system. Of the two umbilical veins, the left persists entire, to form the single umbilical vein of the embryo and cord. The right umbilical vein degenerates into an unimportant vein. The presence of the liver has also modified the proximal ends of the umbilical veins. The left one becomes divided into a capillary net, which

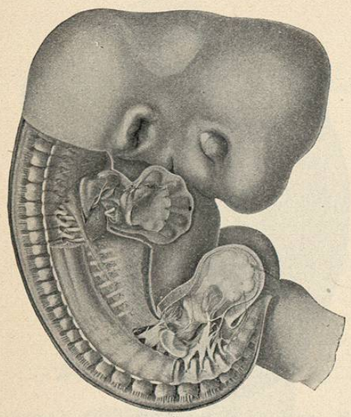

FIG. 5151.—Lateral View of a Human Embryo 11 mm. in Length and About Five Weeks Old. No. CIX., Johns Hopkins University Collection. (Enlarged about 7 diameters.) The dissected area was drawn from a reconstruction. (After Bardeen and Lewis.)

again collects into a short vein that opens into the sinus venosus. The development of the ductus venosus soon forms a channel for most of the blood carried by the umbilical vein. The proximal portion of the inferior vena cava is developed as a new structure. The distal end of this unites with the right inferior cardinal in the region where the renal arteries arise; and the caudal continuation of the cardinal from this point of union becomes the inferior portion of the vena cava. The remaining portions of the two cardinals form the azygos veins. A cross anastomosis develops from the left jugular to the right jugular, and from the common stem thus formed develops the superior vena cava. The proximal portion of the ductus Cuvieri on the left side then loses its connection with the jugular and becomes the coronary sinus of the heart.

By the time the embryo is five weeks old it has attained a length of 11 mm. (see Fig. 5151). The head is still very large and bent at right angles to the main axis of the body. The maxillary and nasal processes, which fuse at a later stage to form the upper jaw, are now more marked and approaching each other. The external nares are nearing the middle line. The external ear is represented by several small protuberances about the first cleft. The general body musculature is well advanced and has its nerve supply. The ribs and the muscles of the thorax and abdomen have grown some distance into the thin membrane, membrana reuniens, which in early stages constitutes the ventral body wall. The limbs are much enlarged and contain a skeletal core of cartilage surrounded by the developing muscles. The arm keeps about two weeks in advance of the leg in its internal differentiation. The vertebral column and ribs are formed partially in cartilage. The fourth pair of the aortic arches still persists entire and the others are modified in various ways to form the larger arteries in this region. The liver has been increasing rapidly in size, and in this embryo as in the preceding stage forms with the heart most of the large projecting abdomen and thorax. The allantois forms a long narrow tube extending from the hindgut into the umbilical cord as far as the chorion. At a later stage the umbilical portion becomes obliterated, while the portion near the hindgut enlarges into the bladder.

During the fifth week the œsophagus elongates and the stomach acquires its characteristic form, as well as an obliquely transverse position, its former left side becoming directed anteriorly and upward, and its former right side looking backward and downward. This explains the distribution of the left vagus nerve to the front of the stomach and the right to the back; for, before this twisting of the stomach began, these nerves had already reached the stomach. The connection of the yolk stalk or vitelline duct with the intestinal canal rapidly becomes less marked, and by the end of this week only a small duct attaches the yolk sac to the intestine.

During the last part of the embryonal stage and the first part of the fœtal stage there are very important shiftings or migrations of various organs in the body. That of the heart and diaphragm from the cervical region into the thoracic region is of especial interest, as other structures are dragged along with them. The large blood-vessels are pulled downward, and such nerves as the recurrent laryngeals indicate this process. Originally they passed directly from the vagus to the larynx just posterior to the fifth aortic arch, and by the migration of the heart and large blood-vessels they are brought into the position seen in the adult. The diaphragm in its descent obtains muscle tissue and its nerve in the cervical region,

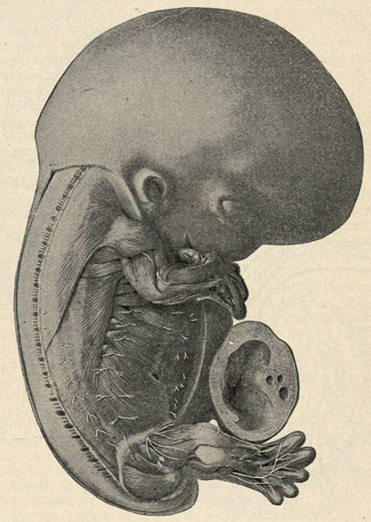

FIG. 5152.—Drawing from a Reconstruction of a Human Embryo 20 mm. in Length and About Seven Weeks Old. No. XXII., Johns Hopkins University Collection. (Enlarged about 5 diameters.) The muscular systems of the limbs and body wall are seen to be well developed. (After Bardeen and Lewis.)

and both are then carried down to the lower part of the thorax. The limbs also exhibit a migration, the arm from the cervical to the thoracic region giving the caudal inclination to the brachial plexus, which originally went straight out into the arm without this caudal inclination. The leg likewise migrates. Many individual muscles also take part in this shifting and migrating, such as the trapezius from the upper cervical region and the





latissimus dorsi from the lower cervical. The path of the nerve from its exit at the intervertebral foramen to its point of entrance into the muscle indicates the path the migrating muscle has taken, while the branching within the muscle probably indicates the direction in which the muscle has increased in size.

During the embryonal stage the yolk sac has diminished to an organ of relatively small size and importance, while the central nervous system, with its greatly enlarged anterior end, the brain, giving to the head its great prominence, becomes the predominating feature of the embyo. The head throughout most of this stage is about equal in bulk to the rest of the body of the embryo.

*Fœtal Stage.*—In an embyro seven weeks old and 20 mm. long the early fœtal features are fairly well marked. The head is nearly erect. The fusion of the maxillary and nasal processes is proceeding rapidly to form the upper jaw, and the nasal pits have approached nearer to the median line. Failure of fusion between these processes gives rise to the various forms of cleft palate and harelip. The arms and legs are much elongated, and show the three segments seen in adults. Fingers and toes are also to be distinguished. Practically every muscle of the body can now be recognized, and has also its nerve supply (see Fig. 5152). Most of the skeletal elements are present in cartilage. Portions of the skull, however, are never so represented, but ossification takes place directly from the condensed mesenchyme. The ribs have extended nearly to the mid-ventral line. The thoracic and abdominal muscles have likewise pushed farther out into the ventral wall of the body.

By the end of the second month the permanent kidney is fairly well formed and the Wolffian body, which so far in the life of the embryo has performed the function of an excretory organ, begins to lose its importance. All but the middle portion, which later forms the sexual gland, atrophies. Its duct in the male forms the vas deferens, in the female degenerates, while in the female the Müllerian ducts form the Fallopian tubes and uterus, and in the male degenerate. Thus by the end of the second month most of the organs which are found in the adult are formed. The main processes which now take place until birth are the growth and shifting about of these organs.

The *third month* establishes the human form, although the head still unduly predominates. The limbs have acquired their definite shape, and the imperfect nails are present on both fingers and toes. The external organs of generation become definitely differentiated, although they make their appearance several weeks earlier.

In the female the genital tubercle remains much less developed to form the clitoris. The genital furrow remains open to form the vestibule and the genital swellings the labia majora. The prepuce and labia minora developing from the genital folds, lie at either side of the genital sinus. The genital swellings in the male when they develop into the scrotum have layers identical with those of the abdominal wall, as seen in the following scheme:

| *Abdominal Walls.* | *Scrotum.* |
|---|---|
| Integument. | Integument. |
| Superficial fascia. | Dartos. |
| External oblique muscle. | Intercolumnar fascia. |
| Internal oblique muscle. | Cremasteric. |
| Transversalis muscle. | Infundibuliform fascia. |
| Peritoneum. | Tunica vaginalis. |

The tunica vaginalis lines the sac, communicating above with the peritoneal cavity; and into this sac later the testicle descends. The anterior end of the ureter now reaches the neighborhood of the suprarenal where it ends in the kidney, which consists of about eighteen lobes, one for each group of tubules connected with the ureter. This lobulation persists until after birth. The suprarenals now fit caplike over the anterior end of the kidney. At the end of the month the fœtus weighs about 120 gm. (3¼ ounces), and measures about 5 cm. (2 inches) in length.

During the *fourth month* hairs devoid of pigment appear on the scalp and other parts of the body, which is now covered with firmer skin of a rosy hue. The eyelids, nostrils, and lips are closed. The anus opens, and the coils of intestine, which before extended into the umbilical cord, now lie entirely within the abdominal cavity. The point of emergence of the umbilical cord lies low down close to the pubes. The head forms about one-fourth of the entire body. The bones of the skull while ossifying are still widely separated. The sexual distinctions of the external genital organs are well defined. By the end of this month the fœtus weighs about 230 gm. (7½ ounces), and measures about 10 cm. (4½ inches) in length.

During the *fifth month* the lower extremities become longer than the arms, nails are well formed, and hairs are more plentiful, but devoid of color. The fœtal movements are distinctly felt by the mother. The sudoriparous glands arise during this month as solid cylindrical outgrowths from the primary ridges of the epidermis into the dermis. Later they become coiled and a lumen appears. The heart and liver share with the head in the undue preponderance which these parts present. At the end of this month the fœtus measures 20 cm. (8 inches) in length, and weighs about 500 gm. (1 pound).

During the *sixth month* the surface presents many wrinkles and is of a dirty reddish hue; the sebaceous coating, the vernix caseosa, begins to appear. This whitish substance is composed of shed surface epithelium, mingled with the secretions of the sebaceous glands; its primary function seems to be the protection of the integument from maceration by the amniotic fluid. The eyebrows and eyelashes begin to grow. The length of the fœtus by the end of this month is about 30 cm. (12 inches), and its weight about 1,000 gm. (2 pounds).

*The Seventh Month.*—The formation of fat causes an appearance of greater plumpness, although the surface is still somewhat wrinkled. The hairs are longer, about 5 mm. in length. The eyelids are now permanently open. The liver is still relatively large; the testicles have descended as far as, or even into, the inguinal canals. Children born at the end of this month may live. The fœtus measures at the end of this period about 37 cm. long (15 inches), and weighs about 1,500 gm. (3 pounds).

*The Eighth Month.*—This and the ninth month complete the fœtal period. The chief changes are great increase in weight, as by the end of the eighth month the fœtus weighs from 2 to 2.5 kgm. (4 to 5 pounds) and measures about 42 cm. in length. The scalp is well supplied with hair, and the finger nails almost reach the finger tips. The lanugo or embryonal down begins to disappear. The subcutaneous fat has increased considerably, giving a more rounded form to the body.

*The Ninth Month.*—During this month there is a relatively large increase in weight, from 2 to 2.5 kgm. to about 3 or 3.5 kgm. (6 to 7 pounds), while the increase in length is only from about 42 to 50 cm. (20 inches). The skin is less highly colored and the lanugo has almost entirely disappeared. The testicles have descended into the scrotum; in the female the labia majora are in contact. Centres of ossification usually appear in the epiphysis at the lower end of the femur, and often in the upper epiphyses of the tibia and humerus.

*Warren Harmon Lewis.*

**GIGANTISM, GENERAL.**—The word giant is derived from the Middle English "geant," the equivalent of the French "géant," which may be traced back to the Greek γίγας.

Very early in the world's history we meet with references to huge beings of supernatural strength. Even before the flood, in the story of Noah, we are informed that "there were giants in the land in those days," and there are stray allusions to giants, Emmim and Anakim, in the accounts of the early Jewish conquests, in the sight of whom the people were "as grasshoppers," to use

the characteristic Eastern hyperbole. Later, we have the celebrated battle between David and Goliath of Gath, one of the few remaining descendants of these Anakim, whose height was six cubits and a span. The Greeks, also, had their giants in the man-eating Cyclopes and Lestrygones. The Titans, too, forty-five in number, whose children were the Gigantes, were of enormous size. They did not fear to encounter the gods, and were said to have heaped up mountains, to have "piled Ossa on Pelion," in order to scale the heavens. All nations, alike in their love of the marvellous and their sympathy with the weaker side, have their stories of unequal battles, recalling the struggle between the pygmies and the giants, waged between brave men and monsters of immense size and strength, in which the lesser power comes off the conqueror. An instance that will be familiar to all is the popular nursery tale of "Jack the Giant-killer," which used to delight us so much in our youth. As is usually the case, human credulity and the innate tendency to exaggeration have magnified many of these tales beyond the bounds of credibility. While it must be admitted that in former times there have been individuals and even races that far exceeded in strength and stature the ordinary run of mankind, the application of the rigid canons of modern scientific inquiry has resulted in the dethronement of the supernatural element and the reduction of the subject, though marvellous enough still, to more manageable proportions. Before passing on to discuss the nature of this curious anomaly of development that we call gigantism, we may with advantage pause for a moment to determine what constitutes giant growth.

This is not so easy as it seems. If any one asks himself the question, "Where does giant growth begin?" he will at once realize that his ideas are somewhat hazy and his language conventional. In popular parlance a giant may be said to be any individual who exceeds in a notable degree the average height of human beings. A person of six feet six or upward would probably be called gigantic. This is, of course, an exceedingly loose and by no means scientific definition. It fixes no limits, it takes no account of weight and strength; in short, it lacks precision. Larcher[1] defines a giant to be "A being who, free in other respects from all defect in the essential characteristics of the organization, excels notably in height other beings of the same race who have reached adult age." In such a case the structural harmony and the relationships between the different parts are manifestly normal, the sole deviation being the striking increase in height. It is scarcely necessary to point out that this definition portrays for us the ideal or perfect giant, a being rather more imaginary than real. No doubt there have been individuals of great size and strength, handsome, well proportioned, and well balanced in all their faculties, but these are the *rarœ* or rather the *rarissimæ aves*. As a matter of fact, the immense majority of giants present the unmistakable stigmata of defect or degeneration. The definition further ignores the fact that gigantism is a process, an anomalous one it is true, but still a process of growth which may and does manifest itself in embryonic life and childhood, as well as in the adult stage. Pierre Marie[2] recognizes two forms of gigantism: (1) *True gigantism*, consisting in a simple exaggeration of the normal process of growth; and (2) *symptomatic gigantism*, a manifestation of pre-existing disease. Meige[3] would restrict the term gigantism to Marie's second class on the ground that the members of the first group are in all respects normal persons, differing in no way, save in height, from other individuals of the same species. This, while no doubt contributing to precision of language and lessening the possibility of confusion in description, is in my opinion too extreme a position to take, for who will maintain that an exaggeration of a normal process of growth is not a pathological manifestation? We ought not, therefore, rashly to conclude that true gigantism and symptomatic gigantism are necessarily or essentially different processes, or that the former should be left out of our consideration of the general subject of gigantism. We shall be helped considerably toward a proper conception of what constitutes giant growth if we consider briefly what may be called the "law of deviation" enunciated by Thoma.

Thoma[4] states, on the basis of an extended series of observations, that in adults the normal length of the body averages approximately 169 cm. in the male and 163 cm. in the female: the normal average body weight is 60 kgm. and 56 kgm. respectively. Considerable variations on one or other side of this norm occur. In one-half the total number of individuals the amount of deviation is anywhere from 0.0 to 3.8 cm. for height, and from 0.0 to 5 kgm. for weight. In accordance with observations he has made, Thoma finds that the fifth multiple of the figures representing the amount of normal deviation, namely, 19 cm. and 25 kgm., is exceeded only once in a thousand individuals. According to this an adult male would be regarded as a giant if his height exceeded 169 plus 19 or 188 cm., or if his weight were more than 60 plus 25 or 85 kgm. The normal limits, however, for the upper well-nourished classes are somewhat higher than the figures given, namely, 175 cm. and 66 kgm., so that the lower limit for giant growth would be more correctly placed at 175 plus 19 or 194 cm., and 66 plus 25, or 91 kgm. (6 feet 4⅛ inches, and 200 pounds 5½ ounces). In the case of new-born infants the normal average for length is 50 cm. and for weight 3.2 kgm. The amount of deviation is approximately 1.4 cm. and 0.28 kgm. respectively. Applying the same rule we may assume giant growth in children if they exceed 57 cm. in length and 4.6 kgm. in weight. For Thoma, then, a giant is literally a man in a thousand. We cannot, however, assume that because an individual exceeds these dimensions he is necessarily a giant. It should be noted that height and weight are not necessarily closely correlated. In true gigantism no doubt they would be, but in many cases we find that those gigantic in stature are not heavier than many normal persons. This is often to be explained on the score of some wasting disease which is present, or that the individuals in question have died or been observed before the consolidation of the body had been properly attained. Further, an excess in weight above the limit of 91 kgm. cannot in itself constitute gigantism, for this weight is frequently attained by those who would be regarded as normal individuals, and has also been attained in cases of diffuse lipomatosis, elephantiasis, and when large tumors are present. Gigantism is quite different from this. Properly understood, it implies not a mere increase in the bulk of any tissue or group of tissues, but rather an abnormal increase in the size of the body as a whole, due to some peculiar and inherent nutritive disturbance. The term *macrogenesy* would perhaps most correctly designate the condition.

Gigantism manifests itself in an excessive growth of the bones, more especially in the direction of length, but also to some extent in thickness. The long bones are most noticeably involved, but all the bones of the body may be to some degree affected. With this there is a corresponding increase in size of the nerves, vessels, and soft tissues generally. The most striking and constant feature in giants, however, is their great height. The deviation in weight is less apparent, is usually less and never more than the increase in height would warrant.

From a pathological standpoint gigantism belongs to the group of tissue hypertrophies, of which there are many less extreme manifestations than the complete giant. Local hypertrophies of undoubtedly developmental origin are not infrequently met with, particularly in the head and extremities. In the case of the head the bones of the cranium and face are usually involved, giving rise to an extensive and remarkable deformity (leontiasis ossea of Virchow), the exact nature of which is somewhat obscure but appears to be essentially a diffuse hyperostosis. The form found in childhood is especially common in the upper limbs, and may be unilateral or bilateral. Apart from these instances of local gigantism, which are characterized mainly by an abnormal increase in the bulk of the affected part, there are other conditions, regarded by some as forms of gigantism, in which the excess is numerical, as, for example, polydactylism, accessory ribs and vertebræ, and supernumerary organs.





Gigantism, or macrogenesy, is comparatively rare as a congenital anomaly. Fuchs[5] in the extensive material of the Lying-in Hospital at Kiel found the average weight of the new-born child at full term to be from 3 to 3.5 kgm., figures which agree accurately with those given by Thoma. This limit was not often passed, and a body weight of 5 kgm. (11 pounds) was of the greatest rarity. In 3,600 births at the Dublin Rotunda only one child reached 5 kgm. Ahlfeld[6] in fifteen years' experience met with no case above 5.1 kgm. Spiegelberg and Wiener[7] observed two infants weighing 5.2 and 6 kgm. respectively. Baudelocque[8] in many years saw only one infant that reached 6.375 kgm. Fuchs (*loc. cit.*) has described in detail two infants that weighed 6.1 and 7.55 kgm. and measured 60 and 65 cm. respectively. The most extensive statistics are those of von Winckel,[9] who in 30,000 births found no child reaching 6 kgm.; in 17,000 cases at Munich only 5 were found weighing from 5 to 5.32 kgm. These dimensions, striking as they are, have been considerably surpassed by some found in English and American literature. Eddowes[10] mentions the birth of a child weighing twenty-two pounds two ounces. The mother was thirty-three years of age, and had previously borne two children of large size. Chubb[11] met with one case in which the child weighed twenty-one pounds. The other children of the family were exceptionally large. The fact that some women have a tendency to bear large children is also well illustrated by an observation of Dickinson's,[12] where a woman was delivered by craniotomy and evisceration of a child weighing sixteen pounds. Her first child weighed nine pounds and her second twenty. Beach[13] records the birth of the child of Captain Bates and Anna Swann, both of gigantic proportions, which weighed twenty-three pounds twelve ounces. Baldwin[25] quotes the case of a woman who after having three miscarriages finally had a child weighing twenty-three pounds. There are at least ten other instances on record of new-born children weighing from thirteen to twenty pounds. The largest child I have been able to find recorded is a case of Dubois,[15] which attained the almost incredible weight of 11.3 kgm. (24 pounds 13½ ounces).

As will readily be understood, the fate of giant children is often an untoward one. Not infrequently they die in the later months of gestation. When brought to term, they have to be delivered by operative interference of some kind, and are often still-born. It is an interesting fact that the dystocia is brought about, not by the head, which usually, unless hydrocephalic, does not exceed in size that of a normal child, but by the size of the trunk. The biacromial diameter is excessive. In Dubois' series of forty-four cases only twenty-six were born alive. Children of 8 kgm. and over are invariably still-born. In those that survive, the excessive size at birth is sometimes compensated for by slow growth subsequently, but the pathological nature of the process is sufficiently indicated by the fact that such children often grow very fast and attain puberty in the third to the sixth year. It is perhaps questionable whether all cases of precocious development, wherein the individual attains the structural and functional characteristics of the adult in early childhood, are to be regarded as manifestations of gigantism. Some at least have this in common with gigantism that they show evidences of early senility. Development is rapid and decay is premature. Phlegmon ("De Mirabilibus," cap. 32) is the authority for the statement that Craterus, the brother of King Antigonus, was an infant, a young man, married and begat children, and became an old man in the short space of seven years. In 1741 a boy was born at Willingham, near Cambridge, who when twelve months old presented all the appearances of puberty and died an old man at the age of five years (Philos. Trans. of the Royal Soc. of London). The subsequent history of unusually large children is unfortunately not often to be traced, but there is some slight evidence to show that they may develop into gigantic adults. Bonardi[16] reports an interesting case which throws some light upon this point. A boy at the age of fifteen had the size and development of an adult male. At twenty-two he began to suffer from pains in the head with nausea, and soon after the hands, feet, maxillæ, and tongue began to increase in size. At the age of twenty-nine he measured 194 cm., and presented all the signs of acromegaly. In other instances, too, the abnormal increase in size has been known to begin quite early. Gilbert of the Hôpital Broussais (quoted by Meige, *loc. cit.*, p. 449) met with an individual who began to grow rapidly after an attack of some acute fever in his earliest infancy and eventually attained the height of 196 cm. The American giant Wilkins began to grow rapidly at the age of four, and reached his full height (245 cm.) at eighteen. As a rule, however, the excessive growth does not become in evidence until some time between the tenth and twentieth years, usually with the onset of puberty.

The student of ancient lore will be interested and amused to see how superstition and the love of the marvellous have combined to render many of the accounts of giants that have come down to us thoroughly unreliable. Judging from these stories, the height to which the human race may attain has varied between wide limits. Pliny, like Augustine, believed that the stature of mankind had deteriorated, but this is not substantiated by the examination of such ancient remains as we possess. The rabbinical legends teem with incredible accounts of the height of the various Biblical characters. Adam's height was calculated to be one hundred and twenty-three feet and Eve's one hundred and eighteen. According to the Biblical account the bedstead of Og, King of Bashan, was nine cubits long. Pliny mentions the giant Gabbaras, between nine and ten feet high, who was brought from Arabia by the Emperor Claudius, and states further that the remains of Posio and Secundilla, found in the Sallustian Gardens in the time of Augustus Cæsar, measured each ten feet three. Josephus refers to a Jew nearly eleven feet high, who was sent as a hostage to Rome by the King of Persia. Some remarkable stories are told of the Emperor Maximin (C. Julius Verus Maximinus) who was born in 173 in one of the frontier villages of Thrace. A shepherd in his youth, he soon became noted for his extraordinary height and strength. He took part in the games given by Septimus Severus to celebrate the occasion of the birth of his son, and overcame sixteen of the most powerful wrestlers without taking breath. The Emperor attached him to his own person and he was made a centurion by Caracalla. Capitolinus says that he was a finger's breadth over eight feet in height. His thumb was so large that he could use his wife's bracelet for a ring. He stopped a wagon with one hand, broke the jaw of a horse with a blow of his fist, and could break its leg with a kick. He is credited with eating forty pounds of meat in a day and used to drink as much as a Capitoline amphora (about twenty-six litres). He became tribune under Alexander Severus, and, conspiring against him later, was elected emperor. He reigned for three years, execrated for his cruelty, and was finally assassinated by the soldiers in 238.

Coming to more recent times, we have some equally extraordinary tales brought back by travellers. Magellan is said by some to have given the name Patagonia to the country he discovered because its inhabitants measured five cubits. Lemaire, in describing his voyage in 1615 to the Straits of Magellan, states that at Port Desire he found several graves covered with stones in which were skeletons of men measuring from ten to eleven feet. More recent travellers have, however, found the Patagonians to be not excessively large; in fact many of them are rather diminutive. The naturalist Turner believed that he saw on the River Plata near the coast of Brazil savages twelve feet high. Accounts more marvellous still are given of giants from nineteen to thirty-six feet high, who have existed at various times in Europe. These are based on the discovery of bones of prodigious size, which were erroneously regarded as human. In

those days nothing was known about comparative anatomy, and the remains in question were no doubt those of some of the lower animals. Sir Hans Sloane, in an elaborate and learned disquisition on the subject, came to the conclusion that the bones referred to were parts of whales, mastodons, elephants, or other enormous beasts, although he thought that some of the stories could not be entirely discredited. It is a fact, however, that in more recent times, when such matters are much more narrowly scrutinized, no such instances of excessive height can be substantiated. Buffon, the great naturalist, usually a reliable authority, had no doubt that human beings had existed who were from ten to fifteen feet high. It is not until we come to the eighteenth century that we get reliable data as to the height of giants. According to Dana[16] not more than a hundred giants have been exhibited in public since 1700, and of this number only about twenty were said to have been over eight feet. Topinard measured the tallest man in the Austrian army, and found him to be eight feet four and a half inches. Winckelmeyer was eight feet six inches. Marianne Wehde, a more recent German giantess, was eight feet four and a half inches when sixteen and a half years old. In view of these observations we must seriously question whether any human being has ever exceeded nine feet in height. Quite a number of giants have been recorded who measured between seven and eight feet, but above this limit the cases are extremely few. The history of these is often extremely interesting. Queen Elizabeth's porter, whose portrait, painted by Zucchero, is now in Hampton Court Palace, was seven feet six inches high. Walter Parson, the porter of James I., was as big. William Evans, the porter of Charles I., was about eight feet high. Cromwell's porter, Daniel, who died a lunatic, attained the height of seven feet six. In the reign of George I., an Englishman, seventeen years old and eight feet tall, was exhibited at the Bartholomew Fair at Smithfield. "Big Sam," the porter at Carleton Place when George IV. was Prince of Wales, was eight feet in height. In a Dutch village in 1712 there died a fisherman called Gerrit Bastiaansen, who measured eight feet and weighed five hundred pounds. As a contrast to this we may cite a giant who was exhibited at St. Petersburg in 1829, who measured eight feet eight, but withal was thin and emaciated.

One of the most celebrated giants was Cornelius McGrath, whose skeleton is now in the museum of Trinity College, Dublin. He was born in 1736 in the county of Tipperary. His parents and the other members of the family were of ordinary size. After the age of fifteen he began to suffer from violent pains in the limbs and began to grow rapidly. At the age of sixteen he was six feet nine. In 1753, six months later, when he first exhibited in public he measured seven feet three inches in his stocking feet. It is said that he was ungraceful in appearance, of low intelligence, and spoke in a childish manner. He died at the early age of twenty-four. His skeleton measures seven feet eight inches.

John Middleton, called the "Child of Hale," was born in 1752 at Hale in Lancashire. His portrait is preserved in Brazenose College. He is said to have measured nine feet three inches.

O'Brien or Byrne, the "Irish Giant," is celebrated not only for his great height, but for his connection with the distinguished anatomist John Hunter. Hunter was particularly anxious to secure his body and made the most extraordinary exertions to obtain it. O'Brien was aware of this desire on the part of the anatomist and was correspondingly averse to being "set up" as a specimen. Shortly before his death, which occurred at the age of twenty-two, O'Brien bribed some of his friends to take his body, and after weighting it with lead to sink it in the sea. The undertaker, however, who had been previously interviewed by Hunter, managed to have the coffin locked up in a barn while the escort was refreshing at an inn. Thereupon some men, stationed there for the purpose, substituted an equal weight of paving stones for the body which was forwarded that night to Hunter. He took it in his carriage to Earl's Court, where it was immediately prepared. It is estimated that it cost nearly five hundred pounds to secure the body. O'Brien is said at the time of his death to have been eight feet four inches high. His skeleton, however, measures only seven feet seven. It is now, together with the kettle in which the body was boiled, in the museum of the Royal College of Surgeons in London.

The successor of O'Brien, Patrick Cotter, who for a time exhibited under his name, was born in 1761. At his death, which occurred at the age of forty-five, he is variously estimated to have been from eight feet one to eight feet seven in height. At one time he was examined by Dr. William Blair, who found him to measure about seven feet ten. He was badly proportioned, and looked like a weakly or even imbecile person. His forehead was low, his pulse feeble, his voice weak, and he suggested in appearance a sickly child that had grown too fast.

Robert Hale, the "Norfolk Giant," who died at Yarmouth in 1843 at the age of forty-three, was seven feet and a half high and weighed four hundred and fifty-two pounds.

Among the better known of the exhibited giants were Captain Bates, of Kentucky, and his wife, Anna Swann, of Nova Scotia. Captain Bates enlisted in the Southern army at the beginning of the American Civil War, being readily accepted on account of his size, although he was only sixteen years of age. By the end of the war he had attained the height of seven feet two and a half inches. He gradually increased in weight also until he turned the scale at four hundred and fifty pounds. While in England in 1871 he married at St. Martin's-in-the-Fields Miss Anna Swann, who measured seven feet five and a half inches. On neither side were the parents of more than ordinary stature.

Chang, a celebrated Chinese giant, died at Bournemouth in 1896, at the supposed age of fifty-one. He was upward of eight feet high.

At the Alhambra in London in 1882 was exhibited the "Queen of the Amazons," who was eighteen years old, and measured eight feet and half an inch.

We owe much of our present knowledge of the processes of growth and development to the epoch-making work of Winslow, Haller, Meckel, and the Saint-Hilaires, father and son. Although of late the interest of scientific men has been somewhat revived in the subject we cannot as yet be said to have made much advance, except that we are beginning to apprehend more fully the nature of the problems involved. We are now realizing the fact that growth and development are a very complicated matter. We see, for instance, that we must draw a distinction between mere growth, or what may be called vegetative force, function, and reproductive power. These three factors are more or less correlated, but the correlation often varies both in kind and in degree. Certain cells are specialized for growth, others for function, others for proliferation. All cells may at some time in their life history be specialized in one or other of these directions according to the demands made upon them, but they cannot be specialized in all three directions to the same extent at the same time. Thus a cell that is about to divide ceases to grow and enters into a resting stage before mitosis occurs. And other illustrations might be given. Moreover, what is true of the cell is true of the community of cells known as the individual. Up to a certain period of life the forces of the body are concentrated toward the main object of growth. Later, function becomes more in evidence. Last of all the power of reproduction becomes established and perfected. In gigantism disturbance of growth in the direction of increased stature and weight is the predominant feature, but, as we shall see, this does not occur as a rule without exacting a corresponding penalty in the degradation of the general bodily functions and the power of reproduction. The causes which lead to this result may be inherent in the germ cells so that they make their influence felt quickly in the construction of the organism,





or they may become operative subsequently to fertilization and segmentation of the ovum, either during intra-uterine life or after birth. These influences may, further, be exerted upon the body as a whole or on some part of it. There is therefore a family relationship between gigantism, dwarfism, and the various malformations and monstrosities. In both dwarfism and gigantism, which are not, as might at first sight be supposed, perfect opposites one of the other, there is not merely an inhibition or an exaggeration of the normal processes of growth, but in the vast majority of cases something more, namely, a perversion of growth. In the normal infant at birth, the head and trunk, but particularly the head, are relatively large. As the time of puberty approaches the picture changes. Growth is rapid and irregular. The limbs are now disproportionately large, the hands and feet being especially prominent. To use a common expression the child has become the hobbledehoy. Only in the later period of puberty does the trunk enlarge, the figure consolidate, until the perfect proportions of the adult are attained. There is a striking parallel between the hobbledehoy stage and what we find in gigantism. In giants the exaggeration of growth is also disproportionate and irregular. The head is often small, or at least about the same size as the head of a normal youth or adult of the same age; the increase in height is mainly due to the excessive growth of the lower extremities as compared with the rest of the body. Here, however, the parallel ceases. Giants are often weakly rather than strong; the sexual organs are apt to be badly developed, and the sexual proclivities are sluggish or delayed. They are liable to contract disease and show signs of premature senility; in fact they rarely reach middle life. Dwarfs, on the contrary, are long-lived. They frequently have the relatively large head of the infant, with evidences of delayed ossification of the cartilages, and genital inadequacy, facts which have caused many to regard dwarf growth as really infantilism. Unlike the giants they frequently possess average or more than average mental powers. It is clear that in both gigantism and dwarfism the disturbance, whatever it is, manifests itself mainly in the rate and extent of the growth, but still to a noteworthy degree in disordered function. And it is not merely the process of ossification that is at fault but the body as a whole—bones, soft parts, and internal organs—is involved. Nevertheless the disturbance of ossification appears to be the controlling force, for it undoubtedly dominates the picture.

Normally, the growth of bone depends on the activity of certain specialized cells—the osteoblasts—which are chiefly situated in the deeper layers of the periosteum, at the extremities of the bones, and along the interosseous sutures. Growth in thickness takes place from subperiosteal osteoplasia; growth in length is due to the influence of the osteoblasts in the spongy ends of the bones and in the epiphyseal cartilages. Inhibition or exaggeration of stature is due in the main to dystrophic changes at the extremities of the long bones, although subperiosteal osteogenesis is also to some extent interfered with. The results depend not only on the inherent vegetative forces at work in the cells, but on the condition of the epiphyseal discs. So long as the discs are movable, growth in length of the bone is possible. This is interestingly borne out by recent investigations with the *x*-rays in certain forms of anomalous growth. Joachimsthal[17] found in some lilliputians that he examined that the bone formation was delayed, and the condition of the discs and of the bone generally was strictly comparable to that found in the child, although the subjects were in the neighborhood of thirty years of age. Hofmeister[18] also in cretinism found that the epiphyseal discs persisted for a long time, and that the epiphyseal ends of the bones grew slowly. In chondrodystrophia fœtalis an ingrowth of periosteum has in some cases been observed between the disc and the end of the bone. The significance of this is not quite clear. In acromegaly, on the contrary, where the increase of size of the bones, still at the distal ends, is in breadth and thickness, rather than in length, there is complete union or synostosis of the epiphyses. With regard to giants we unfortunately have no information on this point, but I think we may fairly infer that, while growth is in excess, epiphyseal synostosis is delayed. The importance of the condition of the epiphyseal discs in modifying the extent and the direction of the growth is also prettily illustrated by the observation of Lorain, who found in some cases of dwarfism premature ossification and union of the epiphyses.

In our discussion of growth and its anomalies so far we have contented ourselves mainly with freeing the subject from entanglements, and so to speak preparing the ground for action. When we come to consider the more remote factors concerned in the question of growth we find ourselves in a much more difficult position. As we do not know what life is we can apprehend its methods and its manifestations only in an imperfect way. Many of our ideas, therefore, have to be based upon inference rather than direct proof.

The part played by heredity in gigantism, as in other anomalies of development, is of considerable interest and importance. This factor might be expected to be more prominent in cases of congenital gigantism, and as a matter of fact it is so, but its influence cannot be overlooked in the other forms. It is a matter of common observation that parents transmit their tendencies and peculiarities to their offspring, and moreover these peculiarities may be traced through several generations; in fact they may become familial or racial characteristics. This law manifests itself in many ways, in the size and configuration of the body, in the color of the skin, the mentality, habits, the susceptibility to disease, and in many minor traits. The peculiarities derived from the paternal and maternal sides may be of such a nature as to neutralize one another, or again they may unite their forces to produce an exaggerated effect, an effect so pronounced as to be marked at once as an anomaly. With regard more particularly to gigantism, we do not meet with the anomaly as a racial characteristic at the present day. At most we can say that some races tend to be tall and large, while others are small or even dwarfed. If the ancient accounts are to be believed giant peoples have, however, existed. Whatever stress we may lay upon this, at the present time gigantism is a sporadic affection. It is a suggestive and striking fact that once the tendency toward gigantism is acquired it is apt to crop out at various times in the same lineal descent, exemplifying the law of atavism. Again it may often be noted that more than one of the children of the same household will be affected. A number of cases might be quoted to illustrate these points. In Dickinson's case (*loc. cit.*) mentioned above, a woman bore three children who weighed nine, twenty, and sixteen pounds respectively. Fuchs' case (*loc. cit.*) was a IX-para. Her sixth child weight 6 kgm., her eighth 6.1, and her ninth 7.55. Her other children had also been heavy. The same thing has been noted by other observers. Goulart refers to a Polish giant who was exhibited in Paris in 1571, and was so tall that in a lofty room he could touch the ceiling with his head. He was married and had a son who promised to be as tall as he was.

James Toller, exhibited in London in 1815, was seven feet nine inches high. His parents were of normal build, but he had two sisters of gigantic stature. Louis Frenz, a French giant, who was born in 1800, and measured seven feet six, had two sisters as tall as he was and one brother who was much larger. The family history of Robert Hales, "the Norfolk giant," is also quite striking. His father was six feet and a half, his mother six feet, in height. One of his ancestors, who lived in the reign of Henry VIII., measured eight feet eight inches. Hales had five sisters who averaged six feet three and four brothers who averaged six feet six. The tallest of the sisters died at the age of twenty, measuring seven feet two. Captain and Mrs. Bates, both over seven feet, had a child which is almost the largest on record. One of the sisters of Chang, the Chinese giant, was even taller than he was, measuring eight feet four.

These facts suggest that this anomaly of growth is due