ism of the smaller branches of the intestinal arteries gives rise to the formation of intestinal ulcers.

Aortic Embolism.—The occlusion of the thoracic aorta by embolism is of very rare occurrence. It may be caused by the dislodgment of large thrombi in the heart or in aortic aneurisms above the point of embolism. Death is instantaneous or occurs within a very short time. Embolism of the abdominal aorta is not of such rare occurrence. In the majority of cases the embolus arises from a heart thrombus. The symptoms may develop suddenly or the onset may be gradual. Pain in both legs, often extreme, is usually present; with this there is associated paralysis, absence of femoral pulsation, and ascending gangrene. Death may occur within a few hours or be delayed for months, in the latter case the result of slowly progressive gangrene or sepsis. Embolism of the iliacs, or of the femoral or popliteal arteries is manifested by similar symptoms varying in degree with the size of the vessel occluded and the location of the embolus.

Coronary Embolism.—Embolism of the larger branches of the coronary arteries causes sudden death, or an attack of extreme dyspnœa and severe precordial pain which may be followed shortly by death. Embolism of the smaller branches may cause anæmic infarction with symptoms of angina pectoris. As a result of the weakening of the heart wall by the infarction rupture of the heart into the pericardial sac may take place causing sudden death, or aneurismal dilatation of the heart may be produced, leading to serious impairment of cardiac efficiency.

Retinal Embolism.—Sudden blindness is produced by the embolic occlusion of the central artery of the retina. Ophthalmoscopic examination reveals a condition of retinal infarction usually without the occurrence of hemorrhage. In embolism of the smaller retinal branches multiple hemorrhages usually occur with more or less pronounced disturbance of vision.

Embolism of Spermatic Artery.—Occlusion of the spermatic artery by embolism is said to have caused gangrene of the testis in a small number of cases.

Diagnosis.—Since the chief symptoms of embolism are of the same nature as those of thrombosis, the differential diagnosis of these two conditions is of main importance. The sudden development and severity of symptoms of arterial anæmia are more characteristic of embolism than of thrombosis. Absolute dependence cannot, however, be placed upon this point, inasmuch as thrombi occasionally occlude with great rapidity, while on the other hand the symptoms of embolism may be slow of development owing to the fact that the embolus either does not entirely obturate the vessel which is later completely closed by secondary thrombosis, or the embolus may be so situated that the secondary thrombosis plays the chief part in the production of the anæmia. After arterial embolism the establishment of the collateral circulation usually leads to a more decided improvement of symptoms than is commonly the case after thrombosis. Absolute reliance cannot be placed upon this factor, since occasionally after thrombosis very marked amelioration follows the development of the collateral circulation. The occurrence of arterial obstruction in young individuals or in adults showing no signs of arteriosclerosis, especially in cases of valvular lesions of the left side of the heart, points very strongly to the occurrence of embolism. If arteriosclerosis is present, the differential diagnosis between thrombosis and embolism becomes much more difficult.

The establishment of a source for emboli in the existence of a previously formed thrombus, cardiac disease, aneurism, infected wound, etc., is the most reliable factor in the diagnosis of embolism. In pulmonary embolism the source may be sought in thrombi in the systemic veins or right heart. In embolism of the systemic arteries the chief source of the embolus is disease of the mitral or aortic valves. Thrombi in aortic aneurisms may also give rise to emboli. Infected wounds, abscesses, acute endocarditis, etc., form the sources of infective emboli. Abortion, separation of the placenta, uterine injections, pregnancy, etc., are conditions in which embolism may occur. Injury of the bones or fat-containing tissues gives rise to fatty embolism. Though cases may occur in which the source cannot be found, and though the existence of a thrombus in one vessel does not exclude the occurrence of thrombosis in others, it is possible, in the majority of cases, to make a correct diagnosis of embolism whenever definite symptoms are present.

Treatment.—Prophylactic treatment may be of the greatest importance in the prevention of the detachment of an embolus from a thrombus. In the case of venous thrombosis of the lower extremities absolute rest of the affected limb, or better of the body as a whole, should be insisted upon, as a very large percentage of the cases of death from pulmonary embolism occur as the result of the patient's movements in walking, bathing, or going to stool. Walking should not be allowed for at least six weeks after venous thrombosis of the lower extremities. Massage or palpation of the affected vein, or even pressure upon it with a stethoscope, as well as all unnecessary movement and manipulation of the limb, should be avoided. Prophylactic measures may be instituted further against the formation of thrombi by stimulation of the heart's action, improvement of the general nutrition, prevention of extension of infection by surgical interference, etc. In the case of acute endocarditis, heart thrombus, aortic aneurism, etc., absolute rest is also essential as a prophylactic measure against embolism.

After embolism has occurred the general indications are relief of pain, absolute rest, proper nourishment, cardiac stimulation, etc. The development of the collateral circulation should be brought about as soon as possible in order to avoid anæmic necrosis. In case of embolism of accessible portions of the body this may be aided by the local application of heat. When infarction has taken place the general indications of treatment are along lines tending to promote absorption and organization of the dead tissues. In the case of gangrene of the lower extremities and intestinal infarction operation according to general surgical principles may be performed.

Aldred Scott Warthin.

EMBRYOLOGY.—The general history of the embryo up to about the end of the second month is given under *Fœtus, Formation of*. The development of special organs is treated under those organs; *e.g.*, for the development of the brain see under *Brain*. There are also included in the Handbook the following special embryological articles: *Allantois, Amnion, Area Embryonalis, Blastoderm, Blastopore, Chorion, Cœlom, Differentiation, Embryos, Gastrula, Germ Layers, Impregnation, Neurenteric Canal, Notochord, Placenta, Proamnion, Segmentation of the Body, Segmentation of the Ovum, Umbilical Cord*, and *Yolk Sac*.

In this article are given, (1) a brief sketch of the history of embryology; (2) practical directions for the study of embryos.

1. History of Embryology.—Although embryology is the department of morphological science now most in vogue among investigators, it has held this high rank but a very short time. Embryology may date its birth, after gestating for many centuries in the womb of science, from the year 1600, when Fabricius ab Aquapendente published his work, "De Formato Fœtu," followed four years later by his "De Formatione Fœtus." After Fabricius came a series of anatomists, who during the seventeenth and eighteenth centuries slowly added to the knowledge of the development of man and other vertebrates; but it was a time of vague general notions, a period when principles which seem to us elementary were still under debate. It was not until Caspar Friederich Wolff published his dissertation, "Theoria Generationis" (1759), that the mere idea of development by gradual differentiation of unformed material could make its way. Wolff is justly regarded as the initiator of modern embryology, for until his views of gradual differentiation (epigenesis) were established correct embryological conceptions were impossible. The next great advance was due to the influence of Döllinger, of Würzburg, a man who inspired many of the best researches. Under him were trained Pander and von Baer, who first definitely ascertained the existence and traced much of the history of the germ layers. Von Baer was a magnificent intellect—among the great morphologists of Germany easily first. His book (1829) on the development of animals has never been equalled for keen insight and original profound thoughts in the domain of morphology. The author is no less remarkable for his observational powers. Kölliker says, with perfect truth, that von Baer's researches "are to be described as unconditionally the best which the embryological literature of all time and all peoples has to show." The third epoch may be said to have begun with the establishment of the cell doctrine by Schleiden and Schwann (1839), after which began the labor of ascertaining the origin and metamorphoses of the cells in the embryo. Schwann's discovery led to the recognition of the real signification of the segmentation of the yolk, which had been previously discovered. The next great change occurred during 1860–1870, after Darwin had given a mighty impulse to biology by the publication of his "Origin of Species"; in this period the germ layers were discovered and described in invertebrates by Kowalewsky, Metschnikoff, and others, and in the course of a few years it was definitely proved that the germinal layers exist in all multicellular animals. Since 1870 a multitude of researches have been carried out, a wealth of new discoveries made, largely in consequence of the vast improvements in the methods of investigation. These improvements have been—first, in regard to the means of preserving ova and embryos; second, in the manners of making sections and staining them.

Of recent writers the student of human embryology must place His and Kölliker first; the former has worked out the anatomy of very young human embryos with surprising skill, and the latter has contributed a vast series of observations on the development of nearly every organ and tissue.

In the history of embryology, then, the following points mark the chief epochs:

1759.—The doctrine of gradual development, or epigenesis, definitely established by Caspar Fr. Wolff.

1829.—The existence of the germ layers demonstrated, and their most important metamorphoses in vertebrates traced out by Carl Ernst von Baer.

1839.—The cell doctrine applied to animals by Schwann, and embryology turned into the study of histogenesis.

1860–70.—The presence of germ layers in invertebrates proven by Kowalewsky, Metschnikoff, and others.

1870–85.—Constantly increasing number of special researches, and steady perfecting of methods.

2. Embryological Methods.—The student of human embryology cannot obtain his material at will, but can only take advantage of opportunity. A considerable number of abortions and miscarriages, natural and procured, occur in every community, and the ova and embryos thus discharged are, in a minority of cases, normal and fresh; the older the embryo the more likely it is to be in good condition. Embryos less than two inches long are best preserved intact; larger embryos are much better opened, and the parts severed and hardened separately. If the specimen is intended only for the study of gross anatomy, it will suffice to preserve it in seventy-per-cent. alcohol, which must, however, be renewed once or twice at first, and the larger the specimen the more necessary is the caution of changing the alcohol.

If the specimen is good enough to be used for section cutting, it must be preserved with more care. Embryos of more than seventy days should be opened and partially dissected if good preservation of the internal parts is desired. (*a*) For general use Parker's fluid (formalin 16 c.c., water 784 c.c., and 96-per-cent. alcohol 1,200 c.c.) may be recommended, as it has great penetrating power; it should be renewed after twenty-four and forty-eight hours, and the quantity of fluid should be about ten times the volume of the embryo. (*b*) For embryos of nine weeks or less preservation intact in Zenker's fluid (corrosive sublimate, 10 gm., potassium bichromate 5 gm., sodium bisulphate 2 gm., water 200 c.c., glacial acetic acid 10 c.c.) or in von Rath's fluid (saturated solution of picric acid 100 parts, hot saturated solution of corrosive sublimate 100 parts, acetic acid 1 part) may be recommended. Zenker's fluid requires from twelve to thirty-six hours, von Rath's from one-half to two hours, according to the size of the specimen. Both of these require to be followed by treatment with tincture of iodine to remove the corrosive sublimate. (*c*) Of all good methods the most expeditious is to place the embryo or organ for five minutes or less in a mixture of 10 parts strong nitric acid and 90 parts water; transfer to sixty per cent. for an hour or two, and then to seventy per cent. (*d*) The simplest method of all is to put the specimen into sixty-per-cent. alcohol for twenty-four hours, then permanently in seventy to eighty per cent.

In preserving embryological material observe the following rules: Handle the specimen as little as possible; do not on any account put it in water or wash it; if it is necessary to keep it moist, wrap a soft damp cloth gently round it; never put a fresh specimen in strong alcohol; never keep a specimen in strong alcohol, *i.e.*, over eighty per cent. The only time when strong alcohol can be safely used is after a specimen has been hardened; and then only to act for twenty-four hours immediately before embedding.

To cut sections: For very small objects, paraffin is satisfactory, but for most of the work of the human embryologist celloidin is the best embedding material. A specimen to be embedded in this material is put (1) for one day in ninety-five-per-cent. alcohol; (2) for one day in a mixture of equal parts ether and ninety-five-per-cent. alcohol; (3) for one day in a thin celloidin solution; (4) embedded in celloidin. To embed, wrap a piece of glazed paper round a *cylindrical* cork, so as to make a paper cup of which the end of the cork forms the bottom; the paper may be fastened to the cork with a couple of pins; the cup must be considerably deeper than the object to be embedded, because bubbles form in the celloidin, and it is desirable to have the celloidin so deep that the bubbles will rise above the specimen; the specimen is placed in the cup, which is then filled with thick celloidin solution. The object may then be pushed into the right position for cutting. The cup is allowed to stand until a film is formed over the celloidin, and is then (5) transferred to a jar of eighty-per-cent. alcohol, where it remains until the celloidin is thoroughly hardened, a process requiring several days. To keep the cork down and the cup right side up, put into the bottom of the cork a sinker made of a heavy bullet and a stout pin or sharp-pointed wire nail. Celloidin is made by Schering, at Berlin, and sold in ounce boxes; it may be dissolved in equal parts ether and alcohol; two solutions are required, one about the consistence of maple syrup, the other like thick molasses.

Celloidin sections must be made under alcohol. The sections are stained and the celloidin is left on; to mount them, place the sections in alcohol on a glass slide, drain off the extra alcohol, and drop on top of the sections a thin filtered solution (fifteen per cent. is good) of white shellac, enough completely to cover the sections; dry the slide at a gentle warmth, say 30° C., until the shellac is hard; clear up with oil of cloves, and mount in balsam. (This method is new, and has not been published before.)

Staining: Small pieces, not exceeding one-fourth of an inch in diameter, may be stained *in toto* before embedding. The best method, on the whole, because the safest, for *in toto* coloration, is to soak the object for one to two days in alum-cochineal, made by boiling seven parts powdered cochineal and seven parts burnt alum with four hundred parts water for at least one-half hour; the solution must be filtered before using. For staining, Mayer's paracarmine and Mayer's hæmatein solutions

may also be highly recommended. For sections it is best to employ a variety of stains; my own experience has led me to consider the following five dyes the most valuable: alum-cochineal, Beale's carmine, Minot's picric acid carmine, alum-hematoxylin (Boehmer's), and Weigert's acetate of copper and hematoxylin. Osmic acid, nitrate of silver, chloride of gold, etc., must, of course, be used for special purposes, and their employment will naturally suggest itself to the experienced histologist at the proper moment.

Both for the sake of comparison and on account of the rarity of young human embryos, and of the impossibility of obtaining the earlier stages of man's development, it is important to study the embryology of mammals and other vertebrates. An admirable guide for such studies is Sedgwick's edition of Foster and Balfour's "Embryology." The best *résumé* of the methods used in embryology is Lee's "Microtomists' Vade Mecum," of which the German edition edited by Paul Mayer is the best.

Charles Sedgwick Minot.

EMBRYOS, HUMAN.—Age.—It has been quite generally accepted that the age of an embryo must be determined by the time of a certain cohabitation. In many cases it was attempted to locate the day exactly. After it had been shown that the ovum is extruded from the ovary at or before menstruation begins, it was then generally admitted that the egg could be fertilized at any point between the ovary and the uterus. The time required for the ovum to pass through the Fallopian tube was considered the time in which it was capable of being fertilized. According to the above, these conclusions are not based on a sound footing, because of the difficulty in obtaining accurate observations, and also because they do not agree with the results obtained from the lower animals. Both Coste and His have shown that the eggs of the hen are fertilized ten or more days after copulation, and the former has shown that the egg is no longer capable of fertilization after it has passed through the lower portion of the oviduct.

Impregnation is nearly always marked by a cessation of menstruation, and it now remains to be shown whether the fertilization takes place during the last menstrual period, or at the time of the first cessation; for it is known from the examination of the ovary in the living subject that ovulation usually comes just before menstruation. Since it seems to be necessary to fertilize the egg just as it leaves the ovary, it is probable that impregnation takes place just before the menstrual period. To locate the menstrual period, from which to compute the age of an embryo, we must consult the tables, which are in part copied from His.

From a comparative standpoint we can easily determine the age of human embryos within four weeks. Counting from the last menstrual period, it is quite easy to see by the size of the embryo whether or not it is, say three or seven weeks old. The table shows that, by counting in this way, embryos of the same size may have a difference of four weeks in age (see Table II., 2, and Table III., 8, 10 and 14). In these cases the age corresponds to the other cases, if from their time twenty-eight days are subtracted. This already indicates that, as a rule, fertilization of the ovum takes place during the ovulation which precedes the first menstruation which has lapsed. After Reichert had shown that menstruation is only a method of clearing out the uterus after an ovulation, and after Leopold had shown that the mucous membrane of the uterus undergoes histological changes before ovulation, it is fair to assume that the latter changes are only preparatory to the reception of the ovum, and that when the unfertilized ovum reaches the uterus, menstruation is only a method of reducing the uterus to its former condition.

Only in four of the cases is it necessary to compute the age of the embryo from the last menstrual period, and it is not fair to assume that just these four embryos have grown too rapidly. All the rest must have twenty-eight days subtracted from their time in order to make them correspond with the above four. These are the main reasons for assuming that the fertilization of the egg takes place just before the first menstrual period which has lapsed. It may be that a great many fertilizations take place during the last menstrual period, but that when menstruation has once begun, the activity of the uterus destroys the ovum, and that, as a rule, only those ova are preserved in which menstruation does not follow the last ovulation. At least the embryological evidence speaks for this, and at present embryologists make their specimens correspond with one another when they reckon their ages from the last menstrual period, minus twenty-eight days.

The tables show, in addition, that in certain pregnancies the first cohabitation followed the last menstrual period. It cannot be that in these cases the ovum of the last period could have been fertilized, for it is quite certain the ovum loses its power of being fertilized shortly after it leaves the Graafian follicle. In the case given in Table III., 1 (B B), the first cohabitation of a newly married woman took place on April 4th, say about five days after the last menstrual period; and the woman ceased menstruating at once, probably on account of the fertilization of the ovum of the following ovulation. If all the cases of newly married women in which there was an early pregnancy were collected, it would, no doubt, be shown that in many of the cases the women did not menstruate at all after marriage. At present, however, I know of four such cases. His has tabulated cases given by Hasler, in which the first copulation, the last menstrual period, and the date of birth of the child are given. In all of these cases the age of the fœtus is from two hundred and seventy to two hundred and eighty days, if the beginning of pregnancy is reckoned from the beginning of the first period which has lapsed. If the beginning of pregnancy is placed at the first cohabitation, the age of the fœtuses varies fully a month according to the time of the cohabitation; if the time which has elapsed between the cohabitation and the first menstruation which lapsed is subtracted from the duration of the pregnancy, then the lengths of the pregnancies are practically alike. Assuming that the lengths of pregnancies should be about the same, it makes it highly probable that fertilization takes place at the time of the first menstrual period which has lapsed rather than at the time of cohabitation.

In several of the cases given in the tables, the last cohabitation took place several weeks before the cessation of menstruation, showing that the vitality of the spermatozoa within the female organs lasts for at least a few weeks. It is probable, however, that the spermatozoa cannot live in the Fallopian tubes or uterus for over a month, because authentic posthumous births always take place within two hundred and eighty days after the father's death.

The general conclusions formulated by Professor His, and accepted by embryologists, are as follows:

1. The beginning of development is the time of impregnation, *i.e.*, at that moment when the spermatozoön enters the ovum.

2. The time the egg leaves the ovary is marked by menstruation, but it is not necessary for the Graafian vesicle to rupture during menstruation; it may take place two or three days before or even during the hemorrhage.

3. The egg is not capable of being fertilized at any point from the ovary to the uterus, but only shortly after it has left the ovary; as a rule, as it is entering the Fallopian tube.

4. The spermatozoa which have entered the female sexual organs must await the ovum in the upper part of the Fallopian tube, and can retain their vitality here several days, or possibly several weeks. The time of cohabitation is, therefore, not directly related to the age of the embryo.

5. The age of the embryo is to be estimated from the beginning of the first menstrual period which has lapsed, although it is possible to have a menstruation after fertilization of the ovum.

6. The age of an embryo can be expressed by the following formula: A = X − M or A = X—M − 28, in which X is the date of the abortion and M the beginning of the last period. The second formula is for embryos in which it is necessary to estimate the age by counting from the first lapsed period.

Preservation.—The human embryos which come into the hands of the embryologists are nearly altogether worthless for careful study, due to careless preservation. Of one-hundred and fifty embryos less than six weeks old, which have come into the writer's hands during the past few years, only a few have proved to be valuable, and these came from two physicians. The main reason why specimens are destroyed, in nearly all cases, is that the ovum is placed in very dilute alcohol, and in so doing it is also handled very roughly. Yet poor specimens are better than none at all, and in all cases all ova should be preserved, even if there is but little hope for a good specimen. Not only should ova which appear to be normal be preserved, but all specimens, for frequently patholog-

Table I.—Embryos of the Second Week.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	Peters	0.19 mm.	0.19 mm	3.0 × 1.5 × 1.5 mm.	30 days.	.....	Einbettung des mensch. Eies. 1899.
2	Breuss	.....	.....	5.0 mm	38 days.	10 days.	Wiener med. Wochenblatt, 1877.
3	Reichert	.....	.....	5.5 × 3.3 mm	42 days.	14 days.	Abhandl. d. k. A. d. Wiss., Berlin, 1875.
4	Siegenbeek van Heukelom	0.325 mm.	.....	5.5 × 4.5 mm	.....	.....	His' Archiv, 1898.
5	Graf Spee	0.37 mm.	1.08 × 1 mm	7.0 × 5.5 mm	5 weeks.	12 days+.	His' Archiv, 1890.
6	No. XI.*	0.8 mm.	1.5 × 1 mm	10.0 × 7.0 × 7.0 mm.	41 days.	13 days.	Dr. Kittredge, Nashua, N. H.
7	Keibel	1.0 mm.	.....	8.5 × 7.75 × 6 mm.	.....	.....	His' Archiv, 1890.
8	Eternod	1.3 mm.	.....	10.8 × 8.2 × 6 mm	34 days.	.....	Anat. Anz., xv., 1898.
9	Graf Spee	1.54 mm.	1.8 × 1.5 mm	10.0 × 8.5 × 6.5 mm.	5 weeks.	12 days+.	His' Archiv, 1890.
	Average	0.79 mm.	1.14 × 1.2 mm	7.2 × 5.8 × 5.4 mm.	.....	12 days.	

* The Roman numbers refer to the embryos in my collection.
+ Twelve days in my estimation, as Graf Spee only in a general way gives five weeks as the time between the last period and the abortion.

Table II.—Embryos of the First Half of the Third Week.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	No. XII	2.1 mm.	1.5 × 1 × 1 mm	18.0 × 18 × 8	41 days.	13 days.	Dr. Ellis, Elkton, Md.
2	Thomson	2.1 mm.	2.6 mm	5.7 mm	42 days.	14 days.	Edin. Med. and Surg. Journal, 1839.
3	His (E.)	2.1 mm.	2.3 × 1.6 mm	8.5 × 5.5 mm	.....	.....	Anat. mensch. Embryonen.
4	Eternod	2.12 mm.	3.0 × 2.5 × 1.75 mm.	16.3 mm	.....	.....	Anat. Anz., XV., 1898.
5	His (Lg.)	2.15 mm.	1.6 × 1.2 mm	15.0 × 12.5 mm	40 days.	12 days.	Anat. mensch. Embryonen.
6	His (S. R.)	2.2 mm.	1.9 × 1.5 mm	9.0 × 8 mm	.....	.....	Anat. mensch. Embryonen.
7	His (Sch.)	2.2 mm.	2.1 × 1.7 mm	.....	.....	.....	Anat. mensch. Embryonen.
8	His (L.)	2.4 mm.	.....	9.0 × 8 mm	.....	.....	Edin. Med. and Surg. Journal, 1839.
9	Thomson	2.5 mm.	2.1 mm	15.0 × 10 mm	14 days.	14 days.	Arch. Ital. de. Biol., 12.
10	Chiarugi	2.6 mm.	1.9 × 1.8 × 1.6 mm.	15.0 × 12 × 8 mm	.....	.....	Anat. mensch. Embryonen.
11	His (M.)	2.6 mm.	2.6 × 1.7 mm	8.0 × 7.5 mm	.....	.....	Verein. Schles.-Holst. Aerzte, 1887.
12	Graf Spee	2.69 mm.	2.5 × 1.5 mm	15.0 × 14 mm	42 days.	14 days.	His' Arch., 1890, p. 58.
13	His (E. B.)	3.0 mm.	.....	.....	42 days.	14 days.	A. f. m. A., 30.
14	Janošik	3.0 mm.	2.5 mm	8.0 mm	43 days.	15 days.	
	Average	2.41 mm.	2.22 × 1.6 × 1.45 mm.	11.7 × 10.6 × 8 mm.	.....	14 days.	

Table III.—Embryos of the Second Half of the Third Week.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	His (B. B.)	3.2 mm.	3.0 × 2 mm	14 × 11 mm	48 days.	20 days.	Anat. mensch. Embryonen.
2	No. LXXXVII	4.0 mm.	.....	24 × 16 × 9 mm	42 days.	14 days.	Dr. Cole, Peru, Ill.
3	Ecker	4.0 mm.	.....	.....	45 days.	17 days.	His' Archiv, 1880.
4	His (III.)	4.0 mm.	3.0 × 2.7 mm	30 × 25 mm	51 days.	23 days.	Anat. mensch. Embryonen.
5	His (Lr.)	4.2 mm.	2.8 × 2.3 mm	15 mm	.....	.....	Anat. mensch. Embryonen.
6	Stubenrauch (K.)	4.3 mm.	.....	.....	52 days.	24 days.	Inaug. Dis., München, 1889.
7	No. CXLVIII	4.3 mm.	.....	17 × 14 × 10 mm	38 days.	.....	Dr. Hoen, Baltimore.
8	Wagner	4.5 mm.	.....	.....	20 days.	20 days.	Müller's Archiv, 1835.
9	No. I	4.5 mm.	.....	30 × 30 mm	.....	.....	Dr. Gavin, Baltimore.
10	Hensen	4.5 mm.	.....	.....	21 days.	21 days.	His' Archiv, 1877.
11	No. LXXVI	5.0 mm.	3 mm	22 × 20 mm	.....	.....	Dr. Mitchell, Chicago.
12	No. LXXX	5.0 mm.	4 mm	24 × 18 × 8 mm	.....	.....	Dr. Branham, Baltimore.
13	His (D 2)	5.0 mm.	4 mm	20 × 15 mm	.....	.....	Anat. mensch. Embryonen.
14	His (W.)	5.0 mm.	.....	25 × 20 mm	21 days.	21 days.	Anat. mensch. Embryonen, pp. 7, 74.
15	His (R.)	5.0 mm.	.....	22 mm	.....	.....	Anat. mensch. Embryonen.
16	Meyer	5.25 mm.	4 mm	22 mm	18 days.	18 days.	A. f. m. A., 36.
17	No. XIX	5.5 mm.	2.5 × 2 × 2 mm	18 × 14 mm	.....	.....	Dr. Williams, Baltimore.
18	No. XVI	6.0 mm.	.....	24 × 18 mm	.....	.....	Dr. Sherwood, Baltimore.
19	Stubenrauch (I.)	6.0 mm.	.....	.....	45 days.	17 days.	Inaug. Dis., München, 1889.
	Average	4.67 mm.	3.3 × 2.2 × 2 mm	22 × 18 × 9 mm	.....	19.5 days.	

TABLE IV.—EMBRYOS OF THE FOURTH WEEK.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	No. CXVI	6.5 mm.	.....	28 × 20 × 10 mm.	55 days.	27 days.	Dr. Ryan, Springfield, Ill.
2	No. II	7.0 mm.	7.0 × 4.5 × 4.5 mm	35 × 25 mm.	52 days.	24 days.	Dr. C. O. Miller, Baltimore.
3	Stubenrauch (IL.)	7.0 mm.	.....	.....	51 days.	23 days.	Inaug. Dis., München, 1889.
4	No. XVIII	7.0 mm.	.....	18 × 18 mm.	.....	.....	Dr. Douglas, Nashville, Tenn.
5	His (B.)	7.0 mm.	4 mm	25 × 22 mm.	.....	.....	Anat. mensch. Embryonen.
6	His (St.)	7.75 mm.	.....	21 × 17 mm.	57 days.	27 days.	Anat. mensch. Embryonen, 8, 74.
7	His (XVII.)	8.5 mm.	.....	20 × 12 mm.	.....	.....	Anat. mensch. Embryonen.
8	Meyer	8.0 mm.	5 mm.	45 mm.	28 days.	28 days.	A. f. m. A., 36.
	Average	7.34 mm.	5.3 × 4.5 × 4.5 mm.	26 × 19 × 10 mm.	.....	26 days.	

TABLE V.—EMBRYOS OF THE FIFTH WEEK.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	Ecker	10.0 mm.	.....	.....	60 days.	32 days.	Icon. Physiol., 28.
2	No. LXXXVIII	10.0 mm.	4.0 mm	30 × 28 × 15 mm	.....	.....	Dr. Brumm, Detroit.
3	His (XCVIII.)	10.3 mm.	.....	35 × 25 mm	.....	.....	Anat. mensch. Embryonen.
4	No. CIX	11.0 mm.	.....	30 × 30 mm.	.....	.....	Dr. Cushing, Baltimore.
5	His (Br.)	11.0 mm.	5.0 × 4.5 mm	30 × 27 mm.	61 days.	33 days.	Anat. mensch. Embryonen.
6	His (XCVII.)	11.0 mm.	.....	30 × 25 mm.	.....	.....	Anat. mensch. Embryonen.
7	His (Rg.)	11.5 mm.	5.5 × 4.5 mm	30 × 27 mm.	.....	.....	Anat. mensch. Embryonen.
8	His (Sl.)	12.5 mm.	6.0 × 5 mm	30 × 27 mm.	.....	.....	Anat. mensch. Embryonen.
9	His (XIX.)	12.8 mm.	5.0 × 4.5	40 × 32 mm.	.....	.....	Anat. mensch. Embryonen.
10	No. XXXV	13.0 mm.	.....	.....	37 days.	37 days.	Dr. C. O. Miller, Baltimore.
11	His (M. 2)	13.0 mm.	.....	.....	64 days.	36 days.	Anat. mensch. Embryonen.
12	His (Br. 2)	13.6 mm.	6.0 × 4.5 mm	35 × 28 mm.	63 days.	35 days.	Anat. mensch. Embryonen, 9, 74.
	Average	11.6 mm.	5.2 × 4.6 × 4.5 mm.	32 × 27 × 15 mm.	.....	34.6 days.	

TABLE VI.—EMBRYOS OVER FIVE WEEKS OLD.

Number.	Observer.	Length of embryo.	Dimensions of umbilical vesicle.	Dimensions of ovum.	Time between last period and abortion.	Probable age.	References, or from whom obtained.
1	His (Dr. 1)	15.0 mm.	6.0 × 5.5 mm	45 × 40 mm.	.....	.....	Anat. mensch. Embryonen.
2	His (S. 2)	15.0 mm.	5.5 × 4.5 mm	35 × 28 mm.	.....	.....	Anat. mensch. Embryonen.
3	His (Lbs.)	17.0 mm.	.....	.....	51 days.	.....	Anat. mensch. Embryonen.
4	No. CVI	17.0 mm.	.....	.....	54 days.	.....	Dr. Gardner, Baltimore.
5	No. XVII	18.0 mm.	.....	40 × 30 × 20 mm.	.....	.....	Dr. Cottrell, Louisville, Ky.
6	No. XLII	18.0 mm.	.....	35 mm.	.....	.....	Dr. Wills, Los Angeles, Cal.
7	No. CXLIV	18.0 mm.	.....	40 × 30 × 30 mm	.....	.....	Dr. Watson, Baltimore.
8	No. V	18.5 mm.	.....	40 × 30 mm.	.....	.....	Dr. Kittridge, Nashua, N. H.
9	No. XXVIII	19.0 mm.	.....	50 × 30 × 20 mm	47 days.	.....	Dr. Sewall, Denver, Col.
10	No. LXXXI	20.0 mm.	.....	65 × 55 × 35 mm.	.....	.....	Dr. Branham, Baltimore.
11	No. XCIV	20.0 mm.	.....	50 × 40 × 30 mm.	.....	.....	Dr. Knill, Detroit, Mich.
12	No. XXII	20.0 mm.	5.0 × 2 × 2 mm	35 × 30 × 30 mm.	.....	.....	Dr. Snively, Waynesboro, Pa.
13	Minot	22.0 mm.	.....	.....	53 days.	.....	Minot's Embryology, 382.
14	His	22.0 mm.	.....	.....	56 days.	.....	Anat. mensch. Embryonen.
15	No. LVII	23.0 mm.	.....	30 mm.	.....	.....	Dr. Howard, Cleveland, Ohio.
16	His (Wt.)	23.0 mm.	.....	55 × 50 mm.	.....	.....	Anat. mensch. Embryonen.
17	No. LXXII	23.0 mm.	.....	40 × 30 mm.	.....	.....	Dr. Arthur, Baltimore.
18	No. XXVII	23.0 mm.	.....	30 mm.	.....	.....	Dr. Thayer, Baltimore.
19	His (Lp.)	23.0 mm.	.....	55 × 50 mm.	.....	.....	Anat. mensch. Embryonen.
20	No. XXXI	24.0 mm.	.....	50 × 30 × 30 mm	66 days.	.....	Dr. Ballard, Baltimore.
21	No. VI.	24.0 mm.	.....	.....	77 days.	.....	Dr. C. O. Miller, Baltimore.
22	No. CXXVII	24.0 mm.	.....	60 × 45 × 40	84 days.	.....	Dr. A. T. Gundry, Baltimore.
23	No. CXVIII	24.0 mm.	.....	50 × 40 mm.	76 days.	.....	Dr. Lupton, Baltimore.
24	No. CXVIII.	25.0 mm.	.....	.....	94 days.	.....	Dr. Booker, Baltimore.
25	His. (Dr. 2)	25.0 mm.	.....	45 × 40 mm	.....	.....	Anat. mensch. Embryonen.
26	No. XCIX	27.0 mm.	.....	40 mm	75 days.	.....	Dr. Carr, Durham, N. C.
27	No. XLV	28.0 mm.	.....	40 × 35 × 20 mm.	.....	.....	Dr. Douglas, Nashville, Tenn.
28	No. XXVI	30.0 mm.	.....	.....	75 days.	.....	Dr. Simon, Baltimore.
29	Minot	32.0 mm.	.....	.....	68 days.	.....	Human Embryology, 398.
30	No. LXXIX	32.0 mm.	.....	50 × 50 × 50 mm.	91 days.	.....	Dr. Briggs, Blackville, S. C.
31	No. CXXIX	32.0 mm.	.....	.....	65 days.	.....	Dr. Gundry, Baltimore.
32	No. CXLV	33.0 mm.	.....	60 × 50 × 40 mm	78 days.	.....	Dr. Watson, Baltimore.
33	No. LII	33.0 mm.	.....	40 × 30 × 15 mm.	.....	.....	Dr. Gavin, Baltimore.
34	No. XCVI	44.0 mm.	.....	.....	84 days.	.....	Dr. Spencer, San Francisco.
35	No. XCV	46.0 mm.	.....	68 × 50 × 50 mm	83 days.	.....	Dr. Watson, Baltimore.
36	No. CV	48.0 mm.	.....	.....	83 days.	.....	Dr. Watson, Baltimore.
37	No. XXX	60.0 mm.	.....	.....	77 days.	.....	Dr. Snively, Waynesboro, Pa.
38	No. XCII	70.0 mm.	.....	.....	90 days.	.....	Dr. Ballard, Baltimore.
39	No. XLIX	70.0 mm.	.....	.....	65 days.	.....	
40	No. XCIII	70.0 mm.	.....	.....	65 days.	.....	Dr. Snively, Waynesboro, Pa.
41	No. XXXIV	80.0 mm.	.....	.....	104 days.	.....	Dr. Ellis, Elkton, Md.
42	No. CXLVI	95.0 mm.	.....	.....	115 days.	.....	Dr. Watson, Baltimore.
43	No. CXVII	100.0 mm.	.....	.....	101 days.	.....	Dr. Ballard, Baltimore.
44	No. CXXXVIII	112.0 mm.	.....	.....	127 days.	.....	Dr. Watson, Baltimore.
45	No. CXLIX	130.0 mm.	.....	.....	125 days.	.....	Dr. Hoen, Baltimore.
46	No. XCVIII	160.0 mm.	.....	.....	125 days.	.....	Dr. Atkinson, Baltimore.
47	No. XLVI	135.0 mm.	.....	.....	143 days.	.....	Dr. Taylor, Baltimore.
48	No. CXXI	210.0 mm.	.....	.....	190 days.	.....	Dr. Ballard, Baltimore.

TABLE VII.—EXTREME AND AVERAGE MEASUREMENTS IN MILLIMETRES OF THE EMBRYO AND ITS APPENDAGES, AS OBTAINED FROM TABLES I. TO VI.

Week.	Measurement.	Length of embryo.	Greatest dimensions of the umbilical vesicle.	Greatest dimensions of the chorion.	Probable age in days.
Second	Extreme *	0.19 to 1.54	0.19 to 1.8	3 to 10	10 to 14
	Average	0.79	1.14	7.2	12
First half of third	Extreme	2.1 to 3	1.5 to 3	5.7 to 18	12 to 15
	Average	2.41	2.22	11.7	14
Second half of third	Extreme	3.2 to 6	2.5 to 4	14 to 30	14 to 23
	Average	4.67	3.3	22	19.5
Fourth	Extreme	6.5 to 8	4 to 7	18 to 45	23 to 28
	Average	7.34	5.3	26	26
Fifth	Extreme	10 to 13.6	4 to 6	30 to 40	32 to 37
	Average	11.6	5.2	32	34.6
	Extreme	15 to 19	5.5 to 6	35 to 50	
	Average	17.3	5.7	41	
	Extreme	20 to 24	.....	30 to 65	
	Average	22.5	.....	47	
	Extreme	25 to 28	.....	40 to 45	
	Average	26	.....	42	
	Extreme	30 to 48	.....	40 to 68	
	Average	37	.....	54.5	

* The extreme measurements of the umbilical vesicle and chorion are the greatest measurements in each case.

ical specimens are obtained which may prove to be of the greatest practical value. *The best and most convenient method of preserving young embryos is to place the unopened ovum, with the least possible handling, in a large quantity of very strong alcohol.* The alcohol of druggists is in no case too strong, and, according to my experience, is as a rule too weak. Often the ovum is wrapped in a towel and then placed in a small quantity of alcohol and water. This may be a method of preserving museum specimens, but it practically ruins every embryo which is preserved in this way. When an ovum is placed in, say, four ounces of strong alcohol, the water of the ovum dilutes the alcohol to a proper strength.

Those physicians who have the proper opportunities should place the specimen as soon as possible, and without opening the ovum, in seventy-per-cent. alcohol, *i.e.*, absolute alcohol reduced by volume to seventy per cent. At the end of a day or two it should be placed in fresh alcohol of the same strength. An excellent method for preserving embryological specimens is to place the membranes, blood and all in a weak solution (five to ten per cent.) of formalin.

A second convenient method is to place a specimen in quite a large quantity of Müller's fluid, to be changed once or twice during the first few days, after which it may be preserved in the same fluid indefinitely. The embryo is fully hardened in about a month, and then it can be washed in water for a day or two, after which it is to be preserved in seventy-per-cent. alcohol.

Ten per cent. nitric acid is a convenient and a most excellent method. The ovum is to be placed in four or six ounces of a ten-per-cent. solution and opened while in the fluid, care being taken not to injure the embryo. According to its size (if not over an inch long), it should remain in the acid for from thirty minutes to two hours. At the end of this time it is to be placed in seventy-per-cent. alcohol.

Another excellent method is to employ saturated aqueous corrcsive sublimate. The specimen is to be treated as in the ten-per-cent. HNO_3, only it is to remain in the sublimate longer. These specimens are then to be preserved in seventy-per-cent. alcohol.

There are many other methods, but if any of the above are employed there will be a sufficient supply of material to aid the study of human embryology. It is really wonderful to see what progress has been made in this study when we consider how difficult it is to obtain good material. Some of the most important discoveries have been made in the careful study of a few well-preserved human embryos, as a glance at the many papers of His and at the excellent text-book of Minot will show.

A great work is done when the specimens are once obtained, but in order to make it complete they must be placed in the hands of a specialist, who can devote all his energies as well as all the additional necessary expense to these the most precious of embryological specimens. *Franklin P. Mall.*

EMBRYOS, HUMAN, PATHOLOGICAL.—This article is based upon the study of fifty pathological human ova which have been collected by me during the past six years. All of the embryos, with but one exception, have been cut into serial sections, thus permitting of a more careful study than is possible from that of the external appearances alone. As far as possible, I have obtained additional data from the physicians who sent me the specimens; these have proved to be of much value in determining the age of them. Sections were also made of the uterine moles, as well as of nearly all of the embryonic membranes sent me. It is almost needless to state that while I was collecting the pathological specimens a considerably greater number of normal ones came into my possession. These have also been cut into serial sections, and they have been constantly used for comparison in studying the pathological ova.

The material at my disposal justifies a much more extensive account than I give. The illustrations could also, with advantage, be much more numerous. In the present article, my aim is to describe in a connected way the specimens as briefly as possible.*

The scattered literature relating to pathological human embryology is very extensive, and in general of not much value. From the numerous communications relating to young pathological embryos, two groups of papers stand out prominently—those of His and those of Giacomini. The more general article by His is published in Virchow's "Festschrift," vol. i., and that by Giacomini, is in Merkel und Bonnet's "Ergebnisse der Anatomie," vol. iv. The results of these two authors I have used as a basis after confirming many of their statements. In general, I am able to confirm all of His' statements, while I find some of Giacomini's obscure. Giacomini's numerous publications are mostly on single specimens, which are usually very young. The nature of his problem, as well as the limited amount of material at his disposal, is a sufficient excuse for any misinterpretation he may have made. His latest paper,[1] published shortly before his death, shows the marked influence the studies of the normal, by Graf Spee and others, have had upon his ideas.

Any change which may take place in the embryo after it is well formed, that is, after the second week, is easily recognizable, provided it has not gone too far. Specimens of this sort can be divided into two great groups:

* A more detailed description of the embryos referred to will be found in an article by me in the Welch "Festschrift," and in Johns Hopkins Hospital Reports, vol. ix.