

Marcy (H.O.)

THE
PLACENTAL DEVELOPMENT
IN MAMMALS.

A UNITY OF ANATOMICAL AND PHYSIOLOGICAL
MODALITY IN ALL VERTEBRATES.

By HENRY O. MARCY, M. D.,

OF BOSTON, MASS.



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RECENT investigations by a number of distinguished scholars have given this subject a new and exceptional interest.

Deductions have been formulated of fundamental importance, not only to the physician and pathologist, but also to the comparative anatomist and scientist. One of the most illustrious scholars² of learned Germany has recently described the human placenta, as a whole, "to be a formation very spongy in character, abounding in blood, which does not easily allow of investigation by the ordinary methods most useful in anatomical researches—namely, the knife and injections;" and from this he finds a reason for the uncertainty which exists in regard to its intimate structure. The teachings of the recent text-books upon physiology and obstetrics in relation to the anatomy and function of the placenta are nearly all similar to twenty years ago.

Dr. Alfred Meadows,³ a well-known author and a careful scholar, may be cited as an example.

"The placenta is simply a mass of blood vessels, having no other structure whatever in its composition. * * It

¹ Read before the Association for the Advancement of Science, Montreal, August, 1882.

² Kölliker. *Entwicklungs geschichte des Menschen und der höheren Thiere*, B. I, 6, 331. Leipzig, 1876.

³ *Manual of Midwifery*, 4th edition. London, 1881.

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will thus be seen that there is no direct vascular communication between the mother and the fœtus, and hence all the eliminative changes necessary for the depuration of the fœtal blood, and the passage of all nutritive materials required for the growth and development of the fœtus, take place by endosmosis through the ends of the fœtal tufts which are being constantly bathed by the maternal blood, and thus act the part of stomach and lungs to the fœtus. The two bloods are kept apart by three structures—the capillary wall, the containing membrane of the tuft, and the lining membrane of the placental sac, which is a natural structure.”

Dr. Foster,¹ a recognized authority in physiology in both Europe and America, states: “As the thin walled allantoic vessels come into closer and fuller connection with the maternal uterine sinuses until, at last, in the fully-formed placenta the former are freely bathed in the blood streaming through the latter, the nutrition of the embryo becomes more and more confined to this special channel. The blood of the fœtus flowing along the umbilical arteries effects exchanges with the venous blood of the mother, and leaves the placenta by the umbilical vein richer in oxygen and nutritive material and poorer in carbonic acid and excretory products than when it issued from the fœtus. * * We have no definite knowledge as to the exact form and manner in which, during normal intra-uterine life, nutritive materials are conveyed to or excretions conveyed from the growing young. * * Speaking broadly, the fœtus lives on the blood of its mother, very much in the same way as all the tissues of any animal live on the blood of the body of which they are the parts.”

Dr. Playfair discusses the subject at greater length, and records the views of a number of recent investigators, and in reviewing the subject states there is much yet to be de-

¹Text-book of Physiology, London. Third edition, 1879. Page 621.

terminated in relation to this abstruse, but interesting subject. Dr. Lusk, in his recently-published treatise upon the science of midwifery, after quoting from a number of authors, gives, as his opinion, that it is "most probable that the (maternal) vessels have become eroded and finally destroyed by the growth of the villi, leaving the blood to flow unimpeded through the intervillous spaces."

Engelmann's observations are of quite a different character. His monograph upon the mucous membrane of the uterus is a model of original investigation. He disposes of many of the fallacies of present teaching, and demonstrates that the chorial villi are much larger than the mouths of the glands they are supposed to enter:

"It was formerly maintained that the villosities of the chorion penetrate the glandular ostia and enter the ducts of the glands themselves, thus forming a comparatively firm connection between the ovum and the surrounding uterine membranes. This is still universally assumed and is held, I am sorry to say, by some most eminent and well-known observers. It is a very plausible theory, which is demonstrated by most striking and conclusive illustrations, duly copied by all, especially obstetrical text-books, but no preparations proving the same are in the hands of any of the authors who advocate its truth, and, indeed, cannot be found."¹

Quotations of similar import might be made from many authors, but these are sufficient to serve as examples of present teaching, and the very generally accepted opinion not only of the formation, but also the function of the placenta.

The lessons of great importance taught by comparative anatomy in clearing up intricate and difficult questions per-

¹ *The Mucous Membrane of the Uterus, etc.*, George G. Engelmann, New York, 1875.

taining to the structures of the human species have been generally undervalued. This method of study and its bearing upon the knowledge of the human placenta has been in a large measure unknown or ignored.

The older masters of the Italian school painstakingly followed and taught these means of investigation. Fillippo Ingrassia and Malpighi recognized this important gain from the knowledge of comparative anatomy, and Fabricius, in his work, "*De Formato Fœtu*,"¹ distinctly emphasizes the importance of comparative observations.

The names of Von Baer, Cuvier, Milne Edwards, Owen, Huxley, Turner, are familiar to every student of to-day, and to these men, as comparative anatomists, medical science owes a large debt of gratitude.

The revival of letters, of recent times in Italy, gives promise of rivalry of the old spirit of her masters which brought the students of the civilized world to her thronged universities. Not least among her scientific investigators, upon whom the mantle of the fathers has fallen, is Prof. G. B. Ercolani, of the old University of Bologna. To his teachings we owe the larger share of that which is here offered for consideration.

It has been generally taught that the maternal portion of the placenta was a tumefaction or a transformation of the uterine mucous membrane.

Owen and Turner affirm that without a decidua there is no formation of a placenta, but they are silent in reference to the development of the decidua. Kölliker distinctly states that "the decidua is a transformation of the uterine mucous membrane and not a new membrane or a product of an exudation as was once believed," although he does not attempt to show which elements of the uterine mucous

¹ Padua, 1604.

membrane compose the decidua, or in what way they are transformed.

It is evident that the only method of ascertaining the origin of the cells of the decidua is to make our investigations in the very first periods of pregnancy. Ercolani has been fortunate in doing this in a considerable number of the different species of animals, and in the atlas of his work¹ gives us most excellent microscopical reproductions of that which ensues. The simplest form of placental development is found in the diffused placenta of the solipeds.

In the non-gravid uterus of the mare,² "the mucous membrane is smooth and velvety, of a rose color, inclining to yellowish; here and there it is doubled over into large and soft folds. In the gravid uterus, on the contrary, the folds are wanting, and over the whole surface of the mucous membrane are scattered vermiform projections winding closely against each other of a very intense deep red color tending to violet, and the surface has a swollen appearance."

Vertical sections of the uterus in an advanced stage of gestation show in the place of the mucous membrane, which in the non-pregnant state is scarcely distinguishable, a uniform layer from one to two millimetres thick which, upon superficial examination, appears like a transformation of the uterine mucous membrane. Into this the villi of the chorion enter and are somewhat uniformly distributed over the whole uterine surface. This so-called tumefied mucous membrane has its origin from the sub-epithelial connective tissue, and consists of an infinite number of simple glandular follicles and may very properly, as designated by Ercolani, be considered a new glandular secretive organ. The villi of

¹ The Utricular Glands of the Uterus, and the Glandular Organ of New Formation Developed during Pregnancy. Houghton, Mifflin & Co., 1880.

² Ercolani, page 35.

the chorion are enclosed by these introflexions and follicular depressions, instead of entering, as was earlier supposed, the utricular glands. These glandular follicles are supplied with an internal epithelium and are developed only during gestation. The opening of these follicles, through which the chorial villus enters, is frequently funnel-shaped. The utero-placental vessels ramify in looped tufts in the connective tissue that rises between the glandular follicles and form a rich vascular net-work. The chorial villi have an independent epithelial covering.

A discussion of the multiple placenta of Ruminants is of exceptional interest in its bearing upon our subject. Of the older authorities Fabricius taught¹ the direct communication of the maternal vessels with those of the foetus, while Harvey² maintained that the fluid secreted by the cotyledons was absorbed by the foetal villi. Needham³, of London, yet more clearly insisted upon the fact that the cotyledons were in function only secreting, while Haller⁴ expressed the thought in a single sentence so terse that we quote: "*In ruminantibus manifestam fit, matrem inter et foetum, non sanguinis sed lactis esse commerciam.*"

Analysis of this fluid by N. Gamgee⁵ shows that it is alkaline and contains, besides water, albumen, fat and inorganic salts. A long known and well established fact is, that rudimentary cotyledons are never wanting in the non-pregnant state, but it remained for Prof. Ercolani to demonstrate that upon the site was developed a new organ of glandular character and that it differed from the diffuse placenta chiefly in being developed over circumscribed areas and possessing a more complex character.

¹ Opera Omnia, Leyden, 1737.

² Padua, 1656.

³ London, 1767.

⁴ Elementa Physiologiæ, t. viii., p. 296. Berne, 1766.

⁵ *Veterinary Review*, No. 46. Edinburgh, 1864.

The single placenta, whether zonarial or discoidal, offers difficulties far greater to its satisfactory study because of its complexity of formation.

The bibliography of the subject forms a chapter in the literature of anatomy and physiology of exceptional interest to the special student, although most confusing to the seeker after knowledge. An admirable sketch of the observations made in this field of inquiry is found in the work of Ercolani above referred to.

We select for careful examination the gravid uterus of the rabbit. A tranverse section of the placental site in the earlier period of pregnancy, about the end of the second week, shows three parts, each clearly distinct :

(1.) The muscular wall of the uterus.

(2.) The placental neoplasm which is developed upon the inner uterine surface.

(3.) Above this is the old uterine mucous membrane tumefied and about to undergo destructive changes.

Two most noteworthy conditions appear. The utero-placental vessels have a lumen almost double the vessels from which they proceed, and, notwithstanding their greater volume, they show in their walls none of the anatomical characteristics which serve to distinguish the arteries from the veins, and which are clearly visible in the uterine vessels. The second and even more important fact is, that these vessels, instead of the ordinary walls, are surrounded with a uniform envelope of cells of a special character, which cannot be distinguished from the cells of the decidua serotina and the maternal placental tissue. The special characteristics of the walls of the vessels, composed as they are seen to be, of only the endothelium, is an objection to the supposition that their development could proceed from the vascular net-work of the old transformed mucous membrane. This is emphasized by the exceptional fact that the

old uterine mucous membrane is detached from the muscular wall, and, with its glands, is undergoing a process of rapid destruction. These facts place it beyond all doubt that the utero-placental vessels and their surrounding cells are the result of a real neo-formative process. In all animals having a single placenta the decidua vera and the decidua reflexa are of new and distinct formative character. The decidua vera is composed of newly-formed cells, which are early arrested in their development, and superimposed upon it is the old uterine mucous membrane usually easily distinguished by its glands, and which, later, is seen in process of destruction and interblending between the external layer of the ovum and the internal uterine wall.

In most animals the newly-formed placental vessels have a uniform diameter and constitute a net-work of small meshes, which reaches as far as and is firmly joined to the chorion. In the meshes of this net-work are found the foetal vessels which unite and enter the cord. By injection of these we have a better demonstration of the relations established between the foetal and maternal portion of the placenta. A careful study affords convincing proof that the umbilical arteries ramify and end in a thin, fine net-work of capillaries in the chorial villi, and are in close contact with the cellular covering which clothes the maternal vessels. Demonstrative evidence of this relationship in the human placenta has been frequently observed by myself where the placenta has been undisturbed in its connections with the uterus for a considerable period after the death of the foetus. The chorial villi become shrunken and easily separate from the decidual sheath, the cells of which remain unchanged.

In certain of the lower animals (*e. g.*, the *cavia cobaya* or guinea pig) Ercolani has observed that the maternal vessels become dilated in their terminal loops. This is of the

greatest importance, since it furnishes an example in rudimentary condition of that which takes place in an extreme degree in the human placenta.

The destructive changes in the uterine mucous membrane of woman after conception are limited to the epithelial layer. After the separation of the decidua vera from the internal uterine surface, it is observed that the muscular wall is covered by a mucous membrane identical with that lining the uterine cavity before impregnation. The uterine mucous membrane is little more than a simple layer of epithelium, and the reproduction of this is all that is required to restore the internal surface of the uterus to its primary state.

During the early period of development of the human placenta the decidual cells form a richly vascular compact layer surrounding the chorial villi. For a limited time the relationship between the parts is not so intimate that they cannot be separated. At this stage, before the maternal vessels become ectasic, the form of development is not unlike the diffused or disseminated placenta.

Charles Robin¹ states "that in proportion as the villi of the chorion subdivide and increase in volume the superficial capillaries of the maternal placenta are largely dilated and form delicate vascular folds, which are interposed between them. The dilatations of the interposed maternal capillaries increase in direct ratio to the development of the chorial villi."

The walls of the proliferating branches of the villi are necessarily forced against the decidual layer of cells covering the ectasic, thin-walled maternal vessel. Thus this is introflected, and a close union ensues. In this manner the so-called placental lacunæ are formed in the fully-developed

¹ Mémoire sur les Modifications de la Muqueuse uterine pendant et apres la Grossesse, Paris, 1861.

placenta, and from this very deceptive appearance it has been held as a demonstrated fact that the foetal villi swim in the maternal blood.

Dr. John Reid was among the first to enunciate the belief that the foetal villi, in projecting, push before them the membranes forming the limiting wall of the placental sinuses, each of them in this way receiving an investment. Schroder van der Kolk and Goodsir taught that the processes of the decidua were prolonged over each villus, and thus separated it from the maternal sinus.

Braxton Hicks states that the placental sinuses, as usually represented, do not exist. He thinks the changes in the foetal blood are effected by endosmosis, but suggests that the follicles of the decidua may secrete a fluid which is poured into the intervillous spaces for absorption by the villi.

The epithelial covering of the vascular loop of the foetal villus is wanting because of the intimate relation which has been established between it and the secretory villus which never loses its own epithelium. The form of the vascular loop of the maternal villus varies very greatly. In the quadruped and in woman the dilatations become lacunose and are actually enormous.

All the vertebrates during the period of embryonic life, in order to complete the marvellous phases of their development, require a special nourishment, which is always furnished them by the mother. This is conveyed to and converted into its own substance by the embryo, and however many and considerable may be the differences met with in these two fundamental factors, the unity running through them readily appears under two general forms, represented by the yolk of the egg in the oviparous animals and by the placenta in vertebrate mammals. In the first the maternal element is stored up in a mass by the mother, and emitted

with the ovum in the quantity needed by the embryo to complete its development. In the second, this nutritive material is furnished by the mother from the placenta, which elaborates it as needful for the developing embryo. These materials, in every case, are absorbed and conveyed to the fœtus by means of its own vascular appendages. Thus nutrition is carried on during the development period in all vertebrates by a single law of physiological modality. The typical anatomical form in the two fundamental parts of the placenta, however wide the variation, is always identical. It consists of a villus of new formation, maternal as well as fœtal, each composed of an internal vascular loop surrounded by a cellular layer and covered by an outer epithelium. The office only of the villi is different—the fœtal *absorptive*, the maternal *secretive*. These villi always come in contact more or less intimate, but the walls of the vascular loops never in any instance touch. This is the more to be emphasized since it invalidates the idea hitherto held, and yet almost universally taught, that the mode of the nutrition of the fœtus is an interchange between the two bloods by endosmosis and exosmosis. The different ways of the interblending of the fœtal and maternal villi give the complex and confusing picture of placental formation.

The belief that the lacunæ were really large cavities as they certainly appeared, and not the maternal vessels greatly dilated, was held as a truth proved and indisputable; and it was through this belief that two other deceptive appearances were received as actual truths; namely, that the villi floated in the maternal blood, and that the epithelium covering them appertained to the fœtus instead of the mother.

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L. S. PILCHER AND G. R. FOWLER,

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