah.)	TRNE TEMP. (Fah.)	Box TEMP. (Fah.)	GEN. METER. (cu. ft.)
12:13 P. M.	62° 15	66° 47	66° 716	507.915
12:28	61.15	66.56		
12:43	61.	66.68		
12:58	60.1	66.92		
1:13	60.1	66.92		
1:28	60.1	66.2		
1:43	60.1	66.29		
1:58	60.1	66.47		
2:13	60.1	66.29		
2:28	60.1	65.84		
2:43	60.	65.39		
2:58	59.5	66.47		
3:13	59.2	65.72		
3:28	60.	66.56		
3:43	59.6	67.02		
3:58	60.3	67.02		
4:13	.....	.....	68.09	891.61
	60.22 (mean)	66.43 60.22	1.374 (gain)	383.695
		6.21 (gain)		

4:15 P. M.—Rectal temperature 106° 5.

May 12.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:38 P. M.	63.41	65.06	66.56	817.67
4:53	63.23	66.38		
5:8	63.8	68.09		
5:23	63.59	67.23		
5:38	63.8	67.79		
5:53	64.04	67.89		
6:8	62.24	66.38		
6:23	61.2	66.8		
6:38	61.	67.23		
6:53	59.2	66.29		
7:8	58.6	65.84		
7:23	59.	63.38		
7:38	59.6	68.09		
7:53	60.7	67.43		
8:8	61.4	67.02		
8:23	61.7	67.33		
8:38	61.7	67.53		
8:53	62.	68.09		
9:8	62.69	68.18		
9:23	62.51	68.27		
9:38	.....	.....	68.9	1134.27
	61.77	67.04	2.34	316.60
	(mean)	61.77	(gain)	
		5.27		
		(gain)		

9:45 P. M.—Rectal temperature 100°.

May 12 and 13.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
10:5 P. M.	64.04	68.45	67.01	156.79
10:26	63.8	68.45		
10:35	64.04	68.84		
10:50	63.92	69.85		
11:5	64.04	68.96		
11:20	64.13	68.96		
11:35	64.22	69.08		
11:50	64.04	69.08		
12:5 A. M.	64.13	69.72		
12:20	64.04	69.96		
12:35	63.8	69.26		
12:50	63.8	69.32		
1:5	63.8	69.44		
1:20	63.44	69.44		
1:35	63.44	69.75		
1:50	63.44	69.35		
2:5	63.40	69.35		
2:20	63.32	69.17		
2:35	62.72	69.44		
2:50	62.48	69.54		
3:5	62.72	69.54		
3:20	62.6	69.75		
3:35	62.96	69.75		
3:50	63.14	70.06		
4:5	.....	.....	70.88	518.86
	63.57	69.31	3.78	362.07
	(mean)	63.57	(gain)	
		5.74		
		(gain)		

4:16 A. M.—Rectal temperature 104° 5.

Ma. 13.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
4:36 A. M.	63.23	67.49	67.28	550.3
4:51	63.23	67.49		
5:6	63.23	67.43		
5:21	62.75	68.		
5:36	62.15	67.02		
5:51	62.15	65.21		
6:6	61.6	64.26		
6:21	62.	63.9		
6:36	61.7	68.27		
6:51	62.1	67.79		
7:6	62.1	68.54		
7:21	62.36	68.63		
7:36	62.72	68.27		
7:51	62.84	68.27		
8:6	62.84	68.45		
8:21	62.72	68.36		
8:36	62.72	68.96		
8:51	62.72	69.08		
9:6	63.05	69.54		
9:21	63.14	69.35		
9:36	.....	.....	69.8	855.14
	62.56 (mean)	67.71 62.56	2.52 (gain)	304.84
		5.15 (gain)		

9:45 A. M.—Rectal temperature 104°.1

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
10:13 A. M.	63.59	66.65	66.176	893.6
10:28	62.84	67.02		
10:43	63.68	67.69		
10:58	62.6	67.13		
11:13	63.23	66.92	66.8	958.39
	63.19 (mean)	67.08 63.19	0.624 (gain)	64.79
		3.89 (gain)		

11:15 A. M.—Rectal temperature 104°.3.

11:32 A. M.—Dog etherized, and the spinal cord cut between the last cervical and the first dorsal vertebrae.

11:38 A. M.—Rectal temperature 104°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
11:55 A. M.	63.23	66.29	64.94	969.32
12:10 P. M.	62.72	66.38		
12:25	62.6	66.47		
12:40	62.48	66.47		
12:50	63.32	66.49	65.72	1037.12
	62.87 (mean)	66.42 62.87	0.78 (gain)	67.80
		3.55 (gain)		

1:21 P. M.—Rectal temperature 94°.

Rise in temp. of air $4.91 = t$. $Q = W \times t \times \text{sp. h.} = 26.74 \times 4.91 \times 0.2374 = 31.169 = \text{heat given to air.}$
 Rise in temp. of water $2.19 \times 130.8589 = 286.5810 = \text{heat given to calorimeter.}$
 $31.169 = \text{heat given to air.}$

$317.75 = \text{dissipation of heat in 5 hours.}$

Hourly dissipation of heat = 63.55

Seventh Period—

Quantity of air (V') = 325.2 at $68^{\circ}.90 - 32^{\circ} = 36.90 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{325.2}{1.075} = 302.5$. $W = V \times 0.08073 = 24.42$

Rise in temp. of air $3.49 = t$. $Q = W \times t \times \text{sp. h.} = 25.17 \times 3.49 \times 0.2374 = 21.8548 = \text{heat given to air.}$

Rise in temp. of water $2.295 \times 130.8589 = 300.3212 = \text{heat given to calorimeter.}$

$21.8548 = \text{heat given to air.}$

$321.1765 = \text{dissipation of heat in 5 hours.}$

Hourly dissipation of heat = 64.4353

Eighth Period—

Quantity of air (V') = 336.02 at $66^{\circ}.91 - 32^{\circ} = 34.91 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{336.02}{1.07} = 314$. $W = V \times 0.08073 = 25.35$

Rise in temp. of air $4.91 = t$. $Q = W \times t \times \text{sp. h.} = 25.35 \times 4.91 \times 0.2374 = 29.549 = \text{heat given to air.}$

Rise in temp. of water $1.665 \times 130.8589 = 217.88 = \text{heat given to calorimeter.}$

$31.774 = \text{heat given to air.}$

$249.654 = \text{heat dissipated in 5 hours.}$

Hourly dissipation of heat = 49.93

Ninth Period—

Quantity of air (V') = 383.695 at $66^{\circ}.43 - 32^{\circ} = 34.43 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{383.695}{1.07} = 358.6$. $W = V \times 0.08073 = 28.95$

Rise in temp. of air $6.21 = t$. $Q = W \times t \times \text{sp. h.} = 28.95 \times 6.21 \times 0.2374 = 42.68 = \text{heat given to air.}$

Rise in temp. of water $1.374 \times 130.8589 = 179.8001 = \text{heat given to calorimeter.}$

$42.68 = \text{heat given to air.}$

$222.4801 = \text{heat dissipated in 5 hours.}$

Hourly dissipation of heat = 44.5

Tenth Period—

Quantity of air (V') = 316.6 at $67^{\circ}.04 - 32^{\circ} = 35.04 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{316.6}{1.07} = 295.9$. $W = V \times 0.08073 = 23.89$

Rise in temp. of air $5.27 = t$. $Q = W \times t \times \text{sp. h.} = 23.89 \times 5.27 \times 0.2374 = 29.8886 = \text{heat given to air.}$

Rise in temp. of water $2.34 \times 130.8589 = 306.2098 = \text{heat given to calorimeter.}$

$29.8886 = \text{heat given to air.}$

$336.0984 = \text{heat dissipated in 5 hours.}$

Hourly dissipation of heat = 67.2197

Eleventh Period—

Quantity of air (V') = 362.07 at $69^{\circ}.31 - 32^{\circ} = 37.31 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{362.07}{1.076} = 336.5$. $W = V \times 0.08073 = 27.16$

Rise in temp. of air $5.74 = t$. $Q = W \times t \times \text{sp. h.} = 27.16 \times 5.74 \times 0.2374 = 37.01 = \text{heat given to air.}$

Rise in temp. of water $3.78 \times 130.8589 = 494.6466 = \text{heat given to calorimeter.}$

$37.01 = \text{heat given to air.}$

$531.6566 = \text{heat dissipated in 5 hours.}$

Hourly dissipation of heat = 106.3313

*Fifth Period—*Fall of bodily temperature in 2 hours $1^{\circ}.7$, in 1 hour $0.85 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.85 \times 0.75 = 12.11 = \text{heat taken from reserve.}$$

$$113.939 = \text{hourly dissipation of heat.}$$

$$12.11 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 101.829*Sixth Period—*Rise of bodily temperature in $5\frac{1}{2}$ hours $1^{\circ}.7$, in 1 hour $0.314 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.314 \times 0.75 = 4.617 = \text{heat added to reserve.}$$

$$63.55 = \text{hourly dissipation of heat.}$$

$$4.617 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 68.024*Seventh Period—*Fall of bodily temperature in 6 hours $0^{\circ}.3$, in 1 hour $0.05 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.05 \times 0.75 = 0.7125 = \text{heat taken from reserve.}$$

$$64.2342 = \text{hourly dissipation of heat.}$$

$$0.7125 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 63.5217*Eighth Period—*Fall of bodily temperature in $5\frac{1}{2}$ hours $0^{\circ}.2$, in 1 hour $0.036 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.036 \times 0.75 = 0.513 = \text{heat taken from reserve.}$$

$$49.93 = \text{hourly dissipation of heat.}$$

$$0.513 = \text{heat taken from reserve.}$$

Hourly production of heat 49.417*Ninth Period—*Rise of bodily temperature in $4\frac{1}{2}$ hours $2^{\circ}.2$, in 1 hour $0.463 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.463 \times 0.75 = 6.5977 = \text{heat added to reserve.}$$

$$44.5 = \text{hourly dissipation of heat.}$$

$$6.5977 = \text{hourly addition to reserve.}$$

Hourly production of heat 51.0977*Tenth Period—*Fall of bodily temperature in $5\frac{1}{2}$ hours $0^{\circ}.5$, in 1 hour $0.091 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.091 \times 0.75 = 1.2967 = \text{heat taken from reserve.}$$

$$67.2197 = \text{hourly dissipation of heat.}$$

$$1.2967 = \text{heat taken from reserve.}$$

Hourly production of heat 65.923*Eleventh Period—*Fall of bodily temperature in $6\frac{1}{2}$ hours $1^{\circ}.5$, in 1 hour $0.231 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.231 \times 0.75 = 3.2917 = \text{heat taken from reserve.}$$

$$106.3313 = \text{hourly dissipation of heat.}$$

$$3.2917 = \text{heat taken from reserve.}$$

Hourly production of heat 103.0396*Twelfth Period—*Fall of bodily temperature in $5\frac{1}{2}$ hours $0^{\circ}.4$, in 1 hour $0.073 = t$.

$$Q = W \times t \times \text{sp. h.} = 19 \times 0.073 \times 0.75 = 1.040 = \text{heat taken from reserve.}$$

$$71.5769 = \text{hourly dissipation of heat.}$$

$$1.04 = \text{heat taken from reserve.}$$

Hourly production of heat 70.5369

EXPERIMENT 113.

A dog. Weight 22 pounds; had been fed in the morning of experiment.
 May 14. 5:10 P. M.—Rectal temperature 103°.

Time	Air Temp.	Tube Temp.	Box Temp.	GENERAL METER.	SAMPLE METER.	Air METER.	SAMPLE CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)
5:30 P. M.	63° 23	67° 02	63° 32	111.41	100	100.023	72.727
5:45	62.96	67.02					
6	62.04	67.12					
6:15	63.23	67.43					
6:30	63.14	67.69					
6:45	63.14	67.9					
7	62.24	67.9					
7:15	62.36	67.8					
7:30	61.36	67.49					
7:45	59	65.96					
8	60.3	66.47					
8:15	59.3	66.29					
8:30	59.3	66.8					
8:45	59	66.47					
9	68.7	67.13					
9:15	58.7	66.8					
9:30	59.9	68.45					
9:45	59.8	68.27					
10	61.2	68.96					
10:15	61.2	69.08					
10:30	61.51	68.84					
10:45	61.72	68.45					
11	61.2	68.18					
11:15	61.3	68.09					
11:30	61.5	68.09					
11:45	.....	.....	68.42	519.75	100.3196	100.2847	72.7795
	61.09	67.59	5.1	408.34	0.3196	0.2617	0.0525
	(mean)	61.09	(gain)	0.3196			(gain)
		6.5		408.6596			
		(gain)					

May 15. 12 midnight.—Rectal temperature 103°. 1 A. M.—Rectal temperature 102°.6.

Time	Air Temp.	Tube Temp.	Box Temp.	GENERAL METER.	SAMPLE METER.	Air METER.	SAMPLE CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)
1:34 A. M.	67° 28	69° 54	64° 76	669.8	100.3197	100.282	72.795
1:50	67.37	69.64					
2:5	67.46	71.15					
2:20	63.5	69.44					
2:35	63.8	69.35					
2:50	65.48	69.54					
3:5	66.21	69.44					
3:20	65.21	69.54					
3:35	62.05	69.75					
3:50	65.75	69.44					
4:5	63.92	68.36					
4:20	62.34	68.27					
4:35	62.14	68.54					
4:50	62.14	68.09					
5:5	60.14	67.32					
5:20	59.1	67.02					
5:35	58.9	66.65					
5:50	58.8	66.47					
6:5	59	66.92					
6:20	58.7	67.02					
6:35	60.9	68.18					
6:5	56.8	65.84					
7:5	55.6	65.12					
7:20	57	66.8					
7:34	59.6	68.84	68.576	977.925	100.667	100.6742	72.8832
	61.97	68.25	3.816	308.125	0.3473	0.3922	0.0882
	(mean)	61.97	(gain)	0.3473			(gain)
		6.28		308.4723			
		(gain)					

8 A. M.—Rectal temperature 102°.8. 9:30 A. M.—Dog given about three ounces of bread.

11:20 A. M.—Rectal temperature 102°.

May 15.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)
11:25 A. M.	61 ^o .44	65 ^o .84	63 ^o .68	1045.9	100.667	100.6472	72.8832	68.5954
11:40	61.64	66.29						
11:55	63.8	67.02						
12:10 P. M.	62.84	66.38						
12:25	61.64	65.84						
12:40	61.94	66.08						
12:55	61.64	66.47						
1:10	62.72	66.47						
1:25	62.48	65.23						
1:40	63.23	66.8						
1:55	63.04	66.56						
2:10	63.32	67.02						
2:25	63.68	67.32						
2:40	63.92	67.32						
2:55	63.32	67.23						
3:10	63.32	67.23						
3:25	63.92	67.9						
3:40	64.13	67.43						
3:55	64.4	67.69						
4:10	65.3	67.49						
4:25	.....	.....	66.8	1434	100.7832	100.825	72.9078	68.6436
	63.08	66.78	3.12	388.1	0.1162	0.1778	0.0246	0.0482
	(mean)	63.08	(gain)	0.1162			(gain)	(gain)
		3.7		388.2162				
		(gain)						

4:30 P. M.—Rectal temperature 102^o.2.

4:40 P. M.—Dog ate half a pound of raw liver.

5:30 P. M.—Injected into the jugular vein twenty minims of blood, eleven days old.

May 16, 10:30 A. M.—Rectal temperature 103^o.6. Dog seems very quiet and sick, injected ten minims of blood, four and a half days old.

12:20 P. M.—Rectal temperature 104^o.8.

May 16.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	AIR METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	AIR CALCIUM TUBE. (grms.)
12:35 P. M.	.....	.....	64 ^o .76	488.9	0.8	0.8245	72.9078	75.9576
12:50	59 ^o .5	65 ^o .48						
1:5	59.4	65.21						
1:20	60.1	66.39						
1:35	60.3	65.39						
1:50	60.7	65.48						
2:5	61.24	66.65						
2:20	61.6	67.02						
2:35	62.14	67.12						
2:50	62.84	68.09						
3:5	63.29	68						
3:20	63.68	68.63						
3:35	64.22	68.27						
3:50	64.4	68.54						
4:5	.....	.....	67.055	709.8	.....	.....	72.9444	76.0344
	61.8	66.94	2.295	220.9			0.0366	0.0768
	(mean)	61.8	(gain)				(gain)	(gain)
		5.14						
		(gain)						

4:20 P. M.—Rectal temperature 103^o.6.

May 16.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	Air METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	Air METER. (cub. ft.)
4:36 p. m.	....	.....	65° 255	754.65	.....	.....	72.9444	76.1007
4:51	66.68	68.54						
5:6	66.47	68.63						
5:21	66.68	69.26						
5:36	66.68	69.35						
5:51	66.29	69.26						
6:6	66.92	69.85						
6:21	66.17	69.64						
6:36	66.77	69.26						
6:51	65.21	69.35						
7:6	64.67	69.17						
7:21	64.04	69.08						
7:36	64.04	69.75						
7:51	64.49	69.85						
8:6	64.67	69.75						
8:21	63.23	69.85						
8:36	62.96	70.06						
8:51	63.32	69.85						
9:6	63.59	69.85						
9:21	64.31	69.95						
9:36	61.9	69.95						
9:51	61.1	70.16						
10:6	61.8	69.75						
10:21	60.4	69.64						
10:36	.....	.....	69.704	1233.2	101.228	101.209	72.9991	76.1007
	64.46 (mean)	69.55 64.46	4.449 (gain)	478.55			0.0547 (gain)	0.0084 (gain)
		5.09 (gain)						

10:45 p. m.—Rectal temperature 103° 8.

11:55 p. m.—Rectal temperature 103° 4.

May 17.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	GENERAL METER. (cub. ft.)	SAMPLE METER. (cub. ft.)	Air METER. (cub. ft.)	SAMPLE CALCIUM TUBE. (grms.)	Air METER. (cub. ft.)
12:26 a. m.	60.16	67.79	66° 47	291.02	101.228	101.209	72.9991	76.1007
12:40	60.	68						
12:55	59.1	66.92						
1:10	59.2	66.38						
1:25	61.48	66.29						
1:40	60.1	68.12						
1:55	60.3	68.84						
2:10	58.7	67.43						
2:25	59	67.79						
2:40	59.2	68.54						
2:55	60.1	68.54						
3:10	59.7	68.72						
3:25	59.3	68.45						
3:40	59.3	68.29						
3:55	59.4	68.2						
4:10	59.7	69.06						
4:25	59.1	68.63						
4:40	58.7	68.27						
4:55	58.9	68.72						
5:10	58.9	68.84						
5:26	62.6	69.44	69.08	727.8	101.3104	101.425	73.021	76.1007
	69.68 (mean)	68.15 59.68	2.61 (gain)	436.78 0.0824	0.0824	0.216	0.0219 (gain)	0.0088 (gain)
		8.47 (gain)		436.8624				

6:55 a. m.—Rectal temperature 103° 4.

May 17. 9:50 A. M.—Dog very quiet; does not seem very sick. Rectal temperature 103°.9.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
10:8 A. M.	65.3	68.18	65.6	823.4	101.3104	101.425	73.021	76.1935
10:23	66.38	68.36						
10:38	65.57	69.17						
10:53	65.66	68.84						
11:8	.....	.....	66.47	919.045	101.3371		73.0221	76.1982
	65.73	68.64	0.87	95.645	0.0267		0.0011	0.0047
	(mean)	65.73	(gain)	0.0267			(gain)	(gain)
		2.91		95.6717				
		(gain)						

11:10 A. M.—Rectal temperature 103°.7.

11:50 A. M.—Dog ate one pound of raw beef.

12:15 P. M.—40 minims of blood, 5½ days old, injected into the jugular vein.

3:30 P. M.—Rectal temperature 104°.8. 30 minims of blood injected into the jugular vein.

4:15 P. M.—Rectal temperature 106°.7.

TIME.	AIR TEMP.	TUBE TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	AIR CALCIUM TUBE.
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	(grms.)
4:32 P. M.	.....	.....	63.86	1072.92	101.3337	101.4275	73.0221	76.1982
4:47	61.94	66.29						
5:2	61.24	66.29						
5:17	61	66.64						
5:32	60.7	66.38						
5:47	61	66.8						
6:2	60.4	67.13						
5:17	60.4	66.01						
6:32	64.22	69.36						
6:47	64.31	69.65						
7:2	66.56	70.43						
7:17	68.9	71.24						
7:32	70.07	72.05						
7:47	70.64	72.14						
8:2	70.06	72.32						
8:17	67.04	71.42						
8:32	63.8	70.34						
8:47	64.76	70.06						
9:2	62.72	69.96						
9:17	63.05	70.16						
9:32	63.44	71.61						
9:47	61.84	71.06						
10:2	61.64	70.61						
10:17	62.14	71.15						
10:32	62.02	70.97	68.99	1487.24	101.4911	101.6416	73.0221	76.2482
	63.91	69.58	5.13	414.32	0.1574	2.2141	0.0129	0.05
	(mean)	63.91	(gain)	0.1574			(gain)	(gain)
		5.67		414.4774				
		(gain)						

10:45 P. M.—Rectal temperature 104°.7.

May 17 and 18.

Time.	AIR TEMP.	TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	
11:52 P. M.	67° 28	68.96	66° 47	511.72	101.4925	101.6425	73.035	
1:7	63.68	70.61						
12:2 A. M.	59.8	68.24						
12:17	66.2	66.68						
12:32	67.28	70.97						
12:47	68.81	71.33						
1:2	64.22	72.59						
1:17	68.81	71.15						
1:32	70.16	72.41						
1:47	70	72.96						
2:2	71.24	74						
2:17	71.33	74.12						
2:32	71.84	74.12						
2:47	72.32	74.21						
3:2	72.08	73.45						
3:17	72.83	74.3						
3:32	72.63	74.57						
3:47	72.73	74.48						
4:2	72.73	74.56						
4:17	72.78	74.56						
4:32	71.69	74.84						
4:47	69.80	73.88						
5:2	68.99	73.45						
5:17	67.76	73.45						
5:32	67.1	72.8						
5:47	66.38	71.72						
6:2	65.39	71.96						
6:17	64.76	71.72						
6:32	.....	.....	72.41	1023.575	101.7	101.771	73.132	
	68.7 (mean)	72.57 68.7	5.94 (gain)	511.855 0.2117	0.2117	0.1285	0.097 (gain)	
		3.87 (gain)		512.0667				

6:40 A. M.—Rectal temperature 104° 8.

10:40 A. M.—Rectal temperature 104° 1.

Time.	AIR TEMP.	TEMP.	BOX TEMP.	GENERAL METER.	SAMPLE METER.	AIR METER.	SAMPLE CALCIUM TUBE.	
	(Fah.)	(Fah.)	(Fah.)	(cub. ft.)	(cub. ft.)	(cub. ft.)	(grms.)	
10:54 A. M.	67.76	70° 06	66° 51.5	1078.37	101.7118	101.7704	73.132	
11:6	67.1	70.06						
11:21	66.44	70.64						
11:36	66.68	70.43						
11:51	67.28	71.51						
12:6 P. M.	66.68	70.97						
12:21	67.37	70.64						
12:36	66.47	71.15						
12:51	.....	.....	68.18	1251.75	101.7852	101.8055	73.1529	
	66.97 (mean)	70.68 66.97	1.665 (gain)	173.38 0.0734	0.0734	0.0351	0.0209 (gain)	
		3.71 (gain)		173.4534				

1:10 P. M.—Rectal temperature 104° 1.

1:5 P. M.—Spinal cord cut between the upper dorsal and the first cervical vertebra. palsy of the hind legs.

May 18. 1:13 P. M.—Rectal temperature 104°.3.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:24 P. M.	.....	.....	65°.864	288.25
1:39	68°.63	70°.25		
1:54	69.08	69.44		
2:9	69.71	71.24		
2:24	69.53	71.15		
2:39	70.04	71.06		
2:54	70.64	70.97	67.532	400.82
	69.6 (mean)	70.68 69.6	1.668 (gain)	112.57
		1.08 (gain)		

2:55 P. M.—Rectal temperature 99°.8.

Heat Dissipation.

First Period—

Quantity of air (V') = 408.6596 at 67°.59 — 32° = 35.59 = t'
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{408.6596}{1.0724} = 381.1$. $W = V \times 0.08073 = 30.8$
 Rise in temp. of air 6.5 = t . $Q = W \times t \times \text{sp. h.} = 30.8 \times 6.5 \times 0.2374 = 47.5275 = \text{heat given to air.}$
 Quotient for box $1278.6 \times 0.0525 = 67.1265 = \text{moisture leaving box.}$
 Quotient for air $1561.5 \times 0.0515 = 80.4172 = \text{moisture entering box.}$
 $\frac{13.2907}{6.2768} = 2.1174 = \text{heat gained from condensation.}$
 Rise in temp. of water $5.1 \times 130.8589 = 667.3804 = \text{heat given to calorimeter.}$
 $47.5275 = \text{heat given to air.}$
 $\frac{714.9079}{2.1174} = \text{heat gained from condensation.}$
 $712.7905 = \text{heat dissipated in } 6\frac{1}{4} \text{ hours.}$
Hourly dissipation of heat 114.0465

Second Period—

Quantity of air (V') = 308.4723 at 68°.25 — 32° = 36.25 = t' .
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{308.4723}{1.074} = 287$. $W = V \times 0.08073 = 23.17$
 Rise in temp. of air 6.28 = t . $Q = W \times t \times \text{sp. h.} = 23.17 \times 6.28 \times 0.2374 = 34.539 = \text{heat given to air.}$
 Quotient for box $888.2 \times 0.0882 = 78.3392 = \text{moisture leaving box.}$
 Quotient for air $786.5 \times 0.0666 = 52.3809 = \text{moisture entering box.}$
 $25.9583 = \text{moisture vaporized in box.}$
 $\frac{25.9583}{6.2768} = 4.1356 = \text{heat expended in vaporization.}$
 Rise in temp. of water $3.816 \times 130.8589 = 499.3576 = \text{heat given to calorimeter.}$
 $34.539 = \text{heat given to air.}$
 $4.1356 = \text{heat expended in vaporization.}$
 $538.0322 = \text{heat dissipated in 6 hours.}$
Hourly dissipation of heat 89.672

Third Period—

Quantity of air (V') = 388.2162 at 66°.78 — 32° = 34.78 = t' .
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{388.2162}{1.071} = 362.5$. $W = V \times 0.08073 = 29.3$
 Rise in temp. of air 3.7 = t . $Q = W \times t \times \text{sp. h.} = 29.3 \times 3.7 \times 0.2374 = 25.7365 = \text{heat given to air.}$
 Quotient for box $3340.9 \times 0.0246 = 82.1861 = \text{moisture leaving box.}$
 Quotient for air $2183.4 \times 0.0482 = 105.239 = \text{moisture entering box.}$
 $23.0538 = \text{moisture condensed in box.}$

23.0538 = 3.6729 = heat gained from condensation.

6.2768

Rise in temp. of water $3.12 \times 130.8589 = 408.2798 =$ heat given to calorimeter.

25.7365 = heat given to air.

434.0163

3.6729 = heat gained from condensation.

430.3434 = heat dissipated in 5 hours.

Hourly dissipation of heat 86.0687

Fourth Period—

Quantity of air (V') = 220.9 at $66.94 - 32^\circ = 34.94 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{220.9}{1.071} = 206.1$ $W = V \times 0.08073 = 16.66$

Rise in temp. of air $5.14 = t$. $Q = W \times t \times \text{sp. h.} = 16.66 \times 5.14 \times 0.2374 = 20.3291 =$ heat given to air.

Rise in temp. of water $2.295 \times 130.8589 = 300.3212 =$ heat given to calorimeter.

20.3291 = heat given to air.

320.6503 = heat dissipated in $3\frac{1}{2}$ hours.

Hourly dissipation of heat 91.6144*

Fifth Period—

Quantity of air (V') = 478.55 at $69.55 - 32^\circ = 37.55 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{478.55}{1.076} = 447$. $W = V \times 0.08073 = 35.9$

Rise in temp. of air $5.09 = t$. $Q = W \times t \times \text{sp. h.} = 35.9 \times 5.09 \times 0.2374 = 40.9826 =$ heat given to air.

Rise in temp. of water $4.449 \times 130.8589 = 582.1912 =$ heat given to calorimeter.

40.9826 = heat given to air.

623.1738 = heat dissipated in 6 hours.

Hourly dissipation of heat 103.8623*

Sixth Period—

Quantity of air (V') = 436.8624 at $68^\circ.15 - 32^\circ = 36.15 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{436.8624}{1.073} = 407.1$. $W = V \times 0.08073 = 32.8$

Rise in temp. of air $8.47 = t$. $Q = W \times t \times \text{sp. h.} = 32.8 \times 8.47 \times 0.2374 = 65.9535 =$ heat given to air.

Quotient for box $5301.7 \times 0.0219 = 116.1072 =$ moisture leaving box.

Quotient for air $2022.5 \times 0.0308 = 62.293 =$ moisture entering box.

53.8142 = moisture vaporized in box.

53.8142 = 8.5735 = heat expended in vaporization.

6.2768

Rise in temp. of water $2.61 \times 130.8589 = 341.5417 =$ heat given to calorimeter.

65.9535 = heat given to air.

8.5735 = heat expended in vaporization.

416.0687 = heat dissipated in 5 hours.

Hourly dissipation of heat 83.2137

Seventh Period—

Quantity of air (V') = 95.6717 at $68^\circ.64 - 32^\circ = 36.64 = t'$.

$V + (V \times t' \times 0.002035) = V'$. $V = \frac{95.6717}{1.075} = 89$. $W = V \times 0.08073 = 7.185$

Rise in temp. of air $2.91 = t$. $Q = W \times t \times \text{sp. h.} = 7.185 \times 2.91 \times 0.2374 = 4.9636 =$ heat given to air.

Rise in temp. of water $0.87 \times 130.8589 = 113.8472 =$ heat given to calorimeter.

4.9636 = heat given to air.

Hourly dissipation of heat 118.8108*

* The sample meters in these heats were not read through an inadvertency, and consequently the moisture could not be calculated; the moisture account had varied so in contiguous periods of the experiments that it was deemed safest to make no attempt at an average.

Eighth Period—

Quantity of air (V') = 414.4774 at $69^{\circ}.58 - 32^{\circ} = 37.58 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{414.4774}{1.076} = 385.2$. $W = V \times 0.08073 = 31.1$
 Rise in temp. of air $5.67 = t$. $Q = W \times t \times \text{sp. h.} = 31.1 \times 5.67 \times 0.2374 = 41.8624 = \text{heat given to air.}$
 Quotient for box $2633.3 \times 0.0129 = 33.9696 = \text{moisture leaving box.}$
 Quotient for air $1935.9 \times 0.05 = 96.795 = \text{moisture entering box.}$
 $\frac{62.8254}{6.2768} = 10.0091 = \text{heat gained from condensation.}$
 Rise in temp. of water $5.13 \times 130.8589 = 671.3061 = \text{heat given to calorimeter.}$
 $41.8624 = \text{heat given to air.}$
 $\frac{713.1685}{10.0091} = \text{heat gained from condensation.}$
 $703.1594 = \text{heat dissipated in 6 hours.}$
Hourly dissipation of heat 117.1932

Ninth Period—

Quantity of air (V') = 512.0667 at $72^{\circ}.57 - 32^{\circ} = 40.57 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{512.0667}{1.082} = 473.2$. $W = V \times 0.08073 = 38.2$
 Rise in temp. of air $3.87 = t$. $Q = W \times t \times \text{sp. h.} = 38.2 \times 3.87 \times 0.2374 = 35.0958 = \text{heat given to air.}$
 Quotient for box $2418.8 \times 0.097 = 234.6236 = \text{moisture leaving box.}$
 Quotient for air $3985 \times 0.0328 = 130.708 = \text{moisture entering box.}$
 $103.9156 = \text{moisture vaporized in box.}$
 $\frac{103.9156}{6.2768} = 16.5555 = \text{heat expended in vaporization.}$
 Rise in temp. of water $5.94 \times 130.8589 = 777.3019 = \text{heat given to calorimeter.}$
 $35.0958 = \text{heat given to air.}$
 $16.5555 = \text{heat expended in vaporization.}$
 $828.9532 = \text{heat dissipated in 7 hours.}$
Hourly dissipation of heat 118.4219

Tenth Period—

Quantity of air (V') = 173.453 at $70^{\circ}.68 - 32^{\circ} = 38.68 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{173.453}{1.079} = 160.7$. $W = V \times 0.08073 = 13$
 Rise in temp. of air $3.71 = t$. $Q = W \times t \times \text{sp. h.} = 13 \times 3.71 \times 0.2374 = 11.4498 = \text{heat given to air.}$
 Quotient for box $2363 \times 0.0209 = 49.3867 = \text{moisture leaving box.}$
 Quotient for air $4941.7 \times 0.0083 = 41.0161 = \text{moisture entering box.}$
 $8.3706 = \text{moisture vaporized in box.}$
 $\frac{8.3706}{6.2768} = 1.3336 = \text{heat expended in vaporization.}$
 Rise in temp. of water $1.665 \times 130.8589 = 217.88 = \text{heat given to calorimeter.}$
 $11.4498 = \text{heat given to air.}$
 $1.3336 = \text{heat expended in vaporization.}$
 $230.664 = \text{heat dissipated in 2 hours.}$
Hourly dissipation of heat 115.3317

Eleventh Period—

Quantity of air (V') = 112.57 at $70^{\circ}.68 - 32^{\circ} = 38.68 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{112.57}{1.079} = 104.3$. $W = V \times 0.08073 = 8.42$
 Rise in temp. of air $1.08 = t$. $Q = W \times t \times \text{sp. h.} = 8.42 \times 1.08 \times 0.2374 = 2.1588 = \text{heat given to air.}$
 Rise in temp. of water $1.668 \times 130.8589 = 218.2726 = \text{heat given to calorimeter.}$
 $2.1588 = \text{heat given to air.}$
 $220.4314 = \text{heat dissipated in } 1\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 146.9542*

* Moisture not calculated.

*Heat Production.**First Period—*

No change of bodily temperature.

Hourly dissipation of heat = *hourly production of heat* 114.0465*Second Period—*Fall of bodily temperature in 7 hours $0^{\circ}.2$, in 1 hour $0.029 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.029 \times 0.75 = 0.4785 = \text{heat taken from reserve.}$$

$$89.672 = \text{hourly dissipation of heat.}$$

$$0.4785 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 89.1935*Third Period—*Rise of bodily temperature in 5 hours $0^{\circ}.2$, in 1 hour $0.04 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.04 \times 0.75 = 0.66 = \text{heat added to reserve.}$$

$$86.0687 = \text{hourly dissipation of heat.}$$

$$0.66 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 86.7287*Fourth Period—*Fall of bodily temperature in 4 hours $1^{\circ}.2$, in 1 hour $0.3 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.3 \times 0.75 = 4.95 = \text{heat added to reserve.}$$

$$91.6144 = \text{hourly dissipation of heat.}$$

$$4.95 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 86.6644*Fifth Period—*Rise of bodily temperature in 6 hours $0^{\circ}.2$, in 1 hour $0.033 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.033 \times 0.75 = 0.5445 = \text{heat taken from reserve.}$$

$$103.8623 = \text{hourly dissipation of heat.}$$

$$0.5445 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 104.4068*Sixth Period—*

No alteration of bodily temperature.

Hourly dissipation of heat = *hourly production of heat* 83.2137*Seventh Period—*Fall of bodily temperature in $1\frac{1}{4}$ hours 0.2 , in 1 hour $0.16 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.16 \times 0.75 = 2.64 = \text{heat taken from reserve.}$$

$$118.8108 = \text{hourly dissipation of heat.}$$

$$2.64 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 116.1708*Eighth Period—*Fall of bodily temperature in $6\frac{1}{2}$ hours 2° , in 1 hour $0.308 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.308 \times 0.75 = 5.082 = \text{heat taken from reserve.}$$

$$117.1932 = \text{hourly dissipation of heat.}$$

$$5.082 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 112.1112

Ninth Period—

Rise of bodily temperature in 8 hours $0^{\circ}.1$, in 1 hour $0.0125 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 0.0125 \times 0.75 = 0.2062 = \text{heat added to reserve.}$$

$$118.4208 = \text{hourly dissipation of heat.}$$

$$0.2062 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 118.627

Tenth Period—

No change of bodily temperature.

Heat dissipated hourly = *hourly production of heat* 115.3317

Eleventh Period—

Fall of bodily temperature in 102 minutes $13^{\circ}.5$, in 1 hour $7.941 = t$.

$$Q = W \times t \times \text{sp. h.} = 22 \times 7.941 \times 0.75 = 131.0265 = \text{heat taken from reserve.}$$

$$146.9542 = \text{hourly dissipation of heat.}$$

$$131.0265 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 15.9277

RECAPITULATION.

	TIME.	HEAT DISSIPATION.	HEAT PRODUCTION.	RECT. TEMP. (Fah.)	REMARKS.
First day.	5:30 P. M. to 11:45 P. M.	114.0465	114.0465	103°	Dog had been fed
May 14, 5 P. M. to	1:34 A. M. to 7:34 A. M.	89.6720	89.1935	102.6 to 102.8	early in the morn-
May 15, 5 P. M.	11:25 A. M. to 4:25 P. M.	86.0687	86.7287	102 to 102.2	ing.
4:40 P. M.—Dog ate $\frac{1}{2}$ lb. raw liver. 5:30 P. M. injected into jugular 20 minims putrid blood. May 16, 11 A. M. 10 minims more.					
Second day.	12:35 P. M. to 4:5 P. M.	91.6144	86.6644	104.8 to 103.6	
May 16, 12.30 P. M. to	4:36 P. M. to 10:36 P. M.	103.8623	104.4068	103.6 to 103.8	
May 17, 12.30 P. M.	12:26 A. M. to 5:26 A. M.	83.2137	83.2137	103.4	
	10:8 A. M. to 11:8 A. M.	118.8108	116.1708	103.9 to 103.7	
11:50 P. M.—Dog ate 1 lb. raw beef. Injected into jugular 40 minims of putrid blood.					
Third day.	4:32 P. M. to 10:32 P. M.	117.1932	112.1112	106.7 to 104.7	
May 17, 4.30 P. M. to	11:32 P. M. to 6:32 A. M.	118.4219	118.627	104.7 to 104.8	
May 18, 1 P. M.	10:51 A. M. to 12:51 P. M.	115.3317	115.3317	104.1	
After section of cord.					
	1:24 P. M. to 2:54 P. M.	146.9542	15.9277	104.3 to 90.8	

SUMMARY.

	TIME IN CALORIMETER.	AVERAGE HOURLY HEAT DISSIPATION.	AVERAGE HOURLY HEAT PRODUCTION.	EXTREMES OF RECT. TEMP. (Fah.)	AVERAGE RECT. TEMP. (Fah.)
First day.	17 $\frac{1}{4}$ hours.	97.4589	97.4838	102.2 to 103	102.6
Second day.	14 $\frac{1}{2}$ hours.	95.4002	94.3229	103.4 to 104.8	103.7
Third day.	15 hours	117.5184	115.5817	104.1 to 106.7	105

EXPERIMENT 114.

A cur. Weight 25 pounds.

June 4. 8 A. M.—Dog ate three-quarters of a pound of cooked beef's liver.

11:53 A. M.—Rectal temperature 102° 6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
11:53 A. M.	69.92	45
12:30 P. M.		
12:45		
1		
1:15		
1:30		
1:45		
2		
2:15		
2:30		
2:45		
3		
3:15		
3:30		
3:45		
4		
4:15		
4:30		
4:45		
5		
5:15		
5:30	75.68		
5:53	74.03	600.504

	74.46	4.11	555.504
	72.73	(gain)	
		1.73		
		(gain)		

5:53 P. M.—Rectal temperature 103° 6.

6:15 P. M.—Dog ate ten ounces of cooked mutton.

6:30 P. M.—Rectal temperature 102° 4.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
6:30 P. M.	73.09	1053.5
7		
7:15		
7:30		
7:45		
8		
8:15		
8:30		
8:45		
9		
9:15		
9:30		
9:45		
10		
10:15		
10:30		
10:45		
11		
11:15		
11:30		
11:45		
12	76.16	1524.6

	73.14	.....	3.07	471.1
	(mean)	.....	(gain)	
			
			

12:10 A. M.—Rectal temperature 102° 2.

12:30 A. M.—Dog ate four ounces of cooked meat.

June 5.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:45 A. M.	.....	.....	74° 21	565.63
1:15	70° 43	75.92		
1:35	70.97	75.92		
1:55	71.78	75.68		
2:15	72.32	75.92		
2:35	72.08	75.92		
2:55	71.42	76.04		
3:15	71.78	76.04		
3:35	71.87	76.16		
3:55	71.6	76.28		
4:15	71.33	76.16		
4:35	70.88	76.04		
4:55	70.43	75.92		
5:15	70.64	75.92		
5:35	70.88	76.28		
5:55	70.97	76.28		
6:15	71.33	76.46		
6:35	71.33	76.91		
6:45	.....	.....	77.27	1164.6
	71.3	76.11	3.06	598.97
	(mean)	71.3	(gain)	
		4.84		
		(gain)		

7 A. M.—Rectal temperature 101° 4.

8 A. M.—Dog ate three ounces of cooked meat.

8:30 A. M.—Rectal temperature 101° 2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
8:48 A. M.	.....	.....	71° 96	172.06
9:30	71° 33	74		
9:50	72.08	74.56		
10:10	72.32	74.88		
10:30	72.52	74.12		
10:50	72.73	74.57		
11:10	72.83	74.48		
11:30	72.89	74.75		
11:48	.....	.....	73.769	447
	72.39	74.48	1.809	274.94
	(mean)	72.39	(gain)	
		2.09		
		(gain)		

12 noon.—Rectal temperature 101° 9

5 P. M.—Dog has had no food since the three ounces of meat at 8 A. M. No food given during the following twenty-four hours.

8 P. M.—Rectal temperature 101° 3.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
8:15 P. M.	.....	.....	69° 32	511.37
8:45	63° 32	69° 85		
9	65.3	69.54		
9:20	64.31	69.08		
9:40	63.68	68.96		
10	63.5	68.63		
10:20	62.87	68.72		
10:40	62.24	68.84		
11	62.14	68.45		
11:26	61.74	68.63		
11:45	61.14	68.55	70.43	831.54
	63.02	68.92	1.11	320.17
	(mean)	63.02	(gain)	
		5.9		
		(gain)		

12 midnight.—Rectal temperature 101° 8.

June 6.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
12:17 A. M.	.....	.....	67.46	901.3
1:20	60.1	66.08		
1:40	59.4	65.3		
2	59.1	65.21		
2:20	59.3	65.18		
2:40	59.3	65.72		
3	58.1	66.68		
3:20	57.8	65.09		
3:40	58.9	67.23		
4	58.6	67.33		
4:20	57.1	65.84		
4:40	57.3	66.56		
5	57.1	66.47		
5:20	56.1	66.08		
5:40	56.9	66.29		
6	56.5	66.08		
6:20	57.8	66.68		
6:47	.....	.....	69.32	1400
	58.09 (mean)	66.11 58.09	1.86 (gain)	498.7
		8.02 (gain)		

6:50 A. M.—Rectal temperature 101°.8.

8:20 A. M.—Rectal temperature 101°.4.

TIME	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
8:50 A.	.....	.....	66.263	400.67
9:20	60.6	65.30		
9:40	59.8	66.29		
10	60.04	67.43		
10:20	59.9	67.33		
10:40	61.24	67.23		
11	62.24	67.23		
11:20	62.6	67.9		
11:40	62.72	67.69		
12 M.	62.96	67.69		
12:20 P. M.	63.23	68		
12:40	63.32	68		
1	63.5	68.18		
1:20	63.15	68.45		
1:40	64.13	68.54		
2	64.49	68.96		
2:20	64.76	69.44	68.54	914.85
	62.41 (mean)	67.73 62.41	2.277 (gain)	514.18
		5.32 (gain)		

2:20 P. M.—Rectal temperature 101°.

June 6. 3:37 P. M.—Rectal temperature 100°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
3:37 P. M.	.....	.....	68°.036	983
4	64°.76	69°.96		
4:20	68.45	69.26		
4:40	68.54	70.64		
5	68.54	70.52		
5:20	68.72	70.88		
5:40	68.99	70.52		
6	69.08	70.88		
6:20	68.9	71.06		
6:40	69.44	71.6		
7	68.81	70.52		
7:25	68.45	70.52		
7:37	.....	.....	70.16	1310.75
	68.43	70.58	2.124	327.75
	(mean)	68.43	(gain)	
		2.15		
		(gain)		

7:37 P. M.—Rectal temperature 101°.2.

8 P. M.—Dog given as much cooked beef as he would eat.

8:30 P. M.—Thirty minims of putrid blood injected into the jugular vein.

June 8. 10 A. M.—Rectal temperature 101°.5. Thirty minims of putrid blood injected into the jugular vein.

3 P. M.—Rectal temperature 103°. Fifty minims of putrid blood injected as before.

4 P. M.—Rectal temperature 103°.8.

4:35 P. M.—Rectal temperature 103°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
5:48 P. M.	.....	.....	67°.676	373
5:50	66°.68	70°.88		
6:10	68.36	70.76		
6:30	69.53	70.52		
6:50	70.16	70.52		
7:10	70.04	70.88		
7:30	70.16	70.97		
7:50	70.43	71.23		
8:10	70.43	71.42		
8:30	70.52	72.2		
8:50	70.88	72.32		
9:10	70.97	72.95		
9:30	70.97	72.95°		
9:50	70.88	73.45		
10:10	70.88	72.41		
10:30	71.06	72.5		
10:48	.....	.....	72.42	749.2
	70.13	71.73	4.744	376.2
	(mean)	70.13	(gain)	
		1.6		
		(gain)		

10:50 P. M.—Rectal temperature 101°.8.

10:55 P. M.—Dog refuses to eat; some purging; injected thirty minims of putrid blood into peritoneal cavity.

June 9. 11:55 P. M.—Rectal temperature 102° .2.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
12:4 A. M.	.....	.....	70 .43	755.25
12:10	70.52	71.72		
12:30	71.42	71.72		
12:50	71.51	71.96		
1:10	71.33	72.08		
1:30	71.06	72.08		
1:50	70.88	72.32		
2:10	70.88	72.32		
2:30	70.25	72.2		
2:50	69.8	72.95		
3:10	69.08	73.04		
3:30	68.59	73.45		
3:50	68.54	73.45		
4:10	68.54	73.35		
4:30	68.24	73.14		
4:50	67.28	73.65		
5:10	67.76	73.35		
5:30	67.46	72.32		
5:50	68.45	72.5		
6:4	.....	.....	75.02	1196.94
	69.53	72.64	4.59	441.69
	(mean)	69.53	(gain)	
		3.11		
		(gain)		

6:25 A. M.—Rectal temperature 102° .4. Refuses to eat.

7:35 A. M.—Rectal temperature 102° .2.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
7:48 A. M.	.....	.....	71 .42	223.8
8	64° .88	69 .85		
8:20	67.04	69.54		
8:40	66.38	70.25		
9	66.2	71.51		
9:20	66.29	71.15		
9:40	66.38	70.64		
10	66.2	70.52		
10:20	66.29	71.96		
10:40	66.2	70.64		
11	66.29	70.97		
11:20	66.56	72.68		
11:40	67.46	71.33		
12:18 P. M.	67.16	71.33	73.52	558.1
	66.41	70.95	2.1	334.3
	(mean)	66.41	(gain)	
		4.54		
		(gain)		

12:18 P. M.—Rectal temperature 102° .4.

3 P. M.—Rectal temperature 102° .6.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gen. Meter. (cub. ft.)
3:50 P. M.	.....	.....	69 .62	636
4:5	68 .72	71° .15		
4:20	70.16	70.06		
4:50	71.87	71.24		
5:10	72.33	71.72		
5:30	71.87	71.96		
5:50	71.78	71.96	70.88	776.4
	71.12	71.35	1.26	140.4
	(mean)	71.12	(gain)	
		0.23		
		(gain)		

5:50 P. M.—Rectal temperature 102° .8.

Dog died June 11.

Rise in temp. of air $8.02 = t$. $Q = W \times t \times \text{sp. h.} = 37.66 \times 8.02 \times 0.2374 = 71.7027 = \text{heat given to air.}$
 Rise in temp. of water $1.86 \times 130.8589 = 243.3975 = \text{heat given to calorimeter.}$
 $71.7027 = \text{heat given to air.}$

 $315.1002 = \text{heat dissipated in 6 hours.}$
Hourly dissipation of heat 52.5167

Seventh Period—

Quantity of air (V') = 514.18 at $67^{\circ}.73 - 32^{\circ} = 35.73 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{514.18}{1.073} = 479.2$. $W = V \times 0.08073 = 38.686$
 Rise in temp. of air $5.32 = t$. $Q = W \times t \times \text{sp. h.} = 38.686 \times 5.32 \times 0.2374 = 48.859 = \text{heat given to air.}$
 Rise in temp. of water $2.277 \times 130.8589 = 297.9657 = \text{heat given to calorimeter.}$
 $48.859 = \text{heat given to air.}$

 $346.8247 = \text{heat dissipated in } 5\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 63.0588

Eighth Period—

Quantity of air (V') = 327.75 at $70^{\circ}.58 - 32^{\circ} = 38.58 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{327.75}{1.073} = 304$. $W = V \times 0.08073 = 24.54$
 Rise in temp. of air $2.15 = t$. $Q = W \times t \times \text{sp. h.} = 24.54 \times 2.15 \times 0.2374 = 12.5255 = \text{heat given to air.}$
 Rise in temp. of water $2.124 \times 130.8589 = 277.9443 = \text{heat given to calorimeter.}$
 $12.5255 = \text{heat given to air.}$

 $290.4698 = \text{heat dissipated in 4 hours.}$
Hourly dissipation of heat 72.6174

Ninth Period—

Quantity of air (V') = 376.2 at $71^{\circ}.73 - 32^{\circ} = 39.73 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{376.2}{1.073} = 348.3$. $W = V \times 0.08073 = 28.12$
 Rise in temp. of air $1.6 = t$. $Q = W \times t \times \text{sp. h.} = 28.12 \times 1.6 \times 0.2374 = 10.6811 = \text{heat given to air.}$
 Rise in temp. of water $4.744 \times 130.8589 = 620.7946 = \text{heat given to calorimeter.}$
 $10.6811 = \text{heat given to air.}$

 $631.4757 = \text{heat dissipated in 5 hours.}$
Hourly dissipation of heat 126.2951

Tenth Period—

Quantity of air (V') = 441.69 at $72^{\circ}.64 - 32^{\circ} = 40.64 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{441.69}{1.073} = 408.9$. $W = V \times 0.08073 = 33.01$
 Rise in temp. of air $3.11 = t$. $Q = W \times t \times \text{sp. h.} = 33.01 \times 3.11 \times 0.2374 = 24.3717 = \text{heat given to air.}$
 Rise in temp. of water $4.59 \times 130.8589 = 600.6423 = \text{heat given to calorimeter.}$
 $24.3717 = \text{heat given to air.}$

 $625.014 = \text{heat dissipated in 6 hours.}$
Hourly dissipation of heat 104.17

Eleventh Period—

Quantity of air (V') = 334.3 at $70^{\circ}.95 - 32^{\circ} = 38.95 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{334.3}{1.079} = 309.8$. $W = V \times 0.08073 = 25.01$
 Rise in temp. of air $4.54 = t$. $Q = W \times t \times \text{sp. h.} = 25.01 \times 4.54 \times 0.2374 = 26.9557 = \text{heat given to air.}$
 Rise in temp. of water $2.1 \times 130.8589 = 274.8038 = \text{heat given to calorimeter.}$
 $26.9557 = \text{heat given to air.}$

 $301.7595 = \text{heat dissipated in } 4\frac{1}{2} \text{ hours.}$
Hourly dissipation of heat 67.058

Twelfth Period—

Quantity of air (V) = 140.4 at $71^{\circ}.35 - 32^{\circ} = 39.35 = t$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{140.4}{1.08} = 130. \quad W = V \times 0.08073 = 10.495$$

Rise in temp. of air $0.23 = t$. $Q = W \times t \times \text{sp. h.} = 10.495 \times 0.23 \times 0.2374 = 0.5733 = \text{heat given to air.}$

Rise in temp. of water $1.26 \times 130.8589 = 164.8822 = \text{heat given to calorimeter.}$

$0.5733 = \text{heat given to air.}$

$165.4555 = \text{heat dissipated in 2 hours.}$

Hourly dissipation of heat 82.7277

Heat Production.

First Period—

Rise of bodily temperature in 6 hours 1° , in 1 hour $0.1666 = t$.

$Q = W \times t \times \text{sp. h.} = 25 \times 0.167 \times 0.75 = 3.13125 = \text{heat added to reserve.}$

$92.461 = \text{hourly dissipation of heat.}$

$3.13125 = \text{hourly addition to heat reserve.}$

Hourly production of heat 95.59225

Second Period—

Fall of bodily temperature in $5\frac{2}{3}$ hours $0^{\circ}.2$, in 1 hour $0.0353 = t$.

$Q = W \times t \times \text{sp. h.} = 25 \times 0.0353 \times 0.75 = 0.6619 = \text{heat taken from reserve.}$

$83.7169 = \text{hourly dissipation of heat.}$

$0.6619 = \text{hourly loss from heat reserve.}$

Hourly production of heat 83.055

Third Period—

Fall of bodily temperature in $6\frac{1}{3}$ hours $0^{\circ}.8$, in 1 hour $0.11707 = t$.

$Q = W \times t \times \text{sp. h.} = 25 \times 0.11707 \times 0.75 = 2.1951 = \text{heat taken from reserve.}$

$75.1897 = \text{hourly dissipation of heat.}$

$2.1951 = \text{hourly loss from heat reserve.}$

Hourly production of heat 72.9856

Fourth Period—

Rise of bodily temperature in $3\frac{1}{2}$ hours $0^{\circ}.7$, in 1 hour $0.2 = t$.

$Q = W \times t \times \text{sp. h.} = 25 \times 0.2 \times 0.75 = 3.75 = \text{heat added to reserve.}$

$82.2869 = \text{hourly dissipation of heat.}$

$3.75 = \text{hourly addition to heat reserve.}$

Hourly production of heat 86.0369

Fifth Period—

Rise of bodily temperature in 4 hours $0^{\circ}.5$, in 1 hour $0.125 = t$.

$Q = W \times t \times \text{sp. h.} = 25 \times 0.125 \times 0.75 = 2.6812 = \text{heat added to reserve.}$

$51.1055 = \text{hourly dissipation of heat.}$

$2.34375 = \text{hourly addition to heat reserve.}$

Hourly production of heat 53.4494

Sixth Period—

No change in bodily temperature.

Hourly dissipation of heat = *hourly production of heat* 52.5167

Seventh Period—

Fall of bodily temperature in 5 hours $0^{\circ}.4$, in 1 hour $0.067 = t$.

$Q = W \times t \times \text{sp. h.} = 25 \times 0.067 \times 0.75 = 1.267 = \text{heat taken from reserve.}$

$63.0588 = \text{hourly dissipation of heat.}$

$1.26 = \text{hourly loss from heat reserve.}$

Hourly production of heat 61.7988

*Eighth Period—*Rise of bodily temperature in 4 hours $0^{\circ}.6$, in 1 hour $0.15 = t$.

$$Q = W \times t \times \text{sp. h.} = 25 \times 0.15 \times 0.75 = 2.8125 = \text{heat taken from reserve.}$$

$$72.6174 = \text{hourly dissipation of heat.}$$

$$2.8125 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 75.4299*Ninth Period—*Fall of bodily temperature in $6\frac{1}{2}$ hours $1^{\circ}.8$, in 1 hour $0.28421 = t$.

$$Q = W \times t \times \text{sp. h.} = 25 \times 0.28421 \times 0.75 = 5.325 = \text{heat taken from reserve.}$$

$$126.2951 = \text{hourly dissipation of heat.}$$

$$5.325 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 120.9701*Tenth Period—*Rise of bodily temperature in $6\frac{1}{2}$ hours $0^{\circ}.6$, in one hour $0.0923 = t$.

$$Q = W \times t \times \text{sp. h.} = 25 \times 0.0923 \times 0.75 = 1.7306 = \text{heat added to reserve.}$$

$$104.17 = \text{hourly dissipation of heat.}$$

$$1.7306 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 105.9006*Eleventh Period—*Rise of bodily temperature in $5\frac{1}{2}$ hours $0^{\circ}.2$, in 1 hour $0.035 = t$.

$$Q = W \times t \times \text{sp. h.} = 25 \times 0.035 \times 0.75 = 0.6563 = \text{heat added to reserve.}$$

$$67.058 = \text{hourly dissipation of heat.}$$

$$0.6563 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 67.7143*Twelfth Period—*Rise of bodily temperature in $2\frac{1}{2}$ hours $0^{\circ}.2$, in 1 hour $0.071 = t$.

$$Q = W \times t \times \text{sp. h.} = 25 \times 0.071 \times 0.75 = 1.331 = \text{heat added to reserve.}$$

$$82.7277 = \text{hourly dissipation of heat.}$$

$$1.331 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 84.0587

RECAPITULATION.

June 4. Dog had eaten at 8 A. M. $\frac{3}{4}$ lb. of cooked liver.

DAY.	TIME.	HOURLY HEAT DISSIPATION.	HOURLY HEAT PRODUCTION.	RECT. TEMP. (Fah.)	REMARKS.
First day.	11:53 A. M. to 5:53 P. M.	92.461	95.59225	102 $^{\circ}$.6 to 103.6	At 6:15 P. M. ate
June 4, 11:50 A. M. to	6:47 P. M. to 11:47 P. M.	83.7169	83.055	102.4 to 102.2	10 oz. of cooked
June 5, 11:50 A. M.	12:45 A. M. to 6:45 A. M.	75.1807	72.9856	102.2 to 101.4	mutton.
	8:48 A. M. to 11:48 A. M.	82.2869	86.0369	101.2 to 101.9	8 A. M. ate 3 oz. of
					cooked mutton.

Has had no food since 8 A. M., and none during following 24 hours.

Second day	8:15 P. M. to 11:45 P. M.	51.055	53.4494	101.3 to 101.8
June 5, 8 P. M. to	12:47 A. M. to 6:47 A. M.	52.5167	52.5167	101.8
June 6, 8 P. M.	9:20 A. M. to 2:20 P. M.	63.0588	61.7983	101.4 to 101
	3:37 P. M. to 7:37 P. M.	72.6174	75.4299	100.6 to 101.2

Dog at 8 P. M. given as much beef as he would eat. At 8:30 P. M. 30 minims of putrid blood injected into jugular

June 8, 10:15 A. M. 30 minims of putrid blood injected.

10:50 P. M. dog refuses to eat; some purging. 11 P. M. injected 30 minims of putrid blood into peritoneal cavity.

Third day.	5:48 P. M. to 10:48 P. M.	126.2951	120.9701	103.6 to 101.8	
June 8, 6 P. M. to	12:4 A. M. to 6:4 A. M.	104.17	105.49375	101.8 to 102.4	
June 9, 6 P. M.	7:48 A. M. to 12:18 P. M.	67.058	67.7143	102.2 to 102.4	Refuses to eat.
	3:50 P. M. to 5:50 P. M.	82.7277	84.0587	102.6 to 102.8	

Died June 11, A. M.

SUMMARY.

	TIME IN CALORIMETER.	AVERAGE HOURLY HEAT DISSIPATION.	AVERAGE HOURLY HEAT PRODUCTION.	EXTREMES OF RECT. TEMP. (Fah.)	AVERAGE RECT. TEMP.
First day.	20 hours.	83.5648	84.2426	101 ^o .4 to 103.6	102 ^o .24
Second day.	18 hours.	59.4355	60.1560	100.6 to 101.8	101.405
Third day.	17½ hours.	98.4978	97.7511	101.8 to 103.6	102.4

EXPERIMENT 115.

A rabbit. Weight 3.5 pounds.

June 4. 12:35 P. M.—Rectal temperature 103^o.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
12:35 P. M.	69 ^o .17	71 ^o .42	69 ^o .92	1026.7
12:45	68.99	71.96		
1	70.04	72.08		
1:15	70.64	72.59		
1:30	71.75	72.86		
1:45	71.51	73.25		
2	72.08	73.76		
2:15	72.42	73.25		
2:30	72.42	73.35		
2:45	72.73	74.57		
3	72.89	75.2		
3:15	72.99	75.2		
3:30	73.4	75.48		
3:45	73.85	75.68		
4	73.94	76.16		
4:15	73.94	76.37		
4:30	74.48	76.55		
4:45	74.93	76.91		
5	75.02	77		
5:15	75.02	77		
5:30	75.65	76.82		
5:45	75.38	77.27		
6:5	.....	.....	71.69	1166.2
	72.85 (mean)	74.76 72.85	1.77 (gain)	139.5
		1.91 (gain)		

6:5 P. M.—Rectal temperature 103^o.6. Rabbit had skin badly rubbed off in taking him out of the calorimeter.

6:45 P. M.—Rectal temperature 103^o.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
7:2 P. M.	71 ^o .96	76 ^o .46	72 ^o .116	166.1
7:15	73.1	76.91		
7:35	74.12	76.37		
7:55	73.85	75.8		
8:15	73.52	75.38		
8:38	73.4	75.2		
8:55	73.3	74.74		
9:15	73.3	74.66		
9:35	73.1	74.84		
9:55	73.09	74.66		
10:15	73.19	74.75		
10:35	73.19	74.66		
10:55	72.53	74.75		
11:15	72.42	74.39		
11:35	73.09	74.39		
12:2 A. M.	.....	.....	73.64	296.5
	73.14 (mean)	75.2 73.14	1.524 (gain)	130.4
		2.06 (gain)		

12:20 A. M.—Rectal temperature 101^o.6.

June 5.

1 A. M.—Rectal temperature $103^{\circ}.8$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:12 A. M.	.....	.....	72.2	299
1:30	.....	.....
1:35	70.97	76.46		
1:55	71.58	75.92		
2:15	72.32	75.2		
2:35	72.08	74.84		
2:55	71.42	74.66		
3:15	71.78	74.48		
3:35	71.87	74.48		
3:55	71.6	74.3		
4:15	71.33	73.88		
4:35	70.88	73.66		
4:55	70.43	73.45		
5:15	70.64	73.14		
5:35	70.88	73.14		
5:55	70.97	73.04		
6:12	.....	.....	73.46	396.64
	71.35	74.33	1.26	97.64
	(mean)	71.35	(gain)	
		2.98		
		(gain)		

6:20 A. M.—Rectal temperature $105^{\circ}.8$.9 A. M.—Rectal temperature $105^{\circ}.4$.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
9 A. M.	.....	.....	69.32	397.5
9:30	71.33	73.45		
9:50	72.08	73.45		
10:10	72.32	73.45		
10:30	72.52	73.55		
10:50	72.74	73.76		
11:10	72.83	73.76		
11:30	72.89	73.88		
12	.....	.....	70.34	483.4
	72.4	73.61	1.02	85.9
	(mean)	72.4	(gain)	
		1.21		
		(gain)		

12 noon.—Rectal temperature $105^{\circ}.4$.*Heat Dissipation.**First Period—*Quantity of air (V') = 139.5 at $74^{\circ}.76 - 32^{\circ} = 42.76 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{139.5}{1.087} = 128.3$. $W = V \times 0.08073 = 10.36$ Rise in temp. of air $1.91 = t$. $Q = W \times t \times \text{sp. h.} = 10.36 \times 1.91 \times 0.2374 = 4.6976 = \text{heat given to air.}$ Rise in temp. of water $1.77 \times 79.544 = 140.7928 = \text{heat given to calorimeter.}$ $4.6976 = \text{heat given to air.}$ $145.4904 = \text{heat dissipated in } 5\frac{1}{2} \text{ hours.}$ *Hourly dissipation of heat* 26.4527*Second Period—*Quantity of air (V') = 130.4 at $75^{\circ}.2 - 32^{\circ} = 43.2 = t'$. $V + (V \times t' \times 0.002035) = V'$. $V = \frac{130.4}{1.088} = 119.8$. $W = V \times 0.08073 = 9.67$ Rise in temp. of air $2.06 = t$. $Q = W \times t \times \text{sp. h.} = 9.67 \times 2.06 \times 0.2374 = 4.729 = \text{heat given to air.}$

Rise in temp. of water $1.524 \times 79.544 = 121.225 =$ heat given to calorimeter.
 $4.729 =$ heat given to air.

 $125.954 =$ heat dissipated in 5 hours.

Hourly dissipation of heat 25.1908

Third Period—

Quantity of air (V') = 97.64 at $74^{\circ}.33 - 32^{\circ} = 42.33 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{97.64}{1.086} = 90$. $W = V \times 0.08073 = 7.266$
Rise in temp. of air $2.98 = t$. $Q = W \times t \times \text{sp. h.} = 7.266 \times 2.98 \times 0.2374 = 5.1397 =$ heat given to air.
Rise in temp. of water $1.26 \times 79.544 = 100.2254 =$ heat given to calorimeter.
 $5.1397 =$ heat given to air.

 $105.3651 =$ heat dissipated in 5 hours.

Hourly dissipation of heat 21.073

Fourth Period—

Quantity of air (V') = 85.9 at $73^{\circ}.61 - 32^{\circ} = 41.61 = t'$.
 $V + (V \times t' \times 0.002035) = V'$. $V = \frac{85.9}{1.085} = 79.2$. $W = V \times 0.08073 = 6.39$
Rise in temp. of air $1.21 = t$. $Q = W \times t \times \text{sp. h.} = 6.39 \times 1.21 \times 0.2374 = 1.8355 =$ heat given to air.
Rise in temp. of water $1.02 \times 79.544 = 81.1349 =$ heat given to calorimeter.
 $1.8355 =$ heat given to air.

 $82.9704 =$ heat dissipated in 3 hours.

Hourly dissipation of heat 27.6568

Heat Production.

First Period—

No change in bodily temperature.
Hourly dissipation of heat = hourly production of heat 26.4527

Second Period—

Rise of bodily temperature in $5\frac{1}{2}$ hours 1° , in 1 hour $0.182 = t$.
 $Q = W \times t \times \text{sp. h.} = 3.5 \times 0.182 \times 0.75 = 0.4777 =$ heat added to reserve.
 $25.1908 =$ hourly dissipation of heat.
 $0.4777 =$ hourly addition to heat reserve.

Hourly production of heat 25.6685

Third Period—

Rise of bodily temperature in $5\frac{1}{2}$ hours 2° , in 1 hour $0.375 = t$.
 $Q = W \times t \times \text{sp. h.} = 3.5 \times 0.375 \times 0.75 = 0.9844 =$ heat added to reserve.
 $21.073 =$ hourly dissipation of heat.
 $0.9844 =$ hourly addition to heat reserve.

Hourly production of heat 22.0574

Fourth Period—

No change in bodily temperature.
Hourly dissipation of heat = hourly production of heat 27.6568

RECAPITULATION.

	TIME.	HEAT DISSIPATION.	HEAT PRODUCTION.	AVER. RECT. TEMP. (Fah.)	REMARKS.
First period.	12:35 P. M. to 6:5 P. M.	26.4527	26.4527	103 ^o .6	
Second period.	7:2 P. M. to 12:2 A. M.	25.1908	25.6685	104.1	
Third period.	1:12 A. M. to 6:12 A. M.	21.073	22.0574	104.8	
Fourth period.	9 A. M. to 12 A. M.	27.6568	27.6568	105.4	

29 October, 1880.

EXPERIMENT 116.

A rabbit. Weight 4.1 pounds.

June 5. 8:30 P. M.—Rectal temperature 103° 6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
8:40 P. M.	.....	.....	68° 12	475.65
9	65° 3	69° 35		
9:20	64.31	68.6		
9:40	63.68	68.24		
10	63.5	67.37		
10:20	62.87	66.8		
10:40	62.24	66.92		
11	62.14	66.56		
11:20	61.74	66.38		
11:40	61.14	65.72		
12:10 A. M.	.....	.....	68.81	580.75
	62.99	67.33	0.69	105.1
	(mean)	62.99	(gain)	
		4.34		
		(gain)		

June 6. 12:30 A. M.—Rectal temperature 103° 4.

12:50 A. M.—Rectal temperature 102°.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER (cub. ft.)
1:10 A. M.	.....	.....	67° 04	580.5
1:20	60° 1	67° 72		
1:40	59.4	65.84		
2	59.1	65.12		
2:20	59.3	65.72		
2:40	59.3	65.48		
3	58.1	65.39		
3:20	57.8	63.86		
3:40	58.9	64.94		
4	58.6	65.12		
4:20	57.1	63.77		
4:40	57.3	64.4		
5	57.1	63.77		
5:20	56.1	63.05		
5:40	56.9	63.23		
6	56.5	62.15		
6:20	57.8	62.36		
6:40	.....	.....	67.298	681
	58.1	64.49	0.258	100.5
	(mean)	58.1	(gain)	
		6.39		
		(gain)		

6:50 A. M.—Rectal temperature 101° 2.

9:10 A. M.—Rectal temperature 100° 8.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
9:20 A. M.	60° 6	63° 86	64° 283	708.2
9:40	59.8	63.95		
10	60	63.77		
10:20	59.9	63.86		
10:40	61.24	64.04		
11	62.24	64.31		
11:20	62.6	64.52		
11:40	62.72	64.85		
12 M.	62.96	64.94		
12:20 P. M.	63.23	65.21		
12:40	63.32	65.39		
1	63.5	65.6		
1:20	63.15	65.96		
1:40	64.13	66.29		
2	64.49	66.8		
2:20	64.76	67.01		
2:50	.....	.....	65.84	819.3
	62.41	65.02	1.557	111.1
	(mean)	62.41	(gain)	
		2.61		
		(gain)		

2:55 P. M.—Rectal temperature 101° 8.

3:50 P. M.—Rectal temperature 101° 6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4 P. M.	64° 76	68° 68	66° 08	853.5
4:20	68.45	69.89		
4:40	68.54	69.98		
5	68.54	69.89		
5:20	68.72	69.98		
5:40	68.99	70.08		
6	69.08	69.98		
6:20	68.90	69.98		
6:40	69.44	70.16		
7	68.81	70.07		
7:25	68.45	68.98		
8	.....	.....	66.92	969
	68.43	69.79	0.84	115.5
	(mean)	68.43	(gain)	
		1.36		
		(gain)		

8:10 P. M.—Rectal temperature 101° 6.

June 7. 11 A. M.—Ten minims of putrid blood injected into the jugular vein.

June 8. 10:30 A. M.—Five minims of putrid blood injected into the jugular vein.

2:40 P. M.—Five minims of putrid blood injected into the jugular vein.

June 8. 4:10 P. M.—Rectal temperature 105° 4.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gas. Meter. (cub. ft.)
4:31 P. M.	.....	.....	65° 6-12	960.3
5:15	.....	70° 88		
5:50	66° 68	70.6		
6:10	68.36	71.24		
6:30	69.53	70.18		
6:50	70.16	71.6		
7:10	70.04	71.69		
7:30	70.16	71.87		
7:50	70.43	72.05		
8:10	70.43	71.87		
8:30	70.52	71.96		
8:50	70.88	72.14		
9:10	70.97	72.23		
9:30	70.97	72.23		
9:50	70.88	72.32		
10:10	70.88	72.23		
10:31	71.06	72.32	67.88	1126.13
	70.13 (mean)	71.92 70.13	2.238 (gain)	165.83
		1.79 (gain)		

10:40 P. M.—Rectal temperature 104° 5.

11:20 P. M.—Injected 10 minims of putrid blood into the peritoneal cavity. Rectal temperature 104° 6.

June 8 and 9.

Time.	Air Temp. (Fah.)	Tube Temp. (Fah.)	Box Temp. (Fah.)	Gas. Meter. (cub. ft.)
11:27 P. M.	.....	.....	68° 36	125.75
12:10 A. M.	70° 52	73° 88		
12:30	71.42	71.6		
12:50	71.51	73.49		
1:10	71.33	73.49		
1:30	71.06	72.8		
1:50	70.88	73.22		
2:10	70.88	73.22		
2:30	72.25	73.04		
2:50	69.8	72.8		
3:10	69	72.41		
3:30	68.54	71.87		
3:50	68.54	71.87		
4:10	68.54	71.6		
4:30	68.24	71.36		
4:50	67.28	71.12		
5:10	67.76	70.79		
5:27	.....	.....	70.04	295.47
	69.73 (mean)	72.41 69.73	1.68 (gain)	169.72
		2.68 (gain)		

5:35 A. M.—Rectal temperature 103° 8.

Rabbit refuses entirely to eat; stays permanently in one position and seems very sick.
 June 9. 6:50 A. M.—Some slimy rectal discharge. Rectal temperature 103°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
7:11 A. M.	.....	.....	69°.272	297.5
7:30	67.36	69.8		
7:45	67.36	69.68		
8	64.88	69.44		
8:20	66.38	69.2		
8:40	66.2	69.08		
9	66.29	68.9		
9:20	66.38	68.72		
9:40	66.2	68.6		
10	67.04	68.36		
10:20	66.29	68.36		
10:40	66.2	68.27		
11	66.29	68.18		
11:20	66.56	68.18		
11:40	67.46	68.36		
12:11 P. M.	67.46	68.18	70.04	431.95
	66.54	68.75	0.768	134.45
	(mean)	66.54	(gain)	
		2.21		
		(gain)		

12:20 P. M.—Rectal temperature 105° 8.

1:10 P. M.—Rectal temperature 102°.2.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
1:17 P. M.	.....	.....	69°.14	445
1:40	64.49	68.72		
2	68.51	68.9		
2:20	68.90	69.2		
2:40	68.63	69.44		
3	69.53	69.68		
3:17	.....	.....	69.44	504
	68.02	69.19	0.3	59
	(mean)	68.02	(gain)	
		1.17		
		(gain)		

3:25 P. M.—Rectal temperature 103°.6.

TIME.	AIR TEMP. (Fah.)	TUBE TEMP. (Fah.)	BOX TEMP. (Fah.)	GEN. METER. (cub. ft.)
4:5 P. M.	68°.72	71°.6	69°.32	507.8
4:20	70.16	71.69		
4:50	71.87	71.87		
5:10	72.33	72.41		
5:30	71.87	72.41		
5:50	71.78	72.41		
6:5	.....	.....	69.71	553.2
	71.12	72.06	0.39	45.4
	(mean)	71.12	(gain)	
		0.91		
		(gain)		

6:10 P. M.—Rectal temperature 103°.3.

June 10. Rabbit died.

*Heat Dissipation.**First Period—*Quantity of air (V) = 105.1 at $67^{\circ}.33 - 32^{\circ} = 35.33 = t'$

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{105.1}{1.072} = 98.04. \quad W = V \times 0.08073 = 7.91$$

Rise in temp. of air $4.34 = t$. $Q = W \times t \times \text{sp. h.} = 7.91 \times 4.34 \times 0.2374 = 8.1498 = \text{heat given to air.}$ Rise in temp. of water $0.69 \times 79.544 = 54.88536 = \text{heat given to calorimeter.}$

8.1498 = heat given to air.

63.03516 = dissipation of heat in $3\frac{1}{2}$ hours.*Hourly dissipation of heat* 18.01*Second Period—*Quantity of air (V') = 100.5 at $64^{\circ}.49 - 32^{\circ} = 32.49 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{100.5}{1.066} = 94.3. \quad W = V \times 0.08073 = 7.61$$

Rise in temp. of air $6.39 = t$. $Q = W \times t \times \text{sp. h.} = 7.61 \times 6.39 \times 0.2374 = 11.545 = \text{heat given to air.}$ Rise in temp. of water $0.258 \times 79.544 = 20.5223 = \text{heat given to calorimeter.}$

11.545 = heat given to air.

32.0673 = heat dissipated in $5\frac{1}{2}$ hours.*Hourly dissipation of heat* 5.8304*Third Period—*Quantity of air (V') = 111.1 at $65^{\circ}.02 - 32^{\circ} = 33.02 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{111.1}{1.067} = 104.1. \quad W = V \times 0.08073 = 8.4$$

Rise in temp. of air $2.61 = t$. $Q = W \times t \times \text{sp. h.} = 8.4 \times 2.61 \times 0.2374 = 5.205 = \text{heat given to air.}$ Rise in temp. of water $1.557 \times 79.544 = 123.85 = \text{heat given to calorimeter.}$

5.205 = heat given to air.

124.3705 = heat dissipated in $5\frac{1}{2}$ hours.*Hourly dissipation of heat* 22.6128*Fourth Period—*Quantity of air (V') = 115.5 at $69^{\circ}.79 - 32^{\circ} = 37.79 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{115.5}{1.077} = 107.2. \quad W = V \times 0.08073 = 8.654$$

Rise in temp. of air $1.36 = t$. $Q = W \times t \times \text{sp. h.} = 8.65 \times 1.36 \times 0.2374 = 2.793 = \text{heat given to air.}$ Rise in temp. of water $0.84 \times 79.544 = 66.81696 = \text{heat given to calorimeter.}$

2.793 = heat given to air.

69.60996 = heat dissipated in 4 hours.

Hourly dissipation of heat 17.4025*Fifth Period—*Quantity of air (V') = 165.83 at $71^{\circ}.92 - 32^{\circ} = 39.92 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{165.83}{1.08} = 153.5. \quad W = V \times 0.08073 = 12.4$$

Rise in temp. of air $1.79 = t$. $Q = W \times t \times \text{sp. h.} = 12.4 \times 1.79 \times 0.2374 = 5.27 = \text{heat given to air.}$ Rise in temp. of water $2.238 \times 79.544 = 178.019472 = \text{heat given to calorimeter.}$

5.27 = heat given to air.

183.289472 = heat dissipated in 6 hours.

Hourly dissipation of heat 30.5482

Sixth Period—

Quantity of air (V') = 169.72 at $72^{\circ}.41 - 32^{\circ} = 40.41 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{169.72}{1.08} = 157.1. \quad W = V \times 0.08073 = 12.68$$

Rise in temp. of air $2.68 = t$. $Q = W \times t \times \text{sp. h.} = 12.68 \times 2.68 \times 0.2374 = 8.067 = \text{heat given to air.}$

Rise in temp. of water $1.68 \times 79.544 = 133.6339 = \text{heat given to calorimeter.}$

8.067 = heat given to air.

141.7009 = heat dissipated in 6 hours.

Hourly dissipation of heat 23.6168

Seventh Period—

Quantity of air (V') = 134.45 at $68^{\circ}.75 - 32^{\circ} = 36.75 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{134.45}{1.075} = 125.07. \quad W = V \times 0.08073 = 10.09$$

Rise in temp. of air $2.21 = t$. $Q = W \times t \times \text{sp. h.} = 10.09 \times 2.21 \times 0.2374 = 5.294 = \text{heat given to air.}$

Rise in temp. of water $0.768 \times 79.544 = 61.089792 = \text{heat given to calorimeter.}$

5.294 = heat given to air.

66.383792 = heat dissipated in 5 hours.

Hourly dissipation of heat 13.2767

Eighth Period—

Quantity of air (V') = 59 at $69^{\circ}.19 - 32^{\circ} = 37.19 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{59}{1.076} = 54.8. \quad W = V \times 0.08073 = 4.4$$

Rise in temp. of air $1.17 = t$. $Q = W \times t \times \text{sp. h.} = 4.4 \times 1.17 \times 0.2374 = 1.2221 = \text{heat given to air.}$

Rise in temp. of water $0.3 \times 79.544 = 23.8632 = \text{heat given to calorimeter.}$

1.2221 = heat given to air.

25.0853 = heat dissipated in 2 hours.

Hourly dissipation of heat 12.5426

Ninth Period—

Quantity of air (V') = 45.4 at $72^{\circ}.06 - 32^{\circ} = 40.06 = t'$.

$$V + (V \times t' \times 0.002035) = V'. \quad V = \frac{45.4}{1.08} = 42.04. \quad W = V \times 0.08073 = 3.394$$

Rise in temp. of air $0.94 = t$. $Q = W \times t \times \text{sp. h.} = 3.4 \times 0.94 \times 0.2374 = 0.7587 = \text{heat given to air.}$

Rise in temp. of water $0.39 \times 79.544 = 31.02216 = \text{heat given to calorimeter.}$

0.7587 = heat given to air.

31.78086 = dissipation of heat in 2 hours.

Hourly dissipation of heat 15.89043

Heat Production.

First Period—

Fall of bodily temperature in 4 hours $0^{\circ}.2$, in 1 hour $0.5 = t$.

$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.5 \times 0.75 = 0.1537 = \text{heat taken from reserve.}$

18.01 = hourly dissipation of heat.

0.1537 = hourly loss from heat reserve.

Hourly production of heat 17.8563

Second Period—

Fall of bodily temperature in 6 hours $0^{\circ}.8$, in 1 hour $0.1333 = t$.

$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.1333 \times 0.75 = 0.4099 = \text{heat taken from reserve.}$

5.8304 = hourly dissipation of heat.

0.4099 = hour' loss from heat reserve.

Hourly production of heat 5.4205

*Third Period—*Rise of bodily temperature in $5\frac{1}{2}$ hours 1° , in 1 hour $0.17 = t$.

$$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.17 \times 0.75 = 0.5219 = \text{heat added to reserve.}$$

$$22.6128 = \text{hourly dissipation of heat.}$$

$$0.5219 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 23.1347*Fourth Period—*

No change of bodily temperature.

Heat dissipated hourly = *hourly production of heat* 17.4025*Fifth Period—*Fall of bodily temperature in $6\frac{1}{2}$ hours $0^{\circ}.9$, in 1 hour $0.1384 = t$.

$$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.1384 \times 0.75 = 0.4256 = \text{heat taken from reserve.}$$

$$30.5482 = \text{hourly dissipation of heat.}$$

$$0.4256 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 30.1226*Sixth Period—*Fall of bodily temperature in $6\frac{1}{4}$ hours $0^{\circ}.8$, in 1 hour $0.128 = t$.

$$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.128 \times 0.75 = 0.3937 = \text{heat taken from reserve.}$$

$$23.6168 = \text{hourly dissipation of heat.}$$

$$0.3937 = \text{hourly loss from heat reserve.}$$

Hourly production of heat 23.3231*Seventh Period—*Rise of bodily temperature in $5\frac{1}{2}$ hours $2^{\circ}.6$, in 1 hour $0.4727 = t$.

$$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.4727 \times 0.75 = 1.4535 = \text{heat added to reserve.}$$

$$13.2767 = \text{hourly dissipation of heat.}$$

$$1.4535 = \text{hourly addition to reserve.}$$

Hourly production of heat 14.7302*Eighth Period—*Rise of bodily temperature in $2\frac{1}{4}$ hours $1^{\circ}.4$, in 1 hour $0.622 = t$.

$$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.622 \times 0.75 = 1.9126 = \text{heat added to reserve.}$$

$$12.5426 = \text{hourly dissipation of heat.}$$

$$1.9126 = \text{hourly addition to heat reserve.}$$

Hourly production of heat 14.4552*Ninth Period—*Fall of bodily temperature in $2\frac{3}{4}$ hours $0^{\circ}.3$, in 1 hour $0.11 = t$.

$$Q = W \times t \times \text{sp. h.} = 4.1 \times 0.11 \times 0.75 = 0.3382 = \text{heat taken from reserve.}$$

$$15.8904 = \text{hourly dissipation of heat.}$$

$$0.3382 = \text{heat taken from reserve.}$$

Hourly production of heat 15.5522

RECAPITULATION.

	TIME.	HEAT DISSIPATION.	HEAT PRODUCTION.	RECT. TEMP. (Fah.)	REMARKS.
First day.	8:40 P. M. to 12:10 A. M.	18.01	17.8563	103° 6 to 103° 4	
June 5, 8:30 P. M. to	1:10 A. M. to 6:40 A. M.	5.8304*	5.4205*	102 to 101.2	
June 6, 8:30 P. M.	9:20 A. M. to 2:50 P. M.	22.6128	23.1347	100.8 to 101.8	
	4 P. M. to 8 P. M.	17.4025	17.4025	101.6 to 101.6	
June 7.	11 A. M.—Ten minims of putrid blood injected into the jugular vein.				
June 8.	10.30 A. M.—Five minims of putrid blood injected into the jugular vein.				
	2:40 P. M.—Five minims of putrid blood injected into the jugular vein.				
Second day.	4:31 P. M. to 10:31 P. M.	30.5482	30.1226	105.4 to 104.5	11.20 P. M.—Ten
June 9, 4 P. M. to	11:27 P. M. to 5:27 A. M.	23.6168	23.3231	104.6 to 103.8	minims of putrid
June 10, 4 P. M.	7:11 A. M. to 12:11 P. M.	13.2767	14.7302	103.2 to 105.8	blood injected
	1:17 P. M. to 3:17 P. M.	12.5426	14.4552	102.2 to 103.6	into the perito- neal cavity.

SUMMARY.

	TIME IN CALORIMETER.	AVERAGE HOURLY HEAT DISSIPATION.	AVERAGE HOURLY HEAT PRODUCTION.	EXTREMES OF RECT. TEMP. (Fah.)	AVERAGE RECT. TEMP. (Fah.)
First day.	13 hours.	.....	19.4955	100° 8 to 103° 6	101.6
Second day.	19 hours.	.....	22.2755	102.2 to 105.8	104.2

The experiments which have just been recorded, although undertaken for the purpose of determining whether there is or is not a greater production of heat in fever than in health, are capable of throwing light upon other problems, and it seems best to examine one or two of these before discussing the main question. There are two inquiries concerning the production of heat in health which may well here be studied. First, as to the existence or non-existence of a regular diurnal cycle of change in the heat production corresponding to the diurnal variations of bodily temperature. Second, as to the effect of food upon heat production. Of the experiments capable of throwing light upon the second of these inquiries No. 110 affords two days for comparison: the first of these days the dog ate one pound of raw liver when entering the calorimeter; the second he was without food. During the first day his average hourly heat production was 105.445; during the second day it was 61.4198 units; further, during the five hours immediately after the ingestion of the liver it was 176.8262, whilst during the second day the highest hourly production reached was 89.2437. The next experiment bearing directly upon the point now at issue is No. 114. During the first day the dog ate at intervals considerably over a pound and a half of meat, whilst on the second day he fasted; the result being that the average hourly heat production was the first day 84.2426, the second day 60.156 units. The decisive results obtained in these two experiments are confirmed by the immediate effects of the administration of food in one or two of the other experiments. They are also in accord with the results obtained by Senator, so that it may be considered demonstrated that the ingestion of a large amount of animal food is usually followed by an enormous increase in the pro-

* There was evidently some mistake made in reading the calorimetrical thermometer in this run, hence in making average it is omitted.

duction of heat. The conclusion thus reached taken in conjunction with the facts that heat still continues to be produced in starvation, and that various functional actions, as muscular movement and secretion in animals, and flowering in plants, have been found by various experimenters to be causes of local heat development, indicates that there are in the animal economy two distinct general sources of heat: first, the destruction, which probably occurs in the blood, of the excess of crude food material; second, nutritive changes in tissue, including all changes in the blood itself at the expense of its permanent constituents. It has not been proven, but it is most probable, that the heat centre, investigated in the previous chapter, affects solely the latter source of animal heat.

The effect of the ingestion of food upon heat production is so great and immediate that, if we desire to discover whether there is a diurnal cycle of alteration in the heat production, we must look at the records of those days when no food was taken, *i. e.*, when there was the greatest freedom from known disturbing causes. Ranging side by side the records of the four experiments at command for present purposes, and inverting the time as necessary to make the records coincide as nearly as possible, we obtain the following table. Each experiment consists of a connected twenty-four hours, although the periods of time did not always actually follow one another as arranged in the table.

EXPERIMENT 110.		EXPERIMENT 112.		EXPERIMENT 114.	
TIME.	HEAT PRODUCTION.	TIME.	HEAT PRODUCTION.	TIME.	HEAT PRODUCTION.
6:16 P. M. to 11:16 P. M.	66.6627	5:11 P. M. to 10:11 P. M.	58.6187	8:15 P. M. to 11:45 P. M.	53.4494
12:10 A. M. to 5:10 A. M.	40.5944	11:3 P. M. to 4:3 A. M.	69.8756	12:47 A. M. to 6:47 A. M.	52.5167
6:23 A. M. to 11:23 A. M.	65.8729	5 A. M. to 10 A. M.	63.86	9:20 A. M. to 2:20 P. M.	61.7988
1:30 A. M. to 3:30 P. M.	89.2437	12:13 P. M. to 4:13 P. M.	84.159	3:37 P. M. to 7:37 P. M.	75.4299

When these experiments were performed the use to which they are at present being put was not thought of. The periods of calorimetrical observation do not therefore correspond closely. Nevertheless the general drift is sufficiently similar for comparison. If we tabulate the periods of maximum and minimum production they will stand as follows:—

EXPERIMENT.	MAXIMUM PERIOD.	MINIMUM PERIOD.
110	1:30 P. M. to 3:30 P. M.	12:10 A. M. to 5:10 A. M.
112	12:13 P. M. to 4:13 P. M.	5:11 P. M. to 11:11 P. M.
114	3:37 P. M. to 7:37 P. M.	8:15 P. M. to 11:45 P. M.

On looking over this tabulated statement it will be seen that whilst there is some correspondence there is also a good deal of divergence. The time of maximum heat production in all is earlier or later in the afternoon; in two the time of minimum heat production is in the evening. This indicates that there is usually a tendency in normal dogs to an increase of heat production in the afternoon, and a diminution of it in the evening. The experiments are, however, not altogether concordant, and are too few to settle the question; but it is evident that if a tendency to a rhythmical production of animal heat does exist, such tendency must be entirely subservient to the accidents of feeding, exercise, etc., and that at least in the dog any diurnal cycle of bodily temperature which may exist must be de-

pendent upon the relations of heat dissipation to heat production rather than upon any dominant alteration of heat production. It is perhaps going too far to assume at present that what is true of the dog must also be true of the man, but the probabilities are that in this respect there is no difference between the two, for my experience seems to show that there is in dogs as well as man suffering from pyæmia an evening rise of temperature.

Coming now to the main question—the one for whose answering the present series of experiments were especially undertaken—I find the evidence of six of the experiments is best displayed by placing the results in tabular form as follows. The seventh experiment differs from the others in that it did not extend over several days, and its results therefore cannot be thrown into the same table with those of the others. The headings of the table explain sufficiently its purport without further comment.

No. of Exp.	FOOD DAY.			HUNGER DAY.			FIRST FEVER DAY.			SECOND FEVER DAY.		
	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.	Average Rectal Temp. (Fah.)	Average Hourly Heat Production.	Hours in Box.
110	102.39	105.445	15	102.83	61.4198	17	103.92	87.4777	15	105.42	92.8252	15
111	104.07	139.4733	17	104.78*	128.0702	17	104.89	130.1177	15	105.39	133.256	20
112	.....	.....	19.25	103.4	68.059	19.25	104.2	62.9151	16	105.08	75.8566	21
113	.....	.....	...	102.6	97.4838	17.25	103.7	94.3229	14.5	105	115.5817	15
114	102.24	84.2426	20	101.4	60.156	18	.....	.....	...	102.4	97.7511	17.5
116†	101.6	19.4955	13	.....	.....	..	104.2	22.2755	19	.....	.....	...

To this table must be added the results obtained in experiment 115 for a single day. On studying the table it will be seen that in Experiment 110 the production of animal heat during each fever day was much greater than during the day of abstinence, but less than when food was taken, also that the heat production during the fever rose with the average daily temperature. In Experiment 111 the day marked hunger day was one of feeding; under these circumstances there was a decline in the production of heat during the fever, but no proper comparison can be made between the fever day and a hunger day. It will be noticed that the heat production was less than when the dog was bountifully fed in health. Experiment 112 conformed in its results with Experiment 110; as did also Experiment 113, excepting that there was a diminished heat production during the first day of the fever. In Experiment 114, during what is marked as "second fever day" there was a production of animal heat much exceeding even that of feeding day, although the average temperature of the animal was very little above normal. The animal was at the time fatally sick, refusing food and dying within forty-eight hours.

A very curious fact is demonstrated by this experiment. If the fever process be considered to be that ultimate disorder of nutrition which produces the excessive

* The dog had $\frac{1}{2}$ pound of raw liver this day. It was not, therefore, really a hunger day; there was also elevation of temperature following an injection of pus, so that the day should be perhaps considered as a "fever day."

† A rabbit allowed to eat all it would.

amount of heat, the experiment shows that the highest development of the fever process may occur when the temperature is lowest; or, in other words, the experiment demonstrates, that excessive nutritive actions accompanied by an inordinate heat production may occur in a febrile disorder although the general bodily temperature remains low. It also throws light upon the apparent subsidence of fever sometimes seen shortly before death in low febrile diseases, showing that an excessive heat dissipation may entirely mask an excessive heat production.

In Experiment 116, the animal was a rabbit; the food day was really one of partial feeding, but the heat production was decidedly less than on the fever day. In Experiment 115 (not in the table), in which the trial was only during a few hours and the animal a rabbit, the production of heat was in slight excess after the full formation of the febrile period, although it was apparently diminished during the forming period of the fever. (See page 225.)

The experiments upon dogs, which have just been detailed, are in close accord with those of Senator. I think the following conclusions must be considered as demonstrated: *In the pyæmic fever of dogs the heat production is usually in excess of the heat production of fasting days, but less than that which can be produced by high feeding; usually the production of animal heat rises in the febrile state with the temperature and with the stage of the fever, but sometimes the heat production becomes very excessive, although the temperature of the body remains near the normal limit. In rabbits with pyæmic fever heat production seems to be even greater than it is in health when food is taken.*

In studying the production of animal heat in the normal dog it was found that there are evidently two sources of it; a portion of the heat being produced by the immediate destruction of food taken in excess of the needs of the organism; and another portion being the result of chemical movements in the stored materials of the body. The experiments upon pyæmic dogs, which have been detailed, show that whilst in fever there is little or no ingestion of food and consequently little or no production of heat from such source, the heat developed by the chemical movements of stored materials in the body is increased or, in other words, that there are increased chemical movements in the tissues during pyæmic fever in dogs.

In rabbits the effect of the immediate ingestion of food upon animal temperature is much less than it is upon dogs, and for obvious reasons: the digestion of such food as hay is a very slow process, taking hours, perhaps days for completion, and the excess in the blood of nutritive material at any one time is not so marked as it is in dogs, which will eat, at one meal, as much of meat as 5 per cent. or more of their entire weight. The two experiments upon rabbits detailed are, however, in accord with the conclusions reached in dogs, for in both of these experiments the heat production was in excess during the febrile state of what it was when there was no fever and when food was taken freely.

It is a matter of the greatest interest to compare these results with those reached by Liebermeister and by Leyden in man. Before doing so, however, it seems best to see how far they tally with those which have been reached by the deductive method as I have termed it; *i. e.*, by calculations based upon the ingesta and egesta of fever. The ablest and fullest discussion of this evidence with which

I am acquainted is that contained in the *Reports of the Medical Officers of the Privy Council and Local Government Board*, New Series, No. VI., London, 1875. It is by Prof. Burdon Sanderson, and I shall quote it in full.

"Heat stands on the same line with carbonic acid, urea, and water, as a part of chemical work done in the living body. To determine whether or not its production is increased or diminished, we have to proceed by continuous measurement just as in the other cases, with this difference, that the measurement of heat is a much more complicated and difficult problem than that of any of the chemical products of life. There are two methods by which it may be attempted. The first consists in estimating the thermogenesis from what is known as to the quantity and 'heat value' of the material daily and hourly consumed in the body, under the conditions to be investigated; the second, in directly measuring the quantity of heat daily or hourly discharged from the body, this quantity being, if the temperature is constant, identical with the quantity produced. In employing the first plan, that of estimation, we depend entirely on certain experiments made about eight years ago at the Royal Institution, by Prof. Frankland (the accuracy of which has been generally admitted), by which the 'heat value' of the 'immediate principles' of food (albumin, fat and some carbonic hydrates), *i. e.*, the quantity of heat yielded by each in complete or partial oxidation, was estimated.

"Of the values obtained, the most important and the most frequently used are those relating to albumin and its product urea, and to fat. A gramme of albumin, according to Frankland, yields 4.998 kilogramme-units of heat in complete combustion, *i. e.*, 4.998 times as much heat as is required to raise a kilogramme of water one degree [C.] of temperature. A gramme of urea yields 2.206 kilogramme-units; a gramme of fat 9.069 k.-units. In the disintegration of albumin in the living body, it does not yield the ultimate products (water, ammonia, and carbonic acid) but nearly the whole of its nitrogen passes out in the form of urea. Consequently in estimating the quantity of heat generated by it in the organism (its 'physiological heat value'), we deduct from its total heat value, the heat value of the weight of urea which is derived from it. Now, each gramme of albumin yields one-third of a gramme of urea, that being the quantity which would be produced by it if all its nitrogen were, in passing out of the body, to enter into the constitution of urea, for whereas albumin contains 15.5 per cent. of nitrogen, urea contains 46.66 per cent., and $\frac{15.5}{46.66} = \frac{1}{3}$. Hence of the total heat value of every gramme of albumin consumed physiologically, as much as belongs to one-third of a gramme of urea (*i. e.*, $\frac{2.206}{3} = 0.735$ k.-units) is lost to the organism. Deducting this from 4.998, we have 4.263 as the 'physiological heat value' of albumin.

"Leyden found, as has been already seen, that his fever patients exhaled during the remission, *i. e.*, when free from fever, 83.8 litres (at 0° C. and 760 mm.) of air in 15 minutes, which contained 3.3 per cent., *i. e.*, 2.79 litres of carbonic acid. A litre of carbonic acid weighs 1.9712 gramme. Consequently the discharge of carbonic acid per 15 minutes was 5.5 grammes or 22 grammes per hour. This gives 528 grammes as the discharge per day. In fever the same patients exhaled 134.6 litres in 15 minutes, containing 3.066 per cent. of carbonic acid, or, 4.127 litres. This gives 32.5 grammes per hour, or 780 grammes in 24 hours, supposing the rate of discharge to be constant. Senator, from determinations made in cases strictly comparable with those of Leyden, estimated the daily discharge of urea in patients on fever diet, but free from fever, as 17.5 grammes. We may therefore take 17.5 grammes of urea (representing 52.5 grammes of albumin), and 528 grammes of carbonic acid as an approximation as near as can be attained to the true estimate of the discharge of a healthy male person on fever diet.

"On these data we may proceed as follows: The physiological heat value of 52.5 grammes of albumin is 229.0 k.-units. The 52.5 grammes contain 27.82 grammes (53 per cent.) of carbon, of which 3.5 take the form of urea in order to leave the organism (for urea contains one-fifth of its weight of carbon, and 17.5 grammes are discharged). Deducting the remainder of carbon (*i. e.*, the quantity not so discharged) from 144 grammes (the quantity of carbon contained in 528 grammes of carbonic acid) we have 119.68 grammes as the quantity of carbon to be accounted for as derived from other sources. Now in inanition or on fever diet there is but one non-nitrogenous source of carbonic acid which we have to consider, namely, the fat of the tissues, consequently it is from that the 119.7 grammes of carbon must be derived. Taking the percentage of carbon in fat as 76.5, we have 156.4 grammes as the weight of fat, which must have been consumed in order to produce

the quantity of carbonic acid actually discharged. According to Frankland's estimate 156.4 grammes of fat yield in disintegration 1419 k.-units of heat. Adding this to the quantities derived from the disintegration of albumin we have 1648 k.-units as the total quantity of heat produced by patients on fever diet but in the apyretic state.

"By substituting for the numbers given above, relating to the discharges in health, those relating to fever, and repeating the process, we arrive at a comparable result as to the febrile production of heat. In fever, according to Senator's estimate, the urea discharge is increased to about 40 grammes daily, *i. e.*, it is about two and a third times as great as it would be on the same diet in health. Leyden's estimate of the carbonic acid discharge has already been given as 780 grammes daily. The physiological heat value of 120 grammes of albumin (the quantity which corresponds to 40 grammes of urea) is 511.56 heat units. The 120 grammes contain 63.6 grammes of carbon, of which 8 grammes leave the organism in the form of urea. The remainder of carbon (55.6 grammes) having been deducted from 212.7 grammes, the total carbon-discharge by respiration (*i. e.*, the quantity of carbon corresponding to 780 grammes of carbonic acid), we have 157.1 grammes as the weight of carbon to be accounted for by the consumption of fat in the body. The weight of fat required for this purpose is 205.3 grammes, which would yield 1862.4 k.-units. Adding this, as before, to the quantity of heat derived from the disintegration of albumin, we have 2373.9 as the total heat production of fever.

"Ranke found in his experiments on himself that on an adequate mixed diet, *i. e.*, on a diet sufficient, and not more than sufficient, to maintain nutritive equilibrium, he discharged in twenty four hours a quantity of nitrogen corresponding to 32.3 grammes of urea, and that his respiratory discharge of carbonic acid was 791 grammes. Proceeding as before we have 413.5 k.-units as the quantity of heat yielded by the disintegration of 97 grammes of albumin, which in this case was of course derived from food. Of the carbon contained in this 97 grammes, 45 grammes would have to be discharged in carbonic acid. Deducting these from the total discharge of carbon, *viz.*, 215.7 grammes, we have 170.7 grammes of carbon, to be accounted for as derived from the non-nitrogenous constituents of food. The diet consisted of 250 grammes of meat (containing a very small proportion of fat), 100 grammes of bread, 70 grammes of farinaceous food, 70 grammes of egg-albumen, and 100 grammes of butter and lard. From previous determinations it was estimated that the fat of the meat contained about 2.8 grammes of carbon, the butter and lard about 67.9 grammes, the farinaceous food about 26 grammes. This leaves 74 grammes to be accounted for as having been derived from the bread, for $2.8 + 67.9 + 26 + 74 = 170.7$. 170.7 grammes therefore represents the balance of carbon in the expired carbonic acid, not already accounted for as derived from the disintegration of albumin. (The actual quantity of carbon contained in the carbonic hydrates of the bread was 80 grammes, so that we have an excess of 6 grammes unaccounted for.) According to Frankland's table the fat would yield 33.19 k.-units, the butter 852.7 k.-units, the bread and other farinaceous food (supposing them to contain 156.5 grammes of starch of which the heat value is 5.232) 819 k.-units. Adding these to the 413.5 k.-units derived from the disintegration of albumin we have $33.19 + 852.7 + 819 + 413.5 = 2118.39$ k.-units as the heat production of a healthy adult on a mixed adequate diet. On similar data derived from other experiments on himself, Ranke estimated his own mean heat production on adequate diet at 2200 k.-units.

"Thus we have for the three conditions we have been considering, namely, inadequate or fever diet without fever, inadequate diet with fever, and adequate diet in health, the following results:—

Inanition	1648.0 k.-units.
Fever	2373.9 k.-units.
Health	2118.4 k.-units.

"The general result to which the preceding calculation leads us, is a very important one, namely that, although as compared with the heat production of an individual on fever diet, the heat production of a fevered person is excessive, it is not by any means greater than the heat production of health, for the highest difference indicated by the numbers stated is, as we shall see immediately, insignificant.

"In estimating the value of this result, there are several considerations to which it is requisite to call attention. In the first place, it is to be noticed that the data employed as representing respec-

tively the discharges of nitrogen and of carbon in fever, are the highest that could be taken; thus, those relating to urea were founded on observations of fevers of short duration, and referred to periods during which the characters of the febrile state showed themselves in their fullest intensity. It is still more important to remember that the estimate of the febrile discharge of carbonic acid in 24 hours, is founded on determinations relating to the rate of discharge during the day only. In comparing the results with those relating to the same patients when free from fever, this error was got rid of, for both sets of observations were made in exactly the same way. Consequently the numbers given above, representing the relation between heat production on fever diet without fever, and on the same diet in the febrile state, may be regarded as accurate; but if we compare either of these numbers with that representing the heat production of health with adequate diet, a correction is required.

“Taken absolutely, both of them are unquestionably too high, for it is well known that the rate of carbonic acid discharge is considerably higher in the day than in the night, so that any estimate of the total discharge from measurements made only during the day is certain to be excessive. Pettenkofer and Voit found that in health the mean discharge during the whole 24 hours falls short of the mean rate during the day by 14 per cent. If we make a deduction of 14 per cent. from the estimated febrile discharge of carbonic acid which was taken as the basis of our estimate given above, of the heat production in fever, we have to take off 109 grammes from our total of 780 grammes. Now the heat discharge corresponding to each gramme of carbonic acid derived from the consumption of fat is 3.23 k.-units; consequently if in fever the difference between day and night is as great as in health, we must take off 352 ($= 3.23 \times 109$) k.-units from our estimate. Thus corrected the numbers stand thus :—

Heat production in fever on fever diet	2021 k.-units.
Heat production in health on adequate diet	2118 k.-units.

“It is further to be borne in mind that the state of things which is understood by the term ‘adequate diet’ is not that of ordinary life. By adequate diet is meant a diet which is just sufficient to maintain nutritive equilibrium, *i. e.*, to balance expenditure by income. Under ordinary circumstances we consume a great deal more food than is required for this purpose. In Professor Ranke’s experiment, the diet of a young man of 24 consisted as we have seen of half a pound of meat, and a pound of bread, besides small quantities of butter and eggs, etc., an amount of aliment which, although it was proved experimentally to be ‘adequate,’ would, in ordinary language, be described as insufficient, and is certainly very inconsiderable as compared with the usual requirements of persons of the same age and sex. From the results of his experiments on more abundant dietaries Ranke inferred that the activity of the thermogenetic processes of his body could be increased to as much as 2700 k.-units per diem, an amount far exceeding the highest estimate that could be made of the possible production of heat in fever.”

It will be seen that the result reached by Prof. Sanderson is in strict accord with that which has been arrived at in my experiments. According to his calculations less heat is produced during fever in the human organism than when the healthy man is fed up to the food limit, but very much more heat is produced in the febrile state than when the man is kept without food. This certainly strongly corroborates the conclusion which I have reached experimentally that the essential portion of the fever is a derangement of nutrition, whereby the heat production at the expense of the accumulated material of the body is increased.

The question may now be answered how can the apparent non-agreement of this conclusion with that arrived at by Liebermeister and Leyden be explained. It has already been shown that the methods of these investigators are not above suspicion.

Granting, however, that their results are correct, they are not really in oppo-

sition with the vital part of the conclusions derived from the experiments detailed in this memoir; in fact they are corroborative of the leading fact established by the present research, namely, that in pyæmic fever in dogs and rabbits the fundamental portion of the disease-process is an increase in heat production by chemical movements in the accumulated material of the organism. It is true that I usually found that this increase was not sufficient to overplus the loss of production from abstinence from food, but sometimes it was more than sufficient. It is possible that the conclusion of Liebermeister and Leyden [that in man there is an absolute increase in heat production; or, in other words, that the overplus of tissue-heat is more than sufficient to overcome the loss of food-heat] is substantially correct, as a general law, although it cannot be admitted that it is demonstrated or without exceptions. The febrile movements in man are much more pronounced and severe than those of the animals experimented upon by myself. A rise of 10° Fah. is not very rare in man, one of 7° Fah. very common, and one of 14° by no means unheard of. In dogs and rabbits I have rarely, if ever, seen a rise of more than 4°, except upon exposure to direct heat, and the usual elevation of fatal pyæmic fever has not been 3°. Under these circumstances it would not be surprising if the overplus of tissue heat production were greater in man than in animals. However this may be, and future human calorimetrical experimentation can alone determine it, it seems almost certain, that, whatever may be the usual course, human, as well as canine, elevation of bodily temperature may occasionally coexist with diminished heat production as compared with that of high feeding; and that the temperature of the body is the result of the play between heat dissipation and production.

It seems to me certain that what is habitual in the lower animals is at least occasional in man, and that elevation of temperature may at times coexist in man with diminished heat production, and that lowered or normal temperature may coexist with increased tissue metamorphosis or chemical movements. Most practitioners of medicine have seen cases of increased tissue change as shown by emaciation and excessive urea secretion without elevation of temperature; or fever cases in which the temperature seemed so out of proportion to the results upon the bodily tissues as to indicate irresistibly that heat retention was playing an important part in producing the fever; or collapse coming on in fevers when the sudden fall of temperature seemed inexplicable by any theory other than a sudden loss of heat.

In conclusion it appears to me that the following proposition is demonstrated for dogs and rabbits, and practically assured for man.

Fever is a complex nutritive disturbance in which there is an excessive production of such portion of the bodily heat as is derived from chemical movements in the accumulated material of the organism, the overplus being sometimes less, sometimes more than the loss of heat production resulting from abstinence from food. The degree of bodily temperature in fever depends, in greater or less measure, upon a disturbance in the natural play between the functions of heat production and heat dissipation, and is not an accurate measure of the intensity of the increased chemical movements of the tissues.

Before leaving this portion of the subject I cannot refrain from calling attention to the strong corroboration which this proposition receives from a study of etiol-

nation in fever. Having no new evidence to offer I again make an extract from the article of Prof. Sanderson, in which he shows that there is in fever an increased metamorphosis of tissue. After a discussion of various analyses he says:

"The general conclusion to be derived from the whole series is that in the early stage of fever a patient excretes about three times as much urea as he would do on the same diet if he were in health, the difference between the fevered and the healthy body, consisting chiefly in this, that whereas the former discharges a quantity of nitrogen equal to that taken in, the latter wastes the store of nitrogen contained in its own juices. That this disorder of nutrition is an essential constituent of the febrile process is indicated by the fact that it not only accompanies the other phenomena of fever during their whole course, but precedes the earliest symptoms and follows the latest. That it anticipates the beginning of fever was first demonstrated by Dr. Sidney Ringer in his investigation of the relation between temperature and the discharge of urea in ague. That the same condition continues after the crisis has past, *i. e.*, the temperature has begun to sink, has been shown by Dr. Squarey from his investigation of eighteen cases of typhus, in all of which the daily excretion of urea was measured, and the variations of temperature were observed during the whole course of the disease, and the observations were continued until convalescence was completely established. In these cases it was found that, whereas the bodily temperature which in this disease rises rapidly at the beginning, and keeps up without sensible abatement during a period which often extends to the middle of the second week, usually begins to fall after the tenth day, the daily rate of discharge of urea, although usually above the normal during the first week, did not attain its maximum until the temperature had been falling for some days.

"The question of the source from which the urea increment of fever comes is one which can be better discussed subsequently. At present it is sufficient to notice that the anticipation of the obvious symptoms of illness, particularly of the pyrexia, by the increased excretion of urea, as well as the continuance of the urea excess during the epicritical period, plainly indicate that pyrexia is not the agent by the direct influence of which the increased secretion of urea is produced.

"Another consideration suggested by the same facts is this, that the mere increase of the percentage of urea discharged, affords an inadequate measure of the waste of nitrogen, *i. e.*, of albumin, which actually occurs in fever; for to form a just estimate, the overlapping at both ends of the process ought clearly to be taken into account. Moreover, in fever there are very frequently losses of nitrogen by the bowels and skin, as well as by exudations, the amount of which scarcely admits of being determined.

"It having been established that there is an increased discharge of nitrogen in fever, it remains to state what is known as to its source. There are two sources which are open to discussion, *viz.*: (1) the albumin of the blood and lymph, and (2) that of the tissues; or, to use the expressions which the researches of Voit have rendered current in physiology, store albumin, and tissue albumin. By the former we understand the albuminous constituent of the corpuscles and plasma as well as of the tissue juice or lymph; by the latter, the material of protoplasm, including that of the blood corpuscles.

"Here the basis of observation is furnished by researches made by Dr. Salkowski, relating to the proportion of potassium salts discharged by the urine in fever, as compared with that of sodium salts. These researches relate to some twenty cases of various forms of febrile disease in Professor Leyden's wards at Königsberg. The research began with an investigation of the relative proportions of potassium and sodium salts discharged by the liquid and solid excreta in health, the observer being himself the subject of observation. The diet being mixed, and the nutritive condition nearly that of nitrogen equilibrium as seen by the constancy of the daily discharge of urea (min. 25.3, max. 27.2, mean of seven days 25.69), the daily quantity of potassium and sodium salts respectively, reckoned as potash and soda, were: potash, 3.094 grammes; soda, 4.207 grammes; so that of the sum of both alkalies potash constituted 41.4 per cent.

"In another individual, a clerk, on low diet without meat, affected with syphilis but in good general health, the soda discharge was about the same, but that of the potash much less, so that the potash percentage varied from 18 to 26. From these and other observations it was concluded that the daily potash discharge of a healthy person on fever diet is less than one gramme.

"The febrile cases investigated were one of relapsing fever, one of erysipelas, and several of pneumonia. In the case of relapsing fever, which was observed during part of the first paroxysm,

the whole of the first remission, and of the first relapse and second remission, it was most distinctly seen, that, whereas during the remission the potash percentage of the total discharge of both alkalis sank to about 18.20, it rose during and especially after each crisis to about 90. In the case of erysipelas and in the pneumonia cases there was a corresponding relative and absolute increase of the potash discharge. There were, however, peculiarities in all the cases which have been fully described by the authors, and are of sufficient importance to require notice.

"On the whole, the absolute quantity of potassium discharged on febrile days is three or four times as great as on non-febrile. As regards soda the results are entirely different. During fever it is seen in most of the tables that the soda discharge is extremely low. As soon as the crisis is passed it at once begins to increase to such an extent that in one day as much soda is eliminated as on all the previous days taken together. Simultaneously the percentage of potash discharge falls to its lowest.

"The augmentation of potash discharge in fever, when little or no meat is being taken, and its rapid decline in defervescence, shows that the augmented production of urea in fever must take place at the expense of some source of albumin which contains potash. We have, therefore, in this fact an answer to the question from which we started. The albumin which serves as a source of urea in fever, is not derived from liquor sanguinis (for the liquor sanguinis abounds in sodium salts, but contains very little potassium), but either from the blood corpuscles, or from muscle, or both.

"The very remarkable diminution of the discharge of sodium signifies of course that in fever, the common salt, which constitutes the bulk of the salts of the blood, is retained; for immediately after the crisis (as shown most distinctly in three of the cases) it passed into the urine in great abundance.

"In addition to increased excretion of potash there is another circumstance which points to the blood corpuscles or to the muscular tissue as the chief seat of disintegration in fever, namely, the increased discharge of coloring matter. Unfortunately, as regards this most important question, sufficient information is wanting. There are, to the best of my knowledge, no comparative determinations either of the proportion of blood corpuscles or (what would be as useful) of the iron percentage of the blood before and after acute fever either in man or the lower animals. The only facts relating to the subject that I know of are (1) that in all febrile diseases, the coloring matter of the urine, which is probably derived ultimately from the blood hæmoglobin, is three or four times as abundant as in health (*see* Neubauer and Vogel); and (2) that after traumatic fever in dogs, there is a very marked diminution, both of the corpuscles and of the iron of the blood. But these observations are quite inadequate to serve as a basis for an opinion as to the proportion which the breaking down of blood corpuscles bears to the total disintegration of fever. Of the many questions which require answering, there is perhaps none which is of greater importance, for if, as appears probable, the destruction of the colored corpuscles is a part of the febrile process, the fact must have a very important bearing, not merely on the process itself, but on its after results. The coloring matter of the blood being the means by which oxygen is distributed to the tissues, the destruction of it must impair every function of organic life."

In order to determine whether there is a rhythm of heat production corresponding to the morning fall and evening rise of pyæmic fever, the following table has been prepared, showing the records of the last fever day in the six experiments. In each case there was a more or less distinct evening rise of temperature. Experiment 116, it will be remembered, was performed upon a rabbit; in the other cases dogs were employed. Unfortunately the days were not commenced at the same time, yet a little comparative study will overcome the defect in the table.

EXPERIMENT 110.				EXPERIMENT 111.			
TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE (Fahr.)	RE.	TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE (Fahr.)	
1:4 A. M. to 6:4 A. M.	69.201	106.92 to 104		11 P. M. to 4 A. M.	134.191	105.4 to 105	
7:42 A. M. to 12:42 P. M.	51.8544	104.9		5:7 A. M. to 10:7 A. M.	129.2479	104.9	
6:27 P. M. to 11:27 P. M.	137.4203	106.02 to 105.8		10:18 A. M. to 3:18 P. M.	126.7412	105.85	
				4:35 P. M. to 9:35 P. M.	142.84	105.85 to 104.4	

EXPERIMENT 112.

TIME	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
4:36 A. M. to 10:36 A. M.	70.5369	104 ^o .5 to 104 ^o .1
10:13 A. M. to 11:13 A. M.	88.062	104.1 to 104.3
12:13 A. M. to 4:13 P. M.	51.0977	104.3 to 106.5
4:38 P. M. to 9:38 P. M.	65.923	106.5 to 106.
10:5 P. M. to 4:5 A. M.	103.0396	106. to 104.5

EXPERIMENT 113

TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
11:32 P. M. to 6:32 A. M.	118.6278	104 ^o .7 to 104 ^o .8
10:51 A. M. to 12:51 P. M.	115.3317	104.1
4:32 P. M. to 10:32 P. M.	112.1112	106.7 to 104.7

EXPERIMENT 114.

TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
12:4 A. M. to 6:4 A. M.	105.4937	101 ^o .8 to 102 ^o .4
7:48 A. M. to 12:18 A. M.	67.7143	102.2 to 102.4
3:50 P. M. to 5:50 P. M.	84.0587	102.6 to 102.8
5:48 P. M. to 10:48 P. M.	120.9701	.6 to 101.8

EXPERIMENT 116.

TIME.	HEAT PRODUCTION.	RECTAL TEMPERATURE. (Fah.)
11:27 P. M. to 5:27 A. M.	23.3231	104 ^o .7 to 103 ^o .8
7:11 A. M. to 12:11 P. M.	14.7302	103.2 to 105.8
1:17 P. M. to 3:17 P. M.	14.4552	102.2 to 103.6
4:31 P. M. to 10:31 P. M.	30.1226	105.4 to 104.5

It will be seen that in Experiment 110 the production of heat was at its maximum in the evening, and regularly diminished towards a minimum in the morning. In Experiment 111 the same regular course was followed. In Experiment 112 the record is not so concordant, the maximum heat production not being reached until after ten in the evening. In Experiment 113 the maximum heat production was in the early morning, the minimum in the evening, the difference between the maximum and minimum being, however, very trifling; whilst in both Experiments 114 and 116 the course was a perfectly regular one from an evening maximum to the morning minimum. Out of the six experiments, therefore, four are in close accord, one is somewhat discordant, and the sixth absolutely reversed. It is remarkable that in the experiment last quoted the usual evening rise of temperature occurred although the heat production suffered no increase. It should be noted, that in the discordant experiment, the difference between the minimum and maximum production of temperature was very slight: that the rhythm of evening and morning rise of temperature was almost absent, and that an injection of putrid blood into the jugular vein was practised just before the animal was first put into the calorimeter. The latter fact probably offers the key of the difficulty, the pus acting immediately upon the bodily functions and thereby deranging both rectal temperature and heat production. In such a disturbing cause is found sufficient reason for not allowing much weight to the exception to the general law outlined in the more accurate experiments, or rather in the experiments performed when the pyæmic fever was fully developed and running a steadier, more typical, and less interfered with course. While, therefore, the experiments cited show that the law enunciated below may not be absolute and cover all cases of pyæmic fever, it does not invalidate it as the normal expression of a typical pyæmic fever.

In pyæmia superinduced in dogs and rabbits there is usually an evening rise of the bodily temperature which is consentaneous with an increase of the production of heat in the organism.

CHAPTER IV.

THE THEORY OF FEVER.

THE preliminary problems which offered themselves at the outset of this study of fever having been solved, the nature and mechanism of the process naturally presents itself for discussion. The first portion of this last problem seems to me sufficiently elucidated by the proposition which has been already formulated in the third chapter of the present memoir, but is here repeated.

“Fever is a complex nutritive disturbance in which there is an excessive production of such portion of the animal heat as is derived from chemical movements in the accumulated material of the organism, the overplus being sometimes less, sometimes more than the loss of heat production resulting from abstinence from food. The degree of bodily temperature in fever depends, in greater or less measure, upon a disturbance in the natural play between the functions of heat production and heat dissipation, and is not an accurate measure of the intensity of the increased chemical movements of the tissues.”

Such being the nature of fever, the mechanism of its production is next in order of study.

It is plain that rise of bodily temperature may be local, or it may be general. A local tissue may from some local cause suffer this rise, but where all parts of the body are simultaneously affected there must be some general bond uniting them together through which is brought about the simultaneous action. There are only two tissues or systems which, uniting together all parts of the body, fuse them, as it were, into one. These are the blood and the nervous system. Any acute physiological or pathological process, not dependent upon original vice of constitution, affecting the whole protoplasm of the body simultaneously and which is equally shared by all tissues, must have its origin therefore either in the blood or in the nervous system.

Is then fever hæmic or neurotic in its origin?

In many febrile diseases there is apparently a poison circulating in the blood, as the *fons et origo mali*. When we produce fever—by injecting a putrid substance in the lower animal or by allowing its entrance from a wound in man—we know that the first step is the presence of a definite poison in the blood. It is perhaps natural to say, under these circumstances, that the fever is hæmic in origin. But what is meant by this term? If the poison, carried by the blood into all parts of the body, acts upon the various tissues everywhere in such a way as to increase in them tissue change; or if, upon entering the blood, it excites such changes in that fluid as to cause the blood to incite the tissues everywhere to fever,

then that fever may be called, with scientific strictness, hæmic. Suppose, however, for a moment, there were a fever centre in the nervous system, and that irritation of a peripheral nerve were capable of causing fever by affecting that centre, such fever would certainly be a neurosis. Granting the existence of a "fever centre" of this kind the laws of life teach us that there must be poisons capable of acting upon it directly, so as to produce fever. Such a fever would certainly be neurotic, although produced through the blood, the vital fluid acting simply as a "common carrier." With this understanding of the terms, distinct, clear proof is at present wanting, that the fever even of pyæmia, of the exanthemata, or of any so-called blood-poisoning is strictly hæmic, since such toxic fever may be due to an action of the poison upon the central nervous system.

There are numerous febrile reactions, whose origin would appear to be due to a peripheral irritation. Such are the so-called "irritative fevers." Of these the most frequent are those caused by inflammations. These inflammatory fevers have however been the subject of very careful and ingenious study by Prof. Billroth and other observers, with the result of at least making it very probable that they are preceded by the formation in the affected part of a poison by whose absorption the febrile reaction is brought about. The memoirs of Dr. Billroth were published in Langenbeck's *Archiv für Klin. Chirurgie*, Bde. VI., ix. xiii., and demand here a somewhat extended notice. The theory of Billroth in these papers is based upon the following facts and argument. It was first clearly proven that fresh pus, *i. e.*, the material formed by the inflammatory process, is when injected into the blood entirely capable of inducing severe fever. It was next noted that in wound-fever a sufficient length of time usually elapses between the reception of the wound and the development of the fever for the dissipation of inflammatory products, and that there are many cases of severe wounds in which no febrile reaction occurs, and that these cases are notably those in which inflammatory products are scanty. To these arguments drawn from clinical and experimental observation, Dr. Billroth adds his failure to produce in dogs distinct immediate fever by peripheral irritations of sensitive nerves, or of the vaso-motor nerves. These irritations were made by him in various ways: by forcible injections of air or of water into the subcutaneous tissues, by suspending weights to nerve trunks, by rubbing the skin of the ears of dogs with croton oil, by irritating nerve trunks with ammonia, by rubbing and tearing the inner coats of vessels with canulæ or dilating tents of sea-tangle, by injecting powders into the blood so as to form emboli, etc. (*op. cit.*, p. 379). This failure to produce fever in dogs by peripheral irritation does not seem to me of overpowering force as evidence, because all fever in dogs is caused with difficulty. The experiments of Drs. J. Bremer and J. Chrobak (*Med. Jahrb.*, Bd. XIV., p. 1) are of greater weight. In these experiments were used dogs in all respects normal, and others in which all nervous connection had been severed between a specified joint and the central nervous system. The investigators found, what I have myself frequently noted, that traumatic fever is developed with difficulty in dogs. They therefore opened and crushed the joints operated upon, and injected them with irritants, such as tincture of iodine, ammonia, oil of mustard. Under these circumstances they found that fever was developed as soon, where all

the nerves going to the part injured had been previously separated, as it was in the normal animal. A very interesting result, apparently unexpected, was that the primary fall of temperature (the shock) did not occur where nerve section had been practised. The experiments were eight in number, and their record seems to show that they were accurately and skilfully performed and reported. I have repeated these experiments of Bremer and Chrobak and obtained results similar to theirs. Two dogs were used; all the nerves of the leg were divided and the wound allowed to heal before operating on the joint. In one instance, to do away with any possible vaso-motor nerve connection, the femoral sheath was destroyed and the artery tied in two places. On opening the joint, some weeks after the operation, and pouring strong water of ammonia over the wound, no evidences of sensation were elicited. Nevertheless, distinct fever was manifested in the dog with an uninjured artery in 24 hours, and in the dog with the artery tied after the lapse of 48 hours; the slow development of the last case probably being due to a slower circulation and absorption owing to the local impairment of the bloodvessels. It is scarcely necessary to point out the very great weight of such evidence as this, in showing that traumatic fever is due to absorption and not to peripheral irritation. A very strong indication of the truth of the views of Billroth is also to be found in the history of antisepticism; I believe it is now generally admitted that, as the antiseptic treatment of wounds is more and more perfectly carried out, traumatic fever becomes less and less frequent. Again, cases of fever, which were formerly thought to be irritative beyond a doubt, are being shown to be probably due to absorption. Thus, although many years since Sedillot affirmed urethral fever to be septic, the general drift of professional opinion, until very recently, was to believe that it is reflex. There are at present three views of its nature prominent: one that it is due to the absorption of a poison; one that it is a reflex irritative fever; one that it is an acute irritation of kidneys usually already diseased. Abundant proof has been furnished by the finding of purulent deposit that in some instances septicæmia is present; in other cases post-mortem examination has revealed acute nephritis. The certain existence of these two classes of cases tends to throw doubt on the existence of a reflex urethral fever, and to indicate that even the mildest cases depend upon a slight septicæmia.

From these facts it would appear that, not only is the so-called sympathetic fever of inflammation really due to a blood-poisoning, but that as our knowledge grows, fevers supposed to be due to peripheral irritations are shown, one by one, to have their origin in toxæmia.

The history of cases of febrile reactions during teeth-cutting, and the relief afforded by relieving the tension of the gums, the fugitive fevers seen in childhood as the product of gastro-intestinal irritation, the various trifling febrile reactions of ordinary life, all seem, however, to indicate a cause more trifling than blood-poisoning, and to point to direct peripheral nerve irritations as provocative of febrile reactions.

When we come to study in the physiological laboratory, the relations between the skin and the interior temperature, we find that they are very intimate; experiments detailed in an earlier portion of this memoir show that irritations of nerve trunks are

capable, not only of lowering the temperature, but, if my interpretation be correct, of absolutely lessening the chemical movements of the body. Then, again, the effect of external cold in at once increasing heat production, as proved by Liebermeister's bath experiments and as borne out by the experiences of every-day life, can scarcely be explained otherwise than by an action upon the peripheral nervous system. We are not, however, left to these deductions from clinical facts. Roehrig and Huntz (*Liebermeister's Handbuch des Fiebers*, p. 268) have found that mild electrical or chemical irritations of the skin increase the bodily temperature. The same observers (*Pflüger's Archiv*, Bd. 4, p. 90) discovered that the application of cold to the skin, as well as external irritations by concentrated salt baths, increases the elimination of carbonic acid and the consumption of oxygen. F. Raalzon (*Ibid.* p. 494) has used mustard plasters as an irritant and found that, when applied to one-tenth of the surface of a rabbit, they produce a very notable increase in the amount of carbonic acid eliminated and of the oxygen consumed.

For the reasons assigned, the possibility of an irritative fever must still be acknowledged, although we are warranted in contending that not only are such fevers much less frequent than was formerly thought, but that all or almost all serious, protracted attacks of fever are due to the absorption into the blood of a poison.

Fever due to the introduction of a poison into the blood appears, at first sight, to be probably produced by an action of the poison upon the general protoplasm. If, however, we take the most ordinary of all such fevers, the malarial—the chill, the fever, and the sweating in their regular sequence and their periodical occurrences most plainly bear testimony to a neurotic origin. When it is further remembered that neuralgia, and various local vaso-motor and secretory disturbances (such as intermittent pneumonia and intermittent diarrhœa) sometimes replace the normal paroxysm, it becomes almost inconceivable that the normal paroxysm can be produced by a general action upon the common protoplasm of the body. Again, in rare instances the malarial paroxysm becomes localized in a certain region of the body, which may exhibit the successive phenomena of "a chill," whilst the remainder of the organism seems perfectly normal in its functions. The following case recently reported by Dr. Meriwether Lewis, of Lenoir, Tennessee, is cited as an instance of such localized malarial fever.

In 1877, Mr. G. M., æt. 30, whilst recovering from an attack of pneumonia, was attacked with chills, which were peculiar in that the sweating stage alone was confined strictly to one side of the body. Under appropriate treatment Mr. M. soon convalesced and remained well for nearly a year, when the ague again made its appearance. During the latter part of this attack the febrile paroxysm seemed limited to a prolonged sweating stage, in which the perspiration was absolutely confined to the right side, and the temperature of the right axilla was $3\frac{1}{5}^{\circ}$ Fah. greater than that of the left.

The various irregular cases of intermittent fever, viewed in connection with the phenomena of the ordinary malarial fever, are only to be accounted for by the explanation that the malarial poison acts in some way upon the nervous system and thereby provokes the febrile reaction. Of course, all the nutritive disturbances

wrought by malaria, many of which may occur out of all proportion to the febrile paroxysm or even without the febrile reaction, are not necessarily the result of an influence exerted upon the nervous system—whether they are or are not so produced is foreign to the present inquiry.

Further, of all diseases supposed to be due to the presence of a poison in the blood, none is more clearly and certainly so than is septicæmia. It has already been demonstrated that the fever of septicæmia, or at least the elevation of temperature of septicæmia in dogs, is largely due to retention of heat: such retention of heat can only be produced through the intervention of the nervous system, no conceivable influence upon the general protoplasm being able to cause the superficial capillary contraction to which this retention must be in a measure due. The fever must therefore in septicæmia be neurotic in origin. From all the facts and reasons which have been given, the following proposition seems to be the logical conclusion: *Irritative fever, if it exist, is produced by an action upon the nervous system. Fever occurring in cases of blood-poisoning is often, and probably always, the result of a direct or indirect action of the poison upon the central nervous system, and hence is a neurosis.*

Before elaborating further the mechanism of fever production, two problems are naturally suggested for solution by our knowledge of the relation of the nervous system to the bodily temperature:—

First. What is the relation of the general vaso-motor system to the febrile state?

Second. What is the relation of the so-called inhibitory heat centre to the febrile state?

The only experimental evidence which I have, throwing light upon the solution of the first of these questions, is found in the effect of section of the cord upon heat production and dissipation in febrile animals. The record of these experiments may be found in *Experiments* 112 and 113.

In the second of these, the rectal temperature of the animal, the hour preceding the section, varied from 104°.1 F. to 104°.8, and the hourly production of heat at the last taking was 115.3317 units, the dissipation being the same. In the hour and 22 minutes immediately following the section, the bodily temperature fell 10°.6, whilst the dissipation of heat rose to 146.9542 units, and the production of heat fell to 15.9277 units. In Experiment 112 the bodily temperature in the 2 hours preceding the section of the cord was from 104°.1 to 104°.3, the heat dissipation and production respectively 86.1625 units and 88.062; after section of the cord the bodily temperature fell 10°.6 in 103 minutes, and the heat dissipation rose to 115.778 units, whilst the heat production fell to 25.148 units. These two experiments show that in fever as in health, section of the cord is followed by an increase of heat dissipation and a decrease of heat production. It will also be further noted that the effect as compared with that in the normal animal is greatly exaggerated. There are various ways of accounting for this exaggeration. A plausible method of explaining the enormous diminution of heat production is in supposing that in fever there is paresis of the so-called inhibitory centre. When the normal cord is cut, the paralysis of the heat inhibitory nerve in some measure

compensates for the effect of the alteration of the circulation upon the heat production, but in fever, if there be already inhibitory heat paralysis, this compensating influence disappears and consequently the reduction in heat production is exaggerated. However this may be, and I do not attach much importance to the point, the proportionately excessive increase of heat dissipation in fever after section of the cord plainly indicates that the general vaso-motor nerves restrain heat dissipation more completely in fever than in health and that consequently the effect of their sudden palsy is more marked. It would appear, therefore, that an answer to the first question has been reached.

In looking for an answer to the second question I have availed myself of the depression of temperature produced by irritating a sensory nerve. It has been previously shown, that, precisely as the influence of peripheral irritations upon blood pressure is a test of the integrity of the vaso-motor system, so is the effect of similar irritations upon bodily temperature a test of the integrity of the inhibitory heat system.

The two following experiments prove that in fever galvanization of a sensitive nerve is able to depress the temperature. If, as contended, this depression of temperature is a test of the integrity of the heat inhibitory nervous system, the conclusion is reached that at least in the two cases of pyæmic fever experimented upon there was not palsy of the so-called inhibitory heat centre.*

EXPERIMENT 117.

A moderate sized male cat.

TIME.	TEMP. (Fah.)	REMARKS.
10 A. M.	101 ^o .5	Injected one fluid-drachm of pus into the flank.
4:20 P. M.	106.5	
4:40	.....	Abdomen opened in linea alba and thermometer inserted into the abdominal cavity; temperature during the remainder of the experiment taken from it.
4:45	106	
4:53	.....	In cutting down for the femoral nerve an artery was wounded, and about $\frac{1}{2}$ f. oz. of blood was lost.
4:55	103	
4:59	103	Current of moderate strength applied to nerve for about half a minute.
5	102.5	
5:5	102	
5:15	.....	Current applied for a brief space.
5:20	101	
5:24	100.75	A very strong current applied for three-quarters of a minute.
5:25	100.75	
5:26	100.25	
5:29	100.5	
5:30	.....	Very strong current applied to nerve for about a minute.
5:31	100	
5:33	100	
5:34	99.75	Cat killed.

* The term inhibitory heat centre is used for brevity, and not as denying the theory that this centre is really a vaso-motor centre for the muscles.

EXPERIMENT 118.

A moderate sized male cat

Time.	Temp. (Fah.)	REMARKS.
10 A. M.	102.9	Half a fluid-drachm of pus injected into the cellular tissue.
10	..	A fluid-drachm injected.
4:30 P. M.	105.5	
11:40	104.25	
11:35	105	Opened the linea alba and transferred the thermometer to the peritoneal cavity.
11:45	104	Strong current applied to the femoral nerve.
11:47	104	Current broken.
11:50	104	
11:55	103.5	
12	103	
12:5 A. M.	102.75	
12:7	102.5	Current reapplied.
12:8	102.75	Current broken.
12:12	102.75	
12:16	102.75	
12:20	102	
12:45	.....	Thermometer retransferred to the rectum.
12:47	102	Cat killed.

The results of these experiments are at seeming variance with those of R. Heidenhain (*Pflüger's Archiv*, Bd. III. p. 510). That observer failed to get a fall of temperature in fever following galvanic irritation of a nerve. The difference probably depends upon the use by Heidenhain of feeble currents whilst those employed by myself were very powerful. The experiments just recorded are confirmed by other evidence. A comparison of the result produced in my experiments by section of the medulla at the pons upon heat production with those obtained in the experiments on heat production in fever will show that in pyæmic fever there cannot be a complete palsy of the inhibitory centre. The increase of tissue change in fever is not sufficient for complete paralysis.

This does not at all show that what increase of chemical movements there is, is not due to a partial loss of power of the inhibitory heat centre. The existence of such partial loss of power would bring into accord the experiments of Heidenhain and myself. Thus it is conceivable that he employing feeble currents, just sufficient to influence a normal centre, failed to affect the paretic centre of the fevered animal; whilst I, using very powerful currents, succeeded in arousing the centre, although partially benumbed by the pyæmic poison.

To determine more accurately the condition of the inhibitory heat centres in pyæmic fever the following experiments were performed. The ear was the part always irritated, and the same Du Bois Reymond coil and galvanic cell were employed so as to give uniform intensity of irritation. -

EXPERIMENT 119.

A rabbit.

NORMAL DAY.			FEVER DAY		
TIME. (Min.)	RECT. TEMP. (Fah.)	REMARKS.	TIME. (Min.)	RECT. TEMP. (Fah.)	REMARKS.
0		Tied down.	0		Tied down.
5	103 ^o .6		3	105 ^o	Current applied at 2.†
6	.....	Current applied at 2½.†	5	105	Current stopped.
8	.....	Current stopped.	9	104.8	
12	.....	Current applied at 2½.	10	104.8	Current applied at 2½.
13½	.....	Current stopped.	12	104.6	Current stopped.
14	102.8		14	104.6	
9*	0.8 (fall)	Current applied 3½ minutes.‡	11*	0.4 (fall)	Current applied 4 minutes.

EXPERIMENT 120.

A rabbit.

NORMAL DAY (No. 1).			NORMAL DAY (No. 2).		
TIME. (Min.)	RECT. TEMP. (Fah.)	REMARKS.	TIME. (Min.)	RECT. TEMP. (Fah.)	REMARKS.
0	103 ^o .2	Tied down.	0		
9	103.2	Current applied at 2½.	8	103 ^o .2	Current applied at 2½.
9:5	.....	Current stopped.	9.5	103.2	Current stopped.
10	103.2		12	.....	Current applied at 2½.
11	103.2	Current applied at 2½.	14	102.8	Current stopped.
13	103.4	Current stopped.	15	.....	Current applied at 2½.
15	103.2		16	102.6	Current stopped.
16	103.2	Current applied at 2½.	18	102.4	
17	103	Current stopped.	20	102	
19	102.8		22	101.6	
20	102.6		25	100.2	Current applied at 2½.
28	102.4		27	101.4	Current stopped.
19*	0.8 (fall)	Current applied 3½ minutes.	29*	1.6 (fall)	Current applied 6½ minutes

* This lower figure is the time from the beginning of the application of the current to the end of the experiment.

† These and corresponding figures in the later experiments apply to the position of the coil upon the scale.

‡ This last remark applies in all the records to the total time during which irritation was practised.

FEVER DAY (No. 3).			FEVER DAY (No. 4).		
Time. (Min.)	Rect. Temp.	Remarks.	Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.	0	.....	Tied down.
6	104 ^o .6		8	104 ^o .7	Current applied at 2½.
6.5	.....	Current applied at 2½.	9.5	104.8	Current stopped.
8	.....	Current stopped.	11	104.6	
10	.....	Current applied at 2½.	12	.....	Current applied at 2½.
12	104.5	Current stopped.	14	.....	Current stopped.
15	104.2	Current applied at 2½.	15	104.5	
16	104.4	Current stopped.	16	104.4	
17	104.4		18	.....	Current applied at 2½.
21	104.2		19	.....	Current stopped.
23	104.2		20	104.2	
25	.....	Current applied at 2½.	24	104	
27	.....	Current stopped.	27	103.8	
29	104		28	.....	Current applied at 2½.
31	103.8		30	.....	Current stopped.
34	103.8		31	103.6	
37	103.6		35	103.6	
			37	103.6	
31*	1 (fall)	Current applied 6½ minutes.	29*	1.1 (fall)	Current applied 6½ minutes.

EXPERIMENT 121.

A black rabbit. Fever produced by injection of putrid blood under the skin. The "second non-fever day" was the day after injection—fever not yet having been developed.

FIRST NON-FEVER DAY.			SECOND NON-FEVER DAY.			FIRST FEVER DAY.		
Time. (Min.)	Rect. Temp. (Fah.)	Remarks.	Time. (Min.)	Rect. Temp. (Fah.)	Remarks.	Time. (Min.)	Rect. Temp. (Fah.)	Remarks.
0	.....	Tied down.	0	.....	Tied down.	0	.....	Tied down.
7	102.2	Current applied at 3.	7	102 ^o .4	Current applied at 3.	6	103 ^o .4	Current applied at 1.
8	.....	Current stopped.	8	.....	Current stopped.	7	.....	Current stopped.
10	102		10	101.8		8	103.6	
11	101.8		11	.....		11	.....
12	101.6		12	.....		12	103.4	
16	101		16	.....		17	102.8	
18	100.8		18	100.8		18	102.6	
20	100.8		20	100.4		20	102.4	
21	.....	Current applied at 1.	21	.....	Current applied at 1.	21	.....	Current applied at 3.
22	.....	Current stopped.	22	.....	Current stopped.	22	.....	Current stopped.
24	100.4		24	100.4		24	102.4	
25	100.2		25	100.2		25	.....
30	100.2		30	100.2		30	101.8	
23*	2 (fall)	Current applied 1 minute at 3. 1 minute at 1.	23*	2.2 (fall)	Current applied 1 minute at 3. 1 minute at 1.	24*	1.6 (fall)	Current applied 1 minute at 1. 1 minute at 3.

An examination of these experiments will show that every effort was made to have the conditions alike during the normal and the fever day. In the first

* This lower figure is the time from the beginning of the application of the current to the end of the experiment.

experiment, the irritation applied on the normal day for $3\frac{1}{2}$ minutes reduced the temperature $0^{\circ}.8$; on the fever day applied for 4 minutes it reduced it only $0^{\circ}.4$. In the second experiment: normal day No. 1, the current was applied 3.5 minutes, the fall $0^{\circ}.8$; normal day No. 2, current 6.5 minutes, fall $1^{\circ}.6$; fever day No. 1, current 6.5 minutes, fall 1° ; day No. 2, current 6.5 minutes, fall $1^{\circ}.1$. In the last experiment the time of application and the strength of current were the same throughout; and the fall the first normal day was 2° , the second normal day $2^{\circ}.2$, the fever day $1^{\circ}.6$.

These experiments certainly indicate that in the fevered rabbit peripheral irritations have less effect in depressing the temperature than in the normal animal.

The most thorough and seemingly reliable study of the temperature of the healthy man, which has been to my knowledge made, is that of Prof. Jurgensen, of Kiel (*Die Körperwärme des Gesunden Menschen*, Leipsic, 1873). These researches developed some very curious and interesting facts, prominent among which were the singular uniformity of the average bodily temperature under all sorts of circumstances, which profoundly influence the production of animal heat. The chief of the disturbing influences tested were starvation, the use of cold baths, and muscular exercise. The subject of the experiment went entirely without food for 62 hours (op. cit., p. 27), and the average temperature was during the two days that of a normal day. Again, when cold baths of 25 minutes' duration each and of a temperature varying from 9° to 11° C. (48° to 52° F.) had been employed, the diminution of temperature during the shivering fits which followed the baths was so exactly compensated by the rise of temperature during the reaction that the normal mean was strictly maintained.

Jurgensen also found that there is a regular diurnal variation of temperature in health precisely similar to that which is known to occur in fever. Thus it was shown that the 24 hours is, so far as human temperature is concerned, divided into a diurnal and a nocturnal period. Early in the morning (about 7 A. M. or a little later) is the minimum of temperature; from this to the maximum of temperature in the evening (about 9 P. M.) constitutes one period, whilst the other is from the maximum of the evening to the minimum of the morning. The last period, the nocturnal, is the shorter, in the proportion of 100 to 136, and has an average temperature of $36^{\circ}.94$ C. ($98^{\circ}.49$ F.); whilst the mean of the diurnal cycle, from about 7 A. M. to 9 P. M. is $37^{\circ}.34$ C. ($99^{\circ}.21$ F.).

Further, Prof. Jurgensen found that this rhythm of temperature was not affected by starvation, cold baths, or other ordinary disturbing influences.

Finally, he determined that in typical fever the daily cycle of temperature so closely resembles that of health, that if each be represented by a curve one over the other with the same abscissa, these curves will be parallel, and the only difference will be in the ordinates of the curves; or in other words, in fever the normal daily cycle of temperature is preserved; the average or mean simply being shifted upwards. To use the language of Prof. Burdon Sanderson the "only material difference between the two conditions is that in fever the norm is $3^{\circ}.267$ F. higher. Whatever be the explanation of this, the fact comes out so clearly as the result of observation, that it cannot be disputed."

Having reached this point, it seems to me that at last we are in a position to determine the theory of fever, but before doing this it may be best to marshal the facts which are at our disposal.

1st. In health there is in man a fixed mean and a normal variation of temperature having a regular rhythm, and this variation is beyond the control of all disturbing causes which do not force the organism beyond the condition of health.

2d. The maintenance of the normal temperature and its rhythm is dependent upon the nervous system, which within certain limits controls both the production and dissipation of animal heat.

3d. So far as our present knowledge goes the chief factor in controlling heat dissipation is the vaso-motor nerves, including in man such nerves as control sweat secretion; these nerves being able by contracting the capillaries of the surface of the body and by drying the secretion of the skin to reduce the loss of heat to a minimum, and by a reverse action to increase it to a maximum.

4th. The only nerve centre proven to exist capable of influencing the heat production without affecting the general circulation is situated in the pons or above it, and whilst it may be a muscular vaso-motor centre, it is more probably an "inhibitory heat centre;" of whichever nature it may be, it must act through subordinate centres situated in the spinal cord.

5th. Fever is a nutritive disturbance in which there is an elevation of the bodily temperature and also an increase of the production of heat by an increase of the chemical movements in the accumulated material of the body; this increase being sometimes sufficient, sometimes insufficient to compensate for the loss of that heat which is derived directly from the destruction of the surplus food in the body, very little or no food being taken in severe fever. The rise of temperature in fever is, therefore, not dependent altogether upon increased heat production, as in fever there certainly is sometimes less production of heat in the organism than there is at other times when the bodily temperature remains normal; also excessive heat production may occur even at the expense of the accumulated materials of the organism without elevation of the bodily temperature.

6th. In fever a daily temperature variation occurs which is parallel to that seen in health, and differs from the normal variation only in having a higher mean.

7th. In fever vaso-motor paralysis when produced is followed by an immediate fall of temperature similar to but greater than that which is produced by a like disturbance in health.

8th. The decrease of heat production which follows section of the cord is much greater in the fevered than in the normal animal.

9th. The so-called inhibitory heat nervous system is not paralyzed in fever, but is less capable than in health of answering promptly and powerfully to suitable stimuli, in other words, it is in a condition of paresis or partial palsy.

10th. The clinical succession and phenomena of a febrile paroxysm, such as that of an intermittent, seem plainly to depend upon the nervous system for their arrangement and relation.

11th. In most cases of fever, and probably in all cases of serious fever, there

is a definite poison circulating in the blood, the poison sometimes having been formed in the system, sometimes having entered the organism from without.

Bearing these facts in mind, the theory of a causation of fever becomes, to my mind at least, very plain. It is simply a state in which a depressing poison or a depressing peripheral irritation acts upon the nervous system which regulates the production and dissipation of animal heat; a system composed of diverse parts so accustomed to act in unison continually in health, that they become as it were one system and suffer in disease together. Owing to its depressed, benumbed state, the inhibitory centre does not exert its normal influence upon the system, and consequently tissue change goes on at a rate which results in the production of more heat than normal, and an abnormal destruction and elimination of the materials of the tissue. At the same time the vaso-motor and other heat dissipation centres are so benumbed that they are not called into action by their normal stimulus (elevation of the general bodily temperature), and do not provide for the throwing off the animal heat until it becomes so excessive as to call into action by its excessive stimulation even their depressed forces. Finally, in some cases of sudden and excessive fever, as in one form of the so-called cerebral rheumatism, the enormous and almost instantaneous rise of temperature appears to be due to a complete paralysis of the nervous centres presiding over heat production and dissipation.

DESCRIPTION OF PLATES.

PLATE I.

THE completed apparatus for measuring the production of animal heat and of carbonic acid: the arrows show the directions of the air currents during action. p = exhaust pump. m = general meter. t = tube thermometer. y = exit tube from the calorimeter. a = inner box of calorimeter. x = ingress tube of calorimeter. z = tube through which sample of air coming from the calorimeter is taken. s = calcium bulbs for absorbing moisture. b = barium tubes for absorbing carbonic acid. m' = sample meter. v = aspirators.

PLATE II.

Fig. 1.—Transverse section of calorimeter. a = inner box. w = water surrounding inner box. x = clasps to hold down the inner box, also clasps of the lid. s = sawdust in which inner box is packed.

Fig. 2.—End of the inner box of the calorimeter. A = door. B = thumbscrews securing the door.

Fig. 3.—Inner surface of the lid to the calorimeter. A = wire, which when in position is imbedded in the soft rubber. c = openings for outlet and inlet tubes. γ = openings for the thermometer. x = openings for the stirrer.

Fig. 4.—Tracing of Experiment 104, p. 150. The irregularity of this and the other tracings upon this plate is due to defects of the instrument with which they were made. At the time it was the only kymographion at my disposal, and the drum was very irregular in its rotation. The tracing shows, however, sufficiently well the effects of irritation of the Hitzig's brain region after section of the vagi, curarization and artificial respiration. At 11:25:30 (+) a mild galvanic current was passed through the regions spoken of: at 11:26 (+) this current was made very powerful: at 11:27 it was withdrawn. The rise of pressure at 11:26 was due to dispersion of the very powerful current and irritation of the trigeminal twigs in the brain membranes.

Fig. 5.—Tracing of Experiment 106, p. 151. This tracing portrays the result of destroying with a needle the Hitzig's regions in the cortex of the brain. The mechanical irritation caused no rise of pressure, and the destruction no fall. Artificial respiration and curarization employed.

Fig. 6.—Tracing of Experiment 106, p. 151. This tracing shows the effect of a very strong current sent through the Hitzig's region of the brain. It is so marked as not to need explanation. Artificial respiration and curarization employed.

PLATE III.

Fig. 1.—Tracing of Experiment 107, p. 154. This tracing represents the effect of galvanizing the sciatic nerve after section of the par vagum and destruction of the Hitzig's region, curarization and artificial respiration being practised. At the first + the irritation was applied, at the second + it was withdrawn. The current was of the same power as in Fig. 2, with which Fig. 1 should be contrasted. The two tracings were from a dog, in different stages of one experiment

Fig. 2.—Tracing of Experiment 107, p. 154. This tracing shows the effect of galvanizing the sciatic nerve after destruction of the Hitzig's region of the brain cortex, section of the vagi and of the splanchnics just above their entrance to the diaphragm; curarization and artificial respiration having been practised.

Fig. 3.—Tracings of Experiment 108, p. 154. In this figure there are two tracings with one abscissa and one second line. The upper tracing was made first, after division of the par vagum, and of the splanchnics just above the diaphragm. The first + belongs to this upper tracing and marks where the galvanic irritation of the sciatic nerve commenced; this irritation was continued 25 seconds. The lower tracing was made later, from the same dog, after section of par vagum and splanchnics as described, and also destruction of Hitzig's region of the cerebral cortex. The second + marks where the galvanic current was applied to the sciatic of the same strength as in the first tracing.

PLATE IV.

Fig. 1.—Tracing of Experiment 101, p. 147. The splanchnics had been entirely severed just above the diaphragm, also the vagi in the neck. Curari had been given and artificial respiration was practised. The lower straight line is the abscissa: irritation was applied by means of a powerful galvanic current to the sciatic nerve, at the point where the curve begins to rise, and was removed just before the tracing begins to drop.

Fig. 2.—Tracing of Experiment 108, p. 154. This tracing represents the effect upon the arterial pressure of interrupting the respiration at 1 minute, 34 seconds of the Experiment. The interruption lasted 8 seconds.

Fig. 3.—Tracing of Experiment 100, p. 146. This tracing shows effect of galvanic irritation of the sciatic nerve, after section of the splanchnics just above the diaphragm and of the par vagum in the neck, curarization and artificial respiration being practised. S represents commencement of irritation, O its cessation.

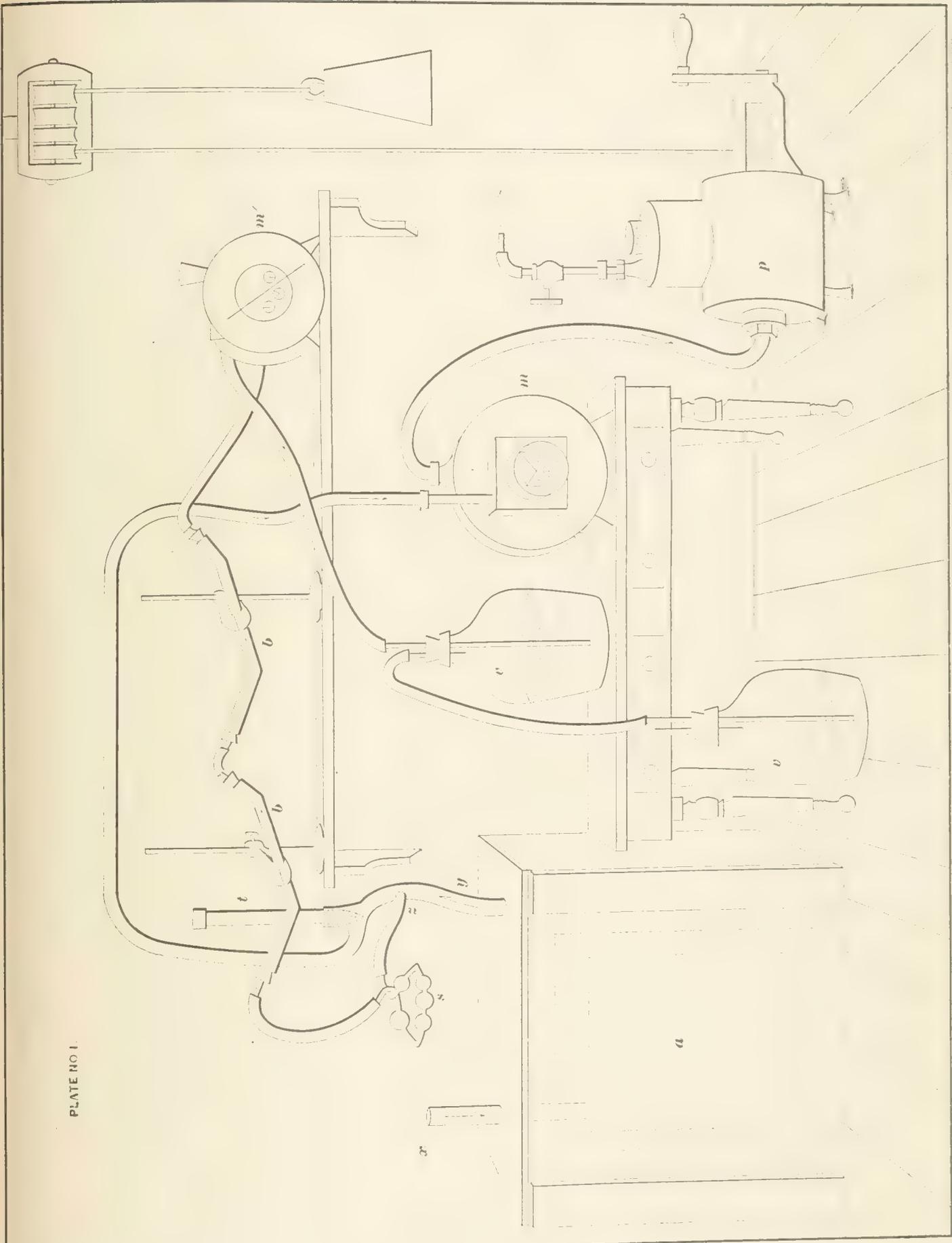
Fig. 4. Tracing of Experiment 98, p. 145. The splanchnics had been cut above the diaphragm, the right possibly not having been entirely severed. At I a powerful current was applied to the sciatic nerve; at O irritation ceased. The vagi had been divided, and curari given: artificial respiration was applied throughout.

PLATE V.

In this plate, Fig. 1 and Fig. 2 are parts of one experiment (109, page 156), both having been made upon one drum and having the same abscissa and second-marker line. Fig. 1 was made by galvanizing the sciatic nerve at +, after section of the par vagum and division of the medulla at its junction with the pons; the dog being curarized and artificial respiration practised. The break in the tracing was produced by the rise of the needle of the manometer above the drum: at ++ the current was broken. Fig. 2 represents the effect of applying a galvanic current in the same strength and method as before to the same dog, after he had suffered further mutilation by section of the splanchnics; + indicates beginning, ++ end of irritation.

Fig. 3.—Tracing of Experiment 106, p. 151. This tracing shows the effect of a feeble current upon blood pressure when applied to the Hitzig brain regions; curarization and artificial respiration being practised. The current was applied and interrupted at points marked; one needle or pole being in each region. The tracing was made with a very inferior cardiometer.

PLATE NO 1.



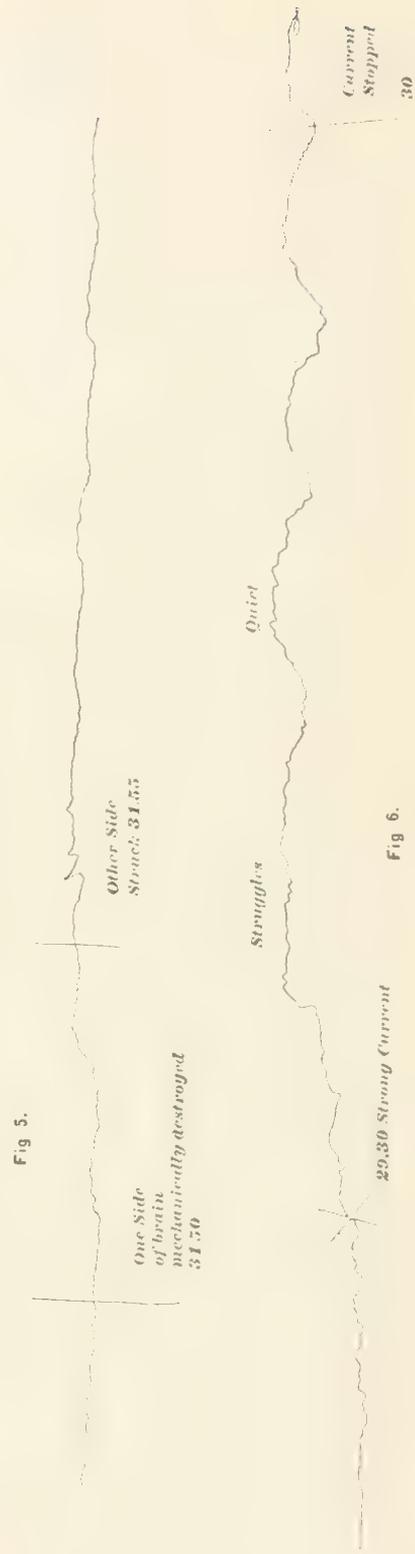
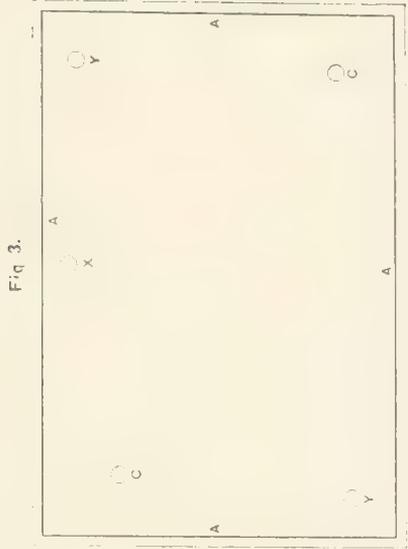
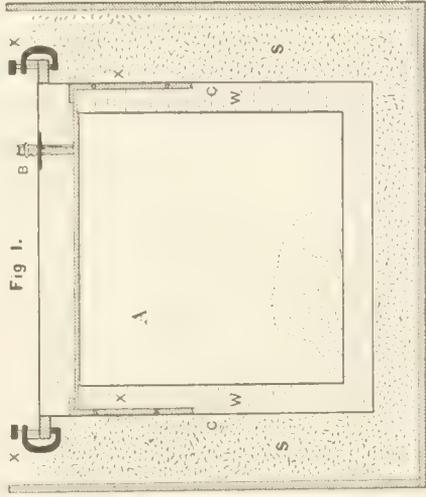
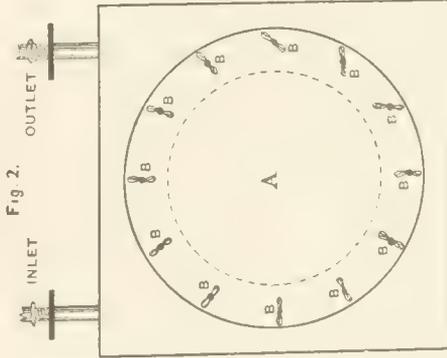
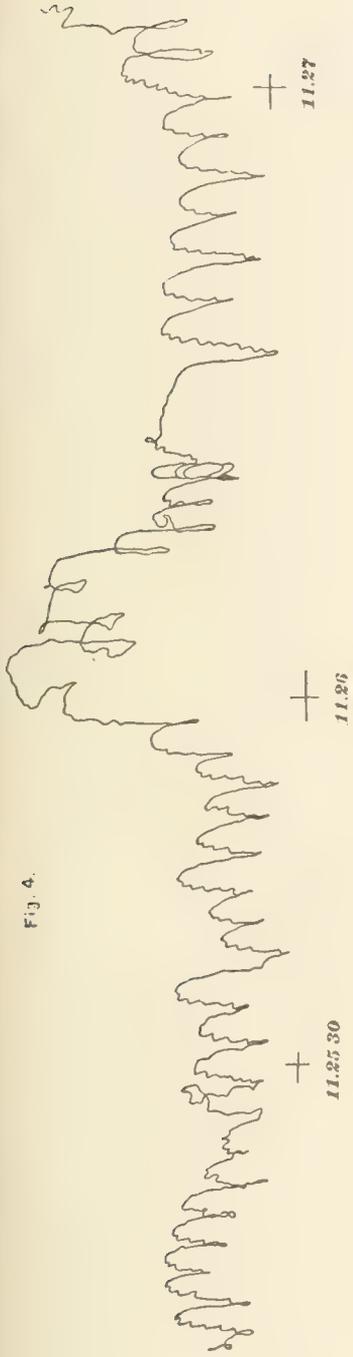


Fig. 6.

PLATE III.

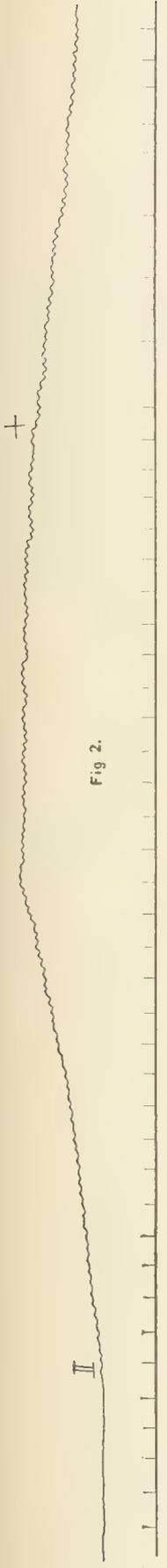


Fig. 2.



Fig. 1.

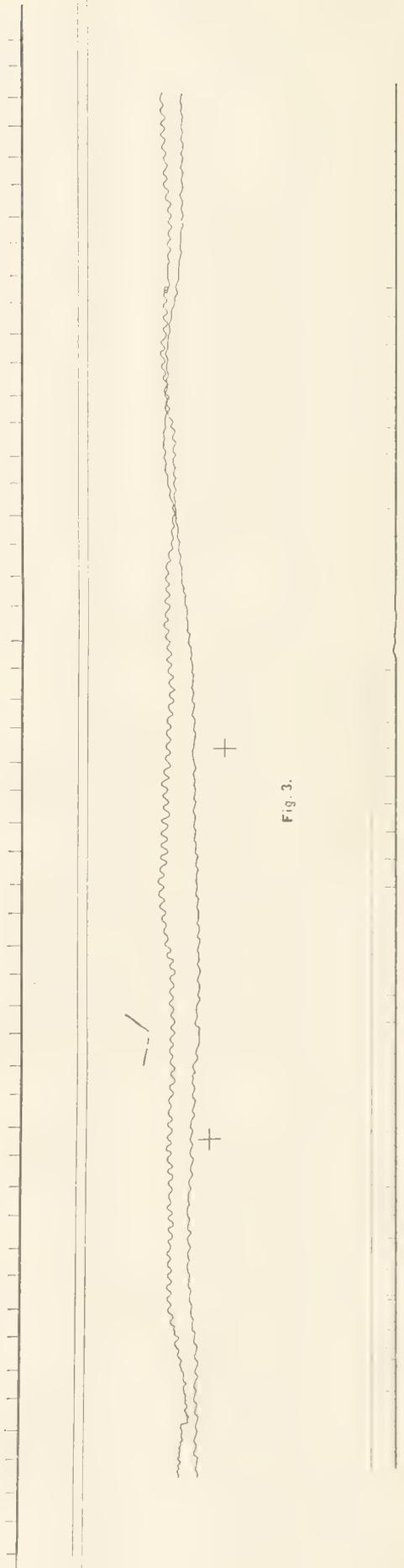


Fig. 3.

PLATE IV.



Fig. 2.



Fig. 4.

X



Fig. 1.

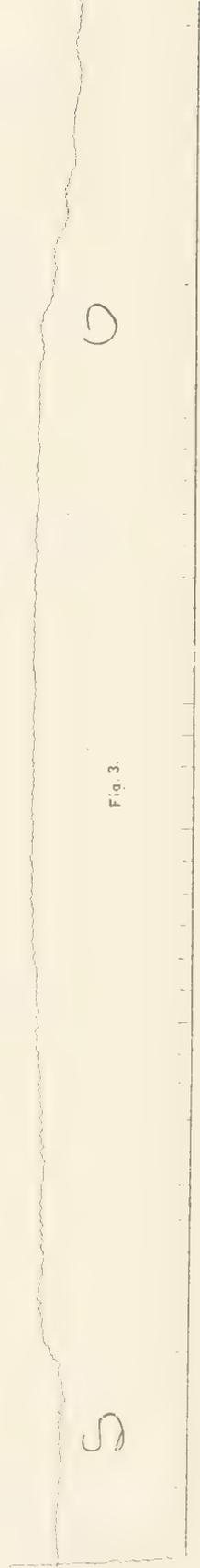


Fig. 3.



PLATE V.

Fig. 3.



Fig. 1.



Fig. 2.



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