ANATOMY AND PHYSIOLOGY

OF

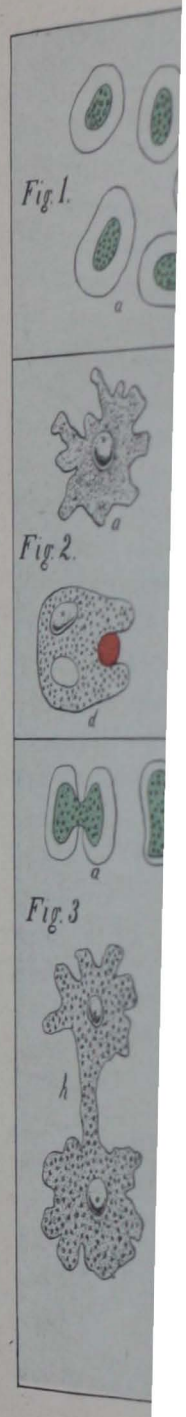
REPRODUCTION.

HEN pursuing the study of "the human form divine," the anatomist or physiologist is often led to pause in the midst of his dissections or observations, and to exclaim with the Psalmist, "Great and wondrous are Thy works." Even the atheist, who recognizes no Omnipotent Hand as the Creator of all the marvels which greet the investigating scientist at every turn, is loth to believe himself to be a creature of chance, and is prone to erect an altar dedicated to the worship of Nature, even if he fails to recognize the God of Nature. That wonderful machine which we call the body is the masterpiece of the Infinite Artist. In every detail of fibre and structure and function, the most marvelous wisdom and foresight are displayed, and such an adaptation of means to ends as none but an infinite mind could devise. In no part of this wonderfully delicate and complicated mechanism is this

more strikingly to be observed than in that portion of the body devoted to the perpetuation of the species,—a function in the performance of which the interests of the individual are subjugated to those of the race. To the set of organs to which this important work is allotted in woman, and to the nature and peculiarities of their several functions, this section is to be devoted; but before entering upon the special consideration of the reproductive system, and as a preparation for the most perfect understanding of the subject, we will take a hasty glance at life and its functions in general, and at the structure of the body and its several parts, with their various functions.

Animated Atoms.—Let us begin at the very foot of the scale of animate being. Did you ever observe the filmy coat of green which covers the bottom of a half-dried pool by the roadside? or the greenish accumulation which occurs in old and uncleansed eaves-troughs? If so, gather a little of this same green substance and bring it to our laboratory where we will study it with care by the aid of a powerful microscope and learn a lesson in the science of life from the lowly forms which we may observe.

Everything being in readiness, we place beneath the microscope a little speck of the green slime, and find that the characteristic color of the same is due to the green coloring of the myriads of minute specks of life of which it is composed. The exact appearance of these under the microscope is well shown in Fig. 1, Plate I, to which the reader's attention is invited. Each little speck is what is known to the biologist as



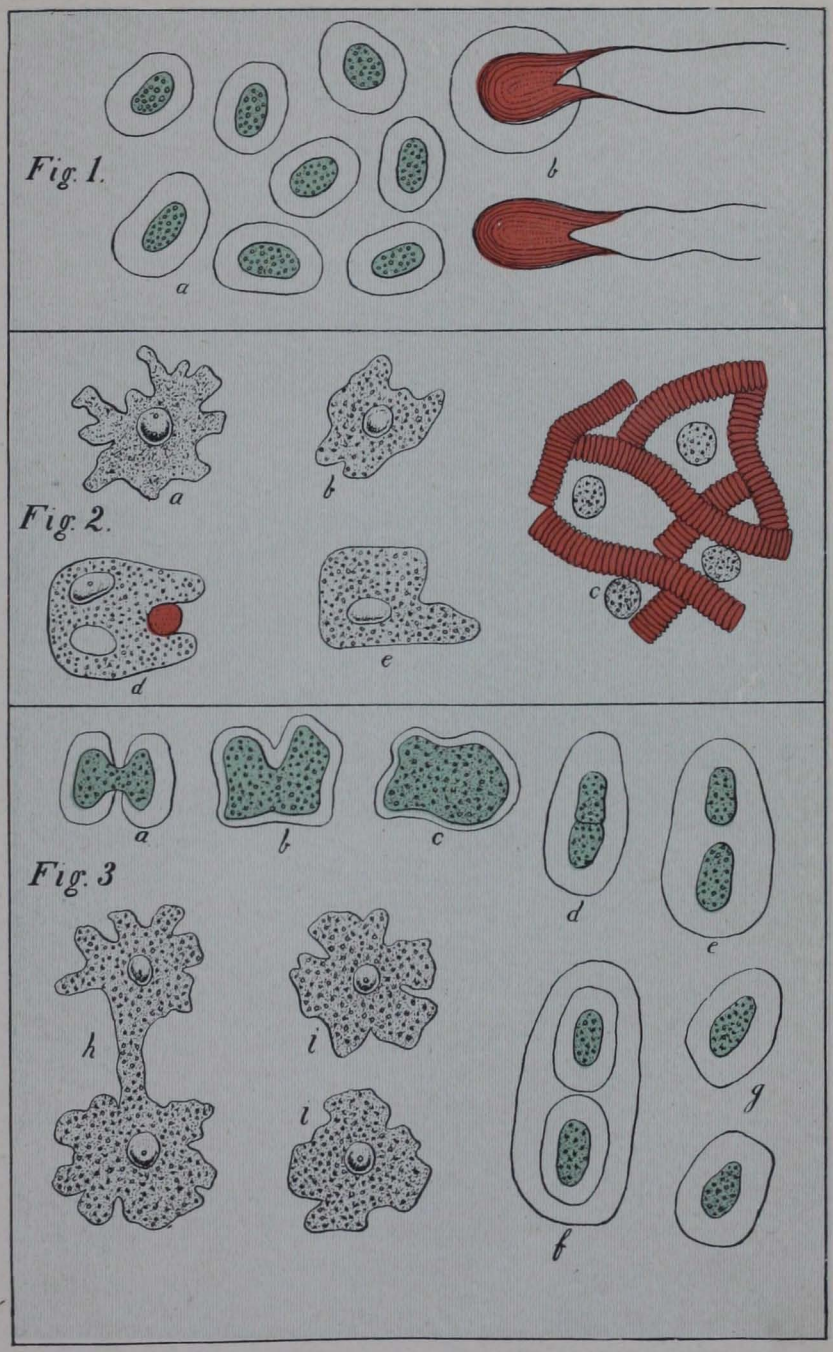


PLATE I.—Low Forms of Life.

a cell. It is composed of a gelatinous substance of the consistence of jelly, transparent in all parts except its center, at which may be seen sundry little greenish specks to which the color of the aggregated mass is due. This humble creature, infinitesimal in size, is as much a living being as the proudest monarch, and bears the name of *protococcus*.

A little careful scrutiny of the object will probably reveal other forms of life closely allied to the species named, such as those shown at Fig. 2, Plate I, which are known as *amœbæ*, and which in many respects differ little from the protococcus. However, there is in reality a wide difference between these two animated specks, for one is a vegetable, and the other an animal. If we had the time at command, it would be most interesting to study closely the characteristics and habits of life of these two representative creatures; but we can only glance a moment at some of their leading points of interest.

1. They are more or less globular in form, in wide contrast with the sharp, angular outlines of a crystal of salt, a snowflake, or a minute grain of sand. This is true of all living bodies.

2. They eat. Although they are not possessed of teeth, or even of mouths, they may be observed to eat, each in its own way, and choosing its own proper food. The protococcus, our little green plant, subsists upon the minerals and gases which exist in the moist earth where it finds its home. A careful examination of the amœba suggests a reason why it is found in close proximity to its humble relative, since

it is found to contain within its central portion, sundry fragments which are evidently the remains of a protococcus upon which it has made a sumptuous meal.

3. They grow. As they absorb and appropriate nourishment, they increase in size, up to a certain limit, each passing through the several stages of existence peculiar to its species. In many of these lowly forms, as in some higher, some of the stages of the existence of a single individual involve such remarkable changes that it loses all semblance of its former appearance and would not be recognized as the same by the most acute observer. This is true of the protococcus, as will be seen by comparing the different forms shown in the Plate.

4. They move about. The property of voluntary or spontaneous motion is usually associated with animals only; but this rule does not apply to the little creatures which are found at the lowermost end of the scale of animate existence. Here both animals and vegetables are endowed with the power of motion. The protococcus, at least at certain stages of its existence, possesses two little filaments by the constant motion of which it propels itself rapidly through the water when it is immersed, or wriggles along the face of a moist surface. The amœba, our atomic animal, possesses still greater powers of motion and locomotion. It has no limbs, no feet, no hands, no wings, and yet it moves about with great facility, and sometimes after a very lively fashion.

5. They increase in numbers. These infinitesimal

beings, like the larger members of the animated world of which they are the types, possess the power of reproduction, by which their respective races may be preserved from extinction. Of the exact modes of reproduction here illustrated, we shall take occasion to speak elsewhere, and need not say more in this connection except to mention that they are essentially the same in each of the two little creatures which we are considering as representatives of the two great divisions of the organic world, animals and vegetables.

6. After living its allotted span of life and performing its due share of labor in the great workshop of the world, each of these two little creatures "pays its debt to nature" and returns to its mother earth whence, directly or indirectly, it came.

Are animals and vegetables then so nearly alike? The verdict of science is that the chief distinction which can be made between these two great classes in the lowest forms is in the character of the food upon which they subsist. The vegetable finds its food in the inanimate elements of the soil, moisture, and air. The animal cannot appropriate this kind of nourishment, and feeds upon the vegetables to which it is so near akin, or upon its brothers of the animal kingdom.

Slight as is the difference between the two classes, animals and vegetables, the difference between lowly vegetable forms and higher, and between the amœba and higher animals, is still less. The giant oak is in reality only an aggregation of living cells each of which is essentially like the protococcus. The mammoth ele-

phant, man himself, is but a community of little creatures of which the amœba is a type. Take a drop of blood from the finger; place it under the microscope, and we find in view thousands of little creatures, some of which are so nearly like the amœba which we found in the slime from a stagnant pool that the most powerful microscope scarcely shows any difference (Fig. 2, Plate I). These little creatures are known as the white blood-corpuscles. Each drop of the vital fluid contains these and millions more of other little creatures known as the red blood-corpuscles, which are simply white blood-corpuscles grown old. Tear off a little bit of tissue from the liver and submit it to the scrutiny of a powerful magnifying glass. This too we find to be composed of curiously shaped little living creatures. These living atoms have each their particular individual work to do; the red corpuscles to carry oxygen, the white ones to repair injured portions of the body and in their old age to become red corpuscles, and the cells of the liver to make bile. In the kidneys are found other peculiar creatures to which is assigned the duty of removing from the body certain impurities which together form the urine. In the stomach are found creatures which are adapted to the work of making gastric juice to digest the food. Other cells in the body, devoted to mechanical work, form the muscles. In the brain and spinal cord are found still other active creatures which do our feeling and thinking for us. Thus the whole body is divided into groups of cells, each group being assigned a special work to do, just as the mem-

bers of a community might be grouped according to the several trades to which its members are devoted.

Having now gained a few fundamental ideas respecting the general make-up of the body, let us proceed to study its several parts with greater care, so that we may be better prepared to understand their relations to each other and to the whole. We will consider first,

THE NUTRITIVE SYSTEM.

All organized beings require a more or less constant supply of new material to promote the processes of growth and repair. In order to make this material, termed food, available for the purpose designed, a set of organs has been provided which are collectively known as

The Digestive Apparatus.—A quaint author described an animal as a stomach with various accessory organs for ministering to its wants. This remark presents in a somewhat exaggerated light the relative importance of the digestive apparatus if we consider the human animal alone; but if we are to regard the animal kingdom as a whole, it cannot be considered as very much overdrawn. By some mysterious alchemy, the exact nature of which is by no means well understood, the stomach reduces to a soluble form and a homogeneous character a great variety of substances which are used as human food, and which after absorption are by further processes still more marvelous and mysterious, converted into the various

tissues and elements which compose the body. The stomach and its accessory organs are the means by which fresh material is brought into the body to take the place of that which has become worn out and useless, and provides the necessary pabulum for the growth and development of the yet immature body. The digestive apparatus consists first, of

The Alimentary Canal, a muscular tube about thirty feet in length, extending from the mouth to the anus, along which are arranged the various accessory organs which take part in the process of digestion. At each end this canal is guarded by a sphincter muscle for the purpose of retaining its contents during the process of digestion. Beginning at the upper end, we will examine in detail each of the organs of digestion in the order in which they occur.

The Teeth, twenty in number in the child and thirty-two in the adult, are arranged in the upper and lower jaws, being equally divided between the two. Their function is to reduce the food to a pulverulent condition so that it may be easily swallowed and may be readily acted upon by the digestive juices. The maintenance of the health of the teeth requires their vigorous use in the mastication of food requiring trituration.

The Salivary Glands.—Arranged on either side of the mouth are three glands, the office of which is to secrete a bland fluid which moistens the food and softens it preparatory to the act of swallowing, and at the same time acts an important part in the chemistry of digestion, as we shall see presently.

The amount of salivary fluid secreted depends very largely upon the length of time the food is masticated, as its secretion is stimulated by the act of chewing.

The Œsophagus, or Meat-pipe.—The back part of the mouth is known as the *pharynx*, which contracts at its lower part to form a small tube which extends downward to the stomach and is known as the *œsophagus*. After the food has been masticated, it is thrown back into the pharynx by the tongue, and by a process of squeezing and pulling is carried down to the stomach.

The Stomach.—This organ, although one of the most important of the various organs engaged in the work of digestion, is not, as is generally supposed, the essential one. It performs only a part of the work of digestion, and may be dispensed with as easily as any one of a number of other organs which are associated with it in the perfect elaboration of the food. The stomach is simply a dilated portion of the alimentary canal, holding about three pints when moderately distended. Its lining membrane is filled with little glands which secrete a fluid known as gastric juice, which contains a peculiar substance known as pepsine, the properties of which we will discuss presently. The gastric juice is intensely acid, and is secreted in great abundance during the process of digestion.

The Intestines.—From the stomach downward, the alimentary canal continues as a small tube for the greater portion of its length, expanding about five feet from its termination to form the large intestine,

or colon, and again contracting a few inches from the end, forming the rectum, its terminal portion. All along its course, but especially in that portion known as the small intestine, this part of the alimentary canal is plentifully supplied with glands which secrete a complicated fluid which has an important part to play in the work of digestion. While the process of digestion is in progress, the intestines are in constant motion, wave-like motions, termed peristaltic movements, traversing their whole length, from the stomach downward, one following another with a sort of rhythmical action. Similar movements also take place in the stomach while that organ is engaged in the digestion of food.

The Liver.—This organ, the largest gland in the body, is located just beneath the ribs on the right side of the body. Its left portion projects over the stomach somewhat. The function of the liver is a complicated one. Besides its work of making bile, to which it may be said to be chiefly devoted, it also performs very important offices in the process of digestion, and other important functions which may be more properly mentioned elsewhere. The bile is conveyed from the liver to the intestine, which it enters a few inches below the stomach, by a duct, which is joined before it reaches the intestine by another duct coming from an organ close at hand which is also involved in the digestive process.

The Pancreas.—This is a gland in many respects closely allied to the salivary glands. The fluid which it secretes, the pancreatic juice, is a very

important digestive agent and very strongly resembles the salivary juice. It will receive further attention when we consider the digestive fluids.

The Spleen.—This organ is so closely associated with the digestive apparatus that it has been long surmised that it is in some way involved in the process of converting food into blood; but as yet, what part, if any, it acts, has not been made out. It is located in the left side, just under the lower border of the ribs. It is usually not large enough to be felt, but often becomes considerably enlarged in persons who reside in a malarious country, sometimes, as in a case which we have now under treatment, to ten or twelve times its natural size, which is scarcely larger than that of the closed hand.

The Portal System.—All the blood from that portion of the digestive system included in the abdominal cavity, is gathered into one large vein by which it is carried to the liver, a very wise provision of nature, since it necessitates that whatever is taken into the blood-vessels from the stomach must pass through this natural strainer before it can mingle with the blood of the rest of the body. This relation of the liver to the portal circulation is important, as it explains some cases of disease of other abdominal organs which would otherwise be inexplicable.

The Five Digestive Juices.—From the above description, it appears that there are five distinct digestive fluids; viz., the *saliva*, the *gastric juice*, the *bile*, the *pancreatic juice*, and the *intestinal juice*. Each of these several juices has its particular work to perform in the digestive process.

Food, in its relation to the digestive organs, may be divided into the following classes :—

1. *Nitrogenous* elements, represented by the albumen of eggs, the lean portion of flesh, and the gluten or vegetable albumen of plants ;

2. *Farinaceous* and *Saccharine* elements, represented by the various kinds of starch and sugar ;

3. *Oleaginous* elements, found in the various sorts of vegetable and animal fats ;

4. *Indigestible* and *Innutritious* elements, as the cellulose of plants and the tendinous and indigestible portions of flesh food.

For each one of these classes, except the last, nature has provided a distinct digestive fluid.

The saliva digests starch, converting it into sugar. It also changes cane sugar into grape sugar.

The gastric juice digests albumen, caseine, gluten, and all other digestible nitrogenous elements, and does not digest any other of the elements of food.

The bile digests the fatty elements of the food, and no others. The digestion of fats consists in their conversion into an emulsion and the saponification of a small portion.

We have still two digestive fluids, the pancreatic and the intestinal, although we have found provision for the digestion of all the digestible elements of food. What use have we for them? Here we see an illustration of the wonderful economy of nature. Lest any small portion of the food should escape without complete digestion, she has provided extra means for the digestion of the several elements of which our food is composed, as follows :—

The *Pancreatic Juice* possesses the remarkable property of being able to digest two of the elements of food, and those very dissimilar in character, the farinaceous and the oleaginous; so that if there is any portion of the starch or sugar which escapes the action of the saliva, it may be acted upon by the pancreatic fluid; and the fats not digested by the bile, still have a chance for digestion by the same agent.

The *Intestinal Juice* is a still more wonderful fluid, since it is able to digest all the elements of food. This remarkable property is undoubtedly due to the fact that it is the combined product of the action of a very large number of different glands, and so is undoubtedly very complicated in its composition.

Absorption.—After the food has been reduced to a fluid state by the action of these various juices, it is absorbed through two sets of absorbent vessels, and in some mysterious manner which is by no means well understood, is converted into blood, a sort of fluid tissue which circulates through the body for the purpose of conveying to the other tissues the required nourishment, and conveying away the worn-out material.

Disintegration and Elimination.—Every movement of a limb, every sensation, even every thought, results in the destruction or breaking down of tissue. The force employed in the various life-processes of the body is evolved at the expense of tissue. Even the act of digestion itself occasions the loss of a certain amount of tissue. This process is known as *disassimilation* or *disintegration*. The result of it is the formation in the body of certain substances known as

debris or *waste products* which are poisonous to the living tissues, and require prompt removal to preserve the body in health. When they are left to accumulate, various diseases arise, and death ensues, sometimes in a very short space of time.

To remove these useless and poisonous substances, a special set of organs is provided, which are termed *eliminative* or *excretory*. Each one of the principal poisonous elements formed in the body has its special organ to effect its removal. *Urea*, the poisonous product of the disassimilation of the muscles, is eliminated by the kidneys. *Cholesterine*, which results from the breaking down of nerve tissue, is carried out of the body through the liver. *Carbon di-oxide*, or *carbonic acid gas*, is eliminated by the lungs. Various poisonous elements are carried out by means of the skin, and still others by the intestinal mucous membrane. By the action of these several organs, the system is kept free from the waste matter which would otherwise accumulate to such an extent as to hinder the various vital processes, and in a short time obstruct them altogether.

Assimilation.—The breaking down and removal of waste products creates a demand for new material, which is supplied through digestion and assimilation. Each tissue possesses the power to repair itself, and this work is constantly going forward in all parts of the body, especially during sleep, when the process of disintegration is less rapid than at other times. Every tissue participates in this process of change, even the hardest bones. The soft tissues change very

often, probably every few weeks or months, while the more solid tissues probably change as often as every few years, if not more frequently. The blood, a fluid tissue, changes completely every few weeks.

THE MOTOR SYSTEM.

All of the voluntary and involuntary movements of the body are the result of the contraction of the minute fibres of the muscles, which constitute the fleshy portion of the body. The bones also participate in many of the bodily movements, particularly those of a voluntary character, by affording points for the attachment of the muscles.

THE NERVOUS SYSTEM.

In the brain and spinal cord, and to some extent in other parts of the body, there are to be found curious little cells, which vary greatly in size and shape, and are exceedingly minute, but which possess similar and very remarkable properties. When examined closely, it is found that these little creatures are provided with delicate prolongations of their substance, which may be compared to fingers, and which may be traced from the cells themselves to the most remote parts of the body in many instances, while in others they seem to be joined to other cells in the immediate vicinity. Some cells are furnished with a very large number of these fingers, while others have but one or two, or even none at all. Certain cells

send fingers to the eye, others to the ear, still others to the nose, others to the tongue, and others to the skin.

Thus it is that the various sensible properties of objects are perceived by the brain. Its cells are extended into the remotest parts of the body by means of their immensely long fingers, and thus are conscious of whatever is transpiring at the surface or outside of the body. Similar fingers are sent out by other cells to the muscles, and muscular action is produced by impulses received from the cells in the brain or spinal cord. Other cells send out fingers to the stomach, and through their influence the work of digestion is performed. Still other cells have charge of the work of the liver in a similar manner. Thus all the work of the body is done through the influence of the little creatures which reside in the brain and spinal cord. By means of fingers sent out by other cells, all the various parts of the body are associated together in the closest sympathy. Every member sympathizes with every other member. When one suffers, all suffer.

THE REPRODUCTIVE SYSTEM.

ALL of the organs and systems of organs thus far considered, relate to the individual exclusively. Their object is the development and maintenance of the individual life. Reproduction has for its object the production of new individuals. This, so far as physiology teaches us anything on the subject, is its sole and entire function. It has reference to the race, not to the individual. Its exercise ought to be wholly unselfish in its object, though the human species, unlike the majority of lower animals, too often prostitute it to basely selfish purposes.

As this book is intended for one sex only, we shall in the consideration of the anatomy of reproduction, confine the description to the reproductive apparatus of the human female, although the consideration of the physiology of reproduction will require us to study to some extent the function in both sexes, and in lower animals.

The organs of reproduction in both sexes may be divided into two classes,— *essential* and *accessory*. The essential organs are those which produce the reproductive elements known as the *zoösperm* or *spermatozoa* in the man, and the *ovum* in the female, the former being produced by the essential organ of reproduction of the male known as the *testicle*, and the latter by the *ovary*, the essential reproductive organ of the female. The other organs concerned in reproduc-

tion in the female are chiefly for the purpose of protecting the young human being during its development. The concise description of the various organs involved in the process of reproduction which we shall attempt to give, will be best understood by reference to Plate A, which represents the middle portion of the body as divided vertically through the center.

Beginning with the most external portion of the reproductive apparatus, we find, first, two fleshy folds known as the *labia*, which unite in front at a prominence known as the *mons veneris*, which, with the *labia*, is in the adult covered with a thick growth of hair. A vertical slit separates the labia, a short distance from the lower or posterior end of which is the *anus*, or circular opening of the lower end of the alimentary canal, or intestine.

Just within the labia are two smaller folds of tissue known as the *labia minora*, which unite at the upper end, forming a sort of sheath, beneath which is the *clitoris*, which corresponds to the *penis* of the male. The clitoris is composed of erectile material, which is also true of the *labia minora*. Both of these parts are abundantly supplied with nerves of sensibility, and together they constitute the chief seat of sensation in the sexual act.

Just below the clitoris is a small opening known as the *meatus urinarius*, the external orifice of the *urethra*, a small passage connected at its inner end with the bladder, and serving as a means of out-let for the urinary secretion.

A short distance below the *meatus urinarius* is an-

other opening which leads into the *vagina*. This opening is usually partially closed by a thin membrane termed the *hymen*. In some cases the vaginal orifice is nearly closed by the hymen, while in others there is but a mere trace of membrane. In exceptional cases the hymen may be wholly absent, or may completely close the mouth of the vagina. The presence or absence of the hymen is not, as was formerly supposed, a test of virginity. As just indicated, it may be absent normally, and cases are not rare in which it persists after marriage or even after childbirth, though it is usually ruptured at the first sexual intercourse.

The *vagina* is a canal lying between the bladder in front and the rectum behind. Its length is usually four to six inches. It is lined with mucous membrane which lies in folds so as to allow distention at parturition. Its walls contain muscular fibres by the contraction of which, at least in part, the canal is made to return to its normal size after childbirth.

Projecting into the inner end of the vaginal canal, as may be seen in the Plate, are to be found the fleshy lips of the lower end of the *uterus*, or *womb*. This organ is pear-shaped in outline. Its length is about three inches. It is somewhat flattened, being about two inches wide at its broadest point, and one inch thick. Its tissue is chiefly muscular, its fibres being of the unstriated, or involuntary, variety, which contract independent of the will, like those of the stomach and bladder. The upper or larger portion of the organ is known as the *fundus*, or *body*, the

lower or tapering portion, as before stated, being termed the *cervix* or *neck*. The cavity of the uterus differs in form in different parts of the organ. In the fundus it is triangular, the apex of the triangle pointing downward. The cavity of the cervix is fusiform. The two cavities, that of the fundus and that of the cervix, are separated by a constriction known as the *os internum* or *internal os*. The lower opening of the cervix or mouth of the womb is termed the *os externum* or *external os*. The uterus lies in the pelvis between the bladder and the lower portion of the large intestine, being somewhat inclined forward from the axis of the trunk. The cavity of the uterus is lined with mucous membrane, which is covered with a peculiar kind of cell known as ciliated epithelium. These cells are conical in shape, being attached by their smaller extremity. The outer or free extremity is covered with minute, hair-like processes which are constantly in motion. In the lower portion of the womb their motion is such as to produce a constant current inward toward the cavity of the body; while in its upper portion their action is in an opposite direction.

The upper angles of the body of the womb are so constituted as to form two small tubes, one on either side, known as the *fallopian tubes*, or *ovi-ducts*, which terminate in a sort of fringe. At each extremity the canal of the fallopian tubes is scarcely large enough to admit a bristle. Through the middle portion of the tube the canal is considerably larger. The fallopian tubes, like the vagina, are lined with mucous mem-

brane, and, as is the case with the uterus also, their lining membrane is covered with ciliated epithelium; but instead of moving inward, the motion of the cilia in the tubes is toward their outward extremity which communicates with the uterus, the object of which is to carry the ovum toward the cavity of the uterus, as will be presently seen.

On either side of the uterus and near its central portion are located the essential organs of reproduction, the *ovaries*. Each ovary is about one and one-half inches in length, and is placed horizontally, as shown on Plate VI. The ovary is held in position and connected to the uterus by a broad fold of membrane known as the broad ligament, which also supports along its upper border the fallopian tube, the outer extremity of which curves downward and terminates near the ovary. Each ovary is also joined by its inner end to the upper angle of the uterus by a small twisted cord known as the ligament of the ovary. When the ovary is cut in two, as shown on Plate IX, and examined by means of a microscope, it is found to be filled, especially near its outer border, with small cells, which are undeveloped or unripe ova, destined to be matured and cast off one at a time at each menstrual period during the life of the individual, some, under favorable circumstances, to be developed into human beings.

The Bladder.—The bladder in females is located in front of the uterus, and is somewhat larger than in the male, its measurement from side to side being greater than from before backward. The urine is dis-

charged from the bladder through a canal about one-fourth inch in diameter, known as the *urethra*, the opening in which is just above the upper edge of the vagina.

The Rectum.—This portion of the alimentary canal, its inferior terminus, lies behind the uterus and the vagina in the hollow of the sacrum, its lower end being guarded by a circular muscle known as the *sphincter ani*. Between the lower part of the rectum and that of the vagina is placed a wedge-shaped body, the broad base of which occupies the space between the anus and the vaginal opening. This structure is known as the *perineum*. It is a muscular structure, but is possessed of considerable solidity, and plays a most important part in maintaining the internal organs in proper position. It is sometimes ruptured in parturition, giving rise to serious disease, as elsewhere shown.

Blood Supply of the Uterus and Ovaries.—The blood supply of these associated organs is chiefly derived from the same source, the uterine and ovarian arteries connecting in such a way as to make the circulation of the ovary and uterus practically the same. The blood-vessels of the uterus are distributed through its substance in such a way as to very readily give rise to passive congestion, being very tortuous, and venous obstruction occurring very easily. This accounts for the great readiness with which the organ becomes subject to diseases of various sorts due to passive congestion.

Nerves of the Uterus and Ovaries.—The nervous supply of the uterus and ovaries, as well as of the other internal organs of generation, is chiefly derived from the organic or sympathetic system of nerves, very few sensory nerves being found in their substance. This accounts for the very great degree of insensibility to pain characteristic of these organs in a state of health. The nervous supply of the ovaries, uterus, and vagina, is still more closely associated than the blood-vessels of these organs, nearly all the nerve-branches being derived from the same source; which accounts for the very close nervous connection which is observed in both health and disease, but particularly in the latter condition. The nerves supplying the uterus and ovaries are chiefly derived from the nerve-centers of the lower part of the spine, which also send branches to the external tissues lying in their vicinity, which undoubtedly accounts for the great prominence of pain in this region as a symptom of uterine disease.

Supports of the Uterus.—The womb is held in place by a variety of forces brought to bear on it. In a state of health and when unimpregnated, the uterus weighs scarcely more than an ounce and a quarter, so that little force is required to retain it in position. Nevertheless, ample means are supplied to keep it in its proper place, such as are sufficient when there is no departure from the conditions upon which depends the maintenance of these organs in a state of health. The uterus is connected with the adjacent organs by six ligaments. Two connect its posterior

surface with the rectum; two other ligaments connect it anteriorly with the posterior wall of the bladder; while its sides are connected with the sides of the pelvis by means of two broad folds of tissue known as the *broad ligaments.* These ligaments are not composed of fibrous tissue as are ligaments in other parts of the body, but are simply folds of the serous membrane lining the abdominal cavity, known as the *peritoneum.* They are not muscular in character, and so do not possess the power of contraction, though they sometimes become contracted as the result of disease.

The broad ligaments, with the uterus, divide the pelvic cavity into two portions. The anterior part contains the vagina, bladder, and the anterior half of the uterus, while the posterior portion contains the rectum and the posterior half of the womb. The ovaries, as before described, are located in the broad ligaments which form this septum. These bands of tissue undoubtedly play an important part in maintaining the uterus in position, and yet they are so placed that they cannot prevent the organ from settling down into the cavity of the pelvis, or changing its position in various other ways, when any degree of force calculated to displace it is brought to bear upon it.

The maintenance of this organ in its proper place is undoubtedly chiefly due to other means than the ligaments just described. Probably the most efficient of these is the support of contiguous organs,—the rectum, bladder, and portions of the small intestine

which lie closely about the uterus,—and the perineum, the wedge-shaped body occupying the space between the lower portion of the vagina and the rectum. The latter organ must be regarded as the chief means by which the descent of the uterus is prevented when the trunk of the body is in a perpendicular position. The perineum is located some distance below the uterus, and is connected with the latter organ only through the vagina; but the vaginal walls possess sufficient firmness when in a healthy state, to act efficiently as a prop for the womb attached to their upper extremity. The efficiency of the vagina as a support for the uterus by the aid of the perineum, is greatly increased by the concavity of its posterior wall, which will be observed by reference to Plate A, being supported behind by the rectum, in front by the bladder, and below by the perineum. The vagina is an efficient means of maintaining the uterus in position so long as its walls retain their proper "tonicity" or firmness.

The muscular walls of the abdomen must also be regarded as an efficient means of supporting the uterus and ovaries in position, acting indirectly through the intestinal viscera. The uterus and ovaries lying in close contact with the organs which occupy the lower portion of the abdomen and the upper part of the pelvis, are supported by them so long as the intestines and neighboring organs are held in position by the abdominal walls. When the muscles of the abdomen lose their tone, so that they no longer support the contents of the abdominal cavity, and allow

them to drop down into the pelvis, the uterus and ovaries will be crowded out of position in spite of the support which they receive from several ligaments, the vagina, and the perineum. It is probable also, that the pyri-form shape of the uterus aids in keeping it in position, the adjacent organs being packed around its lower portion in such a way as to sustain it. This is evidenced by the fact that its position varies with that of the bladder and rectum. When these cavities are both distended, the organ lies higher than when they are empty. When the bladder is empty and the rectum distended, it is tilted over toward the former, and vice versa. The last named means of support for the uterus has been too often overlooked, and, as we shall hereafter show, this oversight has given rise to injurious and unsuccessful methods of treating uterine displacements.

The Pelvis.—This is a cavity formed by the union of several bones, the *ossa innominata* forming the two sides, and the wedge-shaped *sacrum* and *coccyx* the posterior portion. Four joints are formed: one by the union of the ossa innominata,—the *symphysis pubis;* two at the points of union between the ossa innominata and the sacrum; and the fourth by the junction of the coccyx with the lower end of the sacrum. These joints are not flexible joints like those of the fingers, elbows, or most other joints of the body, but are almost immovable under ordinary circumstances, the bones being held together by strong ligaments. In advanced age they often become solid; in fact, this change may occur in males in early life.

The form of the pelvis will be best seen by referring to Plate II. We would call especial attention to the expanded lateral portion of the pelvis, formed by the broad iliac bones, the space between which is known as the *false pelvis*, and to the opening through the pelvis, forming quite an essential cavity, known as the *true pelvis*. The line separating the false and the true pelvis is known as the brim of the true pelvis, a term often used in midwifery, the significance of which ought to be understood on that account. Just opposite the symphysis pubis is a prominent point also of especial interest in this connection, known as the promontory of the sacrum, formed by the upper portion of the sacrum, which projects into the true pelvis, lessening its diameter from before backward. Upon the greater or less prominence of this promontory depends, to a great degree, the ease or difficulty with which child-birth may take place. Attention should also be called to the arch formed beneath the symphysis pubis by the divergence of the lower portions of the ossa innominata, which support the weight of the body in sitting. This arch, with the space between the lower part of the symphysis pubis and the coccyx, forms the outlet of the pelvis.

Differences between the Male and the Female Pelvis.—There are several important differences between the pelvis in males and females which should here receive attention, which will be best understood by referring to Figs. 1 and 2, Plate II.

These may be enumerated as follows :—

1. The bones of the female pelvis are more slen-

der than those of males, and present smoother surfaces.

2. The female pelvis is much wider than that of the male, the distance between the extreme points of the ossa innominata being proportionately much greater than in the male pelvis.

3. The true pelvis is very much larger than in the male; and the distance between the brim and the outlet proportionately less, which is due to the fact that the sacrum is shorter and the arch beneath the pubis much wider than in the male.

4. The sacrum in the female pelvis is much less curved than in the male pelvis, so that the canal of the pelvis is much straighter in the female than in the male pelvis.

Some of the differences above noted are made more apparent by the comparative views of the male and female pelvis given in Figs. 1 and 2, Plate II. It will also be observable that the prominent points on the interior surface of the pelvis project into its cavity to a much greater distance in the male pelvis than in the female.

Some of the above mentioned peculiarities of the female pelvis, particularly the greater divergence of the large bones of the pelvis, give to the female figure its chief characteristics. The ancient Greeks, in their models of female beauty, made the measurement across the hips one-third greater than across the shoulders, reversing these measurements in their representation of male beauty in Apollo. It is this great breadth across the hips which occasions the swinging

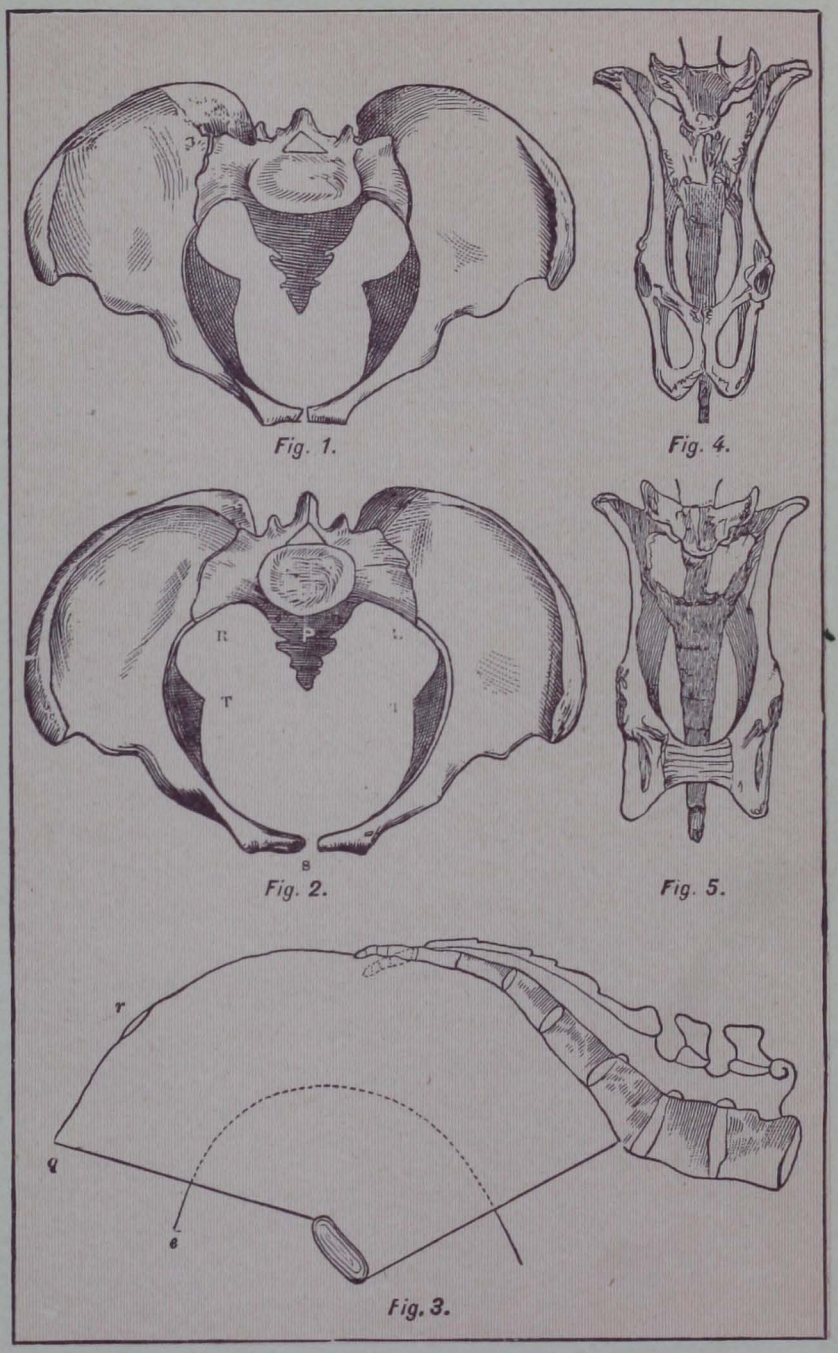


PLATE II.

gait in females in whom the size of the pelvis is unusually prominent. The greater the width, the more marked will be the peculiarity of the gait.

Canal of the Pelvis.—The space between the brim of the pelvis and its outlet constitutes what is known as the cavity or canal of the pelvis. The outlet is very irregular and incomplete in its bony outline, but is rounded and completed by the soft parts. When thus completed, its proportionate length and direction is about as represented in Fig. 3, Plate II. The strongly curved character of the canal will be at once noticed; also the fact that the symphysis pubis, located at the point marked S in Fig. 2, is almost directly under the promontory of the sacrum, P. It will thus be seen that the brim or inlet of the pelvic cavity looks almost directly backward when the person is standing erect, while the outlet of the pelvis looks forward. This peculiar arrangement is characteristic of the human pelvis, and is designed to give to the contents of the abdominal cavity the proper support while the body is in the erect posture peculiar to human beings. In the lower animals the canal of the pelvis is almost straight; which is wholly compatible with the prone position natural to all the lower orders of animals.

Measurements of the Pelvis.—The principal measurements of the pelvis are as follows: from the upper edge of the symphysis pubis to the promontory of the sacrum, four and one-half inches; transversely across from T to T, as shown in Fig. 2, Plate II, five and one-fourth inches; obliquely across from O to L or O to R, five inches. These dimensions are those

obtained by measuring the cavity at the brim. It is found that measurements vary considerably at different portions of the canal. At the middle portion of the pelvic cavity the oblique diameter is more than five and one-fourth inches, while the transverse measurement is only five inches, or one-fourth inch less than at the brim. At the outlet, the transverse measurement is only four and one-fourth inches, or one-fourth inch less than at the brim of the pelvis, and the oblique four and three-fourths inches, or one-fourth inch less than at the brim, and one-half inch less than at the middle of the cavity; while the antero-posterior diameter is five inches, or six when the coccyx is forced back, as it is during the last stage of child-birth. It thus appears that at the brim the transverse diameter is the greatest, at the middle of the cavity the oblique diameter, and at the outlet the antero-posterior. This relation of the different measurements of the pelvis gives rise to the change in the position of the head of the child during child-birth, known as rotation, which will be more fully explained hereafter.

The remarkable curve of the pelvic cavity and the peculiar relation of its several diameters make the act of child-birth in the human female much more complicated and difficult than in the females of the lower animals, in whom the canal is usually straight, although in some instances, as in the cow and the guinea-pig, it is much too narrow to admit of the passage of the young animal. In these cases, however, a remarkable change takes place during the few weeks prior to the termination of pregnancy. In the guinea-

pig, the ligaments which unite the ossa innominata at the symphysis pubis become greatly relaxed, so that the cavity can be greatly enlarged during parturition by the separation of the ends of the bones. This is well shown in Figs. 4 and 5, Plate II. In the cow the same thing takes place at the junctions of the ossa innominata with the sacrum, allowing the bones to be separated at these points to such a degree as to greatly enlarge the pelvic cavity. After parturition, the ligaments in both animals very quickly shorten again, so that the bones return to their normal relation with each other.

A change somewhat similar to that described above takes place in the human female prior to child-birth. Numerous observations have shown that the change which occurs is almost identical with that which takes place in the pelvis of the cow, and occasional instances are known in which the change noted as taking place in the guinea-pig has occurred in the human female. A few years ago, a case of this sort came under our observation, in which the separation of the ossa innominata at the pubis was so great that the bones did not return to their normal position again, but remained movable, giving rise to a considerable degree of motion, which was accompanied by a grating sound whenever the patient exercised upon her feet.

Another interesting fact which should be mentioned in this connection as having an important bearing on the size of the pelvic cavity, is the fact that the several parts of the pelvis sustain different relations to each other in different positions of the body.

When the body is in a standing, sitting, or lying position, the promontory of the sacrum recedes somewhat, making the brim or inlet of the true pelvis larger than when the body is in other positions. When the body is bent forward upon the thighs, the symphysis is tilted forward by the contraction of the abdominal muscles, thus diminishing the size of the brim and enlarging the outlet. This accounts for the positions naturally taken by women during the different stages of child-birth. At the beginning a sitting, standing, or lying position is preferred, while during the later stages, the body is bent forward, or the limbs drawn up.

The Breasts, or Mammary Glands.—These organs are so closely associated with the organs of generation in the female that a description of the latter would not be complete without including at least a general account of the former. The breast is situated between the third and sixth or seventh ribs, and extends from the sternum to the axilla. The left breast is usually a little larger than the right. In the center of the breast is located the nipple, which is of a rose-pink color in a woman who has not borne children, and is surrounded by a ring of tissue somewhat different from the surrounding skin, and of the same color as the nipple. Upon the surface of this ring several little tubercular projections may be seen, at the top of which may be observed, upon close inspection, a number of little openings, which are the orifices of small glands producing an oily secretion which protects the nipple. These minute structures are mentioned on account of the peculiar changes

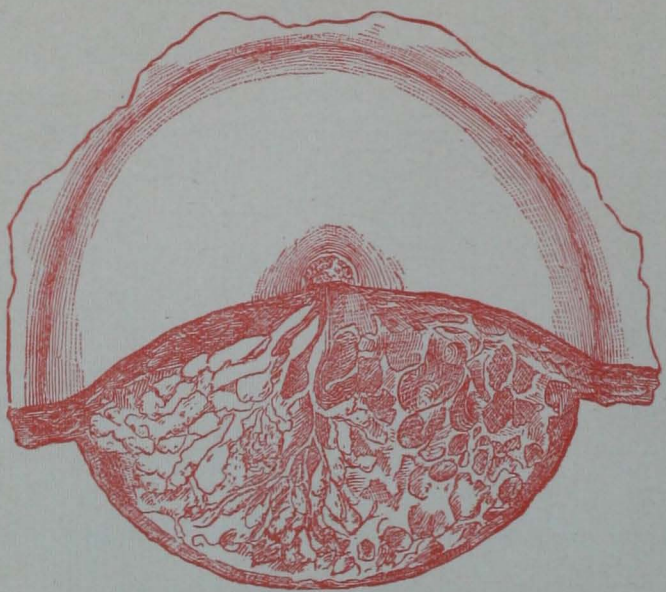


Fig. 1.

Fig. 2.

PLATE VIII.

which occur in them during pregnancy. The nipple is very liberally supplied with blood-vessels and involuntary muscular fibres, and is exceedingly sensitive. Upon being irritated, the nipple becomes charged with blood, undergoing erection, and a slightly pleasurable sensation is produced. The great bulk of the breast consists of fatty or adipose tissue, underneath which is placed the glandular and essential portion of the breast, which consists of a large number of lobes and lobules, as shown in the lower part of Fig. 1, Plate VIII. Each lobule is divided into still smaller lobules, in the interior of which are found a large number of cells, by which the milk secretion is produced. Each lobule communicates with a small duct, which joins with other ducts, and thus forms a larger canal, which in turn unites with other canals of the same character, forming still larger ducts, some fifteen or twenty in number; all of these converge toward the nipple, near which they become considerably dilated, forming reservoirs, in which the milk collects. At the base of the nipple, the ducts are reduced to a small size again, and are continued up through the nipple without uniting together, each opening at the surface by a separate orifice. The milk-ducts and reservoirs contain a large number of muscular fibres in their walls, which are capable of contracting and thus diminishing the size of the tubes. Irritation of the nipple, either by the mouth of the child or otherwise, causes dilation of the openings of the ducts, and at the same time a contraction of the walls of the ducts within the glands, by which

double action the milk is made to flow freely. This action is sometimes reproduced by emotional excitement of any kind, so that the milk is expelled involuntarily and lost. It sometimes happens that irritation of one gland will cause expulsion of milk from the other, so that nursing the child at one breast will occasion a loss of the secretion at the other.

Lymphatic vessels are very abundant in the breast, by which the watery portion of the milk may be absorbed. The action of the lymphatics may be increased by friction, which furnishes an excellent means of lessening the milk secretion when necessary.

The mammary gland is a peculiar modification of the sebaceous or oil glands, which are very abundant in the skin. It is present in all animals which have warm blood and bring forth their young alive. These animals are known as mammals, in consequence of their possession of *mammæ*. A very interesting study in natural history is the peculiar arrangement and location of the mammary glands in different animals. In one animal known as the "duck-bill," a native of Australia, the mammary gland consists simply of a flat surface not covered by hair, which presents numerous little openings for the milk-ducts. In some animals the breast is a cavity or depression in the surface rather than a prominence. In one very curious class of animals known as marsupials, to which belong the kangaroo and opossum, the breasts consist simply of nipples, which are inclosed in a pouch, into which the young are placed after their birth, each young one becoming attached to a nipple,

to which it clings until it is developed; when it undergoes a sort of second birth. The young of these animals are very imperfectly developed when first born. In bats, the breasts consist of a single pair, which are placed upon the chest in the same position as in human beings. In whales, the breasts are located very close to the vulva. In dogs and pigs, the breasts are arranged in a double row extending nearly the whole length of the body.

Certain anomalies and irregularities sometimes occur in the formation of the breasts, which are not uninteresting. Cases are sometimes met in which there are two or three nipples on one gland. In some instances, there are more than two breasts. Usually the extra breast or breasts are located near the ordinary position, but sometimes they are found on distant parts of the body, as the back or thigh, or in the axilla.

In the male, the breast is usually only rudimentary, but cases are on record in which the gland has been abnormally developed in the male to such an extent as to produce an abundant supply of milk. A case is reported in which a colored man acted as wet-nurse in the family of his master for many years.

The secretion of milk in the female breast is not usually formed until toward the termination of pregnancy, but by a long continued process of manipulation and stimulation, the gland may be made to produce milk freely in virgins. In some countries, wet-nurses are systematically produced in this way. The curious fact has been observed that milk is some-

times secreted by the mammary gland in very young infants, the secretion usually commencing at birth or two or three days afterward, and continuing for two or three weeks. Usually only two or three drops can be pressed out of the nipple at one time, but occasionally the amount of fluid is increased to one or two drachms. This anomalous secretion of milk is observed with equal frequency in both sexes.

Before pregnancy, the breast, when fully developed, is hemispherical in form, and possessed of considerable firmness, but after nursing, during which time the breast is considerably enlarged, the tissues become somewhat softer and flabby or pendulous.

THE REPRODUCTIVE FUNCTIONS.

Wonderful as they are in their anatomical structure, the reproductive organs are still more remarkable in the functions which they are designed to perform. To them is allotted the important work of producing new individuals, and thus perpetuating the race. They enable man to become in a certain sense a creator. Their function may be regarded as the highest of that of any of the organs of the body, if we except the brain, the organ of thought and feeling. Although their office relates particularly to new beings, rather than to the individual, their association with the other organs of the body is so intimate that any derangement of function is quickly followed by disease of other parts, as we shall have occasion to show more fully hereafter. Their functions

are also largely controlled by the varying conditions of the body which affect the functions of other organs, sometimes being suspended, sometimes exaggerated, by influences which may similarly affect other organs.

A fact of importance which it is well to understand, is that the sexual function, being the least concerned in the maintenance of individual life, is more likely to be suspended than other functions, when through lack of nutrition, wasting disease, or any other depressing cause, the vital forces of the body are impaired. This fact accounts for the cessation of menstruation in connection with tubercular disease, anæmic conditions of the body resulting from hemorrhage or otherwise, and other morbid states in which the vitality is at a low ebb, instances of which are frequently observed. We have mentioned this fact in this connection for the purpose of correcting the popular notion that the suspension of menstruation, one of the leading sexual functions in woman, is in these cases the cause of the other morbid conditions with which the disease is associated; whereas, as just explained, it is simply a result, and is of no greater significance than other symptoms growing out of the fundamental morbid condition under which the system may be suffering.

Notwithstanding the immense amount of study and research which has been bestowed on the sexual function in man as well as animals, there is still much mystery connected with the subject. Nature has not yet allowed inquisitive man, even when aided by the most powerful microscope and other instruments of

investigation which he has invented, to fathom all the secrets connected with the marvelous process by which new beings are created. Nevertheless a sufficient amount of knowledge has been developed to render this subject exceedingly interesting, and to disperse to a large extent the mists of ignorance by which it has been surrounded from the earliest times down to the present. We shall not attempt to present in the brief space devoted to this part of the subject, all that is known respecting the functions of the reproductive organs, but only some of the more salient points, and such as have some relation to the practical information to which the greater portion of this work is devoted.

In order to make more clear and comprehensible the nature of the function in human beings, we have introduced a few illustrative facts respecting the function in the various lower orders of animals. By these and other means, we have endeavored to so simplify this intricate subject as to bring it within the understanding of all who are sufficiently mature in mind to be capable of comprehending it and profiting by the instruction given in this work.

Ovulation.—A microscopical examination of the fully developed ovary shows that its interior is chiefly made up of an almost infinite number of little sacs, each one of which contains a small cell as shown in Fig. 3, Plate IX. This is true of the ovaries of all species of higher animals. When the female of any species of animal attains a certain stage of development, these cells begin to work toward the surface of the

ovary. One by one they approach the outer surface of the organ, together with the little sac in which each is contained, which increases gradually in size during its approach toward the surface, and finally, when the surface of the ovary is reached, becomes distended to many times its former size, by the accumulation of serum within its cavity. The little cell in the meantime becomes attached to that portion of the sac nearest the surface of the ovary.

By and by the distension of the sac becomes so great that it can no longer retain its contents, when it ruptures with considerable violence, thus allowing the escape of its fluid contents, which sweep along with them the little cell for the development of which this curious arrangement was designed. The final act in the process which we have just described, has been well shown by the artist in Fig. 4, Plate IX. The little cell which is thus forcibly ejected from the ovary by the process just described, is really an egg, composed of a delicate membrane inclosing a yolk.

Viviparous and Oviparous Animals.— Up to very nearly the present time it has been supposed that a radical difference existed in the mode of development of viviparous and oviparous animals, or those which bring forth their young alive, and those which produce eggs to be afterward hatched outside the body. Modern researches, however, have shown that no such radical difference exists, but that the young of all higher animals, including those which bring forth their young alive, are really produced from eggs, the only difference being in the manner in which these eggs are developed.

Procreation a Budding Process.— The affinity between man and the lower orders extends still further down the scale of animate existence. The student of biology is familiar with the fact that in certain low orders of animals, as, for instance, the *hydroids*, the multiplication of the species takes place by a kind of budding. The hydroid is a sort of animated shrub of jelly-like consistence. It is usually found growing attached to rocks and various solid or stationary bodies, in little communities. From the parent stems little buds grow out, some of which after a time break off and swim away as independent little jelly-fishes. These, in turn, become attached to a submerged rock or an aquatic plant, and after becoming fully developed, give rise to other buds, thus perpetuating the species. This is a process of external budding, but in other species of lower animals the same process takes place on the interior of the parent animal. This is the case, for example, with the *distoma*, or "*fluke*," a parasitic creature one species of which makes its home in the human liver. In one stage of its existence, this little animal consists of a long yellow sac, looking like a yellow worm. From the interior of this sac little buds arise, which become developed into new beings, and these, in time, come to resemble their parent, and perpetuate the same curious process.

This same budding process actually takes place in human beings, the little cell or egg ejected from the ovary being in fact nothing more nor less than an interior bud produced in that organ and separated by a

process not very different from that by which the little buds of the *polyp* or the distoma are separated from the parent. The chief difference between the budding process in human beings and in the lower orders referred to, is that in the case of the former the little bud separated from one parent cannot develop into a perfect human being without uniting with a similar bud from another individual of the opposite sex.

Ovulation Periodic. — The above described budding process or casting off of an egg or ovum does not take place continually, but occurs periodically. This is true of all classes of higher animals as well as of the human female. The length of the interval between the periodical repetitions of this process varies in different individuals and different classes of animals. In the human female the ovum is matured once every four weeks, or in twenty-eight to thirty days, a period corresponding very nearly to the lunar month. In the horse, cow, rabbit, and numerous other animals, the period is very much shorter. Completion of the development of the ovum and rupture of the vesicle containing it, is hastened by sexual congress.

Menstruation.—In connection with the maturation and casting off of the ovum, various other changes take place in the sexual organs which are accompanied by a greater or less disturbance of the whole system. In the lower animals this is termed the "œstrus," "heat," or "rut." At this period in lower animals there is usually a considerable degree of congestion of the whole generative apparatus; the secretions of

the vagina and the neighboring parts are greatly increased in quantity and somewhat changed in quality. In the female dog the mucous membrane of the vagina becomes very red and somewhat swollen, and produces an abundant secretion slightly tinged with blood. This secretion also produces at this time a peculiar odor, which attracts the attention and appears to stimulate the passions of the male animal. The same condition is observed in the rabbit, and in certain species of apes the congestion involves not only the sexual organs themselves, but extends to the neighboring parts, involving the skin of the buttocks and thighs and the under part of the tail. The general system of the animal is also affected very considerably. For example, the cow, on the near approach of the œstrual period usually loses her appetite and becomes very restless. If feeding in a field, she will frequently suddenly stop grazing, and run rapidly from one side of the field to the other, looking about in a startled, uneasy manner, and presenting every evidence of peculiar excitement. This condition continues for two or three days, when the animal returns to her natural condition again.

A fact of significance which may be mentioned here is that the female of these animals will not allow the approach of the male except during or just after the œstrual period, which careful observation has shown to be the only time when sexual contact is likely to be fruitful. The bearing of this important fact will be referred to elsewhere.

In the human female, ovulation is accompanied by

changes very similar to those which occur in lower animals as just described. The following is a description of the changes which occur as given by Dalton:—

"The menstrual discharge consists of mucus mingled with blood. When the period is about to come on, the female is affected with a certain degree of discomfort and lassitude, a sense of weight in the pelvis, and more or less disinclination to society. These symptoms in some instances are slightly pronounced, in others more troublesome. An unusual discharge of vaginal mucus then begins to take place, soon becoming yellowish or rusty-brown in color, from the admixture of a certain proportion of blood; and by the second or third day, the discharge has the appearance of nearly pure blood. The unpleasant sensations, at first manifest, then usually subside; and the discharge, after continuing for two or three days longer, grows more scanty, its color changing from red to a rusty or brownish tinge until it finally disappears, and the period comes to an end.

"The menstrual epochs of the human female correspond with the periods of œstruation in the lower animals. Their general resemblance to these periods is very evident. Like them, they are absent in the immature female, and begin to take place only at the period of puberty, when the aptitude for impregnation commences. Like them, they recur during the child-bearing period at regular intervals, and are liable to the same interruption by pregnancy. Finally, their disappearance corresponds with the cessation of fertility.

"The period of œstruation in many of the lower animals is accompanied with an unusual discharge from the generative passages, frequently more or less tinged with blood. In the human female, the bloody discharge, though more abundant than in other instances, differs only in degree from that in many species of animals."

During menstruation, the uterus and ovaries are considerably increased in size by the physiological congestion to which they are subjected. This naturally gives rise, in most cases, to an increased activity of the reproductive instinct, as in lower animals. The nature of the menstrual flow has been the subject of much speculation. As before stated, it consists of the natural secretions of the vagina and uterus, which are greatly augmented in quantity, mingled with more or less blood, in many cases consisting chiefly of blood. When present only in a normal quantity, it has been observed that menstrual blood does not coagulate. This fact has led to the supposition that the blood of the menstrual discharge is different from that of the body in general; but very careful investigation of the matter shows that this peculiarity of menstrual blood is the result of its mixture with the acid secretions of the vagina, by which its coagulation is prevented. This view is sustained by the fact that when the blood is present in large quantity it does coagulate, just as when discharged from any other part of the body.

Whether or not the menstrual discharge is to any degree an excretion, is a question not yet well settled;

but it is perhaps probable that the secretion of the utricular glands, which are found very abundant in the lining of the cavity of the uterus, is to some extent at least, an excretory product. The serious disturbances of the general system which are occasioned by a sudden suppression of the menstrual flow, support this idea. Further support of the same notion is given by the fact that the secretion of urea by the kidneys is diminished fully one-fifth during menstruation. It is not to be supposed, however, that the menstrual discharge possesses anything of the extremely noxious character attributed to it by the ancients, who supposed it to possess the power to blight everything with which it came in contact, even vegetation being said to wither and droop within a few hours after being exposed to its influence.

The length of time that the flow continues varies considerably in different individuals. In some women the flow is present only one or two days, while in others it continues from five to eight days without any apparent injury to health. The average is probably about four days. The amount of the discharge has been variously estimated, some placing it at three or four ounces, and others as high as seventeen ounces, or more. It is probable that the smaller estimate is about the average amount in healthy females. It has been observed that the flow is more abundant in women of indolent or sedentary habits than in those accustomed to active labor; also in persons of feeble constitution than those of robust health. It is also stated that the average amount of the dis-

charge is greater in women residing in cities than in those who reside in the country or in country villages.

The origin of the blood is the interior of the uterus, from the walls of which it exudes very much like perspiration from the surface of the body. For several days previous to the occurrence of the discharge, the mucous membrane of the uterus has been found to undergo peculiar changes, increasing to several times its usual thickness, and undergoing a sort of fatty degeneration, by which the walls of the capillaries are weakened to such an extent as to allow the passage of the blood through them. This change in the character of the mucous membrane of the uterus is undoubtedly a sort of preparation for the reception of the ovum, which is becoming matured at the same time, preparatory to its passage into the uterus.

A considerable portion of the menstrual discharge consists of epithelium which has been softened and exfoliated. Sometimes the epithelium is thrown off in the form of large patches, which frequently have the appearance and consistency of membrane, and which is occasionally so extensive as to present a cast of the inside of the uterus. This has led to the erroneous belief that the mucous membrane of the uterus is actually thrown off at each menstrual period. This is not so, however, even in cases of what is known as *membranous dysmenorrhœa,* in which what appears to be the mucous lining of the uterus is simply a false membrane somewhat similar to the membranous formation in croup.

The ancients held many very singular notions respecting the function of menstruation, among which was the idea that the moon exerted a powerful influence over this function. This notion has retained its hold on the popular mind more or less even to the present time. It has in fact been so firmly held by some, that an eminent French astronomer a few years ago thought it worth his while to devote several years to a careful study of the subject. After making several thousand observations, he stated as the result of his study that no relation whatever could be traced between the menstrual function in women and the phases of the moon.

Vicarious Menstruation.— In some cases in which the regular menstrual flow is suppressed or absent, the discharge of blood takes place from some other part of the body, as from the nose and lungs or stomach and bowels, or even from the surface. This discharge has been termed vicarious menstruation. The flow of blood which occurs in these cases cannot be considered as a natural menstrual discharge. The condition is one of disease, and will be considered elsewhere.

Fecundation.—The process by which the male and female elements of generation are united to form the embryo of the new individual, is termed fecundation. This is a process of so great interest from a physiological stand-point that it will be well worth while to consider it at some length, studying the mode in which it takes place in lower forms of life, and lower animals, as well as in human beings. At

the lower limit of the scale of life, are found numerous species of plants and animals which consist of a single cell. Although, in some of the simpler forms, the different individuals of the same species are to all appearance exactly alike, there being no physical characteristics by which to distinguish the sexes, there is evidence for believing that the property of sex is possessed by these minute creatures, since it has been observed that reproduction does not take place without the occurrence of a process essentially the same as that of fecundation in higher animals. In the case of these lower forms, however, the process of fecundation involves the whole individual, rather than a minute element produced by either sex. In studying this process, a male and a female cell, both so nearly alike that no distinguishing features can be discovered by the most powerful microscope, may be seen to approach each other, and soon after coming in contact, to become so completely united as to form one homogeneous cell. Soon after this takes place, the one individual thus formed begins to subdivide, first separating into two halves, each half again subdividing in the same manner until a large number of individuals are formed from the original two, or from the one individual formed by the union of the first two. In this class of creatures, fecundation involves the loss of the identity of the parents. This form of fecundation or reproduction is illustrated on Plate I, Fig. 3. The rapidity with which the process above described may occur is truly astonishing. In a species of the *protococcus* which sometimes appears in win-

ter, covering in some instances large tracts of country, producing the remarkable phenomenon of green snow, the multiplication is so rapid that more than 60,000 individuals may be produced from a single pair in one hour, and in thirty minutes more time a number exceeding that of the inhabitants of the globe.

In the higher orders of plants we observe a process of fecundation of a much higher type. The male and female elements of generation are produced by flowers, which are the sexual organs of plants. In many cases the two elements are produced by distinct flowers, either from the same plant or from separate plants, although in some cases the two elements are produced by different parts in the same flower. The male element is known to the botanist as the *pollen*, which is produced by the *anthers*, usually borne at the top of long filaments termed *stamens*. By various means, chiefly through the agency of the wind and the visits of insects from flower to flower, the pollen is carried from the male flower or the male parts of flowers to the end of the pistil or pistils of the female flowers, on which the little pollen grains are lodged when the process of fecundation begins. A little sprout is sent out from the pollen grain and down through the pistil of the flower to the ovary at the base of the pistil, in which is secreted a little cell or a number of minute cells, corresponding to the ovum of female animals. When the ovum is reached by the little filament from the pollen grain, the process of fecundation is completed, and the pro-

cess of development begins, and in due time results in the production of a perfect seed, from which another plant may be produced. The reproductive organs of plants and the process of fertilization are well represented on Plate III.

The devices of nature for accomplishing the act of fecundation in plants are so marvelous as to be almost incredible. The following graphic description of the process we quote as a concise statement of the results of the most recent scientific investigations: —

"Deep hidden within the flower's heart lies the little nursery where the seeds are born; most cunningly the pistil and the stamens watch each other like true lovers for a greeting; tenderly the petals close around them in the cool, and open through fit hours of sunlight. And when the stamens and the pistil cannot meet directly, but the message must be borne by insect rovers, then the complication of contrivance to secure the transport of the message almost exceeds belief. The pollen must be brought from a certain spot in one flower and left on a certain spot within another. Says one, speaking of Darwin's investigation of the orchids: 'Moth-traps and spring-guns set on these grounds, might be the motto of these flowers. There are channels of approach, along which the nectar-loving insects are surely guided, so as to compel them to pass the given spots; there are adhesive plasters nicely adjusted to fit their proboscides or to catch their brows, and so unload their pollen-burden; sometimes, where they enter for the honey, there are hair-triggers carefully set in their necessary

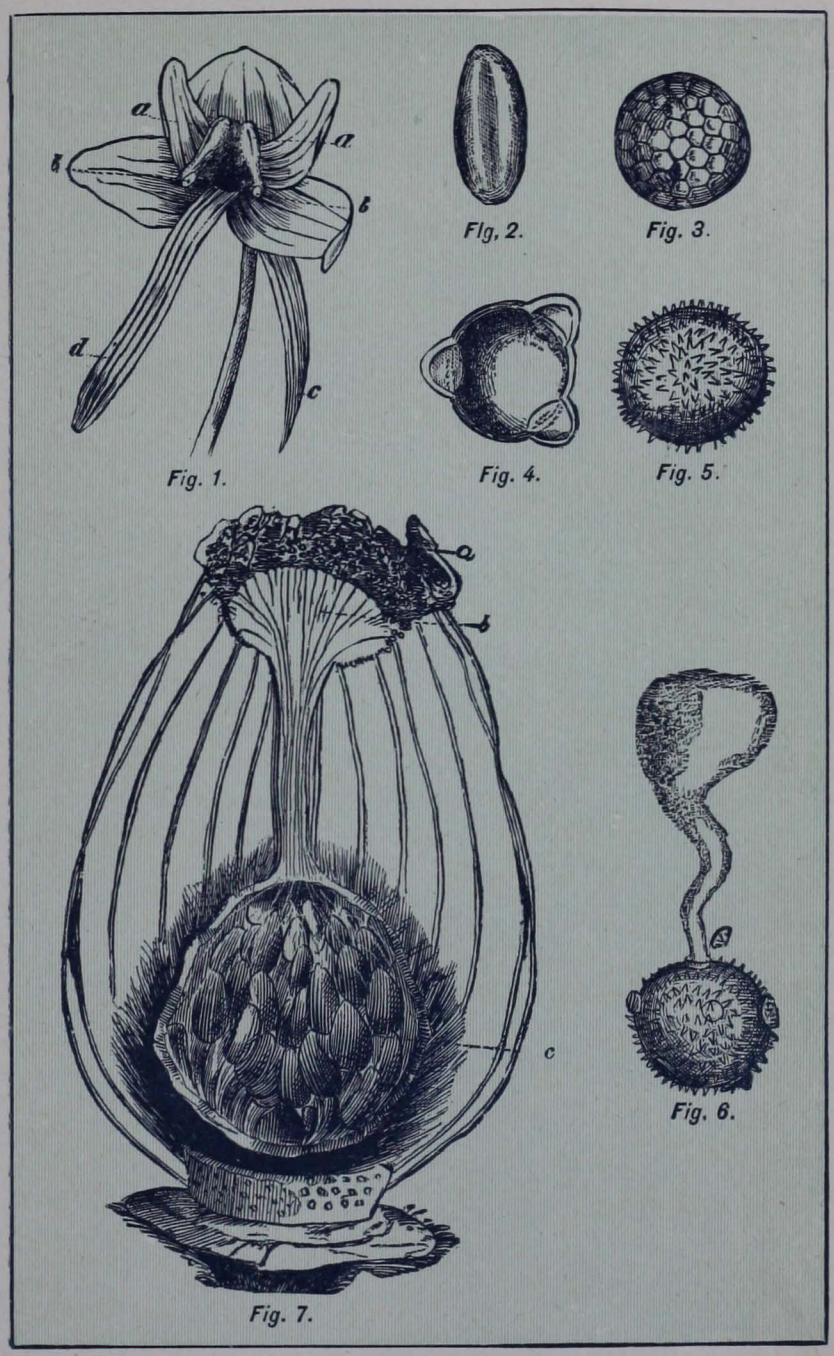


PLATE III.

path, communicating with explosive shells that project the pollen-stalks with unerring aim upon their bodies.'"

In all except the very lowest forms of animal life, reproduction is performed by the union of a male and female element produced by separate individuals or by separate parts of the same individual, as in the case of the higher plants. This is true even of the minute infusoria, which have been demonstrated to reproduce their species by means of eggs.

In some classes of animals, as the tape-worm, earth-worm, snail, leach, and slug, the male and female elements are produced by the same individual, as is the case with many flowers; but with the single exception of the tape-worm, the species mentioned require the union of two individuals to secure the fecundation of the female element.

The curious manner in which fecundation takes place in the tape-worm is shown in Plate IX, Fig. 2. The spermatozoa are discharged from the testicle by an opening close beside the opening of the canal which receives the numerous eggs from the ovary, which constitutes the greater portion of each segment of the body of this curious creature, and readily find their way back into the interior of the segment, where the process of fecundation takes place.

Animals of this class are known as hermaphrodites, possessing, as they do, both male and female organs of generation. As before remarked, however, the earth-worm, leach, slug, and snail, which are also hermaphrodites, require for fecundation the union of two

individuals. This is true of most of the true hermaphrodites, and is probably also true of many hermaphrodite flowers, the sexual organs of such flowers being often so placed that self-fecundation is much more difficult than fecundation by means of pollen brought by the wind or insects from other flowers.

Some curious instances of true hermaphrodism or double sex have been observed in human beings. Most cases of hermaphrodism, so-called, are really cases in which there is deformity of the sexual organs producing a resemblance to the opposite sex, the cause of which will be explained presently. There are a few cases on record, however, in which individuals have possessed in a degree of development more or less complete, both male and female organs of generation. This anomalous condition would be very difficult of explanation if it were true, as was formerly supposed, that the testicles in the male are the analogues of the ovaries in the female. Some of our most eminent modern biologists, however, have disputed this view, which has been so long held and considered thoroughly established, and some observations have been made in the development of the lower animals which have led to the conclusion that the ovaries and testicles, while in a certain sense analogues, are not really so in the same sense as are the clitoris in the female and the corresponding organ in the male. Among the most interesting of these observations were those made by Van Beneden, who studied with great care the development of polyps. He found that the testicle in these animals is devel-

oped from the outer portion of the embryo, while the ovaries are developed from the inner portion. This is not true of organs which are morphologically identical. It is very probable that what is true in the development of polyps is true also in the development of higher animals and human beings. This accounts for the existence of both sets of organs in human beings, and throws some light on the nature of the fecundating process, by suggesting the idea that the male element of generation represents more specifically one portion of the human organism, while the female element represents more particularly another portion, the union of the two making the complete whole.

Peculiar Modes of Fecundation.— In all of the instances thus far mentioned, fecundation takes place within the body of the individual. In some classes of animals, however, fecundation takes place outside of the body. This is true of most fishes. At certain seasons of the year, as is well known, the female fish, loaded with ova, termed "spawn," visits certain localities for the purpose of depositing her eggs. The waters of certain rivers which empty into the sea are sometimes densely crowded with fish seeking their spawning grounds. Impelled by an imperious instinct, they force their way against the most rapid currents, leaping over obstacles, rushing through foaming rapids, never pausing even for a moment until their destination has been reached. At the same time the male fish, led by the same strong instinct, follows closely in the wake of the female, and when she has

reached her destination and deposited her eggs along the gravelly bottom of some shallow stream, he deposits in the same spot the fecundating fluid or "milt."

In a few of the osseous fishes, fecundation takes place by the union of the two sexes, as in higher animals.

In reptiles, the ova are usually fecundated outside of the body of the female, as in fishes. In certain species of frogs, the male, instead of following the female in order to deposit the fecundating fluid at the same spot with the ova, as is done by most fishes, mounts upon her back, and rides about until she has deposited her eggs, at the same time depositing the fluid by which they are fecundated.

In all the animals known as "air-breathing vertebrates," fecundation is performed by means of a union of both sexes, the male element being deposited in the generative passages of the female through the means of the accessory generative organs of the male. This stage of the process, known as copulation or sexual congress, is usually accompanied in the female, as in the male, by a discharge of fluid, the source of which is the two glands situated near the mouth of the vagina. This fluid was formerly supposed to play an important part in the process of fecundation, and was termed by Hippocrates, "female semen." The act is also attended by an intense degree of congestion of the whole sexual apparatus and intense nervous action. The exact manner in which the spermatozoa of the male find their way to the ovum which is usually located high up in the generative

passages of the female, is not thoroughly understood. Some observations have been made which lead to the belief that the uterus, during the sexual act, is in a state of unusual activity.

Some observers have described a peculiar suction action on the part of the uterus by means of which the seminal fluid might be drawn up into its cavity. Something closely allied to this has been observed in lower animals killed directly after the performance of the sexual act. In some of these cases an active peristaltic movement has been noticed in the fallopian tubes, the movement being in the downward direction, evidently for the purpose of facilitating the passage of the ovum to the cavity of the uterus. It is quite possible that a movement of the uterus designed to facilitate the entrance of the seminal fluid into its cavity may take place, although it cannot be said that such an action is thoroughly demonstrated. Indeed, it is known that fecundation may take place when there can be no such action on the part of the uterus, owing to the fact that the female is entirely passive during the sexual act. This is undoubtedly true in most of the occasional cases of rape which have been followed by pregnancy. Pregnancy has been known to occur also as the result of sexual union in which the female was unconscious, in deep sleep, or under the influence of chloroform or a narcotic.

The fact that the action of the cilia of the epithelial lining of the greater portion of the uterus and of the fallopian tubes is in the downward direction, producing a more or less constant current toward the

mouth of the womb, leads to the conclusion that there is some such action on the part of the uterus. It may be considered possible, however, that the spermatozoa find their way to the cavity of the uterus and even higher up in the generative passages by their own efforts. It is well known that when capable of fecundating the ovum, the spermatozoa are very active, and capable of propelling themselves in a suitable fluid by means of their filamentous appendages. The form and structure of the spermatozoön, or male element of generation, in man and some lower animals, is shown on Plate IV, together with human and other ova in various stages of development.

The spermatozoa may come in contact with the ovum either in the uterus, in some portion of the fallopian tubes, or even at the surface of the ovary, fecundated ova having been found in all these localities. After contact, a union of the spermatozoa and the ovum seems to take place. In some lower animals a distinct opening in the membrane surrounding the yolk has been observed, and spermatozoa have been seen crowding their way through this opening to the interior of the ovum. No similar opening has been seen in the ovum of the human female, but there is evidence for believing that such an opening exists, for it is well known that spermatozoa penetrate the wall of the ovum, or at least make their way into the interior. It is possible, however, that this may occur without an opening, as it is a well attested fact that the embryos of trichina pass readily through the mucous membrane of the intestines with-

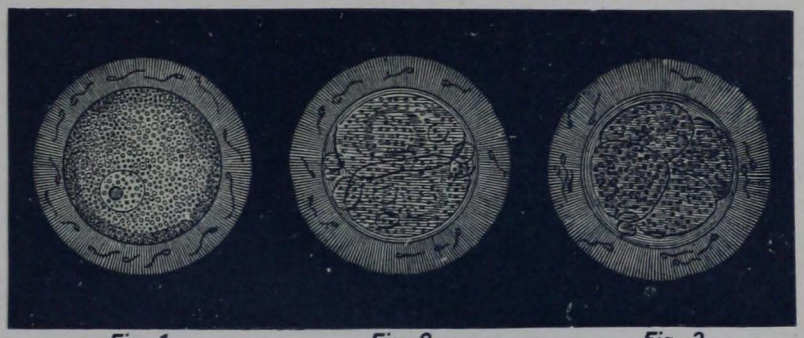


Fig. 1. Fig. 2. Fig. 3.

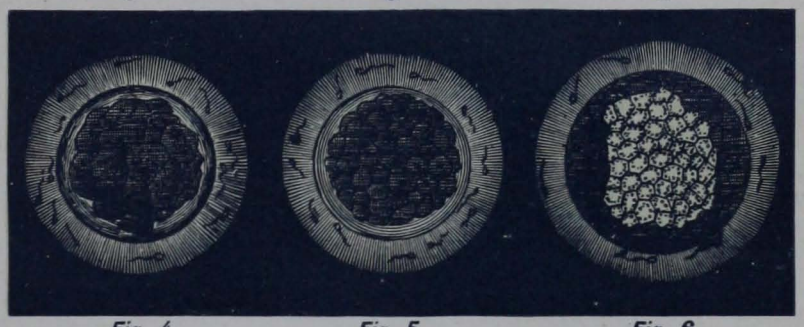


Fig. 4. Fig. 5. Fig. 6.

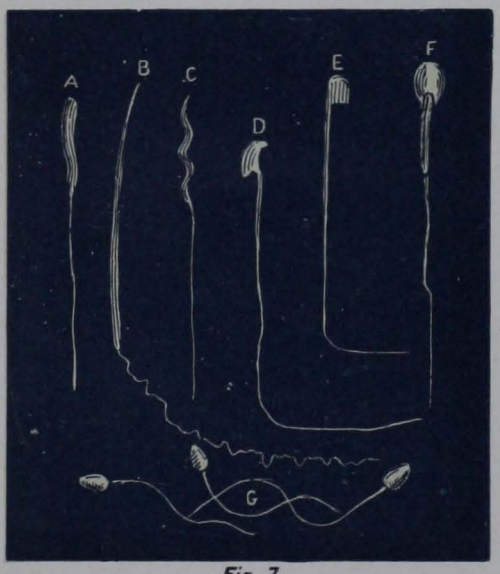


Fig. 7.

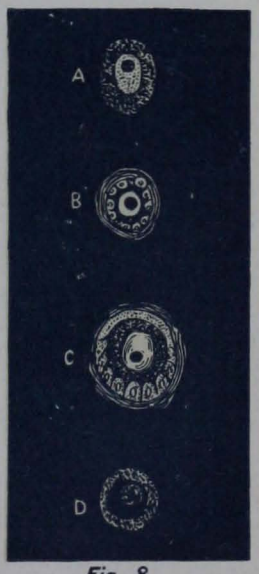


Fig. 8.

PLATE IV.

out the aid of openings. Each ovum is penetrated by a number of spermatozoa, though how many are required for fecundation is not known. Experiments with the eggs of frogs have shown that so small a quantity as three grains of the male fecundating element is sufficient for the fertilization of many thousands of ova.

The Nature of Fecundation.— The process of fecundation seems to be an actual molecular union of the male and female elements exactly similar to what we find in some of the lowest orders, in which the male and female individual are wholly lost in the individual which they unite to form, and which afterward divides into a large number of progeny. Some have supposed fecundation to be a sort of electrical process, the male being the positive element, and the female the negative. This theory is undoubtedly visionary, but it is evident that the male element supplies something which is necessary to enable the ovum to undergo development, since complete development cannot take place without fecundation, although cases are on record in which the ovum has developed to a considerable degree without the influence of the male element. It has also been suggested that the male element supplies a sort of necessary nutriment to the ovum, by which its development becomes possible. The suggestion first made is probably the correct one; viz., that the ovum and spermatozoa each contain certain germinal elements necessary for the formation of the new individual, neither being complete in itself. The only objection

to this theory is the fact that a large number of spermatozoa are apparently required for the fecundation of a single ovum. At any rate, it is well known that in the case of some of the lower animals, as, for example, the frog, a very large number of spermatozoa enter each ovum and disappear in its interior, becoming amalgamated with its elements.

It has been suggested that the sex of progeny may depend to a considerable degree upon the number of spermatozoa which unite with the ovum, a certain number being sufficient to produce males and a smaller number females. The resemblance of children to their father or mother has also been accounted for in the same way; a large number of spermatozoa uniting with the ovum producing a preponderance of the male characteristics of the sex, and a lesser number the contrary.

It is useless to devote space to a discussion of the relative importance of the male and female reproductive elements, since neither is capable of independent development.

Conception.— There is considerable evidence for believing that the union of the spermatozoa with the ovum takes place in some portion of the fallopian tubes. After this has been effected, the ovum usually soon passes down to the cavity of the uterus. Sometimes, when fecundation occurs at the surface of the ovary, the ovum loses its way, and remains in the abdominal cavity. Its progress down the fallopian tube is also occasionally stopped before it reaches the uterus. The result of its arrest in these abnormal

positions will be referred to elsewhere. When the ovum reaches the uterus, it soon becomes attached to some portion of its wall, the mucous membrane having been previously prepared for its reception by a process of thickening and the formation of little pockets, one of which receives the ovum, and to which it becomes attached. The adhesion of the ovum to the lining membrane of the uterus is known as conception. This usually takes place without the knowledge of the individual, but some women claim to be able to detect the moment at which conception takes place by peculiar sensations, usually a slight dizziness or faintness. From this time on, however, in most cases, the ovum gives no indication of its presence for some time, although very great changes in both the uterus and the ovum are taking place. These will be described presently.

It has been determined that conception is much more liable to occur at certain times than at others. In order that fecundation shall take place, it is of course necessary that the ovum should be present in the generative passage of the female either at the time of sexual congress, or soon afterward. Just how long the spermatozoa may remain active in the generative passages of the female, and capable of impregnating the ovum, is not known, but it is certain that they retain their vitality and efficiency for a number of days after copulation. The ovum is also usually retained for some days in some portion of the generative canal of the female, not usually passing off with the menstrual discharge, but some days later. It is

probably retained from four to ten days after the cessation of the menstrual flow. From these facts it is evident that conception will be most likely to occur a few days before or four to ten days after the menstrual period. Many observations have shown that with the majority of females, at least, conception is not likely to occur during the interval between the periods named. This is known to be the case with lower animals, and while it is not universally true of human females, it holds good in a sufficient number of cases to constitute a general law.

Usually but one ovum is produced at a time in a human female. The same is true of the females of many other classes of animals, as the elephant, horse, and cow. In exceptional cases two or more ova are matured at once, and under favorable circumstances may be fecundated, giving rise to multiple conception. Cases are on record also which demonstrate the fact that two conceptions may take place with a longer or shorter interval between, both ova undergoing development at the same time. This is known as superfecundation. In one case observed by a surgeon in the late war, a mulatto woman gave birth to twins, one of which was nearly white, the other much blacker than the mother. At the time of conception the woman was employed as a domestic in the house of a white man, while sleeping at night with a negro husband. The latter was so thoroughly convinced of her unfaithfulness by the sight of the white child that he turned her out of doors, notwithstanding her constant assertion of her innocence. Cases have

also occurred in which a woman has had two confinements with an interval of several weeks, a period not long enough to allow a new pregnancy to occur, but long enough to show that the second pregnancy must have taken place several weeks after the first. That such a circumstance might occur is evidenced by the fact that in some females menstruation continues several months after conception occurs. As the mouth of the womb remains open for some time, there is no obstacle in the way of a second conception in such cases.

Conception cannot of course occur before the period of puberty, previous to which time the cells of the ovaries from which the ova are developed, exist only in a rudimentary condition, as shown by Plate IV. The change known as puberty occurs at or near the age of fifteen years, and conception may occur at any time from this period until the menopause, or change of life, which usually occurs sometime between the ages of forty-five and fifty. Cases are on record in which the ability to conceive has been acquired much earlier or retained until a much later period than the ages mentioned. In one observed case, a girl became a mother at eight, and an instance is given, which seems to be well authenticated, of the occurrence of conception after sixty.

A large number of observations have shown that conception is less likely to occur between the ages of fifteen and twenty than between twenty and twenty-four, so that women marrying young are less likely to be fruitful than those marrying when more mature.

No point in biology is better settled than that the mental, moral, and physical condition of the parents at the time of conception may be impressed on the offspring, and usually has an important influence on the character of the progeny. The influence of the male parent is particularly strong at this time, probably more so than that of the female, whose influence over the offspring is fully as great ultimately, however, on account of the much longer time through which it is exerted during gestation.

Heredity.— How mental, moral, and physical traits of character are transmitted from the parents to the offspring is a problem which has not yet been fully solved, but there is no doubt as to the fact. Stock-breeders well recognize the truth of this principle, and frequently take advantage of it. Strong impressions made on the mother soon after conception has occurred, are likely to exert a strong influence on the child. The patriarch Jacob seems to have understood this physiological fact, and to have made use of it to his own advantage while caring for the flocks of Laban, as we learn from the following passage :—

"And Jacob took him rods of green poplar, and of the hazel and chestnut tree, and pilled white streaks in them, and made the white appear which was in the rods. And he set the rods which he had pilled before the flocks in the gutters in the watering troughs when the flocks came to drink, that they should conceive when they came to drink. And the flocks conceived before the rods, and brought forth cattle, ringstreaked, speckled, and spotted."

Another interesting fact which has been observed is, that an impression more or less permanent seems to be made on the female by the first pregnancy, so that the offspring of subsequent conceptions are made to partake of the characters of the male by whom the first conception occurred. On this account, breeders of blooded animals are very careful to avoid employing an inferior male, especially for the first time that the animal is made to become pregnant, since all subsequent offspring would be likely to partake of the characters of the inferior male first employed. The same thing is often observed in human beings: a woman marries the second time after the death of her first husband, and her children by her second husband are very likely to resemble her first husband as much as the second. The resemblance in the color of the hair and eyes is often particularly noticeable. In case a white woman has had children by a negro, but afterward bears children to a white man, the latter will be very sure to exhibit some of the characteristics of the negro race in a marked degree.

Cause of Sex.— It was long supposed that the right ovary in females and the right testicle in males produced elements which when united in fecundation would develop into males, while the elements produced by the left ovary and the left testicle would develop into females. The erroneous character of this theory has been amply shown by repeated instances in which the right testicle in man or the right ovary in woman have been removed on account of disease, without affecting the ability of either parent to pro-

create males as well as females. A corresponding fact has been observed in cases in which the left ovary has been removed. It is probable that the relation of the ages of the parents to each other has something to do with the determination of sex. For example, when a young and vigorous man marries a woman considerably older and less vigorous than himself, the offspring will be very likely to be males. When the contrary is the case, that is, when a man somewhat advanced in years and not in vigorous health marries a young and vigorous female, the offspring are very likely to be females.

Careful observations have been made which seem to show that the chief circumstance in the determination of the sex is the time in relation to ovulation when fecundation takes place. The evidence is pretty strong that when fecundation of the ovum occurs very soon after menstruation, the offspring will be of the female sex; while fecundation occurring several days later, just before the ovum would naturally leave the generative passages of the female if not fecundated, is pretty certain to result in male offspring. It is thus possible to predict with some degree of certainty whether the result of conception will be a male or female, by noting the time with reference to menstruation when conception occurs.

The idea has been advanced that the sex of a child is determined by influences brought to bear on the embryo after fecundation, but many facts in natural history go to show that the sex of the progeny is determined at fecundation, and there is great probability

that the theory stated in the preceding paragraph is the correct one. There must be also some reason for the theory, since it essentially agrees with the observation previously mentioned with reference to the influence of the relation of the ages and physical condition of the parents on the offspring. The ovum just ready to be cast off, might well be compared to the female advanced in years, and fresh spermatozoa to the young and healthy male married to such a female.

It is perhaps possible also that the number of spermatozoa which penetrate the ovum has something to do with the determination of sex, as well as other physical characteristics.

The Beginning of Life.— The moment fecundation is completed — the process seems to be instantaneous — the life of the new individual is begun. Within a very few hours great changes take place in the ovum, which will be described presently. What was formerly a mere speck of fat and albumen surrounded by a delicate film, is now destined to become, under favorable circumstances, a fully developed human being. This little speck contains all the possibilities of the future of the individual man or woman to be developed from it. From being a mere cell, it has now come to be a human being, of very small dimensions, it is true, but possessed of as indubitable rights, as much worthy of respect, as though it were a matured man or woman.

The idea held by the ancients that individual life did not begin until the change known as "quickening"

occurred, has no basis whatever in fact. No especial change takes place in the embryo at the period known as quickening. Whatever individuality the human being possesses exists in rudimentary form in the ovum, immediately after fecundation has taken place. From this time no radical change occurs. We have simply a process of unfolding and development, which continues until the man or woman has reached full maturity. The immediate bearing of this fact in relation to the means adopted to avoid pregnancy and the crime of abortion will be considered elsewhere.

PREGNANCY, OR GESTATION.

After fecundation, and during the subsequent process of its development, the ovum is treated in various ways by different classes of animals. Many animals, as is the case with many reptiles, deposit the fecundated eggs in the sand or in some secluded location, and give them no further attention. Fishes usually deposit their eggs, and then allow their young to shift for themselves when hatched. There are, however, some very notable and interesting exceptions to this method of treating the young among fishes and reptiles. For example, Prof. Wyman gives an account of a South American fish which carries its eggs in its mouth until long after the young are hatched. In one instance, he found a young fish nearly three inches long in the mouth of its parent. This office seems to be usually performed by the male, who plays the part of nurse for the

young of its mate. The number of eggs usually found in the mouth of these fish during the breeding season is twenty to thirty. The question would naturally arise, How can the fish eat when its mouth is thus employed as a nursery, without swallowing its progeny? Prof. Wyman answers this question by stating the fact that he has frequently found among the eggs filling the mouth of the fish those of other varieties of fish — rarely, however, more than one or two of other species — which leads him to the conclusion that the eggs are allowed to escape from the mouth for a short time while the fish is feeding, being afterward gathered up again.

A curious fish known as the hippocampus, or "sea-horse," affords a similar instance of the male acting as a nurse for its young. The males of these fishes are furnished with a pouch upon the lower surface of the body behind the anal opening, in which the eggs of the female are carefully placed and cared for until hatched.

The continent of Europe is the home of a curious species of reptile known as the "obstetric toad," the male of which attaches the eggs of the female to his legs, carrying them about with him until they are hatched.

Naturalists give numerous illustrations of care for their young on the part of fishes and reptiles. For example, Prof. Wyman describes a female fish which carries her eggs carefully arranged along the lower surface of her body, each one attached to a cup at the end of a cylindrical thread. The same naturalist

mentions a somewhat similar peculiarity observed in the "swamp toad." After the eggs were laid by the female and fecundated by the male, the latter arranges them one by one at regular intervals on the back of the former. In due time, a thin wall of skin grows up around them by which they are inclosed and protected.

A species of tree-frog carries about its young ones on its back, the little fellows hanging on by their mouths.

Another species of tree-frog has a little pouch on its back in which the male carefully stows away the eggs, which are thus cared for until hatched.

Fishes and reptiles usually "lay eggs" either before or after fecundation; but in a few cases, the young are brought forth alive, and a single case has been observed in which a snake has laid eggs and brought forth living young at the same time.

In the human female, as in the females of all the mammalia, the fecundated ovum is retained during its development. This process usually takes place in the uterus, though, as we shall presently see, it may occur elsewhere.

As before stated, while the ovum is becoming matured and ready to be cast off from the ovary, the mucous membrance of the uterus is undergoing a change preparatory to receiving the ovum in case it shall become fecundated. After fecundation takes place, the ovum attaches itself to the wall of the uterus, and changes at once begin in both the ovum and the womb to which it is attached. We will describe first the changes which take place in the latter.

Changes in the Uterus.— After conception, the uterus at once begins to increase in size. The physiological congestion which occurs periodically at menstruation and momentarily during the sexual act, becomes now a permanent condition to be continued for several months. The enormous increase in size of the uterus is the result of this increase of the blood supply. The muscular fibres of the uterus, which are of the unstriated variety and very small in the unimpregnated state, become enormously developed. The blood channels, which are also small, become dilated, in the case of the veins, to an enormous extent, so as to form sinuses.

Changes also take place in the nerve centers from which the uterus derives its nerve supply, especially those of the organic system, which likewise participate in the development which occurs in the other parts of the generative apparatus.

The most remarkable changes of all, however, take place in the mucous membrane lining the interior of the uterus. Something of the character of these changes is shown in Figs. 1 to 5, Plate VI. In the unimpregnated state, the mucous lining of the uterus is very thin and scantily supplied with blood-vessels. After conception occurs, the membrane becomes greatly thickened, and its blood-vessels enlarge and increase in number with great rapidity. These changes soon give to the membrane a velvety appearance. The activity in the development of the membrane is particularly great in the immediate vicinity of the ovum, around which folds of membrane soon

begin to project forward, and very shortly meet over the free surface of the ovum, grow together, and thus completely inclose it. The ovum is now shut up in a cavity by itself, distinct from the general cavity of the uterus.

The remaining changes of the greatest importance which occur are in the ovum itself together with its inclosing membrane, which has been formed from the uterine mucous membrane, and which may be now considered as a part of the developing ovum.

Development of the Ovum During Gestation.—Immediately after fecundation, the ovum begins to grow, and subdivisions take place in its interior. This process is known as segmentation. The nature of the change will be readily understood by reference to Figs. 1 to 6, Plate IV. After this process has gone on for some time, a large number of cells have been formed within the ovum. These cells unite together at the surface of the yolk, forming a sort of membrane, on which presently appears a straight line which is termed the *Primitive Trace*. It is, in fact, a sort of furrow, the sides of which gradually grow up and close above it, subsequently forming the spinal canal of the embryo. The appearance of the primitive trace, as shown by the microscope, may be seen in Fig. 2, Plate VII. Some cases have been observed in the examination of lower animals in which the primitive trace has been double or divided at one of the extremities. This is supposed to be an explanation of the manner in which double monsters are formed. Subdivision of the trace in the end destined to form

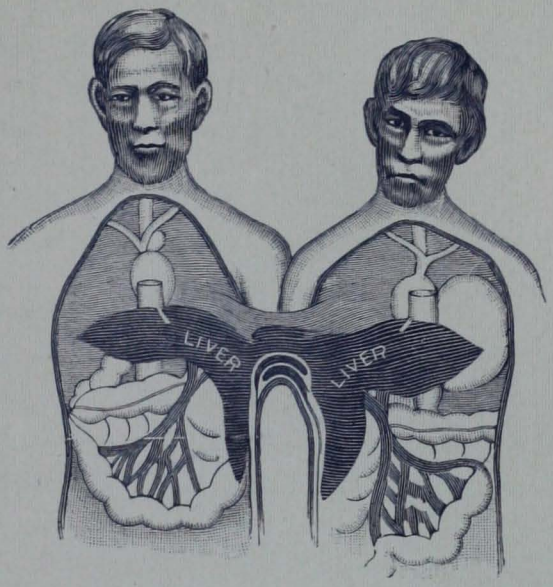


Fig. 1.— Siamese Twins.

Fig. 2.

Fig. 3.

Fig. 4.

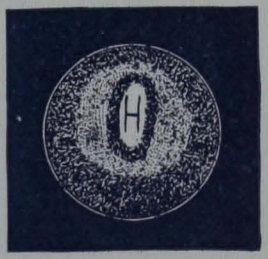


Fig. 5.

PLATE VII.

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the head, as shown in Fig. 3, Plate VII, would give rise to a monster with one pair of legs and one trunk, but with two heads. If the division extended to near the middle of the primitive trace, the succeeding development would result in the formation of a monster with one pair of legs but two trunks more or less completely separated. A trace forked at the end destined to form the inferior portion of the body would result in a monster having one head and trunk with two pairs of legs. Two complete primitive traces united at the center by a band as shown in Fig. 4, Plate VII, would result in embryos joined together like the Siamese Twins. The manner in which the internal structures of these curious individuals were united is shown in Fig. 1, Plate VII.

The membrane of which the primitive trace is formed divides into an inner and an outer layer, between which is formed another layer which again subdivides into two, making four layers in all. From these different layers all of the different parts of the individual are developed, the outer layers going to form the skin, muscles, bones, and nerves; while the inner layers form the walls of the alimentary canal and other internal parts of the body. Thus certain groups of cells are set apart for one kind of work, while to other groups are allotted other functions. One group forms the liver, another the kidneys, another the spleen, another the pancreas. Each group, when its development is completed, performs a function peculiar to itself. Still other groups form the brain, and when their development is complete, per-

form the various offices required for the production of thought, the reception of impressions, and the control of the operations of the body. The various foldings, ingrowings, projection of various parts and absorption of other parts, subdivisions, and other complicated processes by which the development of the individual is completed, we shall not attempt to trace, as information of this kind is too technical to be interesting to the general reader. Some points of special interest will be noted, however. One of the most remarkable of these is the fact that a human being in the process of development passes through various stages, each of which represents the permanent condition of some class of lower animals.

The alimentary canal, as first produced, is simply a straight tube, a form in which it permanently exists in such animals as the eel. After a time, dilations occur in the upper and the lower portion, which ultimately form the stomach and the large intestine. The convolutions of the small intestine are formed by lengthening the canal. The upper dilation — the stomach — is usually on the left side of the body; while the most dilated part of the expanded portion, which ultimately forms the *cæcum*, is placed at the right and lower portion of the abdominal cavity. Cases sometimes occur in which this arrangement is reversed. When this happens, a corresponding reversion occurs in the position of all the other organs contained within the trunk of the body, the liver being upon the left side instead of the right, the heart transposed to the right side, and other corresponding changes oc-

curring. We met a case of this kind a few years ago in a young girl whom we were treating for scrofulous disease, whose heart we were led to examine by complaint of the occurrence of palpitation. After seeking in vain for the presence of the heart in its usual location, we were astonished to find it beating vigorously and without any evidence of disease, on the right side, several inches from its normal position. The idea has been suggested that this peculiarity is more likely to be present in left-handed people than in others, the disposition to use the left hand rather than the right growing out of the abnormal position of the internal organs.

The heart, like the alimentary canal, is at first a straight tube, which, by twisting around itself and undergoing various other changes by which it is divided by longitudinal and transverse partitions into four chambers, finally becomes developed into the heart as found in adults.

The arms and legs are at first simply little buds projecting from the sides of the embryo. As they grow out, their tips are subdivided into rudimentary fingers and toes. Still further development results in the formation of joints and the various segments of the arms and legs. In different classes of lower animals, the developmental process seems to stop short at different stages. In the seal, the feet of which are webbed, development ceases when the subdivision of the original bud has occurred only in part. The same thing is observed sometimes in human beings, in which the fingers and toes are often found

more or less united, in some cases being joined to their tips. In the walrus, the limbs consist of little more than a wrist and ankle, with fingers and toes attached. With animals a little higher in the scale, the limbs are a little more fully developed. Most quadrupeds possess knee and elbow joints. The lion, panther, and other members of the feline species have still more perfectly developed limbs, while in the highest apes the limbs are nearly as free in their movements as in human beings.

As before remarked, we have in the process of development of the human embryo types of all these peculiarities of structure observed as permanent conditions in the lower animals. The human embryo, during the earlier stages of its development, cannot be easily distinguished from the embryo of various lower animals. This is readily shown by the figures on Plate E, which show the resemblance between the embryo of the dog at four and six weeks and the human embryo at four and eight weeks, respectively, to be so close that a casual observer would pronounce them to be identical. It will be observed that at this early period of their existence human beings, as well as lower animals, are furnished wth caudal appendages. In later stages of development, this portion of the body gradually disappears, until in the mature human form it is represented by a mere vestige termed the *coccyx*.

The formation of the face in the embryo is a very interesting process. Like the abdominal and thoracic cavities, the cavities of the nose and mouth are formed

by the closing together of folds or plates of tissue which project from the side and gradually approach each other. When the process of closing together is not quite complete, a deformity known as harelip results. If the deficiency affects the bony cells and soft tissues, an opening is left through the roof of the mouth, which is termed cleft-palate.

Arrest of development may occur at any of the various stages of the process just described. This may involve the embryo as a whole or one or more parts only, while other parts are allowed to go on to full development. It is in this way that congenital deformities arise. The causes of arrest of development are not very well understood.

It should be mentioned in this connection that arrest of development or abnormal development, which also sometimes occurs, are the leading causes of those hideous creatures to which women sometimes give birth, known as monsters. The stories of females becoming pregnant by dogs and other animals, and giving birth to offspring resembling the supposed fathers, undoubtedly originated in the birth of monsters, which were like other human embryos during the first stages of development, but by an arrest of development are born with a resemblance to some lower animal. It is impossible for a human ovum to be fecundated by other than human spermatozoa.

Hermaphrodites, or persons supposed to possess the sexual organs of both sexes, are, as a rule, simply cases of arrested or exaggerated development. Instances are very rare in human beings in which both

ovaries and testicles are found in the same individual, but numerous cases have been observed in which certain parts of the sexual organs of the female were so abnormally developed as to produce a striking resemblance to the organs of the male, and the reverse.

Nourishment of the Embryo. — Soon after the segmentation of the ovum and the formation of layers of cells or membranes at its surface, that portion of it lying next to the uterine wall undergoes a peculiar development. Little vascular loops are formed which interlace with similar loops formed on the surface of the lining of the uterus. These loops become so closely united with each other that the blood-vessels of the ovum, which begin to form at a very early stage, and those of the uterus have only a very thin partition between their walls. Through this delicate membrane the nutritive fluids of the mother's blood pass readily into the ovum. After the circulation of the ovum is fully developed, the blood corpuscles of the mother and those of the embryo are by this arrangement allowed to come very close to each other without coming in actual contact. The blood corpuscles of the mother never pass into the veins of the child, nor vice versa. If any such change did occur, it could be readily detected, as the blood corpuscles of the embryo are of a different size from those of the mother. The interchange of fluids between the embryo and the mother takes place very readily, however, by means of the arrangement briefly described above, which is known as the *placenta*.

As the embryo advances in development, it be-

comes separated from the placenta, but retains connection with it by means of the *umbilical cord*, which contains two arteries and a vein. The arteries convey blood from the embryo, or *fœtus*, to the placenta, from which it is returned by means of the veins. During the passage of the fœtal blood through the placenta, it undergoes a double change, receiving from the blood of the mother nutritive elements by which the process of development may be maintained, and giving back to the mother's blood in exchange the impurities and excrementitious elements which have been derived from the fœtus. This intimate association between the fœtus and the mother through the blood explains the mysterious influence of the former upon the latter which has been before referred to. It is undoubtedly in this way that the impressions are made which give rise to the curious circumstances previously mentioned, that the children by a second husband frequently resemble the former husband in both character and features. Experiments upon animals show that the mother may be affected even fatally by poisonous substances introduced into the body of the fœtus. Cases are also frequent in which the mother contracts constitutional disease from a fœtus which has inherited the same from its father. This is particularly true of syphilis. This relation of the circulation of the fœtus with that of the mother also explains, to some degree at least, the remarkable influence which is exerted upon the fœtus by the physical and mental condition of the mother.

Respiration of the Fœtus. — How the process of respiration could be carried on in the unborn infant was for a long time a matter of deep mystery, but it is now very well understood that the placenta is for the fœtus an organ of respiration as well as of nutrition. The blood of the fœtus is carried to the placenta through the umbilical arteries, charged with carbonic acid gas, and coming into close proximity, in the placenta, with the blood of the mother, — which, through exposure to the air in the mother's lungs, has become charged with oxygen, — an interchange takes place, the carbonic acid gas being absorbed by the blood of the mother, and the oxygen by that of the fœtus, so that the fœtal blood returns in the umbilical vein purified and oxygenated, just as the blood returns from the lungs to the heart in the adult individual. With this fact in view, it is unnecessary to suggest the importance of securing to the mother an abundant supply of fresh air, since she has to breathe for the fœtus as well as for herself. This point will be dwelt upon more at length elsewhere.

The Fœtal Pulse. — The action of the fœtal heart can be distinctly heard through the abdominal walls of the mother, after the fourth or fifth month. In some cases the beating of the fœtal heart has been traced as early as the end of the eleventh week. In order to observe the feeble sounds which are produced by the yet imperfectly developed heart of the fœtus, the ear must be placed upon that portion of the abdominal wall directly over the heart. The point at which the sounds may be most easily distinguished

in the majority of cases is a little to the left of the median line, about half way between the umbilicus and the symphysis pubis. The rate of the fœtal pulse varies from 130 to 160 a minute.

A large number of observations have shown that the pulse of female infants is more rapid than that of males, so that this may be a means of distinguishing between male and female children before they are born. The average rate in females is about 144 per minute; in males, 131.

Position and Condition of the Child in the Womb.— During the early months of gestation, the condition of the child varies considerably. As the end of pregnancy approaches, however, the position becomes more and more constant, and near the end of gestation, in the majority of cases, the position of the child in the womb is with the head downward, and the back forward and to the left, with the limbs in a state of flexion, as shown by reference to Fig. 1, Plate IX.

Amniotic Fluid.— In order to protect the delicate structures of the fœtus from the unpleasant effect of sudden jars to which the mother is liable to be subjected, and for various other apparent reasons, it is not made fast to the interior of the uterus, but floats, or rather is suspended, in a sac filled with fluid, which fills the whole of the interior of the distended womb not occupied by the fœtus. This fluid, known as the *amniotic fluid*, or the "*waters*," varies considerably in quantity, sometimes being so abundant as to amount to dropsy, at other times being barely sufficient to

answer the purpose for which it was designed. This fluid is very complex in its composition, at first resembling very closely the serum of the blood, but as pregnancy advances becoming more and more charged with excretory matters thrown off by the skin and kidneys of the fœtus.

Summary of Development.— The following is a concise summary of the process of development at different stages as given by Flint: —

"At the third week the embryon is from two to three lines in length. This is about the earliest period at which measurements have been taken in the normal state.

"At the seventh week, the embryon measures about nine lines; points of ossification have appeared in the clavicle and lower jaw; the wolffian bodies are large; the pedicle of the umbilical vesicle is very much reduced in size; the internal organs of generation have just appeared; the liver is of large size; the lungs present several lobules.

"At the eighth week, the embryon is from ten to fifteen lines in length. The lungs begin to receive a small quantity of blood from the pulmonary arteries; the external organs of generation have appeared, but it is difficult to determine the sex; the abdominal walls have closed over in front.

"At the third month, the embryon is from two to two and a half inches long and weighs about one ounce. The amniotic fluid is then more abundant in proportion to the size of the embryon than at any other period. The umbilical cord begins to be

twisted; the various glandular organs of the abdomen appear; the pupillary membrane is formed; the limitation of the placenta has become distinct. At this time, the upper portion of the embryon is relatively much larger than the lower portion.

"At the end of the fourth month, the embryon becomes the fœtus. It is then from four to five inches long and weighs about five ounces. The muscles begin to manifest contractility; the eyes, mouth, and nose are closed; the gall-bladder is just developed; the fontanelles and sutures are wide.

"At the fifth month, the fœtus is from nine to twelve inches long and weighs from five to nine ounces. The hair begins to appear on the head; the liver begins to secrete bile, and the meconium appears in the intestinal canal; the amnion is in contact with the chorion.

"At the sixth month, the fœtus is from eleven to fourteen inches long and weighs from one and a half to two pounds. If the fœtus be delivered at this time, life may continue for a few moments; the bones of the head are ossified, but the fontanelles and sutures are still wide; the prepuce has appeared; the testicles have not descended.

"At the seventh month, the fœtus is from fourteen to fifteen inches long and weighs from two to three pounds; the hairs are longer and darker; the pupillary membrane disappears, undergoing atrophy from the center to the periphery; the relative quantity of the amniotic fluid is diminished, and the fœtus is not so free in the cavity of the uterus. The fœtus is now viable.

"At the eighth month, the fœtus is from fifteen to sixteen inches long and weighs from three to four pounds. The eyelids are opened, and the cornea is transparent; the umbilicus is at about the middle of the body, the relative size of the lower extremities having increased.

"At the ninth month, the fœtus is about seventeen inches long and weighs from five to six pounds. Both testicles have usually descended, but the tunica vaginalis still communicates with the peritoneal cavity.

"At birth, the infant weighs a little more than seven pounds, the usual range being from four to ten pounds, though these limits are sometimes exceeded."

We have known instances in which infants have weighed scarcely more than three pounds at birth, and yet have attained normal development afterward, though requiring great care during the first few weeks of life. Prof. Carpenter, of London, in his human physiology refers to a case in which the weight at birth was but one pound. At three and a half years the weight had increased to about 30 pounds.

Length of Gestation.—The length of time required for the development of the young sufficiently to enable them to exist outside the body of the mother differs greatly in different classes of animals. In the horse the period of gestation is 335 days, while the rabbit matures its young in the brief period of 30 days. In the cow about 280 days are required. In the human female, the period intervening between conception and birth is about forty weeks or

ten lunar months. The exact length of the period in an individual case cannot always be determined on account of the difficulty of fixing the exact date of conception; but in those instances in which the circumstances have been such as to render the fixing of the date of conception accurately, it has been found to vary little from 275 to 280 days.

The period of gestation is frequently somewhat shorter than this, many children being born from four to six weeks before the usual time. If the period of gestation is shorter than seven months, the fœtus will not be sufficiently developed to live. Infants born before the full term of gestation require especial care and the most careful nursing, and those born before the completion of the seventh month very seldom survive birth more than a few days. The period of gestation is sometimes extended two or three weeks beyond the end of the tenth month. Cases have been reported in which the period has been much longer than this, but they are not considered authentic.

Quickening.—The term quickening is applied to the time when the mother for the first time becomes conscious of the movements of the fœtus within the womb. This was formerly believed to be caused by the sudden descent of the fœtus from the uterus into the pelvic cavity, but it is now well known to be produced by the movements of the limbs of the child when they come in contact with the walls of the uterus.

This is generally felt about the beginning of the

fifth calendar month from the beginning of pregnancy, or about the middle of gestation. There is no doubt but that the limbs of the fœtus move often and quite vigorously before this period, but they are not felt by the mother on account of the fact that not until about this time does the uterus become sufficiently enlarged to bring its walls in direct contact with the walls of the abdomen. The body of the uterus contains very few sensory nerve fibres, those being distributed in its neck, and it is only after the uterus comes in contact with the abdominal wall so that the shock of the fœtal movements is communicated to the latter tissue, which abounds in sensory fibres, that the mother becomes conscious of the activity of the developing embryo. These movements sometimes become so vigorous as to give the mother absolute pain so as to cause her to cry out in agony. They are the result of a vigorous kicking action on the part of the fœtus.

The period of quickening was formerly considered one of great importance, but is now looked upon as of very little significance except as forming positive evidence of the existence of pregnancy. The idea that at this time the fœtus first becomes possessed of individual life was long since exploded, and the laws relating to criminal abortion which were based on this ancient notion ought to have been repealed at least half a century ago. As we have before shown, individual life begins at the moment of fecundation, and whatever rights the developing being may possess after the period of quickening, it certainly possesses before.

Changes in the System of the Mother During Gestation. — While the remarkable changes previously described are occurring within the body of the mother, it would certainly be very remarkable if some change did not occur in the system at large in some small degree, at least, commensurate in character. As a general rule, the mother's attention is first called to her condition by the fact that the usual monthly sickness does not occur at the proper time, or, if it does occur at all, the discharge is so slight as to be hardly appreciable. There are cases, however, in which menstruation occurs several times after conception takes place, and in occasional instances, the periodical discharge goes on during the whole period of gestation. After a few weeks, in many instances, general symptoms, affecting the nervous system chiefly, make their appearance. After a short time, the increase in size of the lower portion of the abdomen becomes apparent. The latter symptom of course increases rapidly as pregnancy advances.

During pregnancy, a change more or less marked takes place in the organic nervous system, the nerve centers having charge of the function of nutrition taking on unusual activity, so that the blood-making and tissue-building processes are carried on much more vigorously than usual. It is owing to this fact that many women enjoy better health during pregnancy than at any other time.

The development of the muscular tissue of the uterus as it increases in size has been already referred to, as well as the great increase in number and size

of the uterine blood-vessels. The veins of the uterus sometimes become so enormously distended that the blood in passing through them produces a sound somewhat similar to that produced by the passage of blood through an aneurism. This is known as the uterine *souffle* or *bruit*, which is one of the signs by which a pregnant condition is distinguished.

During the period of development of the fœtus, preparatory to its exit into the external world, certain parts of the reproductive system of the mother are also undergoing preparation for this same event. In the normal condition of the vagina and the external organs of generation, child-birth would be impossible, as the soft parts would not admit of the enormous distension required for the passage of the head and pelvis of the child. During the later months of pregnancy, these parts undergo certain developmental changes by which they are prepared for the ordeal to which they are to be subjected. The walls of the vagina become relaxed and thickened and the canal shortened. The external parts also undergo a similar relaxation. The secretions are greatly increased in quantity, and the tissues formerly firm and rigid become soft and distensible.

In addition to the changes above noted which usually occur, marked mental and nervous disturbances are sometimes present during pregnancy. These cannot be considered perfectly normal, however, and hence will more properly receive attention elsewhere in this work.

Extra-Uterine Pregnancy.— As previously intimated, the ovum is sometimes fecundated at the surface of the ovary, and for some reason does not reach its proper position in the uterus before becoming fixed and beginning development. It is well known that full development may take place in other situations than the uterine cavity. This is known as extra-uterine pregnancy. When the ovum after fecundation falls into the cavity of the abdomen and becomes attached to some portion of its lining membrane, there undergoing development, the case is known as one of *abdominal* pregnancy. If the ovum lodges in the fallopian tubes and there undergoes development, which is sometimes the case, we have what is termed *tubal* pregnancy. Recent investigations have also shown that in occasional instances the ovum when fecundated at the ovary may never leave its original situation, but may undergo fecundation there, constituting *ovarian* pregnancy. The course of pregnancy in these cases is very similar to that when the ovum is lodged in its normal position. The subsequent dangers to the life of the fœtus and of the mother which necessarily arise before the termination of gestation will be considered elsewhere, together with the symptoms by which these abnormal varieties of pregnancy may be known.

Parturition.— At the end of gestation, certain causes, the exact nature of which is not fully understood, give rise to the beginning of a process by which the fœtus is expelled from the womb where it has been protected during the process of development. It is probable that the occasion of this action on the

part of the womb is some change in the fœtus or its connections with the uterus by which the latter is led to treat its contents, which it has heretofore tolerated with the greatest impunity, as a foreign body which must be expelled. The contractions of the uterus cause a slight separation of the placenta from its walls, which greatly increases as the contractions continue. The membranes, pressing upon the lower portion of the uterine cavity cause gradual dilation of the cervix. After a time, the membranes rupture, and the amniotic fluid is discharged, allowing the head to come in contact with the neck of the womb. With each pain, the head of the child, in normal child-birth, is pressed down more and more vigorously until it is finally expelled from the uterus and shortly afterward from the vagina, making its exit into the world. The separation of the placenta of course causes a laceration of the blood-vessels by which it is connected with the uterus. This would occasion profuse hemorrhage, which might prove fatal in a few moments, were it not for the fact that the same contraction which occasions separation of the placenta also closes the mouths of the lacerated vessels. It sometimes happens that the uterus fails to contract, particularly after the placenta is separated, allowing the greatly dilated blood-vessels to remain fully distended, thus giving rise to a most alarming hemorrhage, which not infrequently occasions death in a very short time if the proper measures are not promptly applied.

Involution.—Directly after the child is born, the placenta and the membranes by which the fœtus was invested in the uterus, known as the after-birth, are also expelled, and the act of parturition is complete. In four to six days, seldom later than a week, after child-birth, an examination of the uterus will show that it has undergone a very great reduction in size. This process, known as involution, continues until it is reduced to very nearly its size when in a non-impregnated state, although it never becomes quite as small as before. The muscular fibres, which have been enormously hypertrophied, undergo fatty degeneration, and are absorbed. A new membrane is soon formed to take the place of the old one which was thrown off at child-birth with the placenta, and by the end of the second month, the process is complete. A discharge usually follows child-birth, and continues from one to three weeks, which is composed of bloody serum mixed with disintegrated portions of membranes and blood-clots from the cavity of the uterus, and is termed the *lochia*.

Changes in the Child at Birth.—At the moment of birth, a remarkable change takes place in the system of the new-born infant. Previous to this time, its lungs have been wholly inactive, the process of respiration being performed by the placenta. In order to carry on the processes of respiration, purification, and nutrition, all of which functions have been performed by the aid of the placenta, a peculiar arrangement of the circulatory system has been necessary, two arteries and a large vein

passing between the body of the fœtus and the placenta. When the placenta is separated from the uterine walls, the circulation in the blood-vessels of the cord at once ceases. Instantly, an accumulation of carbonic acid begins, and if some other means for the purification of the blood from this poison were not provided, death would occur within a few moments. Just at this critical epoch, the lungs are brought into action. Stimulated by the impending danger to the system of the infant, or by contact of the body with the external air, or by some other means not understood, the lungs begin their important function. This is not of course fully performed at once; time is required for the lungs to become fully expanded and able to do their whole duty in the elimination of carbonic acid gas and the absorption of oxygen. Fortunately, the delicate skin of the infant, which is abundantly supplied with blood-vessels, possesses the ability to transmit oxygen and carbonic acid gas, and is able to supplement the excretory action of the lungs to a very considerable degree. It is on this account, as well as for other reasons, that it is of the highest importance that the young infant should be kept for some time at as nearly as possible the same temperature as that to which it has previous to its birth been accustomed, or about 100° F., since the effect of cold on the skin will be to cause contraction of the blood-vessels, and so prevent it from doing its part in the breathing process. It is not necessary that the temperature of the room should be 100° provided the infant is properly clothed; but the room should be 15°

to 20° higher than is necessary for adults, for the first few days after birth.

In the adult, the blood is obliged to pass through a double circuit in order to complete its tour of the body. Starting from the left side of the heart, it is distributed through the arteries, gathered up by the veins, and returned to the right side of the heart, completing the first circle or first half of its double circuit. From the right side of the heart,—or, in some of the lower animals, the right heart, the two halves being distinct organs,—it is sent to the lungs, and thence through the pulmonary veins to the left side, its starting point. In the fœtal condition, as the lungs are not distended with air, little blood passes through them from the right side of the heart to the left side, so that some other provision is necessary to enable the blood to complete its round. The ingenious arrangement which nature has made for this purpose is a valve-like opening in the partition between the right and left sides of the heart which allows the blood to pass from the right side into the left side, but does not allow a movement in the opposite direction. This is known as the *foramen ovale*. This opening is placed in such a position that the current of nearly pure blood that is brought into the right auricle from the ascending *vena cava* passes directly from it without mingling to any great extent with the impure blood which is present in the right auricle, and enters the left auricle, from which it passes to the left ventricle, and is thence carried to the head, arms, and upper part of the body. An-

other peculiar arrangement in the circulation of the fœtus is the connection between the pulmonary artery and the aorta by which the greater portion of the blood which would pass through the lungs if they were in action, takes a short cut through the duct provided for the purpose to the aorta, which it enters below the openings of the arteries which supply blood to the upper part of the body. This blood consists chiefly of the venous blood returned from the upper part of the trunk. It thus appears that the upper part of the body of the fœtus is provided with pure blood or that which is nearly pure, containing but a slight admixture of venous blood, while that supplied to the lower portion of the body is much less pure in character, being almost wholly venous blood. This fact is given as an explanation of the inferior development of the lower portion of the body at birth, the legs and feet being much less perfectly developed than the arms and hands in the newly born child.

At birth, or soon after, this peculiar course in the circulation of the child is interrupted by the closure of the foramen ovale and the duct communicating between the pulmonary artery and the aorta. It occasionally happens, however, that these openings remain unclosed, in consequence of which arterial and venous blood continue to mingle as before birth, giving the child a bluish appearance, a condition termed *cyanosis*, or blue disease.

Development of the Body after Birth.—At birth, the infantile human being has by no means arrived at a state of complete development. The organs

of the special sense, sight, hearing, and taste, as well as the olfactory sense and the sense of touch, are dull, and the degree of intelligence is small, much less than in the young of many of the lower animals. The development of the lower extremities is very much inferior to that of the rest of the body, while the head is very large in proportion. The following table, showing the difference in proportion of the various parts of the body to the whole, in the fœtus and the adult, is interesting: —

	Fœtus at Term.	Adult.
Weight of the entire body, -	1000.00	1000.00
" " brain, - -	148.00	23.00
" " liver, - - -	37.00	29.00
" " heart, - - -	7.77	4.17
" " kidneys, - -	6.00	4.00
" " thyroid gland, -	0.60	0.51
" " thymus gland, -	3.00	0.00

The arms and legs are curved upward and forward; the chest, abdomen, and all the joints are in a semi-flexed position. The curve of the lower extremities causes the soles of the feet to look toward each other instead of downward as in adults.

During the first few weeks of its existence, the creature does little more than eat and sleep. Its actions are almost wholly if not entirely, automatic or reflex in character. The movements of the hands and feet as well as the act of suckling and undoubtedly also the contortions of the face and its frequent cries, are in no sense volitionary.

The remains of the umbilical cord begin to wither

within twenty-four hours after birth, and by the third day are usually completely dried, after which ulceration takes place at the point of connection with the body by which it is separated and thrown off by the end of the first week. In ten or twelve days the raw surface left by the separation of the cord should be entirely healed.

A short time after birth, the hair is shed and replaced by a new growth. This change involves the eye-lashes and minute hairs of the body as well as the head of the infant. In fact, according to Köl-liker, a very acute observer, the entire cuticle of the new-born infant is shed and replaced by a new epidermic covering. The *fontanelles*, or soft spaces between the unossified portions of the cranial bones, gradually diminish in size, and at the age of four years are almost completely closed.

The teeth of the infant are at birth very imperfectly developed, and wholly concealed in little pockets beneath the gums. They are twenty in number, consisting of two incisors, one canine tooth and two molars, on each side of each jaw. The fully formed teeth make their eruption from the gums in the following order: The two central incisors, or cutting teeth, in the seventh month after birth; the other two incisors in the eighth month; the first molars at the end of the year; the cuspid teeth, commonly known as the eye-teeth in the upper jaw and the stomach-teeth in the lower jaw, at a year and a half, the second molars, which complete the set, not making their appearance until the end of the second year.

This set of teeth is commonly known as the *temporary* or "*milk*" *teeth*. They are retained until the seventh year, during which a change begins to take place by which they are thrown off and replaced by a permanent set, which differ considerably in shape and size as well as in number from the first set. The first permanent tooth which makes its appearance is the anterior molar tooth which emerges from the gum just behind the second temporary molar. This fact should be borne in mind, as this tooth is sometimes mistaken as belonging to the first or the temporary set, since it usually makes its appearance before any of the other teeth are shed, or at the age of about six and one-half years. At the end of the seventh year, the temporary teeth begin to give way to the permanent teeth in nearly the same order in which they made their appearance in the jaw. First the two middle incisors are shed; next the lateral incisors about one year later. Within the next two years, the two molars are replaced by the two bicuspids of the permanent set. One year later, the second permanent molars make their appearance, and between the seventeenth and twenty-first years the wisdom-teeth appear at the extreme end of the gum, making thirty-two teeth in all in the adult.

At the age of about fifteen years, a change known as puberty occurs in both sexes, the nature of which is more fully considered elsewhere.

After the attainment of puberty, the physical development continues, not being perfected until near the twenty-fifth year, when the ossification of the

bones is completed. The development of the brain continues for some years later, not being completed until near the fortieth year.

With the cessation of growth and the attainment of maturity, the vital forces of the system are no longer expended in the processes of development, and hence the various organs of the body are able to manifest their functions more energetically and continuously than during early life. At this period the processes of assimilation and disintegration are just in proportion to the amount of work done.

After a period, the length of which largely depends upon the habits and inherited tendencies of the individual, the period of decline begins. This may be either lengthened or abbreviated in a very large degree by each individual. A person who "lives too fast," will certainly reach the time when the various vital functions begin to fail much sooner than one who by temperate living and careful conformance to the laws of nature conserves and economizes his vital energies. The average length of human life is less than forty years, although many facts and considerations go to show very conclusively that human life would be prolonged to one hundred years, or even greater age, if human beings would strictly adhere to the natural order of life.