say: that is, in their peculiar environment their eyes are no longer of use, and they have therefore degenerated and disappeared, in the course of generations, by the lack of the direct preservative influence of natural selection. So Weissmann thinks that the original immortality of living matter became lost to the non-reproductive cells in the many-celled animals because, being of no value to the species, indeed, on the contrary, threatening the species with an unnecessary burden, natural selection let it alone. To the writer's mind this kind of argument, indeed, the whole idea of panmixia, seems to be very incomplete, it lacks all suggestion of a specific cause. In physiology we are familiar with many examples of retrogression of structure following upon disuse. A muscle or gland thrown out of function by severance of its motor nerve, or a nerve cell cut off from its normal connections, atrophies from disuse. But the explanation given is specific to the extent that it refers the atrophy to an altered metabolism. Functional activity in specialized tissues seems to be necessary for their normal metabolism, and lack of activity, as in the paralyzed muscle, is followed by a perverted metabolism that results in the destruction of the tissue. In the same way the loss of perfect nutrition in the somatoplasm might readily be referred, as in Weissmann's first explanation, to an altered metabolism that, arising spontaneously, was subsequently preserved by natural selection, because it proved advantageous to the species.

Many eminent biologists have found a logical difficulty in understanding how from cells originally immortal cells that were mortal could have been derived by differentiation of any kind. They hold that natural selection can operate only upon a structure that exists, it cannot create a thing outright. If living matter was all originally immortal, how could natural selection, by negative or positive action, produce mortality, if in some degree this latter property was not already inherent in living matter. As one of the objectors (St. George Mivart) puts it, the difficulty is to understand the first step, the beginning of something from nothing. Objections of this kind are of course fallacious; it is curious that they should have been seriously made by eminent men. The words mortality and immortality do not stand for definite things; they are not substances or entities, or whatever term of this kind one may choose to use. On the contrary, they are in this case merely convenient phrases to express the kind of nutrition going on in living things, whether it is self-perpetuating or self-limiting. They are properties that are connected with the physical or chemical structure of living matter, and this latter is a thing that does exist and may be acted upon and modified by natural selection in many ways. Weissmann's conception of an early differentiation in the developing embryo of a somatoplasm and a germ plasm has not seemed to meet with favor in the eyes of many competent biologists. These have claimed that in the early segmentation of the ovum the separate cells that are formed are essentially equivalent; that a complete embryo may be formed from a half or quarter of the egg, and that the nuclei first arising may be changed about experimentally "like a heap of billiard balls" without altering the course of development. In thus denying that the orderly course of development is controlled entirely from within, by a system of differentiating divisions of the ovum, these authors are led to lay more stress upon what may be called external forces. As Hertwig expresses it: "I regard the divergent differentiation of cells as a reaction of the organic material to unlike impelling forces." This point of view would seem to be incompatible with the conception of a continuity of the germ plasm, and it has been said with much force that the truth of this latter hypothesis has not been actually demonstrated. However, those who oppose Weissmann's views become involved themselves in numerous undemonstrated assumptions, and seem often to miss the physiological truism that continuity of living matter does not imply an unchanging organization, but rather a perpetuity of nutrition, a perfect metabolism whereby waste is completely repaired, senescence is made impossible, and death is conceivable only as the result of accidental causes.

In accepting or refusing Weissmann's theory of the origin of death, everything seems to depend upon the validity of his fundamental hypothesis with regard to the absence of natural death among the primitive forms of life. If we admit that there are simple organisms, such as the bacteria or the amœbæ, that do not propagate by conjugation or by any method of multiplication other than simple fission, it would seem logically impossible for such a species to be perpetuated unless its protoplasm is exempt from senility. If we do not accept this solution, then we must suppose either that there is some kind of sexual rejuvenation that has not yet been discovered in these particular forms, or that there is some process of molecular rejuvenation occurring at periods in the life history of such forms that brings the living substance back to its primitive constitution and nutritive vigor. Götte has clearly recognized this necessity, and has proposed a theory that is logically acceptable. According to Götte, death is a necessity immanent in life. As regards the unicellular forms of life, he avoids the difficulty that has just been described by assuming that the process of encystment is the death of the old individual and the beginning of a new one. Encystment, of course, is known to occur among the unicellular forms. During the process the visible evidences of life, such as movement, come to an end, to be renewed again after a certain period, or under more favorable conditions. Götte believes that during the encystment a change of molecular structure takes place. There is first a dissociation or dissolution, which is an actual death, inasmuch as the properties of living matter are lost. This, however, is succeeded by a stage of reconstruction with the formation of new protoplasm possessed of the primitive powers of assimilation, and capable of developing and multiplying for a certain period. This is obviously an hypothesis that it is practically impossible to test by chemical investigations. To the physiologist it will probably not be acceptable on theoretical grounds because of the difficulty of conceiving how matter once in the dead form can again pass into the living form, as the result of spontaneous molecular activities, and without the aid of an exciting or liberating force. Dead matter, as we know it, is converted into the living form only by the process of assimilation on the part of matter already living, whereas the hypothesis of Götte calls upon us to believe that the transition may take place by virtue of the intermolecular movements in the dead matter itself. Encystment, then, according to the theory of Götte, represents at the same time the primitive form of natural death and the primitive method of reproduction. As the metazoa have been derived from the unicellular forms, he further assumes that among the former both natural death and reproduction have been acquired by direct inheritance. As in the protozoa reproduction and death stand in a causal relationship, so in the simpler forms of metazoa, *e.g.*, in the orthonectidæ, this connection is still maintained, inasmuch as the liberation of the ova results in the death of the individual. Among the higher forms the relationship between reproduction and death is not so evident, though the theory demands always a causal connection between the two processes.

It will be evident from this brief statement of Götte's views that he differs from Weissmann, not only in his belief of the necessity and universality of death, but also in respect of the discontinuity of life. Among the protozoa, that propagate by encystment, his theory denies that the new individual is directly sprung from the living substance of the parent cell. On the other hand, the general belief has been that in some way the continuity of life is maintained. Darwin's theory of pangenesis, which was formulated to explain the phenomena of heredity, implies a continuity of living matter between parent and child. It will be remembered that in this theory the ova and spermatozoa are supposed to contain minute germs, gemmules, thrown off from the different cells of the body and collected in the germ cells. Under

the proper physiological stimulation, the gemmules develop into organs like those from which they were derived. The gemmules must be regarded as living matter; hence the theory implies a direct carrying over of living substance from parent to child, a continuity of living matter at least. In contrast with this the theory of Weissmann supposes a direct continuity of germ plasm, the essential part of the germ cells of the child being an actual portion of the germ protoplasm of the reproductive cells of the parents. The immortality of the germ plasm and the direct continuity of the germ plasm are, then, the fundamental parts of Weissmann's theory, and his hypothesis of the origin of death as regards the somatoplasm follows naturally if we accept these premises. It will be observed, however, that Darwin's pangenesis theory may also be regarded as implying the essential immortality of the material composing the germ cells, although neither Darwin himself nor those who have made use of his theory have ever made a specific statement of this kind.

In the older treatises upon the nature of death a distinction was often made between molecular death and somatic death. The former term was meant to include those changes of disassimilation or katabolism, to use a more modern word, which are supposed to be in play in every bit of living matter, and to lead to the formation of dead waste material, such as urea, carbon dioxide, and water. Somatic death was used, as it is at the present time, to describe the final cessation of all vital activities in the body at large. It was supposed that we had here the production of dead from living matter by two entirely different methods. The term molecular death is obviously an unhappy one, and has fallen into disuse, although it is possible that it is an accurate statement of what takes place. The essential nature of the physiological oxidations which lead to the formation of the products of disassimilation is at present a subject of discussion, and will probably remain so for a long time. Treating the subject in the most general way, it seems evident that in disassimilation one of two things may take place. If, for the sake of simplicity, we confine our attention to a single cell, then it is possible, on the one hand, that the formation of the wastes of nutrition is brought about by the actual death and disintegration of portions of the cytoplasm, their places being supplied by new living material formed in other parts of the cytoplasm or in the nucleoplasm. Or, on the other hand, it is equally possible that in normal disassimilation no single living molecule undergoes total destruction. The process of dissociation may be such that only a portion of the molecule is split off, and lost from the cell as dead material, while the remainder of the molecule reconstructs itself from the food material of the cell juices into the originally complex molecule of living matter. This, in fact, is the hypothesis of physiological oxidation which has been proposed by Pflüger with special reference to the metabolisms of muscle during functional activity. His theoretical views have much to recommend them, and some account of them is usually given in the text-books of physiology.

W. H. Howell.

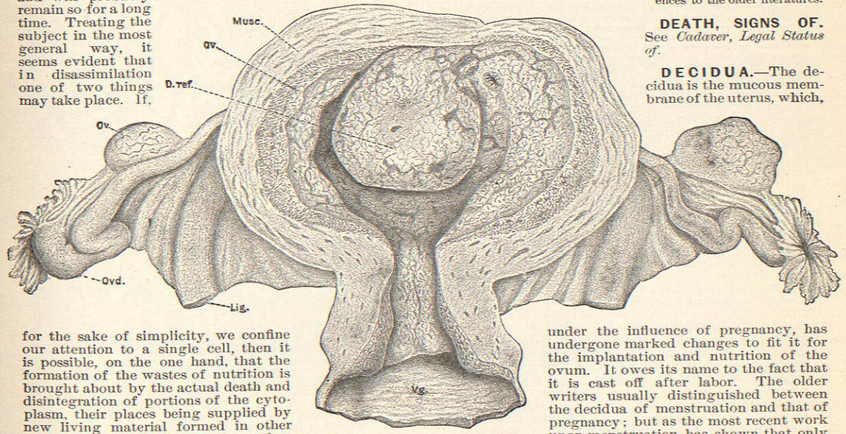

FIG. 1577.—Uterus about Forty Days Advanced in Pregnancy. (After Coste.) *Musc*, Muscularis; *De*, decidua vera; *D. ref*, decidua reflexa; *Ov*, ovary; *Ovd*, Fallopian tube; *Lig*, round ligament; *Vg*, vagina. The uterus has been opened by cutting through the anterior wall, and reflecting the sides.

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DEATH, SIGNS OF.
See *Cadaver, Legal Status of.*

DECIDUA.—The decidua is the mucous membrane of the uterus, which, under the influence of pregnancy, has undergone marked changes to fit it for the implantation and nutrition of the ovum. It owes its name to the fact that it is cast off after labor. The older writers usually distinguished between the decidua of menstruation and that of pregnancy; but as the most recent work upon menstruation has shown that only a minimal portion, if any, of the endometrium is cast off at that time, the employment of the former term does not appear to be justified.

We are not able to state exactly when the decidual formation commences, but

it must be almost immediately after the fertilization of the ovum, as fairly well-marked deciduæ were present in uteri described by Peters and Leopold, which were respectively three and seven days pregnant. Under the influence of pregnancy, whether occurring in the uterus or tubes, the smooth, velvety endometrium becomes

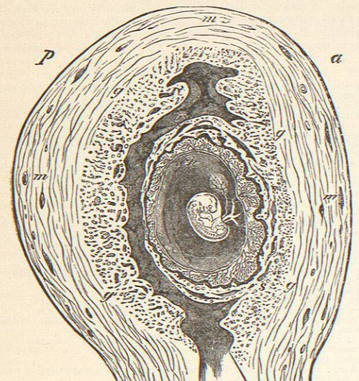

FIG. 1578.—Semi-Diagrammatic Outline of an Antero-Posterior Section of the Gravid Uterus and Ovum of Five Weeks. (After Allen Thomson.) *α*, Anterior surface; *β*, posterior surface; *m*, muscularis; *g*, inner margin of metamorphosed mucosa; *s* to *s*, area of *decidua serotina*; all the parts of the mucosa adherent to the uterine walls not in the area of the serotina constitute the *decidua vera*; *ch*, chorion, within which is the embryo enclosed in the amnion, and attached to the walls of the chorion; appended to the embryo is the long-stalked yolk sac; the chorion is covered in by the arching extension of the mucosa, which is the *decidua reflexa*, *r*, *r*.

markedly thicker and its surface marked by numerous irregular furrows which give it a mammillated appearance, and under the magnifying glass numerous small openings can be distinguished, which represent the mouths of the uterine glands. The decidual formation is limited to the body of the uterus and does not extend below the internal os; though in rare instances, as stated by Franqué and von Weiss, isolated decidual cells may be found beneath the epithelium of the cervical canal.

It is customary to describe the decidua as consisting of three portions: the general lining of the cavity of the uterus—the decidua vera; the portion immediately beneath the ovum—decidua serotina; and the portion surrounding the ovum and shutting it off from the rest of the uterine cavity—the decidua reflexa (Figs. 1577 and 1578). The terms reflexa and serotina date from the time of William Hunter. In the explanatory text to his Atlas, which was edited by his brother John and Matthew Baillie, it was stated that the decidua represented a fibrinous exudate from the lining membrane of the uterus, which formed a complete cast of its cavity and completely covered the tubal openings. Accordingly, when the fertilized ovum reached the uterine end of the tube, it found its passage opposed by the decidua vera, which it was obliged to invaginate before it in order to gain access to the uterine cavity, whence the term "reflexa." By the pushing forward of this structure, the portion of uterus behind it became denuded of decidua, and a new membrane was developed at that point, which was designated as the new or serotinal decidua, to which the ovum became attached.

This conception of the decidua was maintained until 1840, when Weber and Sharkey demonstrated that it contained glandular structures, which they identified with uterine glands. This being the case, it became necessary to explain the formation of the decidua reflexa in a different manner, and it was suggested that the ovum, upon reaching the uterus, found its entire cavity lined by decidua vera, to which it became attached at a point somewhere in the neighborhood of the fundus. Immediately afterward the vera began to proliferate and form a wall around the ovum, which gradually increased in height until it completely encapsulated it. Notwithstanding this change of view, the terms reflexa and serotina were retained until 1895, when His suggested that they be replaced by the terms capsularis and basalis respectively.

We are indebted to the work of Hegar and Maier, Friedländer, and Kundrat and Engelmann, for our earlier knowledge concerning the microscopical structure of the decidua vera. Friedländer, in 1870, pointed out that it was composed of two layers: a compact layer adjoining the uterine cavity, and a spongy or glandular layer adjoining the muscular wall of the uterus, the latter making up the greatest thickness of the membrane. He showed that the former was composed of large, round,

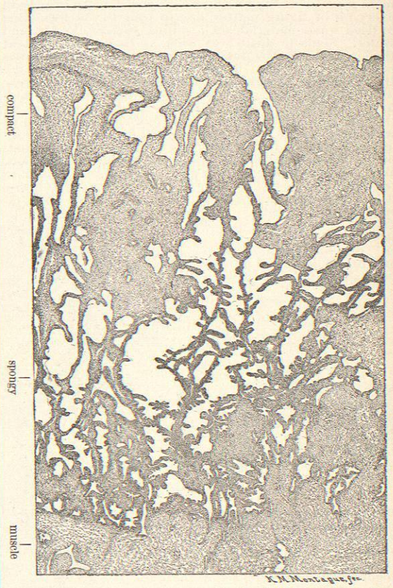

FIG. 1579.—Decidua Vera, Fourth Month. × 16. (From Author's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

oval, or polygonal cells, with large, lightly staining vesicular nuclei—the decidual cells; while the latter was made up of the dilated and hyperplastic uterine glands (Fig. 1579).

The decidua vera increases markedly in thickness during the first few months of pregnancy, and by the end

of the fourth month has attained a thickness of 8 to 10 mm. After this period, owing to the marked increase in the size of the uterus, it gradually becomes thinner, so that at the end of pregnancy it is rarely more than 2 mm. thick. Under the microscope the compact layer is seen to be made up of large, round, oval, or polygonal

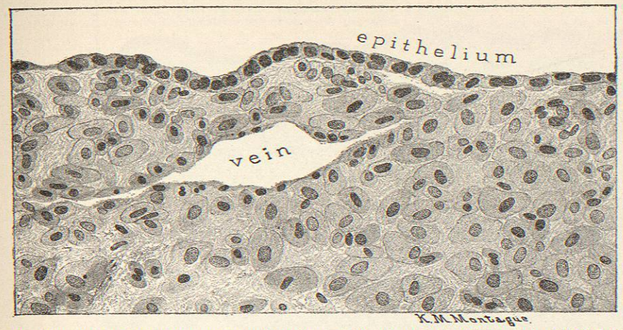

FIG. 1580.—Section through Compact Layer of Decidua. × 420. (From Author's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

cells, which are distinctly epithelioid in appearance, and possess round, vesicular nuclei which stain but lightly with the ordinary reagents (Fig. 1580). When the tissue has been spread apart by hemorrhage or œdema, or in teased specimens, it is seen that many of the cells present a stellate appearance, and are supplied with long protoplasmic processes which anastomose with similar processes from neighboring cells. In the early months of pregnancy the compact layer is traversed by the ducts of the uterine glands, which, however, gradually disappear, all trace of them being lost after the third or fourth month.

The spongy layer is formed by the distended and hyperplastic glands of the endometrium, which are separated from one another by a minimal amount of stroma. In a good many instances the glandular hyperplasia is so marked and the glands assume such irregular shapes that this layer suggests an adenoma in appearance. And on several occasions I have seen competent microscopists diagnose adenocarcinoma of the body of the uterus from the normal scrapings obtained by curetting the pregnant organ.

In the early months, the glands of the spongy layer are lined by a single layer of characteristic cylindrical epithelium. This gradually becomes more cuboidal in shape and undergoes fatty degeneration, and is cast off in great part into the lumina of the glands, though a small part of it remains intact throughout pregnancy, and from it the endometrium is regenerated after labor. In many instances the formation of decidual cells is almost entirely limited to the compact layer, while the stroma between the dilated glands closely resembles that of the non-pregnant uterus.

Klein directed attention to the fact that the epithelial cells covering the surface of the decidua gradually lose their cylindrical shape and become cuboidal and even flattened, and sometimes resemble endothelial cells. He considered this condition quite as characteristic of pregnancy as the development of the decidual cells themselves.

Fig. 1580 represents a section through the compact layer of the decidua vera at the fourth month, and Fig. 1581 a section through a gland and its surrounding stroma from a non-pregnant uterus, drawn under the same magnification; and on comparing them it is readily seen that the decidua differs from the non-pregnant endometrium by a marked increase in the size of the stroma cells, and a marked decrease in the size of the epithelial cells.

As a result of the work of Hegar, Maier, Leopold, Minot, and many other observers, it is now generally admitted that the decidual cells are derived from the stroma cells of the endometrium, and are therefore of connective-tissue origin. The change consists of an hypertrophy of the

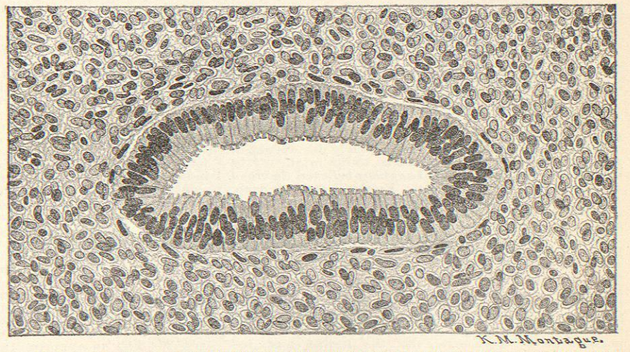

FIG. 1581.—Section Showing a Gland and Surrounding Stroma from a Non-Pregnant Uterus. × 420. (From Author's "Textbook of Obstetrics," Appleton & Co., New York, 1901.)

pre-existing cells, rather than an actual increase in their number.

The connective-tissue origin of the cells in question was still further confirmed by finding that similar cells are formed in the stroma of the folds of the tube in tubal pregnancy, and in the subperitoneal connective

tissue in normal pregnancy. For Schmorl, Kinoshita, and others have shown in women dying just after childbirth that the peritoneum covering the posterior surface of the uterus, Douglas' cul-de-sac, and the anterior surface of the rectum, is frequently studded by small nodules, some of which are just visible to the naked eye, while others are 1 or 2 mm. in diameter, which are composed of cells which do not differ from the decidual cells in appearance, and are undoubtedly derived from the subperitoneal connective tissue.

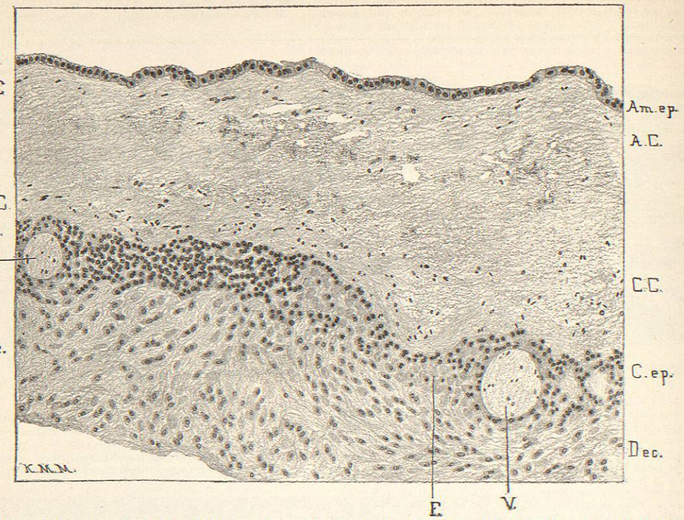

FIG. 1582.—Decidua and Membranes Outside of Placental Site. *Am.ep.*, Amniotic epithelium; *A.C.*, amniotic connective tissue; *C. C.*, chorionic connective tissue; *C. ep.*, chorionic epithelium; *Dec.*, fused decidua vera and reflexa; *V.*, degenerated chorionic villi.

Before their true nature was definitely demonstrated, various theories were advanced as to the origin of the decidual cells. Hennig and Langhans believed that they were derived from leucocytes; Frommel and Overlach, from the uterine epithelium, and Ercolani, from the endothelium of the blood-vessels; but at present these views are of interest only from an historical standpoint.

Decidua Reflexa.—Except for the first few hours after its entry into the uterus, the ovum is completely shut off from the rest of the uterine cavity by the decidua reflexa, which forms a distinct capsule around it. In the early months of pregnancy, this structure does not completely fill the uterine cavity so that a space of varying size exists between the vera and the reflexa. But after the fourth month the reflexa, distended by the growing ovum, comes in contact with the vera, so that the uterine cavity becomes completely obliterated. In a short time the two structures fuse together, after which the reflexa gradually degenerates and disappears. This view was first advocated by Minot, and appears to be well founded, for sections through the wall of the full-term uterus outside of the placental site show that the entire decidua is only from 2 to 3 mm. thick, and in it no trace of the reflexa can be discovered (Fig. 1582).

The reflexa usually attains its greatest thickness at about the second month, when it is from 2 to 3 mm. thick. Sections through it at this time show that it is made up of typical decidual cells, and is covered on its exterior by a single layer of flattened or cuboidal epithelium; while its interior is in contact with the villi of the chorion læve, and at no time shows any trace of epithelium. In its lowest portion, where it is connected with the vera, an occasional gland may be found, and when their ducts are present they are seen to be open only upon the exterior of the membrane.

Until very recently it was believed that the decidua reflexa was formed in the manner which I have already indicated. But Selenka pointed out that it was not so developed in monkeys and other animals; but that the ovum, immediately after its implantation upon the vera, penetrated the surface epithelium and sunk down into its stroma, and that therefore the reflexa was simply the portion of vera which covered the ovum. Peters, in 1899, described what he considered to be a three-days' human ovum in contact with the uterine wall, and clearly showed that it had burrowed down into the vera in the manner demonstrated by Selenka, and therefore concluded that the reflexa represented the portion of decidua vera which covers the ovum, and was not due to the proliferation of the vera, as was previously supposed (Fig. 1583). I have not had an opportunity to examine the pregnant uterus in its earliest stages, but in several very early cases of tubal pregnancy I have seen conditions which tend to confirm Peters' theory as to the mode of implantation of the ovum and the development of the decidua reflexa.

Decidua Serotina.—The decidua serotina is the portion of the decidua which lies immediately beneath the ovum and is in contact with the chorion frondosum, and it is by the union of the two structures that the placenta is developed, the chorion frondosum giving rise to its fœtal, and the decidua serotina to its maternal portion.

Generally speaking, the decidua serotina presents the same general structure as the vera, except that it never attains the same thickness, and rarely exceeds 3 mm. As pointed out in my article upon the *Chorion*, after the first few days of pregnancy it does not consist entirely of decidual cells, but is invaded by large numbers of cells derived from the trophoblastic layer of the ovum, and accordingly its superficial portions are composed of a mixture of decidual cells and fœtal ectoderm. On casual examination it is extremely difficult to distinguish between the two varieties of cells, but after more careful study, particularly when groups of cells are examined, their characteristic differences can readily be appreciated. Usually a layer of canalized fibrin occupies a part of the decidua serotina, and, as a rule, forms the boundary line between fœtal and maternal tissue; the tissue internal to it being composed almost entirely of fœtal ectoderm, with a slight admixture of decidual cells; while the tissue external to it is made up almost entirely of decidual cells with only isolated areas of fœtal tissue.

About the middle of pregnancy numerous giant cells may be distinguished in the deeper layers of the serotina. Friedländer and Leopold believed that they were derived from the decidual cells and made their way into the venous sinuses, and caused thrombosis. But more recent work tends to show that they are simply portions of syncytium which have wandered down into the deeper layers of the decidua and are therefore of fœtal origin.

One of the characteristic features of the decidua serotina is the presence of large numbers of blood-vessels. The arteries pursue a spiral course, and gradually lose their characteristic walls as they approach the free surface of the decidua, where they open into the intervillous spaces. The veins become markedly dilated, and form large venous sinuses, and careful examination of serial sections will show that they communicate by large funnel-shaped openings with the intervillous spaces.

In the third stage of labor the placenta and fœtal membranes become separated from the uterus and are cast off as the afterbirth. Microscopical examination shows that the fœtal surface of the placenta and the membranes is covered by a thin layer of decidual tissue, which corresponds to its compact layer and the upper portion of the spongy layer, and that the separation takes place in the upper portion of that layer, all above it being cast off with the afterbirth, and all below it being retained in the uterus. During the first few days of the puerperium the greater portion of the spongy layer, which has remained in utero, is cast off with the lochia, and only its deepest portion remains behind, from the epithelium of which the new endometrium is regenerated.

J. Whitridge Williams.

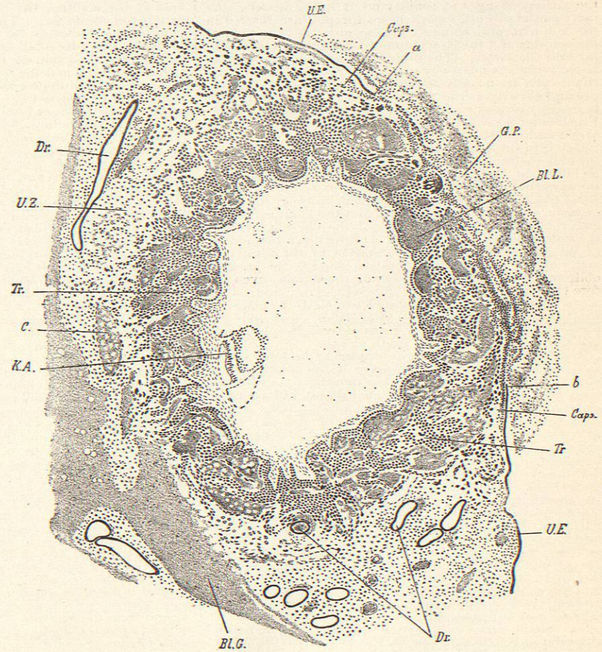

FIG. 1583.—Peters' Three-day Ovum. *U.E.*, Uterine epithelium; *G.P.*, fibrinous plug; *Dr.*, uterine glands; *Caps.*, decidua reflexa; *Tr.*, trophoblast; *Bl. L.*, blood spaces; *K.A.*, embryonic area.

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