# CHAPTER I
# *HOW LIFE BEGINS*[1]

## Life from Life[2]

With the aid of a microscope, we can see that a human being, like most living things, is made up of cells—billions of tiny units of different shapes that build up every part of the body. These cells are not inert building blocks, however, for each is like a little organism in itself, undergoing constant change, but maintaining its complex inner structure, for the cell can absorb and secrete various substances while keeping its own identity. Most cells can grow and reproduce.

Within each cell is a compartment, the nucleus, that contains a number of threadlike or rodlike bodies called *chromosomes.* The set of chromosomes in almost all the cells of individuals of the same species—for instance, in all human individuals—is quite similar in number, size, and structure. Normally there is a set of forty-six chromosomes in each human cell, one of which differs between men and women in size and shape.[3]

The chromosomes contain the genes, complex chemical structures that to a great extent determine the occurrence of inheritable characteristics, both those common to a species and those in which individuals differ. A gene that determines a certain characteristic is present not only in the portion of the body concerned or at the time when the effect occurs, but is generally thought to be in every cell of the body throughout life. Other factors, such as the proper stage of development and the right environment, are necessary for the gene to make its potential effective.[4]

The presence of a similar set of genes in every cell of the body of an individual throughout his life is explained by the way in which cells ordinarily divide. The set of chromosomes in an existing cell is not simply parceled out to the two new cells that result from division. If that were the case, each division would reduce the number of genes in the daughter cells. Rather, the chromosomes form replicas of themselves, so that they come to consist in two distinct strands. Then the pairs of strands physically separate, moving like the players of opposing teams to opposite sides of the dividing cell. The cell pinches in two between the opposing sides, and new nuclei form up around the separated sets of chromosomes. Division in this manner is called *mitosis*.

Another method of division, called *meiosis*, occurs in the formation of the sex cells. During the early stages of the development of each individual, certain cells are set aside and eventually cells derived from these by the usual process of mitosis locate in the testicles, if the individual is a boy, or in the ovaries, if a girl.[5] During the fertile years, some of these cells undergo the special process of division, meiosis. The forty-six chromosomes are reduced by this process to twenty-three, so that a sperm cell or an ovum is peculiar in that it carries only half the chromosomes present in the nucleus of most other cells of the individual.

Of the forty-six chromosomes in most of a human being's cells, half derive from his father's sperm cell and the other half from his mother's ovum. Although we know that the genes received from the father and those received from the mother are somewhat different, when the full set of forty-six chromosomes is examined, the chromosomes appear clearly as two sets of twenty-three. When the sex cell is formed through meiosis, however, it does not simply receive one or the other of these sets of twenty-three chromosomes. In an early stage of meiosis the forty-six chromosomes join in their twenty-three pairs and exchange some of their corresponding genes. Thus new chromosomes are formed that are genetically unlike those in any other cell of the individual's body. The chromosomes in any one sex cell are even unlike those in other cells undergoing meiosis at the same time, since there are so many possibilities of gene-exchange that the results are unique in each instance. In subsequent stages of the process of meiosis, the division of the forty-six chromosomes occurs so that a sex cell is developed having only the half-set consisting of twenty-three chromosomes. Each sperm and ovum, even of the same individual, is genetically different, then, for each one contains half of the individual's genetic inheritance, but in each case a diverse half—like so many half-decks of a very large deck of cards, each half-deck containing different cards, depending upon the shuffle.[6]

The sperm cell, when it is fully developed, is clearly alive as is evidenced by the facts that it receives nourishment and that it swims along under its own power, somewhat like a tadpole. But sperms are much smaller than tadpoles. There are millions of them in a drop of semen, which is mostly a liquid carrier, a kind of transportable pond for the sperm to live in. In contrast, a woman normally produces only one mature sex cell each menstrual period. One or the other ovary prepares a single ovum that bursts from the ovary and is pushed along a tube toward the uterus. Since it contains a good deal of nutritive material, the ovum is much larger than the sperm, and can even be seen with the naked eye. The ovum also is comparatively inert, being moved rather than swimming under its own power. Yet sperm and ovum are alike in being alive, in being genetically unique, and in containing half the genetic inheritance of the man or woman in whom they arise.

Since new human individuals develop from the union of sperm and ovum, it would be more accurate to speak of "how life is transmitted" rather than of "how life begins." The sex cells are formed from the living matter of man and woman; the sex cells are themselves alive. And so the result of their union does not really come to life, but simply comes to be a unified life—a new individual.[7] If the mature sex cells do not unite to form a new individual, they soon die. Their specialization is for reproduction; they are unable to become blood or nerve or bone or muscle or any other sort of tissue unless they join in the development of a new individual.[8]

### Fertilization or Conception[9]

The words "fertilization" and "conception" can be used synonymously to refer to the process of union by which the two parental sex cells fuse to become the first cell of a new individual. The union is not instantaneous; it is a process that takes some time. Thus it is not strictly proper to speak of a "moment" of conception, unless one means to refer to the precise time when a certain stage of the continuous process is completed. Although certain stages can be distinguished, as in the transmission of life as a whole, what is most striking is the continuity of the process as one stage flows smoothly into the next.

The sperm and the ovum meet in the tube that connects the ovary with the uterus. The ovum has been readied, and is pushed along the tube toward the uterus. A sperm that reaches it is one of the few that survive the long trip from the vagina, through the uterus, and into the tube. Millions of sperms must start the trip because there are so many hurdles on the way. Many sperms go right past, seemingly not attracted to the ovum. But there are complex chemical interactions when the two cells come close together.

The ovum is not only far larger than the sperm, but is also enveloped in other cells and in a kind of coating. Passing by chemical means through the cells surrounding the ovum, the sperm reaches its outer membrane like a visitor landing on the crust of a strange planet. However, this very landing reveals that the ovum is not inert. It reacts by surrounding the sperm and helping it come in. This first stage of fertilization also involves other marked and rapid changes in the ovum itself, which makes final preparations for full unification with one of the sperms it has received, while somehow resisting unification with any other sperm that comes along.[10] The ovum is now so obviously alive, after its comparative inertness before the sperm reached it, that this first stage of fertilization is technically called *activation.*[11]

The crucial stage in conception follows. The genetic material brought by the sperm and that present in the ovum are in two packets. These move toward one another and unite, so that the full number of forty-six chromosomes is restored, twenty-three from the mother and twenty-three from the father. The resulting cell is in a full sense called a *fertilized ovum,* but it is no longer merely an ovum—that is, merely a cell derived from the mother containing half her genetic inheritance. Thus the fertilized ovum also is called the *zygote.*[12] Already it is a new individual, for it has the typical set of chromosomes that belong to each cell of the human body. And having derived half its genetic make-up from each parent, the zygote is unlike any cell that belongs to either of them.

The zygote shows rather quickly that it is alive and that it is distinct from the mother. For it begins the ordinary process of cell division, or mitosis, even while it continues traveling down the tube to the uterus. Each cell of the new individual will include a replica of the genetic material first assembled when the contributions of ovum and sperm were united. If fertilization does not occur, the human ovum will not develop further and will not give rise to additional cells like itself. Rather it will soon die and be washed away in the menstrual flow.

If we must point to a certain moment when the new individual begins, then, it should be when the two halves—the half of the normal human genetic make-up contributed by the father and the half contributed by the mother—have completed the process of uniting with each other to form one whole. Certainly this has occurred before the first cell division, for in that division each of the two new cells receives by the usual process of mitosis a full complement of forty-six chromosomes.

### Development before Implantation

The zygote normally will continue along the tube until it reaches the uterus. After a few days it becomes embedded or implanted in the lining of the uterus, which has been prepared to receive it. These early stages of development are critical and interesting. They have been studied and reported on by various authors.

The following is drawn from a report by Arthur T. Hertig, John Rock, Eleanor C. Adams, and William J. Mulligan.[13] The specimens studied were recovered from mothers who required surgery for various reasons. Four specimens regarded as normal were among the eight described.

The first contained only two cells, and was referred to as a *segmenting ovum*—a zygote had undergone a single mitosis. It was recovered from the tube, rather than from the uterus. The two cells remained within the membrane that surrounded the ovum; together they were not larger than the unfertilized ovum. In fact, all four of the specimens studied were about the same size, although the fourth lacked the membrane. In the earliest stages there is considerable development without much change in overall size.

The two-celled specimen was estimated to be about thirty-six hours old, counting from conception. Significantly, these authors chose conception rather than some other point—e.g., ovulation—as the proper time from which to measure the age of these specimens. In this way they tacitly affirmed that the individuals under examination lived a life that began with conception.

The cells of the two-celled individual were not exactly alike. One was smaller and more oval in shape, but had a larger nucleus. Thus already there was the beginning of differentiation, the process that step by step would lead to all the varied sizes and shapes of cells in the many diverse organs and tissues of the mature individual. The reasons for differentiation are not very well understood, and are under intense study by biologists.[14]

The second specimen had twelve cells, and was referred to as a *uterine morula*—because it was found in a uterus and had the characteristic appearance of a little berry. The authors described it as looking, within its membrane, like a small cellophane bag tightly packed with marbles. This individual was estimated to be seventy-two hours old.

The twelve cells of this specimen showed even greater differentiation. One was large and centrally located; the other eleven were smaller. Thus two types of cells were recognized. The larger cell was considered embryonic in potential—it probably was on the way toward forming the body proper of the embryo. The other eleven cells were considered trophoblastic in potential—they were on the way toward forming the membranes and the organ by which the embryo is attached to the mother during its development.

The very fact that there were twelve cells in this individual in itself showed that development and differentiation had begun, for if the cells remained alike during early divisions they would multiply in regular progression: two, four, eight, sixteen, and so forth.

The third specimen consisted of fifty-eight cells, and was referred to as a *uterine blastula*—"blast" means *formative* and "ula" means *little*, a tiny embryo found in the uterus. This individual was estimated to be ninety-six hours, or just four days, old.

The fifty-eight cells had already begun to arrange themselves in a characteristic shape, a sphere with an inner cavity. Of these cells, fifty-three were described as of trophoblastic type; five as of embryonic or formative type.

We might ask why there were so many more of the type of cells that form accessory structures than of those that form the body proper of the developing individual. Apparently, it is a question of first things first. The most essential organ of the individual until birth is that by which it is vitally linked to the mother; therefore, a good part of the resources reserved in the fertilized ovum are devoted to beginning the development of this organ.

The fourth specimen studied consisted of 107 cells. Also referred to as a *uterine blastula,* this individual was judged to be just four and one-half days old. The membrane that surrounded the egg before fertilization had finally been lost, and so the specimen had a pebbly appearance.

Now there were eight cells of the embryonic or formative type, and they were grouped together as a button-like mass, one completely surrounded by the others, two with surfaces on the inside of the blastula, and five partly exposed to the outside. The smaller, trophoblastic cells, were grouped into two types, thirty about the polar region and sixty-nine forming the wall of the blastula. Four of the polar cells were perhaps already beginning to differentiate toward the formation of one of the three layers of tissue that would have formed the embryo a few days later.

### Implantation

The lining of the uterus is prepared during each cycle of a fertile woman to receive and nourish the tiny embryo. Indeed, the mucus secretions of the uterus provide some nourishment and oxygen even before implantation occurs. After its membrane is shed, the blastula sticks to the lining of the uterus. Cells of the lining are broken down to make an opening, and the embryo sinks completely beneath the surface. Maternal blood and tissue now provide nourishment and protection. This process of implantation occurs before the first menstrual period is missed—it has begun by seven and one-half days after ovulation and the embryo is implanted completely within about four more days.[15] Implantation requires a certain co-ordination of the cells lining the uterus and the trophoblast cells of the embryo, which have differentiated in the pre-implantation period.

Why does the menstrual period not come? If it did, the lining of the uterus, including the embryo implanted in it, would be shed. But the process of implantation itself has an immediate effect on the uterine lining, and apparently there is a further indirect effect which keeps the gland (that was formed at the ovary from which the ovum came) secreting its hormone.[16] This hormone prevents the changes in the uterus' lining that would otherwise lead to the menstrual flow. If implantation has not occurred, the gland degenerates, its secretion ceases, and menstruation follows.[17]

Some proponents of abortion have argued in popular discussions that the embryo is a parasite of the maternal organism. The argument is not scientifically sound. A true parasite differs in species from the host upon which it lives. Thus it might be more accurate to say that a parasite may imitate an embryo rather than the reverse, since in nature the relation of an embryo to its mother is a closer one than that of a parasite to its host. In some ways an embryo implanted in the lining of the uterus and a parasite are similar. Though not a parasite in the sense of being a harmful invader of the maternal organism, the embryo does not have a system of organs at the beginning, and so it must make indirect use of its mother's organs. Nevertheless, it is incorrect to call the embryo a parasite, for although the embryo is a distinct individual it is the same in species as its mother.

Another biologically fallacious analogy is contained in the popular argument that the unborn child is no more a person than an acorn is an oak tree. An acorn—like most other seeds—represents an inactive phase in the life-cycle of the plant from which it derives. The human embryo—like most other animals—does not go through such an inactive phase. The word "blastula" refers to the embryo before implantation, and this word comes from a Greek word meaning "tiny sprout." If one must compare the embryo to a particular stage of plant life, then, the tiny seedling would be a more apt analogue than the acorn. But as soon as an acorn has begun to sprout, it is a *seedling oak.* A seedling oak is not the mighty tree it may one day become, but neither is it a mere dormant seed.

### Early Development of the Embryo[18]

It may be of some importance to know what development is shown by the embryo in the time up to thirteen to fifteen days after fertilization. This would mark about the time when the next menstrual period following conception would be expected, and thus it is the earliest date at which a purposeful attempt to induce the abortion of an indicated pregnancy could be made. Some of the drugs now being developed might also be effective in terminating pregnancy at about this time.

The first differentiation of the cells that make up the inner-cell mass occurs when some of the embryonic or formative cells on the inside of the hollow blastula (or blastocyst) segregate and begin to spread over the whole inner surface. As the other embryonic cells multiply they change their shape and spread across one rather flattened surface of the blastocyst. Thus a disk is formed, made up of two layers of embryonic tissue, one of which extends on around the walls of the chamber. From this disk the entire body will develop.

At the same time, the accessory structures are developing even more quickly as the trophoblast differentiates. Very soon the chorionic sac begins to develop—this is the outer membrane of the "bag of waters" in which the baby will be enclosed as development proceeds. The amniotic cavity, which will eventually extend so that its membrane will be the inner surface of the "bag of waters," also begins developing. The body stalk, which will be the umbilical cord, is differentiated. Most important, the trophoblast differentiates and proliferates into a primitive placenta, its outer surface in direct contact with the maternal blood, the surface extended by many *villi* (finger-like projections), which are like roots interlocking with the tissue of the lining of the uterus.

Although the degree of development and differentiation to this stage is not great compared with the whole process from conception until birth, it is nevertheless considerable. The embryo is not merely a mass of undifferentiated cells; it is not simply a cyst in the mother's tissues. An orderly and regular process of development has begun; the stages are so well marked that embryologists can date a specimen within a couple of days by observing its stage of development.[19] Moreover, though not large—less than one-tenth inch including accessory structures at the end of two weeks[20]—the developing embryo has its own structure, unlike anything belonging to maternal tissues.

Indeed, maternal tissues meet and cooperate with the developing embryo, particularly by way of the placenta.[21] The umbilical cord connects the baby to the placenta until the cord is tied and cut. The placenta, which begins developing shortly after implantation, is delivered in the afterbirth. Then it is six to eight inches in diameter, over an inch thick, and weighs about one pound. It consists of tissue developed from the blastula which interlocks with maternal tissue in the lining of the uterus. Normally the bloodstreams of the fetus and of the mother circulate to the point where placenta and uterus meet, but do not come into direct contact. Rather membranes keep the two bloodstreams apart, and nourishment, oxygen, wastes, and other vital factors are exchanged through these membranes that divide the mother and child while they interact, much as a counter divides a clerk and customers while they do business.

Because the afterbirth is no longer of value, we think of it as mere waste to be disposed of, and distinguish sharply between the infant and these accessory structures. Actually this is a prejudice of our point of view. The mother's uterus is an integral part of herself, although as an organ of reproduction it is only useful when she is pregnant. Correspondingly, the infant's placenta—as well as the umbilical cord and the other membranes—is part of himself during the time of his development. The placenta is a true organ of the unborn infant. Until birth it serves more or less completely the functions later assumed by lungs, liver, digestive system, kidneys, and endocrine glands.

While we are quite right in distinguishing between the embryo proper and the accessory structures in view of what we know to be the goal of development—the mature individual—we would be mistaken to distinguish between the life of the developing individual and the accessory structures. A fetus would be as odd without these organs as we would be without lungs, kidneys, and stomach. Hence we should not imagine that in the first weeks little development occurs merely because the development of the tissues forming the accessory structures is much more rapid than that of the embryo proper, which only reaches the stage of being a small, two-layered disk.

### The Embryo during the Next Four Weeks

The next four weeks, during which the embryo is in its third to sixth weeks of development, correspond approximately to the time between the expected beginning of the first missed menstruation and the expected beginning of the next one. This is a critical period for the developing embryo.

A great deal of differentiation and development occurs in the embryo proper during this time. What happens is not merely the multiplication and differentiation of cells, but also their movement from one place to another, the folding of surfaces, the forming or opening and closing of various passageways. The entire process occurs in a regular and coordinated manner, like the performance of a ballet by a well-trained troupe.

By the end of the third week of development, the entire structure is perhaps around one-half inch in its largest dimension, while the embryo itself is only about one-twentieth of an inch.[22] However a great deal happens in this week.

The disk, which has been only two cells thick, begins to bulge at one side—the side where the primitive body stalk is attached. Across the underside of the disk, dividing it in half to the center like a radius, a streak appears, and these differentiated cells move between the two existing layers, making almost the whole disk three-layered. At the same time the disk becomes elongated—oval. Thus the embryo becomes definitely right and left sided. At the end of the streak is an opening, beyond which extends a ridge within the layers. The disk becomes rather pear-shaped, the small end at the origin of the streak. The larger end will become the head of the embryo and the small end its tail.

Of course, there is no head in a proper sense at the end of the third week of development. But the tissues that will later form the nervous system are beginning to differentiate. The head end begins to fold over, bowing forward, and along the center of the back a groove opens and begins to make two folds. The area in which the heart will develop is marked off, and vessels are beginning to form in the embryo.

In the fourth week of development the embryo grows to about one-sixth to one-fourth inch.[23] The embryo is now C-shaped, the head and tail folded over, and the back rounded in a slouch. The groove along the back becomes a tube which soon closes at both ends, and the nervous system begins to develop within it. The brain is on its way toward formation by the end of this week, the lower and less specialized layers developing first. However, even at this early stage the tissues that will become the eyes differentiate and begin to develop.

Most remarkable is the development of the circulatory system. The heart takes shape from a simple tube, veins and arteries are formed, and blood cells—the embryo's blood—are manufactured. Before the end of the week the heart takes its first beat and circulation begins. As the blood circulates it begins its function of removing wastes from and bringing nourishment and oxygen to all parts of the embryo proper, which is becoming more and more insulated from the maternal tissues by the developing membranes.

Other rudiments of organs of the digestive system, the respiratory system, the urino-genital system also begin developing, but more slowly. The process of development is always orderly, and the head tends to develop more quickly than the rest of the body. At this stage, of course, the embryo does not look like a mature human being. The segments that have developed along the back, some of which will later become the spinal column, and the arches on the head make the four-week-old individual look to us rather like a fish. In fact, to the unpracticed eye vertebrate embryos of this age would not differ much. Nevertheless, the difference is there, established in the genes.[24]

Sometimes it is said that "ontogeny recapitulates phylogeny"—that is, that the development of each individual follows out the steps by which the species evolved from lower forms. But this is not really true; the actual situation is much more complicated than is suggested by this outdated slogan, which was formulated by a nineteenth-century German biologist, Haeckel. Individuals of diverse species are more similar during the early stages of development than they will be later on, just as babies look more alike than adults do. The arches which become gills in fish become other structures (such as tonsils) in mammals. While at a certain stage of development of fish and mammals these structures appear similar, at that stage they are not yet gills even in the fish. The segmented ridge along the embryo's back is not a fin—in *both* fish *and* mammals it is incipient backbone. Thus it is altogether misleading to talk about the "fish-stage" of the human embryo, since the individual is definitely human from the beginning and its path of development at every stage is peculiar to its species. Moreover, by eight weeks a human embryo is obviously such even to the inexpert eye, and an expert can tell at a glance whether an embryo is human or not much earlier.[25]

The next two weeks, the fifth and sixth of the life of the embryo, show further rapid growth and differentiation. The increase in size is between four and five times; by the end of this period the embryo approaches an inch. Around the beginning of the period, limb buds appear; by the end, hands are present and fingers are beginning to appear. The face is beginning to take shape. Bones are beginning to grow; the long bones and the base of the skull begin hardening by the end of the sixth week.

Within the head the brain rapidly develops as its tissues undergo further growth and differentiation. The hemispheres of the brain take shape, first as a bulge at the upper end of the growing nervous system, but they rapidly grow during these and the following weeks to roof over the rest of the brain. At these early stages, of course, the brain-roof is not fissured, and the functions of the brain are not immediately established.[26] During this period the eyes continue their development, which will take a long time to complete, and the nasal passages open up. The ears begin to develop. Still the nerves that will connect these with the brain are only beginning to grow.

The heart and the circulatory system, already functioning, continue to develop while they work. To keep pace with the changing stages of the development of the organism it serves, the heart undergoes many transformations, the last of which do not occur until birth.

Although breathing is still months in the future, the air passages and lungs form very rapidly. By the end of six weeks the bronchial tubes have branched as many as eight times. Similarly the digestive system shows marked development. The mouth begins taking shape and the tube to the stomach develops. The stomach and duodenum develop rapidly to their permanent shape and relative position. The intestines are also developing although the lower tract is not yet open. Liver and gallbladder are rapidly developing—in fact, at one point the embryo is ten percent liver.

The urinogenital system also takes shape. The sex of the individual was written into his makeup at conception, and by the end of the sixth week male can be distinguished from female embryos by their sex glands.

### Stages in Later Development

At eight weeks, the developing individual is called a *fetus*. The dividing line between embryo and fetus is rather arbitrary—the word "fetus" is simply Latin for *offspring*. But there is some reason for making a distinction, since during the sixth and seventh weeks the embryo takes a more and more obviously human appearance, while all the major parts and organs are laid down and the process until birth is one of refinement and growth. For this reason, treatises on human embryology follow general development rather carefully in the early stages, but summarize the general development after six to eight weeks, following the further development of various parts and organ systems in distinct sections.

Sometimes the completion of the twelfth week of pregnancy—counting from the last menstrual period—has been suggested as an appropriate cutoff point for abortion because after this time the necessary operative procedure may entail increased danger to the mother. At this point the fetus has completed about ten weeks of development. It is more than one and one-half inches from crown to rump; it has an erect head, nicely formed limbs, is well along in the process of bone formation, has the outlines of nails on fingers and toes. The spinal cord is in its definitive form. External sexual organs are becoming definitely male or female and all the internal organs are undergoing further refinement. For example, at this time the kidneys are able to secrete and the anal canal is formed.[27]

The stages of development of the nervous system also may be of special interest. Considering the way in which development occurs, it is extremely difficult to say when anything begins, since everything can be traced back to less and less differentiated primordia. Thus the earliest stages in the differentiated development of the nervous system occur soon after implantation when the folds begin to appear that will later form the tube of brain and spinal column. A few weeks later nerve cells are forming, and the brain has undergone considerable development by the end of six weeks. But the onset of function is another matter, and one extremely difficult to determine.[28]

For example, it has sometimes been argued that there is no effective functioning of the nervous system until late in pregnancy. Even when the nerve cells themselves develop, it is argued, the myelin sheath which surrounds them is not immediately present, and full functioning is thought to be possible only with completion of this process. The fact is, however, that some nerves never are myelinated and the myelination process does not occur simultaneously to all the nerves that will be myelinated. Myelination begins in the fourth month of development, but is not completed until a child is two or three years old.[29]

One's nerve cells are practically all present at birth, because although nerve cells grow in later life, they usually do not multiply. Yet for most parts of the brain that will be myelinated, the process has not proceeded through its most intense phases even at birth—e.g., in the optic tract it has only begun a month or so before normal birth, goes through the intense phase during the second and third months after birth, and is not completed until the infant is ten months old.[30] Yet any observant parent knows that an infant has some use of his eyes from birth.[31]

Rather than argue theoretically about the onset of functioning of the nervous system, it may be more enlightening to consider the facts that have been discovered by experimentation. These experiments were conducted on live, human embryos received from abdominal surgery on pregnant women. Of course, one cannot say whether the abnormal situation of the embryo may have caused it to respond otherwise than it normally would have done, but certainly its nervous system gained no potential from its condition of ebbing life.

The first responses to tactual stimulation have been observed in embryos of about five and one-half weeks (counting from fertilization, or about seven and one-half weeks of "menstrual age").[32] At first there is merely a tightening of the neck when a fine hair is touched to the skin around the mouth region, but in three weeks this becomes a pulling to the opposite side, then a bending (as if to begin doubling up). In the twelfth week of development the response is more specialized; this already begins as early as seven and one-half weeks when the embryo will begin opening its mouth if its lower lip is tickled. These early responses are not uncoordinated and isolated, as is demonstrated by double stimulation. If a fetus of eight and one-half weeks is tickled around the mouth, it bends away to the opposite side; if it is tickled in the palm of its hand, the fingers partly close. But if both areas are stimulated simultaneously, only the first response occurs, as if avoidance were taking priority over grasping!

Now what does this ability to respond indicate? First of all, it indicates the presence of some sensation, since the skin surface must be sensitive if it responds to stimulation. Second, it suggests that the infant in the uterus may be active (quickening) well before the mother becomes aware of it around the sixteenth or seventeenth week. This date is in any case relative to the mother's experience and sensitivity. Movements can be detected with a stethoscope at about the fourteenth week,[33] and some pregnant women believe they feel the infant move at that time or even a week before.[34]

Still it would be misleading to say that the sensitivity demonstrated even at the embryonic stage shows that the embryo is aware of pain. Awareness is complex and admits of degree. And pain has many psychological dimensions; it is not a simple sensation. If the front of the roof brain is surgically removed, an individual may not suffer from pain, while still being aware of the sensation, which apparently comes to consciousness in virtue of another part of the brain.[35] Moreover, the sensitivity that admits of stimulation of a reflex-response is considered by many to be distinct from even the purely sensory component of pain.

But one must not too quickly say that the fetus can feel no pain. Certainly the sense seems to be established in some parts of the body of the infant at birth, even if he is quite premature. It is by no means certain that nerve endings are altogether specialized for various modalities such as touch, heat, and pain even after development,[36] and there is all the more reason to think that there would be non-differentiation at early stages of development. So far as the argument about the myelin sheath is concerned, the fact is that not all nerve fibers that do conduct pain are myelinated even in the adult.[37] Perhaps the question whether the response of the embryo to touch is an indication of sensitivity to pain would best be answered by denying the distinction of modalities that will later develop.[38]

Whether such primitive sensations also are "felt" or not is much more a metaphysical question—the answer to which depends on one's theory of the mind-body relation—than a factual one. For if one thinks of body and mind as two quite distinct entities, it might well make sense to speak of sensations that stimulate behavior without in any sense being felt. If one thinks of the individual as more unified, however, the fact of responsiveness may be sufficient to demonstrate that the stimulus is felt, even if only in an initially undifferentiated modality from which the diverse modalities of touch and pain will become differentiated only after some time.

## Parthenogenesis

To this point we have been concerned with the normal process by which a new human individual comes to be. *Normal*, of course, merely means what happens for the most part, or what proceeds toward the completion of a goal which we, viewing the process, have in mind—i.e., the developed and viable infant. Before concluding this chapter, it would be well to consider briefly a few of the many variations from the normal that may occur. Our interest will be restricted to those that might raise questions of importance for the subsequent discussion.

Parthenogenesis is the development of an embryo from an unfertilized ovum. This occurs as a normal event among certain non-mammals.[39] We may view it as a variant of sexual reproduction, wherein some asexual reproduction also may occur. Experimentally, fatherless turkeys have been bred, and it has been reported that induced parthenogenesis has occurred even in the rabbit. In the rabbit, however, development apparently does not proceed beyond very early stages unless the ovum divides peculiarly so that the normal, full complement of chromosomes is restored.[40] Of course, all the individual's genetic constitution in this case would derive from the mother.

If parthenogenetic development were to occur in a human, either naturally or artificially, it would raise two interesting questions. First, can we think of individuality as being determined altogether by genetic makeup, when such individuals would have all their genetic makeup from their mother, and yet would be distinct from her? Second, how can we sharply distinguish between the unfertilized ovum—not yet an individual—and the zygote, if the latter may arise from the former alone? Does not parthenogenesis suggest that the ovum and the fertilized ovum are really equivalent, so that the latter is no more a new individual than the former?

The first question requires two answers. If, on the one hand, the parthenogenetic individual arises from its mother making use of only half her genetic makeup, then the cells of the offspring will remain distinct from those of its mother by this fact alone.[41] On the other hand, if this peculiarity of development begins only after the ovum has undergone part of its normal development, as seems likely, the shuffling of genes will have produced peculiarities in the makeup of the offspring that altogether distinguish it from its mother.[42] Thus in any case the individual developing parthenogenetically would be genetically distinct from its mother.

The answer to the second question is that even if parthenogenesis is proved to occur in human beings, this still would not prove that every ovum is a new individual in the sense that the fertilized ovum clearly is. To begin development parthenogenetically, the ovum of a mammal must be treated in some abnormal way—e.g., cooling or heating beyond the normal range of body temperature. The fact that there are definite differences among species in susceptibility to such development also suggests that a genetic factor is involved. Thus it may well be that not every ovum even of the same species would be potentially susceptible to parthenogenetic development. But even if all could be stimulated to such development, this would by no means prove the equivalence of the zygote and the unstimulated, unfertilized ovum. It would rather demonstrate the opposite, for the stimulation leading to such extraordinary development is precisely what the human ovum normally does not undergo.

## Twins

What we have to say here about twins will apply also to triplets, quintuplets, and so forth.

There are two types of twins: fraternal and identical. The former are merely multiple, simultaneous pregnancies, while the latter derive from the same sperm and ovum. At some point after conception, the developing product of conception divides so that two individuals are formed having the same genetic constitution.

This phenomenon raises two questions. First, how can the zygote be individual at the moment conception is completed if it is potentially able to develop into two individuals by dividing after that moment? Second, how can individuality be determined genetically if identical twins, admittedly distinct individuals, can share the identical genetic constitution?

To answer the first question it would be interesting to know just when the split occurs that leads to identical twins. The answer seems to be that the division does not always occur at the same stage of development. It is possibly sometimes as late as the primitive-streak stage, which does not occur until after implantation, but in other cases it may occur prior to implantation.[43] These suppositions follow from the evidence of various arrangements of the accessory structures, which are more or less completely distinct. If they are not completely distinct, it may be assumed that splitting did not occur until *after* the structures in question were formed.

But it is one thing to know when splitting occurs, and another to know when two individuals begin to be present, for duality may be established before the two individuals divide. Most identical twins have separate amnions—the inner membrane of the "bag of waters."[44] Since this membrane begins to form at or shortly after implantation, it seems likely that the duality is established before that time in almost all cases. Even if there is but one amnion, duality may be established considerably earlier, for splitting at the primitive-streak stage is most unlikely to be the result of environmental conditions, and so may arise from a peculiarity of blastula formation that brings about two foci on a conjoined embryonic disk.

Apart from this consideration, it also is important to notice that there is a genetic factor involved in identical twinning.[45] This fact strongly suggests that not every zygote is capable of developing spontaneously into identical twins. The question—How can what is potentially two individuals actually be one?—really only can be asked with regard to those zygotes that do, in fact, develop into identical twins.

If we assume that the duality which leads later to formation of twins is not already determined in the zygote, we can answer the question in the following way. Two individuals can develop from one in such a case much as two individual animals of many lower forms can develop by the division of a single, existing individual. Which one of the two new animals is to be identified with the original individual that was divided? In a case of this sort, perhaps neither. It has been suggested that we should think of identical twins as *grandchildren* of their putative parents, the individual that divided being the true offspring, and the identical twins children of that offspring by atypical reproduction.[46] By this theory a certain number of human individuals would cease to be shortly after conception. However, there is a rather substantial wastage in the first two weeks anyway, as we shall see shortly.

The second question about twins was: how can individuality be determined genetically if identical twins share the same genetic constitution?

The answer to this question requires a clarification of the concept of individuality. The notion of *individual* is that of one unified in itself and distinguished from others. But unity and distinction are rather slippery terms. If we consider a tree that both reproduces from seed and grows in clumps we may not know whether two sprouts we see coming up are two trees or only one clump. If the sprouts are from different seeds, they will be genetically different from each other. But if they are from only one seed, we will ask ourselves for some other criterion for distinguishing them—e.g., we will have several trees when the clump is well enough established so that parts of it can be transplanted to different locations. Thus there is relativity in the concept of individuality.

The zygote, whether it will become a single or a double embryo, is genetically distinct from its parents as soon as it is formed. It is unified in its own genetic character and divided from theirs, and this is an adequate criterion of its individuality in this relationship.[47] But identical twins are thought of as individuals because we discern distinct masses, each of which functions in itself as we expect a human being *at that stage of development* to function. The growth pattern is our chief key in the early period.

But we must realize that this criterion of individuality for identical twins can break down more or less seriously. The two may never separate completely, and so we have various forms of conjoined (Siamese) twins. These blend continuously into many types of double monsters, in some of which elements of what might have been one twin become abnormally incorporated in the other.[48]

In some of these cases, the twins though joined and sharing some common parts nevertheless have some quite distinct human functions. For example, conjoined twins with two heads and one stomach could be sleeping with one head while being amused with the other, and simultaneously digesting in a single stomach. Here there are two individuals for some functions and there is one individual for others. We would like to say "two" without qualifying, because we regard the functions of the head as more important than those of the stomach. If there is only one brain, we are likely to think there is one individual with some spare parts.

What these considerations show is that identical twins certainly do not lack individuality when we consider them in comparison with others even though their individuality in relation to one another may be qualified and puzzling. If anyone wishes to argue that identical twins cannot be individuals in any relation until they are distinct from each other, he shall have to hold that conjoined identical twins, especially those sharing some organs, are not human individuals at all. Though he might be happy to think this when looking at some ugly, asymmetrical double monster, he would have difficulty holding the same view consistently when considering some pair of appealing, symmetrical conjoined twins.

## Mosaics

Recent experiments with mice have demonstrated the possibility of producing just the opposite result from identical twins. Two fertilized ova in a morula stage of development have been combined to form a single individual which—placed in a mother mouse of a different strain—has developed through the blastula and later stages to normal birth. Such mice contain tissues of two genetically individuated types. Success has been obtained with paired morulae of at least sixteen cells each—this is in the pre-implantation stage and would correspond to about three days after ovulation in the human being.[49] There have been reports of no such experiments with human beings. Perhaps the same thing could be caused artificially, but it is questionable whether it occurs naturally.[50]

These experiments show that at this stage of development the cells are not differentiated in an irreversible way. However, implantation cannot occur without definition of function and the development of a specific shape—that of the blastula.

The judgment we should make about the individuality of mosaics is parallel to that we have made concerning twins. So long as the two morulae are distinct from each other they are distinct individuals, separated from their parents genetically and from one another by their position and functioning. Once combined the two cease to be as such and form one new individual. The situation is analogous to that in a grafted plant, where fusion between previously existing individuals can be obtained. The fact that this is possible by no means indicates that the two plants were not alive and individuated prior to their fusion, but rather demonstrates just the opposite.

## Monsters

The question of monsters is often treated illogically, since abnormalities seem to stimulate deep anxieties and feelings of disgust in many of us. Perhaps much of the mystery would be taken out of the matter at once if we would consider that accidents and disease can strike before birth much as they do afterward. An individual can be rendered hardly human (and still permitted a few minutes to live) by a bullet blowing away half his skull and brain. Surgery for cancer can leave one without many of his normal parts and organs. In such cases we do not doubt one remains a human individual until death intervenes.

Here we do not wish to discuss the entire question of congenital abnormality. Rather we wish to treat a single question: should we consider monsters to be true, human individuals? Is everything coming out of the womb to be considered a human being?

The first thing to be said in answer to this question is that not everything that appears to be an embryonic development really is one. There are certain tumors, called *teratomas*, that include various types of tissue, jumbled together without much order. Such a tumor may, for example, contain some hair, some skin, some teeth, some muscle. The tissue may seem to form a part of a body—e.g., there may be fingers with nails growing. Many biologists and physicians going by appearance have believed these tumors to be embryos whose development had gone astray. But authoritative and recent examination of the question has led to the conclusion that these growths are simply tumors—rather disorganized but somewhat differentiating bundles of material deriving from an individual's own body. Teratomas are not malformed embryos. They do not develop from a zygote, but from stray cells which perhaps were misplaced in the course of the individual's own early development, and hence which retain a capacity for growth and differentiation somewhat similar to that of embryonic formative tissue.[51]

Another type of monster is one that has not developed properly in the head region. In one condition, called *anencephaly*, a fetus is delivered lacking the top of the head and having little brain tissue. What has happened is that for reasons unknown the neural tube failed to close, the brain could not develop properly, and the amniotic fluid destroyed what nerve cells did develop. This type of monstrosity is more or less due to inheritance, and it occurs in a fairly large number of cases, perhaps two to six per thousand live births. Very shortly after birth, the monster dies because it cannot live for long once the umbilical cord is cut.[52]

Are such monsters to be considered human individuals? Genetically they are human and individual, although the degree of abnormality makes us wonder if the specimen is a human being. One possible view, if the abnormality is determined from the beginning, is that such individuals should be considered human only in their origin. Another possible view is that such monsters should be considered in much the same way we do an individual whose head has been blown off by a gun shot. The consequence is similar. This way of viewing the matter is favored by the fact that in the anencephalic embryo there is normal development up to a certain point, but the failure of the neural tube to close leads to degenerative changes.

The double monsters that result from the imperfect separation of identical twins and the anencephalic monsters just described both illustrate an important point. Monsters are merely variations from the normal course of specifically human development. They are not beings of a different species—as if human conception could lead to the genesis of some other sort of animal. Much of the horror of monsters in earlier times probably arose from a suspicion that they resulted from copulation with sub-human animals. This explanation of the monster birth is of course absurd.

Sometimes normal development is interfered with by something coming from outside the embryo. That was the case with the thalidomide babies, in whom sleeping pills blocked the normal development of the limbs. A drug helpful to the mother could not be handled by the developing embryo, with whose prime function of growth and differentiation it interfered. Something similar happens with the rubella (German measles) virus, which can cause cataracts, heart defects, or deafness in a certain proportion of the babies of women who have the disease in the first twelve weeks of pregnancy. The effect in a given case depends upon the particular system that is beginning to develop at the time the disease strikes, although not every system developing at that time will be damaged. Rubella does not lead to severe mental retardation, for example, except in one or two percent.[53]

Another source of abnormalities is genetic. Here something goes wrong so that there may be one too many or one too few chromosomes. An example is Down's syndrome (mongolism). Or the pattern of chromosomes may appear normal, but some of the genes may be damaged or destroyed—a situation called a "mutation." In cases of this kind, the genetic material that remains is still human, although somewhat altered from the normal complement. When such individuals can develop in a fairly normal way to birth, and can exercise human capabilities within certain limits afterwards—as is true of those with Down's syndrome—there can be no doubt that conception has initiated a human life, although an abnormal one.[54]

Genetic abnormalities may be viewed as experiments that nature is making. In a given environment, an individual could be more or less damaged by such an experiment, but could conceivably be helped. However, most experiments turn out badly. The important thing is that "normal" only means a range of variation that leaves an individual well-equipped to deal with his particular environment. For this reason there are all sorts and degrees of abnormality, and not every abnormality means that an individual is a monster.

We reach the margin of human specificity, however, when we consider genetic anomalies that may arise from accidents in the formation of the sex cells themselves or in fertilization. Sometimes, although fertilization occurs, there are three or more whole sets of chromosomes, instead of the normal two sets. This may result from fertilization of an ovum by two sperm, or by some abnormal development in the forming of either ovum or sperm.[55] In cases of this sort, the individual never survives until birth—the outcome, as in many other genetic abnormalities, is spontaneous abortion.[56]

The efficiency of nature in preventing such anomalies from developing makes discussion of them rather academic. Perhaps even greater and more serious anomalies occur, and they may in part account for non-implantation or failure of development before the third week.[57] In these cases in which the specific pattern of human genetic structure is so transformed that embryonic development cannot occur, we might reasonably hesitate to refer to the life of the abnormal conceptus as an "individual human life." Still we can call such life "human" in the sense that it originates as a deviation from normal human development.

The consideration of monsters therefore can bring us to the conclusion that not everything coming from the womb should be considered a human being. The specimen may not result from conception, and then it would be a tumor, not a deformed embryo. It may be a human being only in the sense that someone dying of a wound that has destroyed most of his brain remains human until he dies. It may be human in its conception, but incapable of developing beyond a few hours, a few days, or a few weeks. In such cases, especially if the specifically human genetic pattern is greatly transformed, we may not consider the conceptus a human individual. Finally, various lesser abnormalities occur, compatible with at least some human development. In these cases we are undoubtedly dealing with damaged human individuals.

This discussion suggests that there is naturally a considerable loss of life before birth. Our final task in this chapter will be to investigate its extent.

## Pregnancy Losses

The actual extent of loss of human life, apart from induced abortion, in the whole period between conception and viable birth is extremely difficult to determine, and available studies leave much to be desired. One study investigated losses in New York City in 1960 and arrived at the conclusion that the total loss would be about 295 per thousand, or around 30 percent.[58] However, in this study 185 of the losses were extrapolated to the period 0–7 weeks on the basis of 110 losses for which there was evidence in the remaining period of pregnancy.

Another study, conducted on a large scale and on a fairly careful basis, produced evidence of 142 deaths per thousand conceptions.[59] The authors of this report speculated that the death rate in the early weeks actually is higher, since in some cases women must become pregnant and expel the products of conception without knowing it.[60] Nevertheless, they did not extrapolate to the early period, and if they had done so, the result would be higher than 295 per thousand, though not in the proportion 110:142, since this study included some early losses in the 0–7 weeks period.

A different way to attack the problem is by deducing the probable loss in human beings from what is known of other mammals. This is the basis of the often repeated statement: "One-third to one-half of all fertilized ova perish before birth." It was published in 1944 in a popular treatise on human embryology by George W. Corner; his basis was research published over twenty years previously, in 1923, on pigs and other animals.[61] Whether the rate of pregnancy losses in other species is a sound basis for drawing conclusions about humans is questionable, especially because other species differ considerably among themselves in this respect.

A better approach to the question is to consider the proportion of normal to abnormal individuals discovered in the human specimens that have been studied of very early products of conception. In the study of Hertig, Rock, Adams, and Mulligan on which we drew near the beginning of this chapter, four normal and four abnormal specimens were found.[62] A few years previously, Dr. Hertig discussed some of this material and some other specimens that attained implantation at a conference concerned with pregnancy wastage—i.e., losses during the whole time between conception and viable birth.[63] His conclusion at that time was that although 40 percent of the specimens were more or less abnormal, only about 12 percent were defective in such a way that they would have caused noticeable abortion—many of these specimens showing defects similar to those found in the peak period of pregnancy loss between nine and fifteen weeks.[64]

Other contributors to this symposium, relying on earlier, published work of Dr. Hertig and Dr. John Rock, estimated the rate of loss variously at 25–35 percent.[65] A 1954 United Nations study noted that the abortion-rate based on the first 28 of Hertig's and Rock's embryos would be "at least 25 percent" but added that much more information would be needed for any valid generalization.[66] In its conclusions, 20 percent was stated to be the "most conservative estimate" of pregnancy losses.[67]

A few years later, in 1956, Drs. Hertig and Rock themselves published a summary of their work on thirty-four specimens from the first seventeen days of development.[68] They concluded that twenty-one were normal and thirteen (just under 40 percent) were abnormal. Of course, this group includes the eight pre-implantation specimens, of which half were abnormal. Of the nine that were implanted, two altogether lacked an embryonic disk. The conclusion was drawn that probably *most* of these abnormal specimens would inevitably have been aborted naturally, some perhaps without a menstrual period being missed.

More recently, Dr. Hertig again analyzed these same data and concluded that in any one month, with optimal conditions for fertilization, about 15 percent of the ova never are fertilized, 10–15 percent do not implant, 28–33 percent implant but do not cause a missed period, and only 42 percent cause a delayed or missed period.[69] This 42 percent represents about half the fertilized ova. The implication is that about half of those conceived die within about two weeks after conception. Dr. Hertig adds, but without giving any evidence, that 27.6 percent of those that survive the first two weeks do not go to term.[70]

If we accepted this figure, we would conclude that only about 36 percent of those that begin life naturally survive until normal birth. However, Dr. Hertig reaches his conclusions on the basis of only six more specimens than the sampling that the U. N. study considered as an inadequate basis for generalization. If the percentage of cases in which fertilization does not occur at all were taken as higher than the 15 percent Dr. Hertig estimated—and he admitted elsewhere it could be as high as 42 percent—the percentage of loss would decline very rapidly.[71]

Moreover, in the actual examination of the results of one thousand spontaneous abortions, Dr. Hertig found 48.9 percent with absent or defective embryos, most with no embryonic mass at all.[72] If these specimens already were causally determined to be so at the time of fertilization, it seems doubtful whether we should say that a human life was lost, or merely that a fertilization occurred from which no individual ever could have developed.

Our conclusion is that the most conservative estimate of loss of life before birth is 20 percent. The upper limit suggested by Dr. Hertig's calculations is unproved and seems excessively high. However, the rate of loss could well be 50 percent—one of every two. If so, about as many individuals die before birth, naturally and spontaneously, as are born alive if they are not purposely aborted. Of these that die naturally before birth, most die after implantation—probably less than 30 percent die before this stage.[73] Including those that survive, less than 20 percent—probably even less than 15 percent—of all blastulas fail to implant.

This conclusion, while not exactly heartwarming, should at least put to rest the image sometimes conjured up in popular writings and discussions that there are three or more times as many conceptions naturally aborted as develop normally, and that 30 percent or more of conceptions never proceed as far as implantation. The large numbers sometimes given indicate that ovulation and conception are being confused. Obviously, in a very high proportion of cases, ovulation does not lead to conception, because conditions are not "optimal"—i.e., there is no intercourse at the appropriate time or contraception is used. The proportions of implantation failure sometimes given at 30 percent or more probably arise from a misreading of Dr. Hertig's conclusions.

## A Note On "Viability"

The word "viability" has been avoided in this chapter but it is likely to be used in arguments about abortion—for example, when it is suggested that abortion be permitted as long as the unborn is not "viable." The concept is that prior to viability the fetus could not live apart from the mother; after viability it could live apart. A dividing line at twenty-six or twenty-eight weeks of gestation is sometimes suggested as the appropriate demarcation of viability.

The notion of "viability" defined in any such simple fashion is without biological and medical foundation. The word does not even appear in standard medical indexes.

The reason why is not difficult to discover. Dr. Carl L. Erhardt and his colleagues studied mortality among infants born in New York City, 1958–1961. In general, they discovered that neonatal mortality—that is, deaths within the first twenty-eight days after live birth—mounted steeply as the length of pregnancy shortened below thirty weeks and as the birth weight dropped below fifteen hundred grams (about three pounds, five ounces). But 45 percent of white and 58 percent of non-white babies born during the twenty-sixth or twenty-seventh weeks of pregnancy survived through the neonatal period. Even under twenty weeks of pregnancy, more than twenty percent of those born alive survived the neonatal period.[74]

From this study alone—we could cite others—it is clear that "viability" is relative and does not provide a clear line of demarcation. Besides length of pregnancy, such factors as the weight and the race of the fetus make a significant difference. Of course, beyond a certain point there are no survivors. However, this point, whatever it happens to be, also is relative to present methods of caring for the premature. With improved techniques and equipment, going beyond the incubator toward the artificial womb, probably the vast majority of fetuses could survive apart from their mothers after twelve or fourteen weeks of pregnancy.[75]

Perhaps even more misleading than the factual oversimplification involved in the idea of "viability" is the assumption that ability to live independently is a suitable criterion of individual identity. Biologically this is certainly not true, for the fetus is genetically and functionally an individual from its beginning, but it is not capable of living independently until long after its birth. The mother's breasts are a biological sign of the infant's continuing dependence for survival, although in human beings dependence is prolonged far beyond weaning.

Indeed, one might question whether even the strongest of us is ever able to live wholly independently. Obviously, many who are retarded, handicapped, ill, and aged are as dependent upon others for survival as is the "non-viable" fetus.