meridian, and upon the unification of time by the adoption of a universal time, has agreed upon the following resolutions: —

1°. The unification of longitude and of time is desirable as much in the interest of the sciences as in that of navigation, of commerce, and of international communications. The scientific and practical utility of this reform far outweighs the sacrifice of labor and the difficulties of re-arrangement which it would entail. It should, then, be recommended to the governments of all the interested states to be organized and confirmed by an international convention, to the end that hereafter one and the same system of longitudes should be employed in all institutes and geodetic bureaus, for general geographic and hydrographic charts, as well as in astronomical and nautical almanacs, with the exception of those made to preserve a local meridian; as, for instance, the almanacs for transits, or those which are needed to indicate the local time, such as the establishment of the port, etc.

2°. Notwithstanding the great advantages which the general introduction of the decimal division of a quarter of the circle in the expressions of the geographical and geodetic co-ordinates and in the corresponding time-expressions is destined to realize for the sciences and their applications, it is proper, through considerations eminently practical, to pass it by in considering the great measure of unification proposed in the first resolution.

However, with a view to give satisfaction at the same time to very serious scientific considerations, the conference recommends, on this occasion, the extension, by the multiplication and perfection of the necessary tables, of the application of the decimal division of the quadrant; at least, for the great operations of numerical calculations for which it presents incontestable advantages, even if it is wished to preserve the old sexagesimal division for the observations, for charts, navigation, etc.

3°. The conference proposes to governments to select for the initial meridian that of Greenwich, defined by a point midway between the two pillars of the meridian instrument of the observatory of Greenwich; for the reason that that meridian fulfils, as a point of departure for longitudes, all the conditions wished for by science, and because, being at present the best known of all, it offers the most chances of being generally accepted.

4°. It is suitable to count the longitudes, starting from the meridian of Greenwich, in the sole direction from west to east.

5°. The conference recognizes for certain scientific wants, and for the internal service in the great administrations of routes of communication, — such as the railways, steamship-lines, telegraphic and post routes, — the utility of adopting a universal time, along with local or national time, which will continue necessarily to be employed in civil life.

6°. The conference recommends as the point of departure of universal time and of cosmopolitan dates the mean noon of Greenwich, which coincides with the instant of midnight or with the commencement of the civil day, under the meridian situated twelve hours, or a hundred and eighty degrees, from Greenwich.

It is agreed to count the universal time from 0 hour to 24 hours.

7°. It is desirable that the states which, with a view to adhere to the unification of longitudes and of time, find it necessary to change their meridians, should introduce the new system of longitudes and of hours as soon as possible.

It is equally advisable that the new system should be introduced without delay in teaching.

8°. The conference hopes, that, if the entire world agrees upon the unification of longitudes and of hours by accepting the meridian of Greenwich as the point of departure, Great Britain would find in this fact an additional motive to make, on its part, a new step in favor of the unification of weights and measures by adhering to the *Convention du mètre* of the 20th of May, 1875.

9°. These resolutions will be brought to the knowledge of the governments, and recommended to their favorable consideration, with an expression of a hope that an international convention — such as the government of the United States has proposed — for confirming the unification of longitudes and of time should be decided upon as soon as possible.

ORIGIN OF THE MESODERM.

THE origin and composition of the mesoderm has been the subject of perhaps more discussion than any other single point in the whole range of embryology. Observers have given the most conflicting statements, for the most part due to incomplete observations; but now we are at last in a position to eliminate many of the false descriptions and to harmonize fairly well those we must regard as correct.

The first important advance was accomplished by His, who made the fundamental discovery that the mesoderm is not homogeneous, but double, in its origin. The ectoderm, entoderm, and part of the mesoderm, he distinguished under the common name of 'archiblast,' from that portion of the mesoderm which is related to the connective-tissue group (connective tissue proper and endothelia), and which he supposed to grow from the yolk (in the chick) into the archiblastic tissue or cells, which, from the first, are constituent elements of the embryo. His maintained that the parablast-cells were derived from the white elements of the yolk, but in that respect he is believed to be in error; nevertheless to His belongs the great honor of having first insisted upon the duplex development of the middle germ-layer. This knowledge is the key to the solution of one of the fundamental problems of animal morphology.

The researches of Professor His have been confined to vertebrates. One cannot but feel that his views would have been modified in many details, if he had included the lower types, also, in his investigations. The discoveries of others, however, have gradually made it clear that among invertebrates, also, the twofold composition of the mesoderm exists. The path to this generalization may be said to have opened out upon the announcement by Alexander Agassiz that in echinoderms the lining of the body-cavity and water-vascular system is derived from the entoderm. Selenka and others have since shown that the rest of the mesoderm is derived from scattered and isolated cells, which are thrown off from the other layers into the space between the ectoderm and entoderm. It was thus clearly shown that in this class of animals the mesoderm primitively consists of two epithelial evaginations and of scattered and independent cells of amoeboid character. The fundamental importance and the far-reaching significance of this discovery were unfortunately not appreciated at the time.

For several years past I have been accumulating materials for a work on 'Comparative histology,' and have meanwhile directed my attention chiefly to the classification and genesis of tissues. These preliminary studies led me to various conclusions, among which was the conviction that amoeboid cells were the primitive representatives of the mesoderm, and that from them was derived a large part of the mesodermic tissues. This view I published in 1879;[1] but the article has, so far as I am aware, been entirely overlooked by subsequent writers, and I therefore venture to call especial attention to it now, as the opinion I then advocated has since become a current embryological generalization. To the cells I gave the name of 'mesamoeboids.'

The investigations of Hatschek, whose brilliant discoveries have not yet received their deserved recognition, have revealed that in Bryozoa, Mollusca, Annelida, and Amphioxus, the mesoderm arises, 1, from cells, such as we have seen may be classed under the head of mesamoeboids; 2, from two paired masses of cells, his 'mesodermstreifen,' whose origin from the entoderm is rendered probable in all cases, and certain in some, by known characteristics. These stripes either have from the first, or soon acquire, a distinctly epithelial structure. Hatschek appears to have recognized the bearing of his observations nearly as we conceive it now; and to him, I think, we should accord the honor of having first clearly and definitely recognized the dual histogenesis of the mesoderm.

F. M. Balfour, in his writings, particularly in his 'Treatise on comparative embryology,' made the next important step by pointing out that the vertebrate mesoderm probably arose as a pair of diverticula from the gastrula cavity; and he gave a new meaning to, and justification of, this theory, by insisting upon the homology between the blastopore of the Ichthyopsida and the primitive streak of the Amniota; for from the walls of the former, as well as from the substance of the latter, the paired outgrowths of the middle layer arise. The deficiency in Balfour's presentation of the subject lies in his failure to recognize the importance of the mesamoeboids.

The brothers Hertwig have published a series of contributions to the solution of the problem, and have embodied their general results in an article entitled the 'Coelomtheorie.' As we have shown, their predecessors had pretty well established the necessity of regarding the mesoderm as consisting of two parts, — *first*, the paired epithelial portion derived from the entoderm, forming the lining of the body-cavity, and giving origin to the peritoneum, muscle-plates, genital glands, etc.; *secondly*, scattered cells, giving origin to the connective tissue, the endothelia, vessels of the circulation, the blood, and lymph. These conclusions, however, had never been systematically collated and coherently presented. The brothers Hertwig performed this task with characteristic ability and success. Guided by their own important original researches on several animal types, and utilizing the results of others, they succeeded in demonstrating the prevalence of the same composition of the mesoderm in the

[1] Minot: Preliminary notice of certain laws of histological differentiation. *Proc. Boston soc. nat. hist.* xx. 207.

majority of animals. Their own most important addition to our knowledge appears to me to be their analysis of the morphology of muscular tissue, by which they removed the most important difficulty against the final acceptance of the generalization. While we thus recognize the great services rendered by the brothers Hertwig, we are impelled also to express our regret that they have not been more generous in their acknowledgment of the achievements of previous investigators; for their theory was mainly the result of a judicious combination of what had been before published. To them belongs the merit of ripening the fruit which was already formed.

To the mesamoeboid portion of the mesoderm the Hertwigs gave the very appropriate name of 'mesenchyma.' For the epithelial portion no satisfactory name has yet come into use: therefore I venture to propose 'mesothelium.'

In applying this generalization which we have been considering to vertebrates, difficulties and objections were encountered. To set these aside, Professor Oscar Hertwig has published two special researches, the second of which appeared recently, and is reproduced in abstract below.

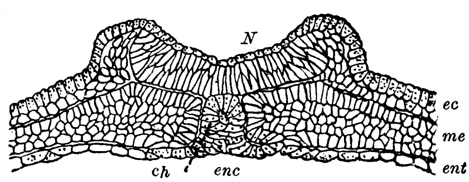
In this review, only a few salient points of the history of this most important of recent embryological discoveries are given; but I cannot close without a strong expression of my regret at being unable to notice many valuable contributions to the subject, — a pleasure which the limited space at my disposal compels me to unwillingly forego.

In continuation of the extended researches on the origin of the mesoderm previously given to the world by his brother and himself, Oscar Hertwig now publishes the results of his investigations on the development of the middle layer in the frog, adding a discussion of its origin in other vertebrates. The early stages in the frog are described with great minuteness, and with far less concision and directness than we should have anticipated in any of Professor Hertwig's writings.

The essential points brought forward are the following. In the first stage, while the blastopore still appears as a round white spot, the primitive *darm* (urdarm) has the well-known form. Its inferior and lateral boundaries are the cells of the entoderm; but along the dorsal line the cells offer a different histological character, being pigmented, and consisting of three or four rows of small cells. In Triton, however, there is a single row of high cylinder cells. This dorsal band includes the *anlage* of the notochord, and is named by Hertwig 'chorda-entoblast.' Around the blastopore the mesoderm is already present, forming a paired extension running forward as a lateral mass on either side, and a median division lying below the blastopore. Around the edges of the blastopore all the layers are united: throughout the remainder of its extent the mesoderm is separated by a narrow space from both ectoderm and entoderm. The mesoderm and the chorda-entoblast are both histologically similar to the ectoderm; and Hertwig, on that account, believes they are both derived from the outer germ-layer. (This conclusion we think is founded upon an insufficient basis.)

In the next stage the blastopore remains merely as a white point, and the medullary folds and median dorsal furrow appear. The notochord is developed under the dorsal furrow as a thickening of the median portion of the chorda-entoblast, which butts against the ectoderm, so that the mesoderm is excluded from the axial line. Ultimately the lateral portion of the chorda-entoblast enters into the formation of the intestinal wall; but in Triton the whole of this peculiar band is changed into the chorda, which, being formed by an invagination, exhibits a slit in transverse sections of early stages. No such slit is seen in frogs. There is a fold formed at the lateral junction of the chorda-entoblast with the rest of the entoblast; and along that fold the entoderm is fused, without demarcation, with the mesoderm. Around the blastopore the three layers still present essentially the same arrangement as before; the mesoderm has grown out around the whole ovum, except a small area on the ventral side, where the ectoderm and entoderm (yolk) are in immediate contact.

In the next stage, when the whole length of the broad medullary groove is clearly marked out, and indeed in later stages also, the absolute independence of the notochord of the mesoderm, and its development out of and gradual separation from the chorda-entoblast, are to be clearly recognized (see the accompanying figure). In the region of the blastopore, where the mesoblast is continuous with the other layers, there are two projecting lips, on one side formed by the entoderm proper, on the other by the chorda-entoblast. These lips enclose a fissure between them, which is a small evagination of the enteric cavity into the mesoderm.



Frontal section through a frog ovum in which the medullary ridges have begun to appear. *Ent*, entoderm; *enc*, chorda-entoblast; *ch*, notochord; *me*, mesoderm; *ec*, ectoderm; *N*, nervous system.

In a later stage the anus is developed *behind* the blastopore as a simple ectodermal invagination, the bottom wall of which breaks through. No such relations between the germ-layers have been found here, or elsewhere, as around the blastopore.

The points, then, of special importance, brought out by Hertwig, are, 1°, the existence of the median dorsal band of cells, the chorda-entoblast, entering into the formation of the entodermic wall, but resembling in character the ectodermal cells; 2°, the development of the mesoderm as a paired outgrowth from the blastopore. In part second of his paper, Hertwig reviews the published investigations on the embryology of other classes of vertebrates. He accepts the homology of the primitive streak in Amniota with the blastopore. He is fairly successful in proving the same relations of the germ-layers to exist in all vertebrates. He also discusses the various objections advanced against the *coelomtheorie*, according to which the mesoderm is an epithelial layer, bounding the body-cavity. He draws from his observations and arguments the following conclusions: 1. The mesoblast grows as a continuous mass from acknowledged epithelial layers; 2. In all vertebrates there early appears a fissure in the mesoderm, limited parietally and viscerally by epithelium, as can be especially well seen in elasmobranch embryos; 3. From this epithelium are derived true epithelial membranes in the adult, from which are developed the peritoneum, kidneys, sexual glands, etc.; 4. The primitive mode of origin of the mesoderm is probably that described by Kowalevsky and Hatschek in Amphioxus, —an invagination of an epithelial membrane (entoderm); 5. In the true vertebrates the mesoderm grows out as a solid mass, in which the fissure appears later. This must be regarded as a secondary modification, for we frequently find hollow organs making their first appearance as solid *anlagen;* e.g., the central nervous system of teleosts, many sense-organs, and most glands. These considerations lead collectively to the final conclusion that the mesodermic plates are morphologically epithelial evaginations homologous with those of the invertebrates.

CHARLES SEDGWICK MINOT.

ACOUSTIC ROTATION APPARATUS.

IN a recent number of the *Zeitschrift für instrumentenkunde*, Dr. V. Dvořák gives an account of the various forms of apparatus which have been devised to show attraction or repulsion due to sound-waves, or to gain a continuous rotation.

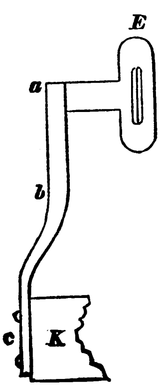


FIG. 1.

Such experiments require a good volume of sound for success. That this may be obtained, not only should the tuning-fork be in accord with the resonator-box on which it is placed (the most convenient form of sounding-body for the purpose), but also the elastic system, consisting of tuning-fork and box, should be capable of vibrating in unison with the fork and the air in the resonator. The three sounds are called the fork, the air, and the wood tone. In order to get the last, the resonator should be stuffed with cotton-wool, and a piece of cork put between the prongs of the fork; then, by rapping on the top of the fork, the whole system is vibrated very much as it would be by the up-and-down motions of the lower part of the fork when free. By cutting away the walls of the resonator to make them thinner, the system may readily be brought to the right pitch. In most of the resonators in common use the wood tone is too low, owing to the wood being already too thin.

The fork used by Dr. Dvořák was *G*, having 392 vibrations per second. It weighed 265 grams. As a resonator, an ordinary pine box was used, about 13.5 cm. long, 11 cm. broad, and 10.5 cm. high. In one side a round hole was cut, large enough to make the air tone of the right pitch. The wood was 8 mm. thick. From the top and bottom it was shaved off for the purpose explained above. The dimensions of the box were entirely accidental, but proved to be good.

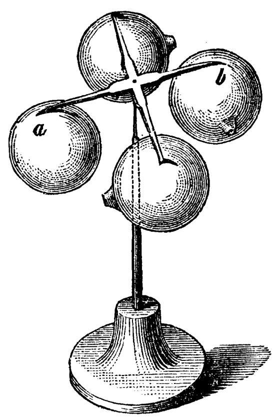


FIG. 2.

By using an electro-magnet to keep the fork in continuous vibration, the results are naturally more sure. The form of magnet which has proved satisfactory is shown in fig. 1. *E* is the magnet, with a core made of iron plates. This magnet is placed between the prongs of the fork, and is held by the wooden arm *a c*, to the lower end of which is fastened the resonator *K*. At *b* the arm is bound to a firm support, so that the system of fork and resonator is perfectly free.

The resonator-wheel (fig. 2) is the first form of rotating apparatus described. It consists, as shown in the illustration, of four glass resonators on the four arms of a wheel. For a fork of 392 vibrations, the spheres should be about 44 mm. in diameter, with openings 4 mm. across. Rotation was obtained with the fork 40 cm. away.

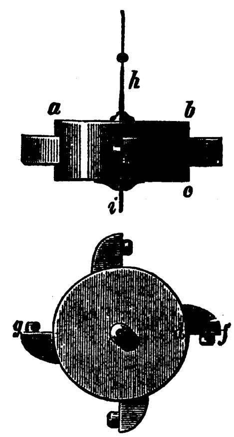


FIG. 3.

As a modification of this wheel, a rotating resonator (fig. 3) may be made of a flat cylindrical pasteboard box, having a number of side-openings, each ending in a short piece of tubing of size to make the resonator respond to the fork. When suspended by a silk thread, *h*, such a resonator