per second depends upon the density, and in solids and liquids this secures the destruction of the fundamental vibrations as the energy of vibration is increased, at the same time developing the multitude of irregular ones shown in the spectrum; while in a gas the number of impacts per second is many times less than the regular rate of vibration, and this secures the time for either fundamental or harmonics, and the consequent spectra. The number of vibrations n the hydrogen atom makes when the wave length is .0131277 mm. will be $n = \frac{v}{\lambda} = \frac{3 \times 10^{11}}{.131277} = 2286 \times 10^{10}$.

Let v^1 represent the velocity in free path motion of the atom at 0° Cent. and 760 mm. pressure = 1860-000 mm. Their amplitude a will equal $\frac{v^1}{n} = \frac{1860000}{2286 \times 10^{10}} = 8134 \times 10^{-11}$ m. Comparing this with the diameter of the atom $\frac{8134 \times 10^{-8}}{5 \times 10^{-7}} = .162$. That is the amplitude is equal to .162, the diameter of the atom at 0°.

Assuming a temperature higher than this, say 273° Cent., then the energy of the atom in its free path motion compared with that it has at 0° will be as $\sqrt{2} : 1$ and $1 : \sqrt{2} :: 1860 : 2630$ m. per second, and as before amplitude a will equal $\frac{v^1}{n} = \frac{2630000}{2286 \times 10^{10}} = 115 \times 10^{-7}$. This compared with the diameter of the atom gives $\frac{115 \times 10^{-7}}{5 \times 10^{-7}} = .23$. That is, the amplitude is equal to .23 the diameter at 273° Cent., a difference of .068 for 273°.

With same data the maximum temperature of the hydrogen atom may be calculated for as

$$(.162)^2 : (.7854)^2 :: 273° : 6419°$$

which would be the highest temperature the atom could have if it could have such an amplitude, and this will be reduced as the thickness of the ring increases. Any additional energy the atom would receive could not possibly heat it but would be expended either in rotating it or in giving to it a free path motion. In like manner the amplitude for a single degree is found to be .0098 diameter, or very nearly one-hundredth the diameter.

For other atoms than hydrogen when they have the same energy their amplitude must vary inversely as their mass, so that for oxygen the amplitude at 273 would be $\frac{.162}{16} = .01$ its diameter, and its maximum temperature will be $6419 \times 16 = 102704°$ Cent., a number altogether too high for the same reason as was given for hydrogen, namely it assumes that the ring has no thickness.

If these computations have any value they may be applied to the solution of the temperature of the sun.

The elements having the greatest density must have the highest maximum temperature. In the sun twenty-five elements have been determined spectroscopically and the average density of these twenty-five is 63. Now on the hypothesis that these elements exist in equal quantities in the sun, which is not very probable, the maximum temperature of that body woulp be about 400000° Cent.

As at absolute zero each atom is quite independent of every other atom, that is, matter has not a molecular structure, so, at certain high temperatures that differ for different substances, all molecular groupings must be broken up and the atoms are quite dissociated from each other, and this dissociation must occur before the maximum temperature is reached; it would appear that whenever at the sun the temperature approached its maximum, then the elements would be elementary, uncombined, and if compounds are observed or appear probable from phenomena witnessed, that will be the best evidence that the temperature is decidedly lower than the above figure. For hydrogen the dissociation temperature is only about 700° Cent. which is only about one-ninth its maximum.

MARSH'S ODONTORNITHES.*

Were there no other proofs of his zeal and success in extending the bounds of knowledge, the writer of this magnificent monograph would be famous as—for ten years at least,—the sole discoverer, describer and possessor of the remains of Extinct Toothed Birds of North America.

It may befall almost any diligent explorer to find the remains of some species previously unknown, but few have had— or so well-deserved—the privilege of presenting to the world a new series of facts embodying a new idea, at once easily appreciated by the many, and serving the few as material for profound consideration. That a bird with teeth is, most literally, a *rara avis*, may be conceded without extensive acquaintance with either Latin or Ornithology; on the other hand, it is probable that naturalists have not yet wholly realized the import of this fulfillment of a prediction which might have been made legitimately—though we are not certain that it ever was —at any time during the last twenty years.

Aside from the Appendix, the present volume embraces detailed descriptions of the bones and teeth of *Hesperornis* and *Ichthyornis*; a general description of the "Restoration" of each genus; and a "Conclusion" embracing the author's views upon the taxonomic relations, and probable evolution of these two forms, together with *Archæopteryx*.

The following are the principal characteristics of the two American genera, chiefly as recapitulated upon p. 187. In *Hesperornis*, the articular ends of the vertebral centra are saddle-shaped, as in recent birds; in *Ichthyornis* they are biconcave, as in many fishes: *Ichthyornis* has a prominent sternal keel for the attachment of the muscles of the well-developed wings; in *Hesperornis*, the sternum is without a keel, and each wing is represented by only a rudimentary humerus: the wing-bones of *Ichthyornis* have tubercles evidently for the attachment of feathers; no signs of feathers have been observed with *Hesperornis*, but they doubtless were present in life: in both genera, the caudal vertebræ are few, so that the bony tail is short as in recent birds: in both, the mandibular rami seem to have remained permanently ununited by bone: in both, as indicated by casts of the cranial cavity, the prosencephalon was narrower than in recent birds of

*Odontornithes: A Monograph on the Extinct Toothed Birds of North America; with thirty-four plates, and forty woodcuts. With an Appendix giving a Synopsis of American Cretaceous Birds. By Othniel Charles Marsh, Professor of Palæontology in Yale College, Memoirs of the Peabody Museum of Yale College, vol. 1; pp. 201. This memoir will also form vol. vii, Survey of the 40th parallel.

similar size, a point of much interest, in view of what has been noted by Prof. Marsh with regard to the brains of extinct Mammals: finally, both forms had *well-developed teeth in both jaws*, but those of *Hesperornis* were implanted in a continuous groove, while those of *Ichthyornis* had separate sockets.

Prof. Marsh calls attention to the peculiar combination, in *Ichthyornis*, of a low feature—the biconcavity of the vertebræ—with a comparatively high method of implantation of the teeth, and adds: "Better examples than these could hardly be found to illustrate one fact brought out by modern science, that an animal may attain great development in one set of characters, and at the same time retain other low features of the ancestral type. This is a fundamental principle of Evolution."

Naturally, the teeth are described and figured with especial fullness and accuracy. Their general features are distinctly reptilian, as would have been inferred. Curiously enough, in neither genus does the dental series reach the tip of either jaw, and, in *Hesperornis*, "the extremity of the premaxillary bone, back to the nasal openings, has its surface pitted with irregular vascular foramina, indicating apparently, that it was once covered with a horny bill, as in modern birds." P. 8.

With the exception of *Archæopteryx*, all the known odontornithic remains are in the Museum of Yale College, but their discoverer is clearly of opinion that more are to be found:

"These three ancient birds, so widely different from each other, and from all modern birds, prove beyond question the marvellous diversity of the avian type in mesozoic time, and also give promise of a rich reward to the explorer who successfully works out the life-history of allied forms, recorded in ages more remote." P. 189.

He even ventures to define the leading features of the, at present, hypothetical progenitor of the entire group of birds: "In the generalized form to which we must look back for the ancestral type of the class of birds, we should therefore expect to find the following characters: Teeth in grooves; vertebræ biconcave; metacarpal and carpal bones free; sternum without a keel; sacrum composed of two vertebræ; bones of the pelvis separate; tail longer than the body; metatarsal and tarsal bones free; four or more toes, directed forward; feathers rudimentary or imperfect; quadrate bone free." P. 188.

As compared with this generalized form, our modern birds, while endowed with intense functional activity, and in some structural features—especially as to their true dermal appendages—a most highly specialized group, are nevertheless, odontologically considered, degenerated and retrograded creatures.

The general bearing of the facts given in this memoir upon the question of evolution has been well stated by Prof. Marsh upon a previous occasion.

"*Compsognathus* and *Archæopteryx* of the Old World, and *Ichthyornis* and *Hesperornis* of the New, are the stepping-stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought to be impassable."

So far we have had to deal either with facts, or with hypotheses based upon those facts and warranted by the prevailing opinions respecting evolution in general. There remains to be considered the bearing of these same facts upon the zoological relations of the toothed birds to the rest of the class. Here there is room for very wide disagreement, and the only point, perhaps, upon which all seem to be in accord, is that the Birds, as a whole, form a *class* of vertebrates, whether or not they should be combined with the reptiles as a super-class or sub-branch—Sauropsida.

The advantages of employing a single technical term like *odontornithes* in place of *aves dentatæ* or *toothed birds* will be generally conceded, and the use of the term as a convenient designation of certain forms need not imply more than is implied by the words *swimmer*, *flier*, *apoda*, etc. The real question is, do the toothed birds constitute a natural subdivision of the class Aves, comparable for instance with the Marsupials among the mammalia? If not do they constitute an order or a family, or, finally, are they—or some of them—simply representatives of two or more natural groups, differing from the other members of those groups, and associated together, by the possession of teeth?

In a natural classification, we expect to find animals collocated either because they agree in many particulars, or because they have in common one or, more features of primary importance For example notwithstanding their immense variety in size, form, habit, existing birds present a remarkable uniformity of structure, even in some apparently insignificant details. On the other hand, although *Amphioxus* differs from all other Vertebrates in so many respects that nearly all generalizations as to the branch must be accompanied by a qualification, yet it shares with the rest a developmental feature and a general arrangement of organs which keep it within the branch and separate it from all other animals, excepting perhaps the Ascidians.

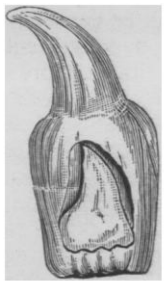
Prof. Marsh regards *Archæopteryx*, *Hesperornis*, and *Ichthyornis*, as the representatives of as many orders of the subclass Odontornithes, to which he applies the names Saururæ, Odontolcæ, and Odontotormæ. The first of these names had been employed already by Hæckel and Huxley, who, however, had made the Saururæ, Ratitæ(ostrich, etc.) and Carinatæ, (all other birds) subclasses of the class Aves. Marsh does not say what he thinks should be done with the Ratitæ, but if he is correct in his opinion (p. 3.) that "*Hesperornis* and *Ichthyornis* differed more from each other than do any two recent birds," it would seem to follow that the Ratitæ can no longer constitute a subclass of the recent and toothless birds.

In the condensed statement of the characters of the orders (p. 187) it is shown that we are unacquainted with the mode of implantation of the teeth of *Archæopteryx*, with the form of its vertebræ and sternum, and with the extent of union of the mandibular rami. The characters enumerated are the *presence of teeth*, *small wings*, *separate metacarpalia and a bony tail longer than the body*.

It will be seen that, excepting the teeth, any generalization respecting the Odontornithes as a whole, must be accompanied by a qualification respecting one or two of the orders. Prof. Marsh points out that the three groups present unequal degrees of affinity. But even if we exclude *Archæopteryx*, the only characters which are at the same time common to the

Odontolcæ, and Odontotormæ and absent from recent birds, are the *narrowness of the prosencephalon, the persistent separation of the mandibular rami and the presence of teeth.*

That the presence of teeth has been regarded by Prof. Marsh as the principal—if not the only essential—characteristic of the Odontornithes, is indicated by the following passages from the present work, or from previous papers.



TOOTH OF *Hesperornis Regalis*, SHOWING GERM OF YOUNG TOOTH.

"Both of these types possessed teeth, a character hitherto unknown in the class of birds, and hence they have been placed by the writer in a separate sub-class, the Odontornithes." P. 3.

"That *Archæopteryx* belongs to the Odontornithes, the writer fully satisfied himself by a personal examination of the well-known specimen in the British Museum. The teeth seen on the same slab with this specimen agree so closely with the teeth of *Hesperornis*, that the writer identified them at once as those of birds and not fishes." P. 186.

In speaking (p. 191) of the "bird remains found in the Green-Sand deposits of New Jersey," our author says; "as neither jaws nor teeth have yet been detected, it is at present impossible to say whether the Eastern species belong to the Odontornithes."

Before the discovery of the teeth, he had characterized the *Hesperornis regalis* as a "gigantic diver related to the Colymbidæ." His preliminary description of the same bird had been to the same effect, with the addition "that it differs from the Colymbidæ so widely in the structure of the pelvis and posterior limbs as to demand a place in at least a separate family."

In the present publication, however, our author is of opinion that "the struthious characters seen in *Hesperornis* should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a gigantic swimming ostrich." P. 114.

That Prof. Marsh's opinion as to the taxonomic value of the teeth is shared by zoologists generally, is shown—at least negatively—by the absence of dissent from his own views and from those of such reviewers as Newton and Woodward. The former speaks of the "teeth, whence the *Ichthyornis* has been made the type of a distinct sub-class." The latter, writing of the same genus, says: "The possession of teeth and biconcave vertebræ, although the rest of the skeleton is entirely avian in type, obviously implies that these remains cannot be placed in the present group of birds, and hence a new sub-class, Odontornithes is proposed for them." In the added note, respecting *Hesperornis*, Woodward does not state whether he was then aware that the vertebræ of that genus lacked the biconcave character. Hence it is not certain whether he would regard it as an odontornith by reason of the teeth alone.

Prof. Huxley does not distinctly mention the degree of separation of the toothed birds from the rest, but he says that the *Hesperornis regalis* "in a great many respects is astonishingly like an existing diver or grebe, so like it indeed, that had this skeleton been found in a museum, I suppose—if the head had not been known—it would have been placed in the same general group as the divers and grebes of the present day."

So far as I am aware, no objection to the erection of a sub-class upon a purely dental basis, has been offered, even upon the part of some who have not usually been slow in critcising our author's conclusions.

Yet Prof. Marsh himself appears to be by no means settled in his conviction as to the taxonomic relations of the forms in question, since his "Conclusion" contains the following qualified expression of opinion: "For the present, at least, it seems advisable to regard the Odontornithes as a sub-class, and to separate them into three orders."

The above intimation of a willingness to review this part of the subject removes the hesitation which one naturally feels in differing from the highest—and, in one sense, the only—odontornithological authority, and I therefore venture to offer certain considerations which seem to have been overlooked hitherto.

1. Are the other characters of the toothed birds such as to warrant their separation as a sub-class? In other words, can we conceive of *edentulous* Odontornithes as we have Vertebrates without vertebræ, and Edentates provided with teeth?

2. Why should the presence of teeth in certain birds be accounted of more taxonomic significance than the absence of the same organs in the members of other classes? The truly edentulous edentates are held to form merely families or sub-orders; the (toothless) turtles are commonly regarded as an order of reptiles; and Prof. Marsh himself has established the sub-order Pteranodontia, the "distinctive feature of which as compared with the other Pterosauria, is the absence of teeth."

3. If birds with teeth had been known to us at all times, or in the recent state, or in great number and diversity, is it probable that, the entire group having the rank of a class, we should have been led to form two primary groups, the Odontornithes and the Anodontornithes.

4. How would the question appear in case unmistakable evidences of teeth are found in the embryos of recent birds? That such signs will be sometime discovered can hardly be doubted, especially when the embryology of the ostrich is as well known as that of the common fowl. Some are even now of opinion that such structures have been seen. So cautious a compendium as Rolleston's Forms of Animal Life, says: "dental papillæ, with caps of dentine, have been observed in the embryos of Psittacidæ." Since, however, Prof. Marsh holds (p. 13) that the "vascular papillæ seen by St. Hilaire and others were apparently portions of the horny beak," we may consider the point unsettled.

5. May it not be that, in our natural surprise at the

HESPERORNIS REGALIS, MARSH.

unexpected presence of teeth in connection with an otherwise bird-like structure, we have overestimated the true taxonomic significance of the facts, and lost sight, for the moment, of our customs in other groups? May it not be, indeed, that we have been unconsciously affected by the phenomenal nature of most of Prof. Marsh's palæontological discoveries, and that we have not only been unduly impressed by the facts, but also influenced in some degree by the general admiration for the discoverer's achievements, so as to refrain from questioning his conclusions? Yet, as has been shown already, our author has kept his own mind open upon this very point, and it is to be hoped that he may have the pleasure and the honor of discovering other forms of Aves dentatæ, affiliated in other respects to the several groups of existing birds, and held together only by their teeth.

Hereafter such problems as are involved in this memoir will be discussed more advantageously in the light of the considerations respecting the Evolution and Classification of Vertebrates which have been presented recently by Prof. Huxley.

So admirable is the present work as a whole that one shrinks from any criticism of details. Upon the following points, however, some improvement could, perhaps, have been made:

While insisting upon the lack of bony union of the ends of the mandibular rami in the American Odontornithes, our author makes contradictory statements in regard to the tissue by which they were joined during life. On pages 11 and 179 it is said to have been *ligament;* on page 123, and in the explanation of plate 1, *cartilage* is specified, while on page 112 the union is said to have been "as in serpents." Judging from the appearance of the surface shown in plate 1, fig. 4, the union was ligamentous rather than cartilaginous, but there may have been a mingling of the two kinds of tissue.

The date of the discovery of *Hesperornis* is given as November, 1870, on page 2, but as December on page 195.

It would have greatly facilitated references if there had been given in this volume a complete Bibliography of Odontornithology, together with a statement of the dates of discovery of the various forms, and the dates of their assignment to more comprehensive groups than species and genera. The synonymy as given under the species named in the Appendix does not quite meet this want.

In view of the aid which evolution has received from embryology, it would seem that even a special palæontological memoir like the present might have contained some expression of the author's expectation that light may sometime be thrown upon the problems involved by the careful scrutiny of the development of certain recent birds, notably the Struthionidæ.

B. G. W.

REPORT SUBMITTED TO THE ACADEMY OF MEDICINE ON THE SUBSTITUTION OF MARGARINE FOR BUTTER AND LARD IN THE PUBLIC ASYLUMS OF THE DEPARTMENT OF THE SEINE.—M. Riche finds that pure butter yields a quantity of fatty acids insoluble in water ranging from 86.5 to 88 per cent of the weight of the pure fatty matter, whilst in all the other fats and animal oils, and in almost all vegetable oils, there is from 95.20 to 95.80 per cent of insoluble fatty matter.

ON THE SOUTHERN STARS AND OTHER CELESTIAL OBJECTS.

BY J. H. POPE, NEW ZEALAND.

This paper embodies the results of observations made during the last eight years. While most of the work is original, yet, when the object described is important, and an account of my observations could not be satisfactorily given without reference to the work done by previous observers, their facts and opinions have been quoted. An apology is scarcely needed for giving a short *résumé* of the facts known about the great star *Alpha Centauri;* accordingly, a very brief history of this remarkable object, from Lacaille's time (1750) to the present has been given.

The instruments used were an 8½ inch reflector, by Browning, and a 4¼ inch equatorial of superior quality. The measures of angles and distances have been obtained by the methods described in my paper in last year's "Transactions."* The angles of position will, I have little doubt, be found to be good, but the atmosphere has not been steady enough of late to admit of the best use being made of oblique transits. I have, however, little doubt that such measures of distances as are given will be found to be very satisfactory approximations to the truth. For the spectroscopic work recorded in this paper I have used an admirable little star-spectroscope, by Browning. This instrument has enabled me to determine, quite satisfactorily, the class to which the stars examined belong, and, in many instances, to say that the spectrum lines of certain elements are probably present. As, however, the means at my disposal did not permit me to make accurate *measures* of the positions of lines, my work in this department should be looked upon as the results, so to speak, of a "flying survey," useful perhaps, in its way, but to be superseded when more thorough and accurate determinations can be obtained.

It should be stated, however, that, while depending on eye estimation alone, it would be very unsafe for an observer to say, that a conspicuous line, for instance, in the greenish blue of the spectrum of a certain star was certainly the F hydrogen line; yet it is unlikely that a practiced eye, one trained to recognize the position of certain lines in spectra that have been already measured, could be mistaken, in any large proportion of cases, in picking out, say, the principal Fraunhofer lines in a stellar spectrum. On the whole, it seems to me that such determinations as are given in this paper are not without a real value, if carefully made. Many years must elapse before the lines in the spectra of the southern stars can be accurately measured by methods like those employed by Dr. Huggins. In the meantime such results as those here given are all that are available. These serve to give us a certain amount of information that can be thoroughly relied on; they enable us to state, further, that the existence of certain physical conditions, and the presence of certain elementary substances in certain stars, are highly probable; and, possibly, they are calculated to create or stimulate in us a desire to learn more certainly and fully the constitution and physical habitudes of the stars.

The objects are treated of in the order of their Right Ascension, and the places of the stars when given, are taken from the "First Melbourne Catalogue," epoch, 1870.

The first star on the list is *Achernar* or *α Eridani*. This fine first magnitude star is very nearly pure white, without any discernable tint, except possibly a slight shade of blue. This star belongs to Padre Secchi's first class of stars, the type of which is the giant sun *Sirius*. In the case of typical stars of this class, the spectrum is

* Trans. N. Z. Inst., Vol. XI., Art. X.