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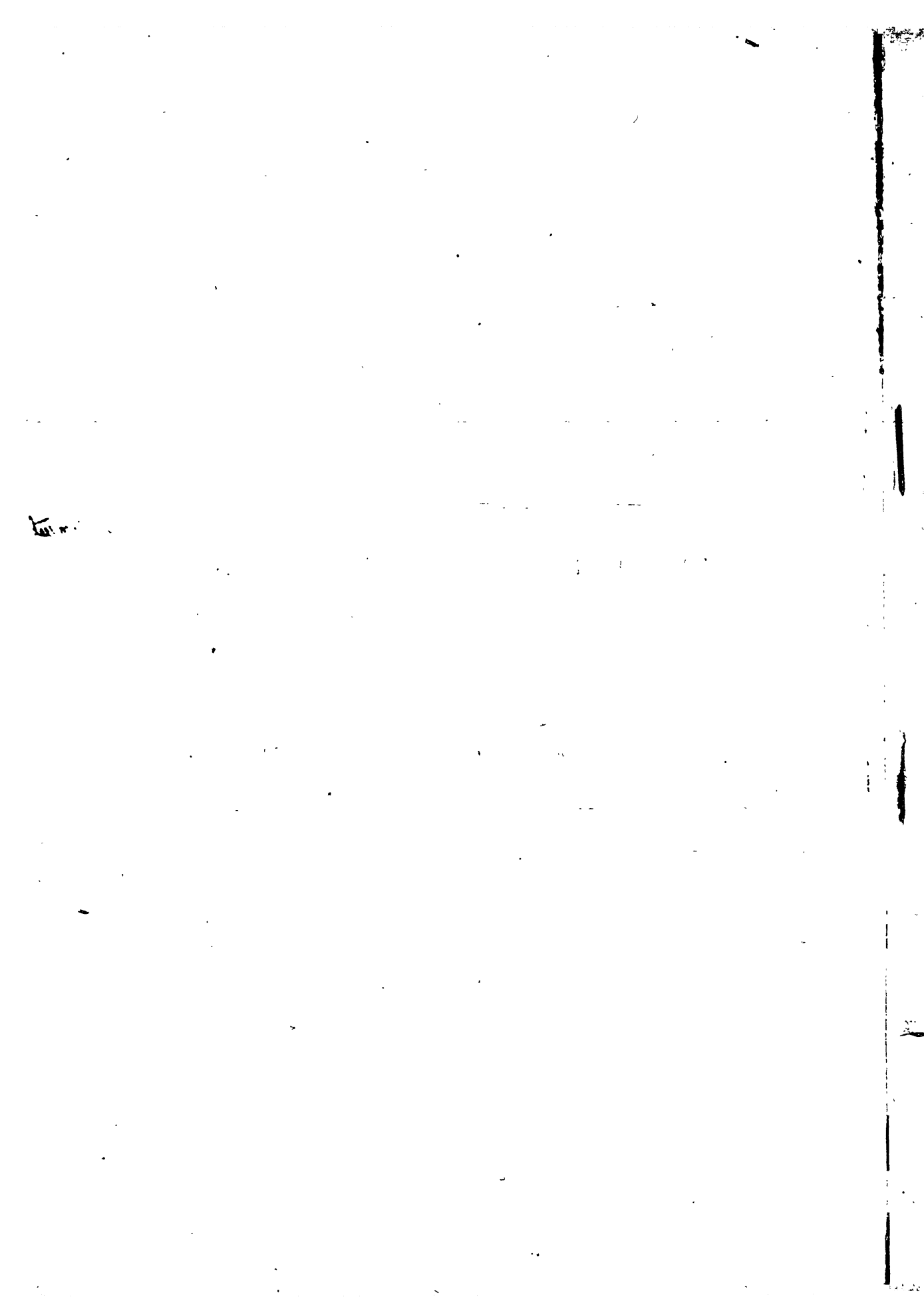
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THE BIOLOGICAL BASIS OF MENSTRUATION.

BY

J. C. WEBSTER, M.D., (Edin.), F.R.C.P.E., F.R.S.E.

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THE BIOLOGICAL BASIS OF MENSTRUATION.¹

BY

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At the present time there is universal ignorance as regards the causation of menstruation, its meaning as a sexual character, and the method by which it has become established among the higher mammals.

The following views have been advanced to explain the meaning of the process :

1. *Relation to Ovulation.*—For a long time it has been believed that ovulation and menstruation are so closely related that they occur at or about the same time, the former being the cause of the latter.

Of those who hold this view, some think that the blood-discharge results from a general pelvic congestion, supposed to be present during the ripening and escape of the ovum. Thus, Mathews Duncan often compared the menstrual flow to the red flag outside the door of an auction-room, which indicates that something is taking place inside.

Others regard menstruation as a process induced by ovulation necessary to the preparation and development of the ovum, in case it should be fertilized.

A careful examination of the evidence on which these statements are founded reveals their untrustworthiness. It is, indeed, a wonder that they have so long been believed.

The following facts relating to maturation and escape of the ovum are now definitely ascertained. These processes are usually in operation some time prior to the development of the phenomena of puberty before menstruation appears; sometimes they occur in childhood and

¹ Read before the Montreal Medico-Chirurgical Society, Jan. 12th, 1897, and before the New York Academy of Medicine.

in foetal life. There is no proof at all that pelvic congestion takes place, either coincident with or secondary to these processes, at any time in a woman's life.

Ovulation may also occur without menstruation in the dodging-period of puberty and of the menopause; for several years after the menopause as Hegar has pointed out; during lactation; in certain diseased conditions, *e.g.*, anæmia, phthisis, lead-poisoning. Pregnancy may take place at any of these times. DeSinéty describes an interesting case which he examined, of a woman, 38 years of age, who had never menstruated. In the ovaries there was the normal condition of Graafian follicles, and *corpora lutea* indicating that ovulation had taken place. The body of the uterus was undeveloped.

Then, in abdominal and *post-mortem* sections made at all times between menstrual periods, Graafian follicles may be found on the point of rupture or recently ruptured; and in examinations made during menstruation, no sign of ovulation may be visible.

(In this connection it is interesting to note that Heape examined the pelves of forty-two monkeys (*Semnopithecus entellus*) during their menstrual periods and found evidences of ovulation being in progress in only two cases.)

It is a common observation that extensive disease of both ovaries, *e.g.*, cystoma, suppuration, malignant growth, may not effect the menstrual function to any appreciable extent in many cases.

These various facts are sufficient, it seems to me, to overthrow the view that menstruation is a necessary accompaniment or sequel of ovulation.

Yet it can scarcely be denied that there is some relationship between the processes.

Removal of the ovaries is followed by cessation of menstruation though in a certain number of cases this does not happen. As an interesting instance of this, may be mentioned Lawson Tait's patient from whom both ovaries and tubes along with a part of the uterus were removed, menstruation still continuing.

These exceptions have been carefully considered by several authorities, lately by Bland Sutton. He states that the reported cases have been mostly those in which chronic inflammation in and around the appendages has been present, or those in which operation has been performed for myoma uteri. His explanation of the persistent menstruation is that either small bits of the ovary have been left behind, or that in the cases of myoma a submucous tumour may exist leading to hæmorrhages. Many cases have undoubtedly been recorded in

which after removal of the ovaries for fibroid, menstruation has continued.

The long held view of supernumerary ovaries is discarded by Bland Sutton. He thinks that these so-called structures are merely small bits separated from the main mass of the ovary by deep fissures.

In several of these cases of unchecked menstruation, second operations have been performed by which small bits of ovary left from the first operation have been removed, being followed by a complete cessation.

2. *Relation to the Fallopian Tubes.*—According to Lawson Tait, removal of the tubes, the ovaries being left *in situ*, is followed in 95% of cases by cessation of menstruation. This remarkable statement has been little noticed. If it can be established by extended observations, it proves that there is some close relationship between the tubes and the menstrual process.

3. *Relation to a Special Nervous Mechanism.*—Johnstone has advanced the view, supported by Lawson Tait and others, that the menstrual act is a special function related to a distinct nervous mechanism. They think that possibly a special nerve trunk running in the upper part of the broad ligament may convey the regulating currents. Johnstone suggests that *when the ovaries or tubes are removed, menstruation is checked because this nerve is ligatured or divided*. In the cases in which removal of the appendages is not followed by cessation of the flow, he thinks that the nerve may have escaped division or ligature, owing possibly to its being placed low in the broad ligament.

While undoubtedly believing in this special nervous mechanism of menstruation it seems to me that possibly the nerve tract is not so limited as Johnstone suggests. The plexiform nature of the nerves about the uterus is so complex that it is presunable that the impulses affecting the mucosa of the uterine body travel by many routes in the broad ligaments.

4. *Relation of Menstruation to Conception.*—By some it is believed that menstruation is a process for preparing the uterine mucosa for the engrafting of the fertilized ovum, that it is in fact, an essential feature. This idea was promulgated when it was thought that the ovum required a connective tissue free from covering epithelium to become engrafted on. I have repeatedly urged its improbability on the following grounds:

a. In all mammalians below *homo*, so far as is known, the ovum grows in relation to the epithelium-covered uterine mucosa and does not require a connective-tissue surface. The uterine epithelium is

undoubtedly non-essential, but it is destroyed by degenerative processes and by the trophoblastic action of the outermost layer of the foetal epiblast. As far as our observations go in human development the same processes occur there.

b. Pregnancy may occur in a girl before the onset of menstruation, at a time therefore, when the mucosa cannot be denuded by that process.

c. It may occur during the lactation period, long after the uterine mucosa has been restored, and at a period in which menstruation is in abeyance.

d. It may take place in one of the periods of amenorrhœa during the progress of the menopause.

e. It may occur in periods of amenorrhœa due to diseases *e.g.*, anæmia, phthisis.

f. Clinical experience of cases of pregnancy following a single coitus proves that development of the ovum may begin at any time, not necessarily immediately after menstruation. (It must be stated that this evidence is of doubtful significance, owing to the uncertainty in our knowledge as to the time it takes the ovum to pass from the ovary down through the genital tract and as to how long the spermatozoa may live in the tract.)

g. Pregnancy may occur in the rudimentary horn of a malformed uterus, menstruation never having taken place in that horn.

(Whereas, as P. Müller points out, there is no record of pregnancy having ever occurred in the horn of a bicornuate uterus which is atresic in its lower part; menstruation goes on in it, as we know, the blood accumulating above the atresia).

h. It may occur years after menstruation has ceased at the supposed menopause. An interesting example is Renaudin's case in which a woman of sixty-two was delivered though she had not menstruated for over ten years.

i. In male pseudo-hermaphrodites, possessing testes but no ovaries, the vagina, uterus and tubes may be present and menstruation may go on regularly or irregularly.

Another view is to the effect that, along with the maturation of the ovum, the endometrium swells as the first stage in the formation of a decidua which will receive the ovum if it be fertilized. If fertilization does not occur, breaking down of the superficial portion, the so-called "menstrual decidua" occurs, and the menstrual discharge takes place; in this way menstruation may be regarded as the expression of the failure of a process meant to be initial to pregnancy. For, if fertilization occurs, it is thought that the swollen mucosa advances to form the decidua of pregnancy.

This view, it is evident, is based upon a fallacious assumption, and my objection to the last mentioned theory may be quoted to refute it.

There is no proof whatever that changes in the mucosa accompany maturation of the ovum, and the best evidence we possess regarding the alteration in the uterine mucosa during menstruation, viz., the observations of Johnstone, Bland Sutton, Heape, Minot and Mendl goes to show that practically only blood and small portions of the lining epithelium escape. There is normally no exfoliation of a layer worthy the name "menstrual decidua."

I think this term is a bad one ; it is to be clearly understood that no change occurs in the connective tissue elements of the mucosa during menstruation, viz., enlargement of cells. This change only occurs in connection with the influence of a fertilized ovum.

Löwenthal has advanced still another explanation. He believes that menstrual bleeding is neither a physiological function nor an accompaniment of one, but that it is due to innumerable repetitions of an unnatural state of things, viz., the non-fertilization and death of the ovum. He says that the swelling of the uterine mucosa is the result of the embedding in it of the last ovum discharged from the ovary. If this ovum be fertilized the swelling mucosa goes on to form the decidua of pregnancy ; if no fertilization takes place, the ovum dies, and as a result of this death a breaking down occurs in the mucosa. He, therefore, regards the menstrual flow as having all the characteristics and effects of other bodily hæmorrhages.

Löwenthal's view is a piece of speculation without any factual basis. No one knows anything about the unfortunate ova which do not fulfil their highest destiny. It is a sympathetic imagination which makes them cling in their downward course to the walls of a repellant uterus, forcing changes upon that organ, in the fond hope that a wandering spermatozoa may cleave to it in consummative union.

Fanciful also the picture of death following bitter disappointment, the coincident decay of the dead ovum's resting place and the final bearing away in a blood-red funeral stream of the fragments of a once active individuality.

Johnstone believes that the simplest definition of menstruation is a periodic wasting away of the corpuscles that are too old to undergo the changes which must occur in connection with the attachment and development of the fertilized ovum. He does not regard the endometrium above the internal os as mucous membrane, but as belonging to adenoid tissue.

Menstruation is for it what the lymph stream is to the lymph-gland or the blood stream to the spleen. The development of the

corpuscular elements, he thinks, takes place in the endometrium, as in the blood-glands, spleen, thyroid, etc.

The existence of menstruation in the human female and its absence in the mammalian orders below the Primates, he explains by postural differences, and by difference in the structure of the endometrium. From his studies he is of the opinion "that nature has supplied the endometrium with an abundant lymph stream, which in the unimpregnated state washes away the ripe material to the general circulation exactly as it does any other lymph corpuscle. But in woman, where, on account of its erect position, the uterus has to depend on the tenacity of its own fibres for the preservation of its shape, no such thing as loose tissue of a lymphatic network can be depended upon. So, to preserve the integrity of the uterine wall, the emulgent stream is poured into the cavity of the body, and got rid of through the vagina."

5. *Relation to Body Metabolism.*—Geddes and Thomson in their "Evolution of Sex" have advanced the theory that the menstrual process is related to the balancing of anabolism and katabolism in the female organism.

After puberty a surplus is produced in the system because the anabolic preponderates over the katabolic. When pregnancy occurs this excess is spent in the nutrition of the ovum during its parasitic intra-uterine life and during lactation. When these methods of using the anabolic surplus are wanting, menstrual losses occur in order that it may be got rid of.

Biological Considerations.—Scarcely any attention has been given to the consideration of menstruation in its biological aspects.

The speculation of the distinguished biologists, Geddes and Thomson, is one of the most suggestive which has yet been advanced, and it is worthy of an elaborate study.

The careful investigations of many forms of plant and animal life by zoologists and botanists, have enabled the biologist to establish a distinction between "maleness" and "femaleness" not only in terms of morphological characters but of psychological and physiological reactions. It is only recently, however, that sex differences have been investigated on these more subtle and difficult bases of inquiry. Too long have reproduction and sex been considered by themselves as if they were something to be disassociated from the general physiology of the organism.

The most important sex-distinction which has been established is that which has to do with the general metabolism, or protoplasmic chemistry of the body. Every living cell and every organism is continually representing two forms of metabolism: one, the anabolic, by

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which nutrition is taken in, waste repaired, energy stored, structure improved or altered; the other, the katabolic, by which potential is changed into kinetic energy and movement or activity manifested, structural alterations induced and waste created.

Throughout the animal kingdom the distinctive and predominant characteristics of the male sex is katabolism and of the females, anabolism.

Generally speaking, the males show activity, continual expenditure of energy, disruptive metabolism: the females, passivity, quiescence, constructive metabolism.

The same distinction is also found in the plant world. The lines of inquiry on which this generalization has been made are the following:

1. A study of sexual characteristics in the fully developed state and in the history of the individual.
2. An investigation into the condition of the lowest forms of animal and plant life, where sex has its beginning.
3. Observation of normal and pathological changes in the reproductive apparatus.
4. Experimental inquiry into the nature of the factors which determine sex.

Details regarding these lines of research are beyond the limits of this paper, yet some reference must be made to them.

As regards the differences found in the adult forms in the invertebrata and among fishes, it may be stated that in general the body temperature is lower in the female. (This is so in many plants). Their longevity is greater. They are in general larger and more sluggish in habits. The males expend energy more freely, thus preventing storage-accumulation and increase in size. Among birds and mammals, while the general metabolic differences exist the males are usually larger than the females owing to special factors which have come into operation and which do not exist in the lower orders of life. Darwin and Geddes have explained these. They show that the differences in size in the higher forms are mainly in bones and muscles. This is explained partly by the extra stress and strain thrown on the males while the females are in a state of pregnancy and caring for the young: partly by the strengthening effect of fights between the males, the strongest tending by natural selection to perpetuate their kind: partly by the effects on the female constitution of the excessive reproductive demands found among the higher animals.

The distinction between the sexes is universally marked in the spermatozoon and ovum, the former being small, active, energising

katabolic; the latter large, passive, highly nourished, anabolic. While the metabolic differences between male and female have been mainly studied in plants and the lower animals, some work has also been done in the human subject, though here the difficulties are greater owing to the greater complexity of the organism.

Blood.—The red corpuscles are more numerous in the male, and the percentage of hæmoglobin greater than in women. The specific gravity is the same until puberty. Afterwards it is higher in men than in women during the sexual life. In old age it is usually higher in women.

It is thus evident that the menstrual life is associated with a fall in the specific gravity of the blood.

Pulse rate.—The pulse rate is slower in men than women. This holds good for nearly all animals.

Respiration.—Men produce more carbonic acid than women as estimated by the breath. After puberty the amount is nearly double that produced by women. It increases in the latter during pregnancy and after the stoppage of menstruation.

Excretion.—The urine of women is usually lighter in colour than that of men, and its specific gravity lower. The amount of urinary solids is both absolutely and relatively less than in the case of men, especially during the reproductive era of her life.

It is highly probable that those features which we call secondary sexual characters, *e.g.*, richer pigmentation, excess of hairs and feathers, activity of scent glands, etc. which are found in the males are but the multiform expressions of the katabolic predominance in the male organism. And it is important to note that in the great run of cases these characters are fully developed as maturity is established. In early life there is practically no physiological distinction between the sexes. The establishment of the reproductive functions is associated with the development of sexual features, which, as Darwin has pointed out, modify the males to a much greater extent than the females, throughout almost the entire animal kingdom. "Generally," he states, "the female retains a closer resemblance to the young of her own species than to other adult members of the same group."

Experimental evidence regarding the influence of various conditions in the production of sex, points also strongly towards the conclusion that "in the determination of sex, influences inducing katabolism tend to result in the production of males, as those favouring anabolism similarly increase the probability of females (Geddes and Thomson). Poor or abnormal food, deficient light, moisture, exercise, excessive lactation and other conditions tending to diminish the repair-supply

or to cause a surplus of waste—the katabolic habit, tend, in experiments made on lower animals, to the production of males. Such tests strengthen the view that the male is the index of a preponderating katabolism, and the female of an equally marked anabolism.

Now, throughout the greater part of the animal kingdom, this anabolic predominance in the female affords the means of counteracting the katabolic influence of the part she has to play in reproduction.

During the sexual life of females among most of the Primates, the anabolic habit does not find sufficient employment in supplying this destructive influence. An overplus exhibits itself in the production of milk during the early period of the child's life, and, after lactation, in a discharge of blood from the uterus.

Cases of menstruation during lactation might by this theory be easily explained. The production of milk does not use up the anabolic surplus, which, therefore, becomes disposed of through the sexual menstrual outlet.

In all mammalians below the primates the balance is regulated without the occurrence of any loss through menstruation; reproduction, lactation, the care of the offspring and their moving habits apparently making such demands upon the maternal anabolism that no surplus corresponding to the menstrual blood of the human female is produced by the system.

(In the vegetable kingdom, also, it is interesting to note, "the distinctly anabolic overflow of nectar ceases at fertilization, and the surplus of continual preponderant anabolism is drafted into the growing seed or fruit."—Geddes and Thomson.)

One of the most striking characteristics of menstruation, as observed in the human female, is its variability in type, and in the quantity and duration of the discharge.

One need not specify these in detail. I wish in particular to direct attention to the great range of variation in the time of its appearance in relation to the development of those other phenomena which we call the "sexual characteristics."

In the majority of cases these features *e. g.*, activity in ovulation, menstruation, hair-development, growth of breasts, etc., become established at a definite period, known as puberty, which, as we know, varies according to climate, race, environment and other conditions.

But of far greater importance are the variations which prove that there may be no concurrent incidence in the determination of the phenomena in the individual. They are as follows:

1. Menstruation may begin very early in life, even within the first year, without the development of any of the other outward signs of

puberty. These become marked, at varying periods in different cases, and in different orders. Generally, they appear together after a number of years, but sometimes the breast changes precede the others, sometimes the growth of hair, sometimes the changes in bodily contour.

2. In other cases, the development of menstruation at a very early period may be associated with one or more of the other secondary sexual characteristics. Thus the breasts may be well-marked, or the external genitals well-developed, or the voice altered. The other features appear in later years.

3. In other cases some of the secondary sexual characteristics other than menstruation may be developed in very early life, this function becoming established sooner or later afterwards. Thus the breasts may become well-marked, menstruation following after months or years. In a case recorded by Bouchut, in which the breasts were well-formed at birth, menstruation began at the age of 22 months, and the rest of the sexual features became marked in the succeeding 2 years, so that at the age of 4 years the child had all the characters of a fully developed girl.

Sometimes the breasts and external genitals may develop early together. Sometimes the latter alone may be very early marked, being followed sooner or later afterwards by menstruation and the other phenomena.

Sometimes the breasts develop early along with axillary and pubic hairs, being followed after months or years by menstruation.

Sometimes the body-contour may resemble the adult form, the hair and external genitals being well developed, at a very early period; the appearance of menstruation and the growth of the breasts being delayed for months or years.

4. As regards the condition of the internal genitals, only a few opportunities have presented themselves of observing them in the above-cited cases, so that it is impossible to know in how many ovulation was in progress or the uterus well-developed. It is, however, clearly established that in some of these precocious cases ovulation is in progress and the uterus with adult features. There can be no doubt, therefore, that puberty may be completely developed in the first years of life as regards the physical changes. As is to be expected the psychical alterations are wanting.

5. Finally, the cases must be alluded to, in which during infancy and child life, ovulation has been noted, though none of the other signs of puberty have been present. It has been found in progress even before birth. In the great majority of cases of normal develop-

ment of puberty, it may be in progress several months before the other phenomena appear.

In the adult state marked variations are found as regards the degree to which the sexual characters are developed.

These need scarcely be specified, so commonly are they observed by physicians.

They affect the breasts; the pubic and axillary hairs; the formation of the external genitals; the type, quantity and duration of the menstrual discharge; the psychical development. These differences exist between different races and between the various members of the same race.

From the consideration of the many facts to which I have referred we are forced, it seems to me, to regard the menstrual function as a highly specialised means, gradually produced, in the evolution of the highest mammals by which the two great factors in tissue metabolism—the anabolic and katabolic, are properly balanced.

Normally it becomes established along with the various phenomena which characterise the development of sexual activity—at puberty, because it is then that the metabolic habit peculiar to females, viz., predominance of anabolism manifests itself.

The rythmical character of the menstrual function has probably been gradually determined by the forces of evolution, and the marked range of variations which it presents in the human female (unassociated with pathological conditions) points very strongly to an early period of instability in the process, preceding its present fairly fixed habit. It is, indeed, impossible for us to think of a rational explanation for the peculiarities which are found except on the ground of biological variations—atavistic reminiscences.

The menstrual function, then, being closely correlated with the well recognized sexual characters is, like them, undoubtedly closely related to a nervous regulating mechanism, the nature of which is unknown as yet. There may be a special cord centre governed by still higher cortical centres, but there is also a subtle and intimate connection between the sexual functions and the general nervous mechanism of the body.

As Johnstone ably states in regard to the uterus, “its association with ovarian activity is that of two separate departments of an army, each of whose work must be thoroughly accomplished before the one common object can be attained. They are both controlled by branches from the sympathetic system, and instead of their actions being determined by each other, their orders come from that higher power which controls all functional activity.”

It is this correlation which has been wrongly interpreted, especially in the case of the tubal and ovarian functions, with neither of which is the process *directly* connected. That it is indirectly related to them and capable of being influenced by them cannot be denied, and that of the whole sexual apparatus the ovaries are the "predominant partner" is not to be wondered at. We have proofs enough as regards their influence on body-metabolism, *e. g.* in osteomalacia, marked improvement immediately follows removal of the ovaries. Whether this be due, as Curatulo believes, to the secretion by these organs of a chemical substance capable of facilitating the oxidation of the phosphoric organic substances supplying material for the bone salts, or, whether it acts merely by altering an ill-proportioned relationship between anabolic and katabolic functions, thus secondarily affecting the diseased process, is only a matter of speculation.

After the removal of the ovaries in gynæcological practice, certain effects are noted, which must be associated with altered neuro-trophic functions. Thus "heats" or "flushes," vaso-motor storms are very often troublesome features. The uterus tends to shrink, the gland-tissue of the breast tends to atrophy, while fat is often increased in the body. There is, however, very great variation as regards the effect of removal on the sexual characters. These are so marked as to demand a careful investigation for the purpose of determining them accurately and of establishing a comparison between the bodily changes following the operation and those taking place in connection with the normal climacteric. At present many exaggerated ideas are current.

While, in the majority of cases, removal of the ovaries is followed by an altered body-metabolism owing to the absence of the most important sexual organ, marked by disappearance of the anabolic overflow of menstruation, it is not surprising that variations should occur in the alterations produced, so that instances might occur in which the menstrual function does not cease. It is certainly not an uncommon experience to find discharges of blood from the uterus after the operation, apparently, an indication that the changes in body-metabolism are being brought about but gradually in these cases.

As regards the relation of the tubes to menstruation, if Lawson Tait's observations be accurate, viz: that after their removal menstruation ceases in the great majority of cases, the ovaries being left behind, the explanation may be, either that such a marked alteration in the genital tract may reflexly alter all the sexual functions along with body-metabolism, or that it may bring about the result through an indirect influence (such as inhibition of function) on the ovaries.

Bland Sutton's statements as regards the effects of removal of the tubes are directly opposed to those of Lawson Tait. His words are, "the Fallopian tubes exercise no influence on menstruation, and in order to produce artificial amenorrhœa both ovaries must be completely removed." I do not consider that Bland Sutton is justified in making these statements from the facts given by him. He quotes a few cases in which ligature of the tubes was performed without causing a cessation of menstruation. Tait, however, speaks of *removal of the tubes*, a much more serious disturbance.

Though there can be little doubt that menstruation has been established in the higher mammals by a gradual process of evolution, we have been entirely in the dark as to the steps of this process. Seeing that it is limited to the anthropidæ and simiadæ, the earliest appearance must have taken place among some common ancestors of both.

The peculiarity probably first began as a variation, which proved to be advantageous and by natural selection became a fixed character, being transmitted from generation to generation. Had it been of no advantage it would have been eliminated.

The only suggestion which has yet been advanced as to the possible advantage of this variation is that of W. E. Fothergill, who believes that it consisted in a greater tendency to conception owing to the rawing of the uterine mucosa.

This suggestion cannot be entertained in the light of present knowledge. We know that rawing of the surface is not necessary to the attachment and nidation of the fertilised ovum and that in the great mass of the mammals it does not occur.

The introduction of menstruation in the evolution of the mammals has not been associated with greater but with diminished fertility, for there can be no doubt that the non-menstruating mammals are on the whole by far the most prolific.

Indeed, natural selection, has acted in the highest ranks of the animal world not in the direction of establishing a numerical superiority, but one based on the specialisation of individual characteristics in a selected number.

The advantage of the variation in our distant progenitors must therefore be sought for in relation to factors tending to diminish the number of offspring and to improve the quality of the individual.

As to the origin of the variation, the only reasonable speculation seems to be that it is associated with the development of the single uterus, with the diminution in the number of offspring, with the determination of the semi-erect or erect posture, characteristics found throughout the Primates, at least in the simiadæ and anthropidæ.

(The division of the Primates, known as the lemuridæ, stands by itself. These forms are believed not to be in the direct line of the other divisions but a separate offshoot from some early common mammalian stock. They have a double uterus and, so far as we know, do not menstruate.)

Of prime importance I believe, among these factors is the change from the bicornuate to the single condition of uterus. In the great mass of mammals with the former variety, the excess of anabolism is used up in the large demands of breeding and nursing. When the single uterus appeared as a variation marked by a diminished area for the attachment of ova, the unused anabolism found an outlet in the escape of blood.

It is possible that this took place at first from different parts of the body thus helping to explain the occasional occurrence in females of "vicarious menstruation."

If this were the case, natural selection must have acted in eliminating all except those in whom the blood escaped from the uterus.

But it is also likely that the tendency to sit on the ischial tuberosities and to move about more or less in the semi-erect position may have somewhat determined the occurrence of the congestion chiefly in the pelvis, relief being found by a discharge from the delicate mucosa.

The blending of two blood-supplies in a single uterus, which had previously been distributed to two cornua, must have had an influence in inducing a special tendency to uterine congestion.

Probably also another factor helped to determine the localisation of the congestion to the pelvis, viz: the habit already fixed among many of the lower mammals of the periodic pelvic congestion of the rutting period.

In the beginning it is likely that the menstrual discharge took place at irregular intervals (thus explaining the occasional irregular types which are now found among females.)

Natural selection would here come into play in determining regularity of type.

Females who were irregular in regard to the discharge would be objects of inconvenience to the males who would very soon learn to seek out and prefer those whose unseemliness manifested itself only at expected and definite periods, and so gradually regularity would come to be the predominant feature in succeeding generations of offspring.

It is a striking fact that among all races there is a careful avoidance of menstruating females by the males. This is particularly marked in most primitive peoples. Very possibly it had its origin in

a feeling of disgust on the part of the males, and it is not difficult to understand how among the earliest human beings, there might gradually develop the belief that women were possessed of some unclean or evil spirit which had to escape periodically.

It is thus easy to explain the universal though varied customs and practices prevalent in many races, by which the woman is forced at her periods to avoid association with others, to abstain from coitus with men and to withdraw even from observation in order that her evil influence might not spread.

Next, it is of great interest to inquire into the possible gains that might result from the fixing of the menstrual process in females.

It is a remarkable fact that in the highest mammals, viz: the simiadæ and anthropidæ, is found the highest development of the altruistic principle as exhibited between parents and offspring. As Westernmarck points out, among the invertebrata the male is interested only in the act of fertilisation, while the female shows no further concern or responsibility after she has laid her eggs. In the lower vertebrata parental care is almost unknown, though there are a few exceptions, *e. g.*, chiefly in the chelonia; the males caring for the young in some cases, the females in others, while in a few instances there is joint parental attention.

In the birds, however, it is the rule that the parents live in most intimate relationship, both during and after the breeding season, the female hatching and rearing, the male acting as protector and provider of food.

Among the great mass of mammalians, below the primates this is not the case; the mothers alone showing great concern for the young offspring while generally the males are only interested in the females at the rutting time.

Exceptions are, however, found *e. g.*, among whales, seals, certain deer, moles, squirrels and a few other forms; the parents remain together after the birth of the young, the male acting as protector.

Among the Primates the rule is that the males and females unite in a more or less enduring partnership, both having great concern for the care of the offspring, the males possessing one or more wives. There is an abundance of facts to establish this statement and from them Westernmarck has established his induction in a masterly work, that our human marriage is an inheritance from an ape-like ancestor, controverting the long held belief of Sir John Lubbock and others that our progenitors formed one vast free-love community where promiscuity of sexual intercourse prevailed.

This habit is therefore another interesting possession of mammals

with a single uterus. It marks a great advance in the character of the individual above the types found in the lower orders of animal life.

Very evidently it was fostered by means of natural selection, being most essential where the female gave birth to a small number of young who passed a long time in a state of helpless infancy and tutelage. Such a species, undoubtedly, stands a better chance of surviving when the parents unite their energies in the task of protecting and nurturing the offspring.

Indeed, it would appear that the great determining factor of conjugal relationship is care for the young. Among several primitive races (and in some of the highest) marriage is never supposed to be established until offspring appear.

• Wherever in the animal kingdom we find that the parents have no concern with their offspring, the females give birth to a very large number of offspring—the prodigality of births allowing of the safeguarding of the preservation of the species. Thus the cod lays each year about a million eggs, to which she gives no after-care, and, probably, the greater number become destroyed. On the other hand the turtle-dove lays only two eggs, but owing to the care which the parents give to the young they generally grow to maturity.

Another important point to notice regarding intercourse between the sexes, is that while among the majority of mammals there are special times of pairing, conditioned by various necessities, different in different species, among the quadrumana the rule is probable that fruitful intercourse may take place at any time, though undoubtedly exceptions occur owing to conditions of food, environment, etc. In the evolution, therefore, of the higher mammals possessing one uterus, there has been a departure from the condition of periodic excesses of sexual rioting to one in which there is especially in the female, a more diffuse and consequently less intense manifestation of the sex instinct.

The menstrual function occurring regularly in animals so placed, must have served beneficially in giving the mothers continually recurring periods of ensured rest (for so far as we know coitus is universally desisted from during menstruation) and in teaching the males continual lessons in self-restraint.

Relation of Menstruation to Rut.—There is a wide-spread belief that these phenomena are identical. Thus a very recent writer (Letourneau) states that “menstruation is essentially identical with the intimate phenomena of rut in the females of mammals and corresponds to an ovarian congestion, or to the swelling and bursting of one or more Graafian follicles. A few writers have in recent years

disputed this view, among whom may be chiefly mentioned Lawson Tait.

There are many who believe that the rut or œstrus, or pairing time, is conditioned by ovulation—that ova are only shed at these intervals causing the phenomena. There is no basis of facts for this statement. The examination of many rutting animals proves that ovulation goes on at all times. The origin and significance of rut are uncertain, but it seems probable that the habit has been developed by natural selection for the purpose of limiting the chance of fertilisation to certain seasons mainly with reference to dietetic and climatic requirements for the offspring.

Among the mammalians this period is found at all times of the year. Thus, the bat pairs in January and February; the wild cat and fox in February; the weasel in March; the musk ox in August; the badger in October; the orongo-antelope in November and December.

When the different cases are enquired into it will be found that the time of pairing is related to the duration of pregnancy, it being necessary that the young should be born at a time when they stand the best chance of living.

Thus the majority of mammals produce offspring early in the year; in the tropics at the beginning of the rainy season—the time of birth evidently being related to abundance of food, water, warmth of climate, conditions most favourable to existence. In polar and temperate regions the animals pair at a later period than in warm countries. These differences are seen when the same species are placed under different climatic conditions.

When no definite pairing system exists, as among elephants, whales, many rodents, the explanation is very evident. The conditions of their environment and of their food supply are such as not to necessitate the birth of offspring at special times.

Among the primates it is doubtful if there is a rutting season among many species. It is stated by some observers that it exists in the orang-outang and gorilla. In general it is to be expected that in the simiadæ and anthropidæ, whose food supply is of a much more diverse nature than in the lower mammalians, consisting of animal and vegetable matter in different forms, there is no necessity for the birth of offspring at special times. Moreover, it must be remembered that the anxious time as regards the newly born does not last only for a few months after birth in the simiadæ, but for years, the period of infancy being long just as in the case of *homo*. It is therefore likely that as far as food requirements are concerned one season is as propitious as another for birth.

Another important factor must be borne in mind, viz: that where there is a strong development of parental affection and conjoint parental care for the young, an important additional reason exists for diminishing the necessity of special pairing seasons. This is all the more marked in the anthropidæ where, owing to a higher intelligence, individuals learn to combat the injurious influences of their environment and to make it possible for the offspring to have as good a chance of surviving at one time of the year as at another.

If then, there be found exceptional cases of special pairing season among the higher primates, it must be because natural selection has conserved the habit in relation to the special conditions in which those species are placed.

Among the reptilians and birds, the rule is that pairing occurs in the spring, and it is probable, that, as Westermarck points out, the worldwide association of the springtime with the awakening of sexual affinities has been based upon the observations made mainly on birds.

The modifications in the pairing season which can be induced by artificial means, *e. g.*, domestication, are a strong evidence in favour of the influence of external influences on reproduction among the higher vertebrata. Indeed, it is evident that just as rut becomes adapted to the requirements of separate species, so it may become altered in relation to the needs of individuals under varying conditions.

Another interesting fact must be mentioned viz: that while the rutting-period is practically the only time when the females will copulate with the males, the menstrual period is the time above all other periods when they will not engage in this act. This is universal among mankind and is true for the simiadæ as far as our observations go.

Moreover, the changes in connection with rut result among other things in softening and dilating the outer genitals for the reception of the penis, they being at other times in many animals too much constricted for this. It is well-known that a bitch will not generally allow the dog near her until the rut has been in progress for a time, *i. e.*, until the vulva and vagina are sufficiently dilated.

So far as our facts go, it seems likely that rut in the higher vertebrates is merely the expression of the force of sexual affinity necessary to ensure fertilisation of the ovum, which is found throughout the whole animal kingdom, diffusely spread in the lower forms, highly specialised and limited in the upper forms owing to the influences of environment and natural selection, and affecting both males and females alike. This participation of the males is important to bear in mind. It is found everywhere. Thus many fishes when the love period arrives put on brilliant colours, become vigorous and play about

among the females in the most lively fashion—evidently in a state of sexual excitement. In some, *e. g.*, the stickleback and salmon great pugnacity is manifest. The male salmon develops a special crook in connection with the lower jaw at this time, while the teeth enlarge, markedly. Among many amphibians also many changes affect the males, sexual desire becoming very marked. Among the reptilia similar changes occur, the male tortoise for example being fierce and noisy. In snakes the scent-glands become active during the pairing-season.

Among the birds the changes in the love-season are very marked. The male is altered in various ways and takes to dancing, coquetting and to vocal and instrumental music. His scent-glands grow active; his ornaments become more marked, and he develops strong fighting tendencies.

Among mammals the intensification of sexual desire in the males, accompanied with a feeling of jealousy and a keenness to fight, is universal. In all orders the voice is used in the rutting-time more than in any other season. Indeed, the porcupine and giraffe are said to be mute at all other periods. In stags the larynx and thyroid enlarge when rut comes on. The nose of the male sea-serpent becomes greatly elongated. In the bladder-nose seal the hood covering the head becomes markedly inflated. Scent-glands emit strong odours. In some cases the colour of the skin changes. *Among the great majority of females no such marked changes occur.* They play their normal role of passivity, the changes brought about by the wave of sexual excitement being mainly psychical.

In many mammalians the only physical changes recognizable at the œstrus are congestion of the soft parts in the pelvis, dilatation of the vulva and the vagina, and the free discharge of mucus which is often blood-stained. These differences between males and females in regard to the rutting period are in keeping with the organic distinction to which I have so often referred in this paper.

The manifold changes in the males are the outcome of their predominant katabolism.

The females need to conserve their energies, *i. e.*, their anabolic surplus, for the strain of pregnancy; consequently there is no waste in outward exuberant manifestations, except in very slight measure in the cases to which I have just alluded.

Finally, it may be stated that the relation of rut to menstruation in mammalian evolution is simply this—that when, owing to the various reasons which I have elaborated in an earlier part of this paper, menstruation appeared as a new variation, one of the factors in determining the escape of the anabolic overplus by way of the genital tract was the habit already fixed, in many of the mammalians with a bicornuate uterus of the periodic yearly pelvic congestion of the rutting time.