the centre of each follicle, is the thick, structureless zona of the ovum, which appears to be as if compressed or encroached upon by the lengthening radial cells of the follicular epithelium. At the same time the ends of the cylindrical cells that abut upon the zona appear to have acquired a common bond of union, like a basement-membrane. At D is represented a belt of follicular epithelium, broken at the upper side, and without any traces of the ovum within it. The follicle E exemplifies perhaps the most common appearance of the belt of epithelium surviving after the abortion and disappearance of the ovum; the originally circular belt (in section) has become almost straight, and the shrivelled zona of the ovum lies toward its under surface and almost clear of it. The different forms of the belt of follicular epithelium depend partly on the plane of section; but there is little doubt that the originally circular belt (as it appears in section) unbends, and becomes a slightly curved cylinder, the shallow concavity of which corresponds to the original central space where the ovum lay. At F is shown the belt of epithelium doubled up, and with a stalk of connective tissue issuing from its concavity. These various surviving conditions of the follicular epithelium appear to belong to follicles which had not become greatly expanded; the ovum had filled the central space exactly, and there had been no development of *liquor folliculi*. There are, however, aborted follicles of a much wider circuit, such as that represented at G; in this case the extensive belt of epithelium is thrown into folds, and it is further noticeable that the elongation of the epithelial cells is hardly perceptible, and that there is no uniform basement line either on the outer or inner surface of the belt.

"The peculiar cortical structures of the supra-renal bodies, and their position relative to the rest of the organ, may be readily made out in any good section of a well-prepared supra-renal of the horse. Fig. 15, H, is a low-power view of such a section, made perpendicular to the surface. The outermost stratum is a zone of connective tissue of considerable thickness. Next to that comes the zone of peculiar structures above referred to."

These peculiar cortical bodies of the supra-renals Dr. Creighton regards as homologous to the remains of Graafian follicles in the ovary, from which the ova have not been discharged, but have decayed. His conclusion is that "the morphological resemblance between the ovarian and the supra-renal structures is not only close, but it is complete." I must, with all due deference to the work of an observer of so much distinction, say that, so far as I can see, this position has yet to be proved.

The Ovaries at Puberty.

What has already been said about the growth and ripening of Graafian follicles before puberty constitutes one of the many arguments in favor of the view that menstruation and ovulation are wholly distinct processes, and abundant examples can be given of them being carried on each independently of the other. The statement made by Dr. Robert Barnes, that, if the ovaries are extirpated or become atrophied, menstruation does not reappear, is not accurate; and equally incorrect is his assertion that the first ovular dehiscence corresponds with the first appearance of the menses. It is perfectly certain that ovulation is by no means a periodic process, in the sense of being monthly, and the fact that a periodic flow from the uterus is almost confined to the human race is sufficient to show that it is not in the ovaries that we have to look for the cause of this curious and objectionable phenomenon, for which no one has ever yet suggested a useful object. Where this cause does exist we do not know, but it is quite certain that, as it continues for months, in some cases, after the removal of both ovaries, it cannot be in those glands. Nor is it in the uterus, for in most cases removal of both ovaries arrests the function immediately; and in the somewhat short experience I have, up till now, had of the removal of small ovaries, this has been always immediately effected, and completely, when I have been obliged to remove the tubes as well. I have, therefore, a growing suspicion that we shall find in the monthly movement of the tubes, or in their structures, at any rate, the real source of the monthly discharge from the uterus.

It is perfectly certain that no one has yet recorded one instance in which the tube has been seen fastened on to the ovary before or after the menstrual period of life, as it is during that period. Yet ovulation goes on before puberty and after the climacteric freely. The change in size and vascularity of the tubes at puberty, and their diminution at the climacteric, and the beginning and cessation of their movements, form the most curious of all the remarkable features of those functional changes, and are quite enough to show either that the tubes are most markedly under the same periodic influence as that which produces the menstrual flow, or that they themselves are its cause. Finally, I have, during the last few years, had the opportunity of seeing the ovaries of a number of women, whose abdominal cavities I have had to open for various conditions not connected with diseased ovaries, and I have always found that

during menstruation the tube is fastened on the ovary, whether there be a ripe follicle at the point of adhesion or not; that both tubes were generally fastened to their respective ovaries, though in one ovary there may have been no appearance of a ripe ovisac; that I have very frequently seen an ovisac on the point of bursting, or just burst, when the patient was midway between two menstrual periods, this being a very frequent experience, as I always selected, when I could, a time midway between the periods for my operations, and in these cases I never found the tube fastened on the ovary. Finally, I have removed, in two cases, ovaries with the tubes fastened on them, during menstruation, in none of which were there any ovisacs approaching ripeness.

From these facts, and from others which will be detailed in another chapter, I am persuaded that ovulation is wholly independent of menstruation, and *vice versa;* that the most important feature of the menstrual period is the movement toward the ovary of the trumpet-shaped opening of the tube, and the grasping of the gland by it; that this grasping continues nearly throughout the period of menstruation, and that it is only a matter of the chance of there being a ripe ovisac within the grasp of one or other of the tubes that true ovulation—that is, the passage of the ovum into the uterus—takes place, and there is a possibility of conception. If this be not so, it is quite impossible to see how many married women escape having progenies immensely numerous, seeing the numbers of ripe ova which are produced, and the regularity of menstruation. If ovulation were coincident with menstruation, the probabilities of a woman with healthy organs, who married at twenty, and ceased to menstruate at forty-eight, would be to have eighteen children, instead of six, which is her average as at present. Besides this, the number of sterile women would be greatly diminished, and the increment of the human population would exceed all management. Diminishing our death-rate, or—to speak more accurately, as we should, for we all must die—increasing the average death-age as we do, by the abolition of wars and zymotic diseases, it is not difficult to see that some other agency must step in to aid civilization. If we produced as many young as do the lower animals, civilization would be an impossibility; the life-struggle would be so keen that barbarism must prevail. The inevitable law of evolution has, therefore, secured some process—we do not yet know what—by which the proportion of reproduction is limited, and we are Malthusians despite ourselves. Look at the myriads of young procreated by fish, only to serve for food to themselves or birds. Between them and ourselves there is a change gradually effected through the whole scheme, till we produce, as a rule, one child at birth, occasionally two, and very rarely three or four. These exceptions are clearly atavic. In some of the higher apes there are signs of something like a menstrual period, but as all such features in animal history become perverted in confinement, we do not know much about them. But in the lowest human races the signs of menstruation are very faint, their labors are very easy, and their whole sexual history different from that of the highly civilized races. It is abundantly proved that, just as civilization (and I use the word in its most literal sense) advances, so does the increment of sexual trouble among women. The flexions, and atrophies, dysmenorrhœas and menorrhagias which affect town-bred women are comparatively unknown to their peasant sisters, and the healthily abundant procreative power of a country laborer's wife is a frequent source of envy to the patrician dame.

In all this menstruation is the chief factor, and I suspect the want of synchronism between the embracement of the ovary by the oviduct and the discharge of the ovum, perhaps also the incomplete maturation of the ovum, will be found to be the most important features of the change.

That menstruation is a new feature in sexual life, introduced high up in the scheme, and has no analogy to the œstrus or rut among the lower animals, is surely proved by the close reasoning of Arthur Farre (article *Uterus:* Encyclopædia of Anat. and Phys.).

The changes effected upon the general system by the accession of puberty do not concern us here, and therefore I shall limit myself to those concerning the ovary and oviduct, and for the observations on which my conclusions are based I am indebted to my own researches entirely.

The structure of the ovary does not seem to be changed in the least by the accession of puberty, save in its vascular arrangements. Before puberty the mesovarium is thin and transparent, occupied by arteries and veins probably as numerous as they are afterward, but straighter and much smaller, the veins especially being but slightly pronounced, and quite different from the appearance of a bag of purple worms which they often have in after-life. After puberty these vessels become convoluted and distended. The ovary itself is slightly increased in size, but no very marked alteration in this respect is to be made out, a matter upon which Henning's measurements are confirmatory. The chief alteration consists in a greater size of the arterioles, a thickening of their muscular coat, and their assumption of a helicoid form, which I have been wholly unable to recognize in the

ovary prior to puberty. This, however, is an extremely difficult point to decide, for I greatly suspect that this helicoid arrangement of the arteries in the ovary, and perhaps in other glands, may be due to the degree of tension at which they are injected. It is at best difficult to make out, for the thickness of a transparent section seems but rarely to contain a complete coil, and however numerous and complete the coils may be, it is not difficult to see that the method of examination is such that they may be missed. I have, however, so often seen sections of such helices in ovaries after puberty, and especially in the glands of multiparous women—though I have often entirely failed to find indications of them in similar ovaries—that I cannot help thinking that there is some reason in their presence, which will be found to affect the condition resembling the engorgement of erectile tissue which the ovary assumes during menstruation, but more particularly during pregnancy (v. Heming). In normally erectile tissue these helices have been regarded as the intrinsic mechanism of the engorgement—a view which I have never been able to accept, for I have never realized that they can be more than a means of permitting the elongation of the vessel when the diameter of the organ is increased. When it is empty, they are coiled up like the slack of a rope, and therefore it is that I have already said that the helices present in a microscopical section will greatly depend on the tension of the injection. If the organ is greatly distended, the arteries will be straight. If slightly distended, they will or may be coiled, and I think it quite possible that my not having found them in ovaries before puberty may be due to the fact that the tissue of the gland is then more easily affected by distention, and that their absence may be from faulty preparation. Still it is likely that the altered hæmic condition of the gland after puberty may produce them.

To inject an ovary before puberty is not an easy task, and to get the opportunity of examining one is rare. I have therefore not been able to get perfectly satisfactory results as to the condition of the vascular supply of the ovisacs. What evidence I have, however, shows that there is little difference in it from what is found after puberty beyond this, that it is possible the vessels are all larger, though upon this point I can say nothing positively. But of this I am certain, that all the phenomena which occur in the rupture of an ovisac and the closure and healing of the cavity are in common occurrence before puberty, and that the characteristic arrangement of capillaries in what is called the *corpus luteum* can be seen long before the occurrence of menstruation.

Spiegelberg says (*Monatschrift für Geburtskunde*, 1867) that he has seen the inner layer of the ovisac distinctly marked off, and possessed of a yellow color, as early as the second year of life. I certainly have seen, in one ovary of the ninth year, an appearance which I could not have told from an adult *corpus luteum* of about fifteen days after the rupture of the ovisac.

In fact, the whole process of ovulation goes on before puberty, and the only difference then made is the important addition of the carrying the ovum into the uterus, and the possibility of its being there impregnated. These additions, however, do not affect the function of the ovary, which was complete before that, as is proved by the parthenogenetic production of ovarian tumors, and, in comparative anatomy, by complete parthenogenesis.

It will serve our purpose, then, if we now complete the description of the normal anatomy of the ovary by detailing the history of an ovisac after its formation.

The mature human ovum measures $\frac{1}{120}$ of an inch in diameter, and its germinal vesicle probably about $\frac{1}{800}$ of an inch, though its exact measurement, free from yolk-substance, has probably not yet been made. The nucleolus, or germinal spot, is about $\frac{1}{3000}$ of an inch in diameter. The ovum lies at first centrally in the ovisac, or Graafian vesicle, but in the ripening of the latter the ovum moves toward the periphery of the sac, and is always to be found close to the surface of the ovary when the sac ultimately bursts. This movement is variously explained, but the more certain processes are, the formation of a *liquor folliculi* by the solution of the epithelium, especially in the outer part of the sac, and the effusion of the fluid on the other side of the ovum, pushing the *discus proligerus* against the thinned wall. This wall is of two layers, the outer being formed of the stroma of the ovary and the peritoneum, and the inner, at first non-vascular, from the follicular epithelium. This inner layer rapidly thickens, becomes vascular, and takes on a distinct yellow color, long before the follicle is ready to burst. It has been called the *membrana granulosa*, but this extra name does no more than describe one of its characters, and leads to confusion. It is the epithelial layer, and it thickens everywhere but at that point where the ovum lies in contact with it, ready to issue forth at the moment of rupture, and the ovum is lightly retained in its place by a cellular attachment to this layer at the indefinite margin of the *discus proligerus*. By the time the ovisac is ready for rupture this layer has become very thick and vascular, and is composed entirely of large, round, and rapidly growing epithelial cells. The vascularity of the walls of the ovisac is most

marked at the point of impending rupture, and its vessels are visible to the naked eye on the surface of the ovary. The rupture takes place at last, and the ovum escapes either into the peritoneal cavity, where it perishes, save in exceptional cases, or into the pavilion of the oviduct, whence it is conducted to the uterus. I believe that the ovum falls into and perishes in the peritoneal cavity in by far the greater number of cases, and that the passage of it into the uterus occurs only in a small minority of the ova produced. The vessels ruptured in the act of the escape of the ovum bleed slightly, and this hemorrhage occupies the emptied cavity, and must, in many cases, along with the *liquor folliculi*, also pass into the peritoneal cavity. I have repeatedly seen a clot hanging from a ruptured ovisac into the cavity of the peritoneum, and on one occasion I saw the follicle rupture before I had touched the ovary, which lay exposed on a uterine tumor. Spiegelberg (loc. cit.) tells us that in women this hemorrhage is very insignificant, as it is also in the cow. In the mare and sheep it is entirely absent, and is most marked in the sow. I have seen nothing to make me believe that in women it is ever so severe as to be pathological, but I can easily imagine that sometimes it may really be so, and may explain those rare and mysterious cases of recurrent pelvic hæmatocele of limited extent, of which I have lately seen a most curious instance in the wife of one of my professional brethren.

After the rupture the follicle collapses, and the thickened inner coat is thrown into a series of convolutions strikingly resembling those of the brain, though I am by no means sure that these convolutions are not indicated before the rupture occurs. I have seen them in an unruptured ovisac before puberty, but as the ovary had been pickled in chromic acid for section-cutting, they may have been produced by preparation. I have also seen them in an unripe sac opened immediately after removal of the ovary. Here again they may have been produced instantaneously by the relief of tension. On a favorable opportunity I shall freeze a fresh ovary before cutting it, and settle this interesting question.

The rent in the ovisac soon heals, and the cavity is again closed, with a small clot in its centre, and this clot was formerly accredited as the source of all the phenomena of the much-discussed corpus luteum. It deserves no such distinction, and it soon becomes decolorized and is absorbed, so that the points of the convolutions come into contact, ultimately coalesce, and finally form the stellate cicatrix which marks for a long time the site of the ovisac. The capillaries of the inner or yellow coat are very regular, and, in a well-injected section, resemble

very much those of a villus of intestine. They spring from a small helicoid arteriole, having very thick muscular walls and two layers of fibres exactly like the arterioles of the kidney, in the outer wall of the ovisac. This arteriole breaks up at once into a ramifying meshwork, which seems to lie between the two coats of the sac, and which probably provides the vessels seen on the outer surface of the ovary at the point of rupture. From this meshwork straight wide capil' aries run down in the centre of each lobe to its apex, giving off small branches to each side. At the apex of each villus or lobe (from a section it is quite impossible to say which of these words is correct, though I think *lobe* would be the proper one) comes a vein which runs down between the lobes to the point of vascular origin, and between these interlobular veins and the intralobular arteries there are universal systems of capillary communication. Along the free margins of the lobe seems to run a system of communicating canals, and this it is which causes me to regard this second system of vessels as the veins, together with the fact that I cannot make out that they have thickened muscular walls. In the absence of a successful double injection, which I have never accomplished, this interpretation of these structures may be inaccurate. Within the meshes of vessels are seen the regular round epithelial cells, so arranged as to give a general contour of convolution, and in the cavity are the altered blood-corpuscles.

The lack of greater precision in this description is to be explained by the fact that the preparation of an ovary fortunate in all respects is very difficult, and I have but seldom succeeded, and that for some years now I have been too much engaged with practice to follow up the research, which requires abundant and uninterrupted leisure.

The disappearance of the red color of the central clot is the first change observed in the contracting cavity, and with this the whole forms a yellow convoluted patch. As it contracts the yellow color disappears, this change being effected in about two months in the non-pregnant state. The microscopic characters of the change consist in the disappearance of the cells, said to be brought about by fatty degeneration, though of this I have seen no evidence. This absorption is accompanied by the shrivelling of the blood-vessels and their final disappearance, so that, in eight or ten months, nothing is left but a star-shaped cicatrix extending into the substance of the ovary; but this probably in time entirely disappears in a young ovary. After impregnation these changes are effected much more slowly, owing to the altered nutrition of the whole organs, so that the yellow color may not disappear for twelve or fourteen months (Farre), and the

shrinkage of the cicatrix may take two years to be effected. It by no means follows, however, that an ovisac thus delayed in disappearance has been the seat of an ovum which has been fertilized, for I have seen three such corpora lutea in the ovary of a woman who had been confined only seven months before my operation, of one child—her only one. Farre says that during pregnancy in such ruptured ovisac there is a special increase in the thickness of the epithelial lining, and a larger deposit of oil-granules, but I have failed to get confirmation of his statement. During pregnancy, and for some time after it, the ovaries are especially increased in size by enlargement of their vessels, and so are the contained corpora lutea. The distinguished author just quoted says: "The *true corpus luteum* is the follicle in its largest condition of growth, as it appears after impregnation; whilst in all other conditions, when it has not been stimulated to full growth by impregnation, and whether before or after rupture, it has been called a *false corpus luteum*, so long as it possesses the yellow color." The differences are therefore only questions of degree, and cease to give any special characters long before other indications of pregnancy have passed away. To elevate this structure, therefore, into a medico-legal importance is not to be justified; and after a very extensive acquaintance with ovaries I would not venture to give an opinion, from any number of corpora lutea, as to whether they indicated past pregnancy or not. The great battle on this point has been singularly barren of results.

At puberty a very marked change is effected in the appearance and functions of the Fallopian tube or oviduct. Before puberty the tube is small and straight, and the size of the fimbriæ insignificant. When injected, its vascularity is not a very leading feature, and certainly presents a most marked difference to the peculiarly abundant blood-supply visible in its large-meshed network of capillaries in adult life. The muscular fibres of the fimbriæ are also very ill-defined before puberty, and no evidence is offered by any one that it ever makes any kind of functional movement. In adult life, as every one knows, one or both tubes seek their respective ovaries, and become attached to them for a time, which I believe to be concurrent with menstruation, by cellular adhesion. Permanent adhesion, the result of peri-oöphoritis, is often met with in women who have led lives of prostitution, and in them a sort of permanent metrorrhagia is by no means rare.

In the tube of a girl under the age of puberty I have been unable to find any of the ciliated epithelium which afterward lines it.

My conclusions are, therefore, that the changes in the ovary

at puberty are entirely vascular; that in the tube they are vascular, muscular, and epithelial. But that the most important change of all is the functional movement of the tube, the absence of which alone makes pregnancy before puberty impossible. Otherwise I do not believe that puberty has much to do with procreative power in women.

During the climacteric period a series of changes are effected in the sexual apparatus which make themselves felt throughout the system, but the results of which are not apparent in the structures themselves for some considerable time after the menopause. Ritchie and others have shown conclusively that the formation of true ova goes on long after this event, and I have seen in ovaries of very old women structures which I could not have decided as being in any way different from those seen in the ovaries of women at the prime of life. It is quite certain that the growth of ova persists till the end of life, though with advancing age it gets feebler, the cells become less numerous and less mature. The ovaries, however, continue to be the seat of cell-growth, and pathological cysts are formed in them sometimes even at the very extreme of old age, at a time when operative interference becomes hopeless on account of the age of the patient. The general atrophy which accompanies senility affects,

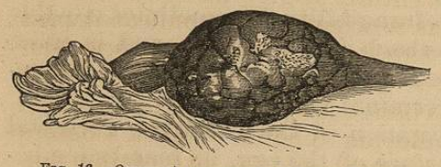

FIG. 16.—Ovary at menopause. (Arthur Farre.)

FIG. 17.—Senile ovary. (Arthur Farre.)

of course, the ovaries, and late in life they are usually small and shrivelled, abundantly marked by scars, and having all the appearances of having been worked out. But even then they exhibit traces of all their old products, and I have seen an ovary from the body of a woman nearly seventy years of age, which it would have been impossible to say might not have been removed from the body of a woman of thirty.

The changes which are most apparent are those effected in the uterus and tubes. These structures rapidly diminish in size, and the tubes are straightened and cease their movements. Here we have further proof that ovulation and menstruation are wholly independent, that menstruation is not dependent on the ovaries or on ovulation. I think also that there is additional evidence in favor of the view to which I am inclined—that menstruation is wholly a function of the Fallopian tubes.

The ovary, then, is simply a gland, developed as other glands, and formed of similar elements; its peculiarity is, that its cell-nuclei have special powers during a certain time of life; and this simplification of its physiology does much to simplify its pathology.

A few sentences from Balfour, concerning the phenomena observed in the maturation and impregnation of the ovum, may here be fittingly introduced. I take them verbatim, as it is a point upon which I have made no research.

"Every ovum, as it approaches maturity, is found to be composed of (1) a protoplasmic body or vitellus, usually containing yolk-spherules in suspension; (2) of a germinal vesicle or nucleus, containing (3) one or more germinal spots or nucleoli. The germinal vesicle, at its full development, has a more or less spherical shape, and is enveloped by a distinct membrane. Its contents are for the most part fluid, but may be more or less granular. Their most characteristic component is, however, a protoplasmic network, which stretches from the germinal spot to the investing membrane; but especially concentrated around the former germinal spot is a nearly homogeneous body, with frequently one or more vacuoles, occupying one of the eccentric positions within the germinal vesicle, and it is usually rendered very conspicuous by its high refrangibility, is sometimes capable of amœboid movements (Auerbach and Hertwig), and is more solid and more strongly tinged by coloring agents than the remaining constituents of the germinal vesicle.

"During the further maturation of the ovum the germinal vesicle moves toward the surface of the egg, its membrane becomes absorbed, and it is metamorphosed into a spindle-shaped body, this being done at the expense of the germinal spot. One end of this spindle enters a protoplasmic prominence at the surface of the egg, the spindle itself dividing then into two, one half remaining in the egg, the other in the prominence. This prominence, at the same time, becomes nearly constricted off from the egg as a polar cell, and a second polar cell is similarly formed. That part of the spindle remaining in the egg is converted into a nucleus—the female *pronucleus*—and this is moved toward the centre of the egg. On the entrance of one spermatozöon into the egg the head of the sperm is converted into another nucleus—the male *pronucleus*. Around this latter radial striæ immediately appear, and these travel toward the female pronucleus. The fusion of the two pronuclei, through the connecting striæ, form the first segmentation nucleus."

CHAPTER II.

ERRORS OF DEVELOPMENT AND DISPLACEMENTS OF THE OVARIES AND OVIDUCTS: SALPINGITIS, HYDROSALPINX, PYOSALPINX, HÆMATO-SALPINX, AND FALLOPIAN PREGNANCY.

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