Giants and Dwarfs : A Study of Growth

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Human beings seem to be in the middle of a world of living things, some of which are giants like the giant whales weighing fifty tons, and so large that an elephant or a giraffe could find room inside them. In the very early days of the world giant lizards (dinosaurs) existed, ninety feet from nose-tip to tail ; their skeletons still exist in a fossil state, turned many, many ages ago into stone. The largest living thing is one of the great trees like our Eucalyptus, over 400 feet in height and forty feet or more around the base of the trunk ; on the other hand some living things are so extremely small so that even using a microscope magnifying 2,000 times they can only just be seen, while some are invisible, though we know of their presence in large numbers (viruses).

These giant lizards were tremendous creatures, but seem to have been killed off thousands of years ago. Why ? Probably they became too specialised ; that is, very limited in action and very specially built for this action, so that when some great climatic change came (very hot and dry conditions, or very wet and cold), they could not adapt themselves, and perished. The human skeleton, especially the limbs, are much less specialised than is the case with many other animals. Our arm, wrist and fingers are more like those of a frog than are the limbs of a dog or horse. The horse walks on his toenails (hoofs) ; and his legs, especially from the knee down, are altered to suit great speed. Man's adaptability gives him the power to live over a more extensive area of the globe than most if not all other animals.

Is it of any value to be a giant ? Are animals better because they are bigger ? This is not an easy question to answer. Probably there is an optimum, a best size for every animal.

John Bunyan describes how Christian, in the " Pilgrim's Progress ", met certain great giants sitting down. Professor Haldane says they had to be sitting down, because if they stood up they might have broken their legs. The trouble is that as weight increases, the bones need to increase in strength. Now weight depends on *volume*, which, like the volume of a room, is decided by the *cube* (length, breadth and thickness multiplied together) ; and this extra weight in the giant has to be supported by the bones, whose strength depends on number of *square inches* in their *section*. Just as in a building on pillars, an increase in size and weight of the building demands a very much greater increase in thickness of the pillars.

These ancient lizards had massive bones to support their great weight, and must have been slow and cumbersome in their movements.

Human giants have always interested people ; even modern boys and girls see pictures of Jack, the giant killer, and listen to the story of the great giant who makes them shiver as he says " Fee, fi, foh, fum, I smell the blood of an Englishman. Be he alive, or be he dead, I'll grind his bones to make my bread ".

The fairy tales tell also of dwarfs, the little men who delved in the mines all day and lived at night all together in the house that Snowdrop visited.

In the old Greek tales Cyclops (with his single eye in the centre of his forehead) hurls great stones at the ships of Ulysses ; but, temporarily blinded, fails in his attempts.

John Bunyan, in his immortal book, tells of the pilgrim's progress, and how Christian meets Giant Pagan and Giant Despair.

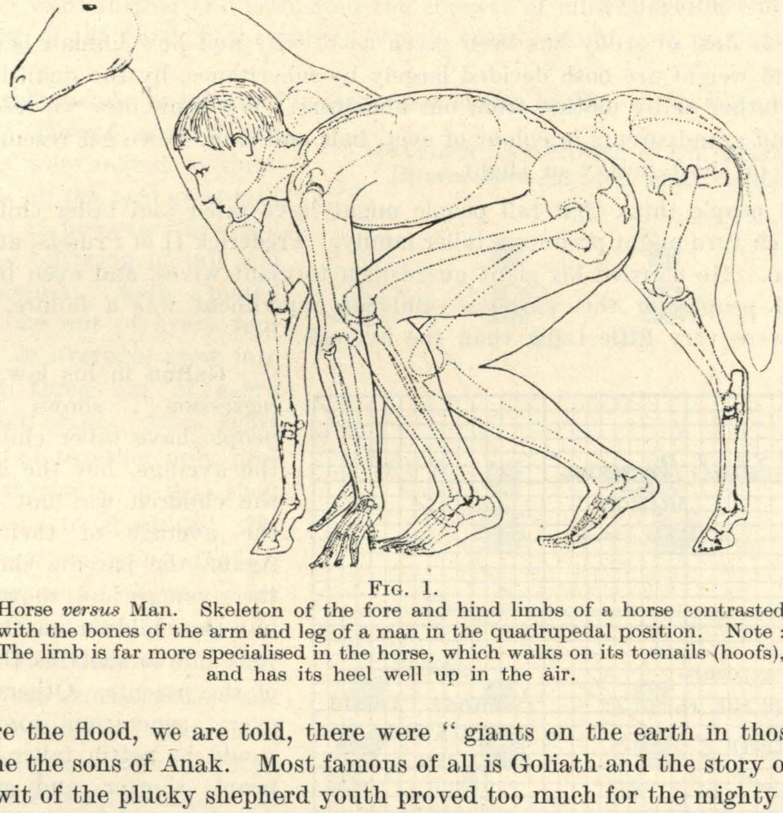


FIG. 1.
Horse *versus* Man. Skeleton of the fore and hind limbs of a horse contrasted with the bones of the arm and leg of a man in the quadrupedal position. Note : The limb is far more specialised in the horse, which walks on its toenails (hoofs), and has its heel well up in the air.

Before the flood, we are told, there were " giants on the earth in those days ". Later come the sons of Anak. Most famous of all is Goliath and the story of how the skill and wit of the plucky shepherd youth proved too much for the mighty Philistine champion. (Goliath is recorded as measuring six cubits and a span. A span, the stretch from thumb to little finger, is about eight and a half inches, and two spans make a cubit. Goliath thus measured nine feet two and a half inches, which is about the height of the highest giant recorded in modern times—nine feet three inches.)

Size and strength combined with intelligence always impresses, and Maxentius the giant German soldier became Emperor of Rome.

Our tallest English king, Edward the 1st (" Longshanks ") stood head and shoulders above his knights, and was taller even than Richard the Lionheart.

Our forefathers used to paint on the walls of churches a colossal figure occupying the whole height of the building, to represent the giant St. Christopher. As this saint was taken as their protector by travellers, this custom was appreciated by them. In Spain St. Christopher has been adopted as the patron saint of motorists !

While these extremes of growth, giants and dwarfs, attract attention, the real scientific interest is in growth. Growth is a characteristic of life. Every living being, every animal or plant, has some time of its life when it is growing. Growth (that is increase in size) goes hand in hand with development (increase in complexity), so they may be discussed together. Growth may be compared to a building going up story after story (*i.e.* increase in size). Development, similarly, is the furnishing of that building: the windows, doors, flooring, cupboards and stairs, and so on (increase in complexity).

A great deal of study has been given as to why and how human beings grow. Height and weight are both decided largely by inheritance, by the qualities handed down by father or by mother from our ancestors. We know how we resemble our parents and grandparents in colour of eyes, hair and skin, so we get resemblances in being tall or short, heavy or slight.

Some people think that tall people might have taller and taller children, and they in their turn might produce a taller family. Frederick II of Prussia, at any rate, thought so. He married his giant guardsmen to giant wives, and even bribed and kidnapped people for this purpose. But his experiment was a failure, for their children were very little taller than the average.

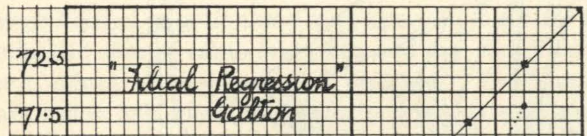


FIG. 2.

Galton in his law of "filial regression", shows that tall people have taller children than the average, but the average of the children was not as tall as the average of their parents. Again, the parents shorter than the average had short children, but the children on the average were not so short as the average of the parents. Otherwise, with every generation some people would be gettin taller and some people shorter, and giants and dwarfs would in a century or so become quite common, but this is not the case.

Galton collected the measurements of the height of a large number of parents and children. He calculated the average height of all the children of parents whose height was 65·5 inches (65 to 66 inches), 66·5, 67·5 and so on, and plotted them on the graph. The children of the shorter parents were not so short on the average, and the children of the taller parents not so tall, though in general taller parents had tall children, shorter parents short children. Galton called this tendency of children to be nearer the average than their parents " filial regression ". The degree to which the line of the children resembles that of the parents (diagonal) is the measure of the force of hereditary resemblance. The parents' height is obtained by adding one-thirteenth to the mother's height to allow for the difference between men and women, and halving the heights of the two parents now added together. But for this tendency to regress, more and more giants and more and more dwarfs would be produced, which is not the case.

Galton went further and estimated the chances of inheritance, in the degree of resemblance of the child to the parent, which works out for both parents at about one in two.

That tallness can be inherited in plants was shown by Mendel, working with sweet peas. He showed that if tall sweet peas were mated to short sweet peas, *all* the seed grew into tall plants. If, however, these tall plants (the offspring of tall and short parents) were mated together, one out of every four seeds (on an average) grew into short and three out of every four into tall plants. These short plants mated together only produced short plants, so that they were pure as to shortness. He found out, after testing, that of the four mentioned one was short (pure), one was tall (pure), and two were tall hybrids—talls that could produce shorts one in four. Hence he considered that tallness in the sweet pea was an inherited factor which was dominant to shortness, a corresponding inherited factor, and that these factors could be kept separate (segregated) to reappear in succeeding generations.

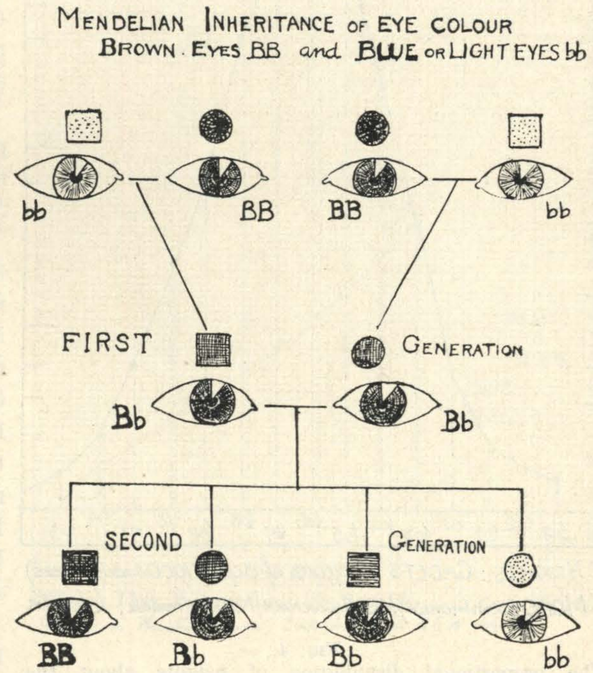


FIG. 3.

Mendel, in his studies on heredity in sweet peas, showed how characters tended to be inherited in pairs of opposites, one of which was dominant, the other recessive. A dominant parent mated to a recessive, all the offspring would be dominant in appearance. One of these mated to a similar type would produce a recessive once in four offspring. Brown (*BB*) and blue or light (*bb*) eyes behave in this way. Mated together, all the first generation will be brown (dominant) (*Bb*). Such browns, if mated, will produce blue eyed offspring (*bb*) once in every four.

In spite of a hybrid parent (*Bb*) the offspring light eyed (*bb*) is pure bred as to that quality. The hybrid parent, though brown eye, is a " carrier " of the recessive character of light eyedness.

Tallness can appear suddenly without warning—a mutation or sudden change (de Vries). Mutations may repeat themselves in the offspring ; but human giants and dwarfs, though they may appear suddenly in a family of ordinary height, usually have children of ordinary height themselves.

Another side of inheritance is the difference in height of the races of mankind. The tallest (averages) are Polynesians (Maoris) and Patagonians, 5 ft. 10 ins. ; next come the Scottish. In our own race we find the order is Scot, Irish, English and Welsh. But we find many shorter races, such as the Japanese and Southern Chinese, while in Africa and India pigmy races have been found (evidently mutations).

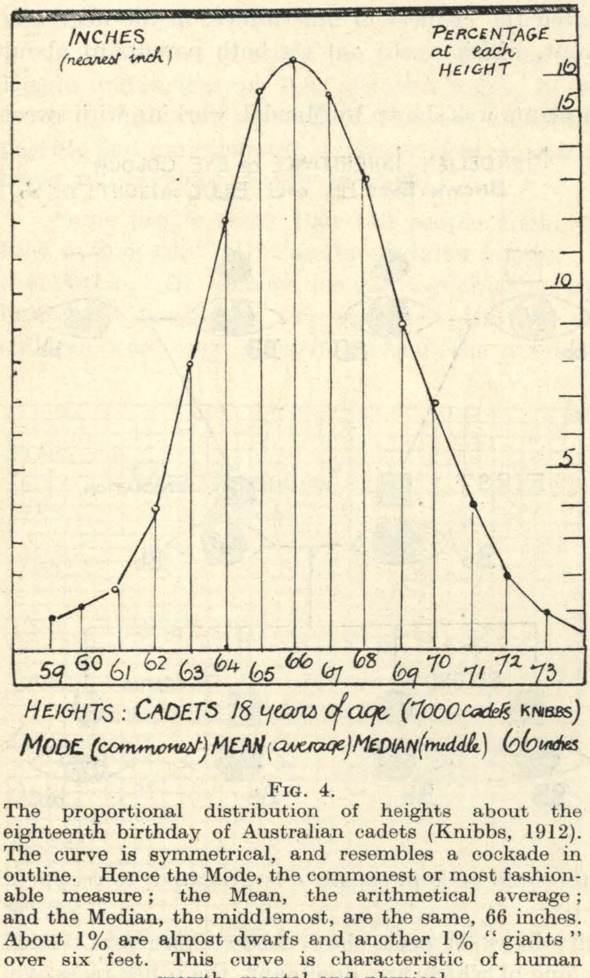


FIG. 4.
The proportional distribution of heights about the eighteenth birthday of Australian cadets (Knibbs, 1912). The curve is symmetrical, and resembles a cockade in outline. Hence the Mode, the commonest or most fashionable measure ; the Mean, the arithmetical average ; and the Median, the middlemost, are the same, 66 inches. About 1% are almost dwarfs and another 1% "giants" over six feet. This curve is characteristic of human growth, mental and physical.

If we want to make comparisons between individuals, it is obvious we must allow for race.

In our own race as a whole the average height is about 5 ft. 8 ins. in men and 5 ft. 4 ins. in women. That is, if every man were measured and all the heights added together and divided by the number measured, we get the mean or average result. Do not make the mistake that every British man is 5 ft. 8 ins. in height. Probably only about one in every six will be of that height.

Suppose, after measuring 10,000 men, we place in a row, say six feet apart, men of every inch or so in height—5 ft. 8 ins., 5 ft. 9 ins., 5 ft. 10 ins., and so on up to 6 ft. 6 ins., and on the other hand 5 ft. 7 ins. down to 4 ft. 10 ins. Then we placed behind each of these men a line of men the same height (within half an inch). We would find about 1,600 men 5 ft. 8 ins., about 1,400 one inch taller, and 1,400 one inch shorter, 1,000 men 70 inches and 66 inches respectively, and so on. If we looked now for the giants 6 ft. 6 ins. or more, and the dwarfs 4 ft. 10 ins. or less, we would not expect more than one of each in every 10,000.

If you looked down on such a collection from above you could draw a curve to include the various columns. This would be symmetrical, rather like a cockade in form, and in accord with the binomial theorem (see your algebra). Exactly the same curve is given as the result of tossing, say, ten pennies 1,000 times, recording the number of all heads—all tails, nine heads and one tail, nine tails and one head, and so forth. It is the result to be expected where a number of causal factors are operating, as certainly occurs in growth.

First, what is the growth period? Weight can increase throughout life by people getting steadily fatter, but the full height is reached with adult life or earlier. A man's bones are " set ", fully strengthened with lime salts, by about 25 years of age, though little growth in height occurs after 18 years. The military age is 18 to 45 years. Girls reach this maturity more quickly than boys, namely about 21 years of age.

Growth in height and weight is not uniform throughout this period. Boys start life as babies longer and heavier than girls, and at first are growing more rapidly. This rate soon becomes equal, and then from about the ninth birthday girls grow faster than boys, so that at about 11 they are the same height and weight, and from 13 to 15 or so are taller and heavier than the boys of the same age ; at 13 they are growing their fastest, but the pace then falls off. The boy, on the other hand, begins to grow more quickly at 13, and at 15½, when he is growing fastest, catches up and is definitely taller and heavier at the 18th birthday. As young adults, men are four inches taller and fourteen to twenty-four pounds heavier than women.

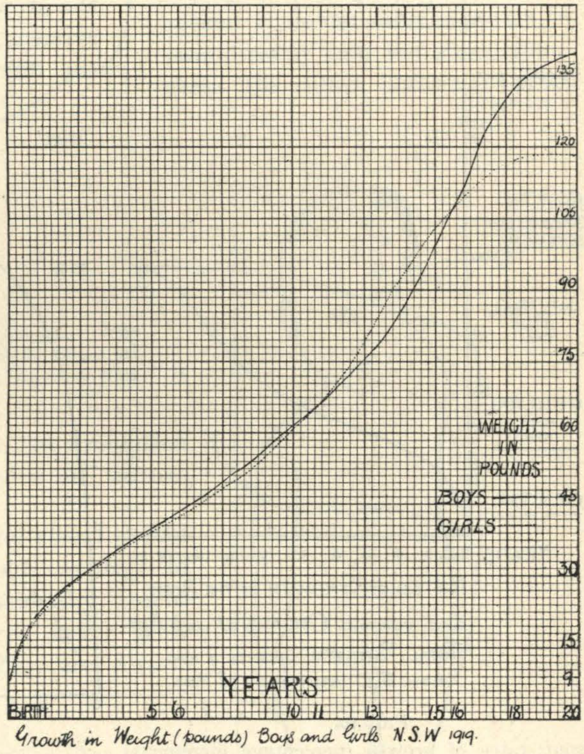


FIG. 5.
Chart of average growth in weight (pounds) of Australian boys and girls (N.S.W.). Note the girls are heavier between the eleventh birthday and 15½ years of age. The boys again become heavier at 15½, and at 20 years are 15 lbs. heavier on the average.

This change, opposite in boys to girls at 13 to 15½, is part of the development and change of the boy and girl into the youth and maiden and the appearance of the sex characters of the man and the woman.

Another lack of uniformity is seen in the growth during the year. Weight is put on chiefly from February to July, then in August comes a sudden check and slow growth for the rest of the year (even a loss of weight in summer). At least five-sixths of the weight increase for the twelve months is put on during the first five months.

Height, on the other hand, is chiefly put on from September to February—just the reverse of weight. This is a deep-seated change like the hibernation of animals, or like moulting. The kangaroos sent to the London Zoo made their care very difficult by putting on fur for the Australian winter, a time corresponding to the summer in England, and moulting during the Australian summer, which is the cold winter in England.

Another interesting variation occurs in the growth and development of the different systems of the body. The bones and muscles, the digestive organs, the heart, the lungs, and so on, all grow at the general body rate ; but the sex organs do not grow actively till puberty, that is about 13 in girls and 15½ in boys, and rapidly develop from then to maturity.

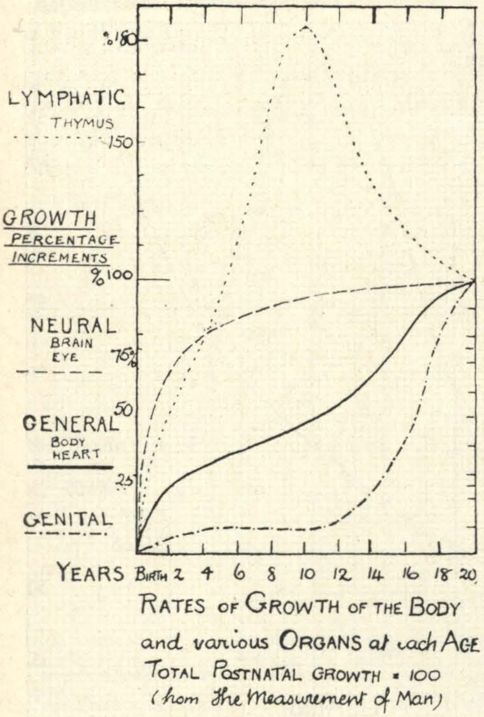


FIG. 6A.

Human rates of growth (percentage increment) according to system. Growth is calculated as the percentage increase for the year over the previous year's measurement. The early growth of the brain (75% before the third birthday), the apex of lymphatic and thymus growth at 10 years, the general physical growth rapidly increasing after the thirteenth birthday, and associated with a still more rapid growth of the genital system.

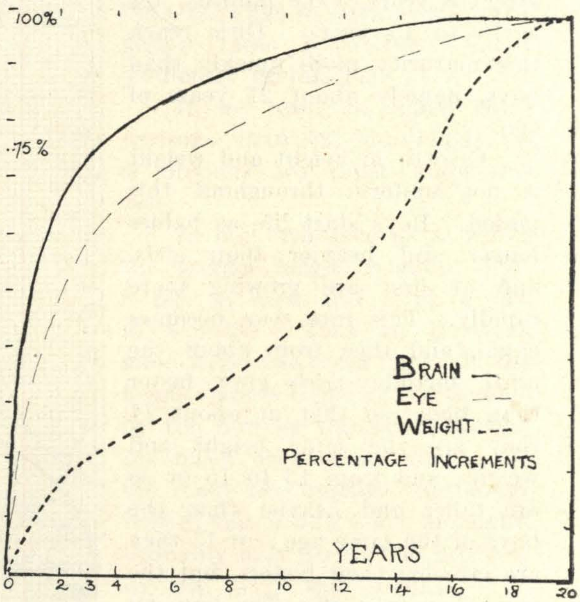


FIG. 6B.

Rate of growth of brain and eye compared with that of weight (percentage increment). Brain and eye increase at a similar rate, about 75% and 63% of their total growth occurring before the third birthday ; only about 22% of the total weight has then been attained.

The brain, nervous system, and the eye differ entirely. Their very rapid growth takes place in infancy. At the third birthday the brain has increased three times its birth weight. To reach its final size of four times the birth weight takes another eighteen years. The relatively large head and eyes of the child are well known.

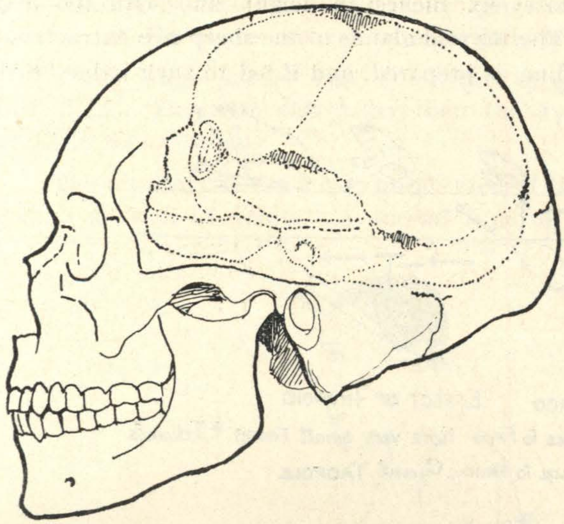


FIG. 7A.
Human adult and baby skull to show relative size. The whole skull of a baby at birth will fit inside the space for the brain in the adult skull. The adult brain is four times its birth size.

What decides growth? In different parts of the body are found certain organs or glands well supplied with blood, but producing no external secretion, such as saliva from the salivary glands or tears from the lachrymal gland. They produce, however, special chemical substances which pass directly into the circulation; these are called hormones (from a Greek word, messenger). They pass in the circulation throughout the body and stir up activity in various ways.

The best known is the thyroid gland situated just above the "Adam's apple" or thyroid cartilage of the neck. The thyroid gland is occasionally absent or not active in babies. Such children never grow up properly (like "Peter Pan"). They are dwarfs

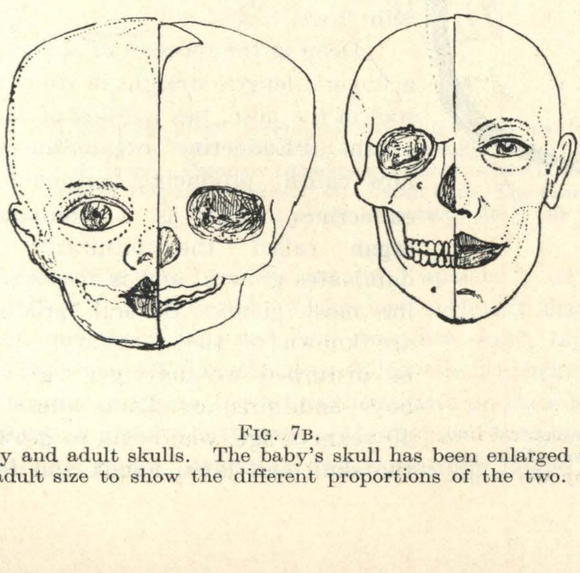


FIG. 7B.
Baby and adult skulls. The baby's skull has been enlarged to adult size to show the different proportions of the two.

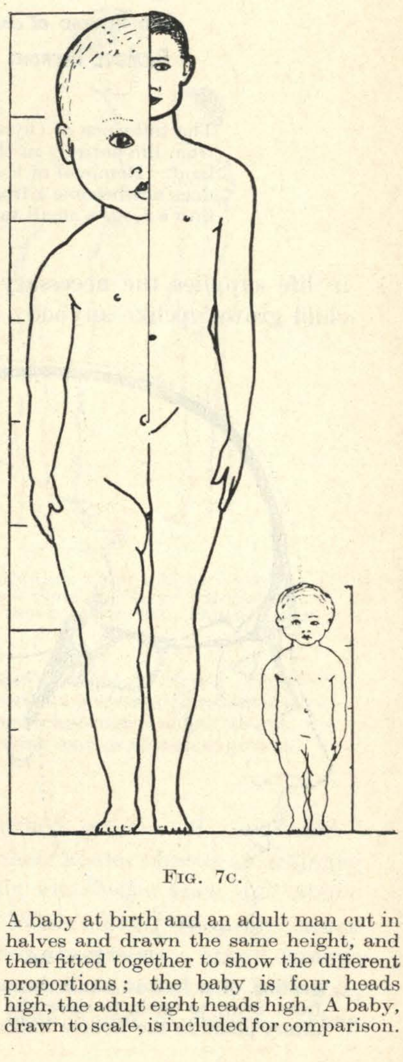


FIG. 7C.

A baby at birth and an adult man cut in halves and drawn the same height, and then fitted together to show the different proportions; the baby is four heads high, the adult eight heads high. A baby, drawn to scale, is included for comparison.

physically and mentally, about thirty-six inches in height, and with too little intelligence even to go to school. The thyroid glands of the sheep are extracted, a substance called thyroxin, rich in iodine, is prepared, and if fed to such babies early

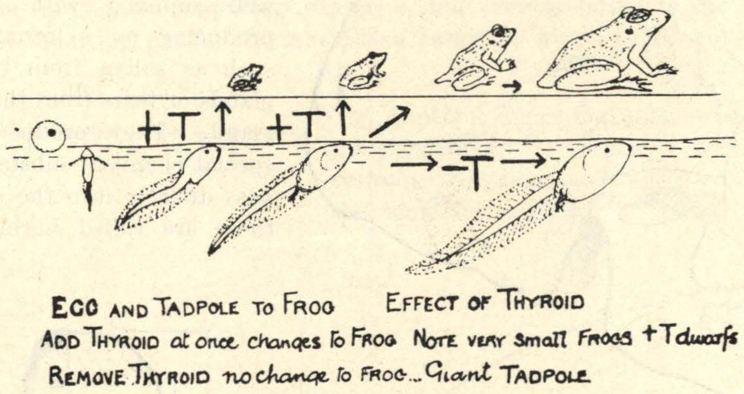


FIG. 8.
The influence of thyroid on the growth of tadpoles and their change over from life entirely in the water into frogs capable of living in the air and on land. Removal of the thyroid allows the growth of a giant tadpole which does not become a frog. Thyroid added to the water causes a rapid change into a frog, a small tadpole becoming a minute frog instead of reaching full size before changing.

in life supplies the necessary " message " to the growth cells of the body and the child grows up like anybody else. Excess of thyroid does not produce giants, but a very active restless excitable state in which people " burn up " too quickly. Tadpoles put in a thyroid solution rapidly become adults, perhaps only half an inch in length ; but remove their thyroid and they may become very large tadpoles, but never turn into frogs.

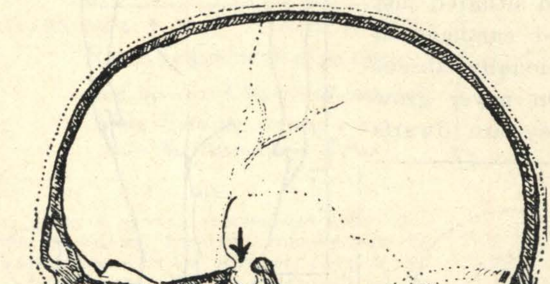
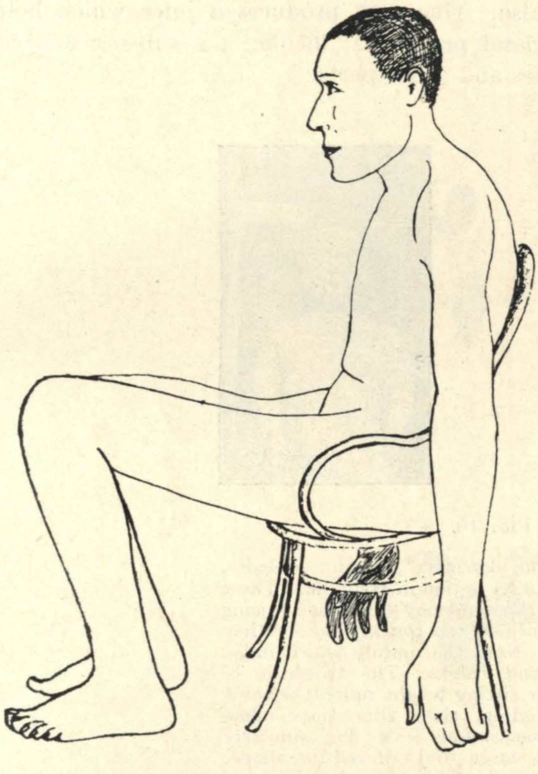


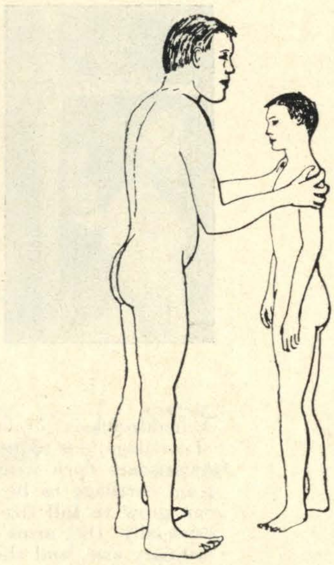
FIG. 9A.
Section of a human skull through the central line from front to back, to show the position of the pituitary gland in the hollow indicated by the arrow.

Deep in the recesses of the skull, a finger's length straight in from the root of the nose, lies another of these organs. ("Endocrine" organs they are now called, producing hormones or endocrines.) This is a compound organ called the pituitary. It dominates growth, and is responsible for most giants. Several products are known of the pituitary. If it be disturbed we may get very fat boys and girls, or again adults of 40 years of age, who begin to grow—the skull and jaws, hands and feet, and the ends of the body may grow enormously. A man's head may become so big as to wear a size 12 hat, or his feet enlarge to a 16 boot size.

Every large school has a fat boy or girl, say twelve stone weight at the age of 12. They are also taller than the average, and frequently do excellently at their school work.

The pituitary is the most complicated of these glands in action, and it produces dwarfs as well as giants. A special type of dwarf results from its disturbance :





A pituitary giant and an average man. Note the large extremities (head, jaws, feet, hands).

FIG. 9B.

A pituitary giant (acromegaly), height 8 ft. 3 ins. (99 inches), weight 20 stone. Arms 43 ins. long, hand 11 ins. long. The extremities (the hands, feet and jaw) are disproportionately large. Compare these measurements with those of the average man : height 68 ins., weight 154 pounds, arms 27 ins., hands 8 ins. The pituitary gland excites this giant growth even in persons 30 to 40 years old.

" achondroplasia ". This means " aplasia ", or disturbed growth of " chondro " cartilage. Their heads are large and curiously shaped, their bodies almost of ordinary size, but their arms and legs are quite short, especially above the knee and above the elbow, just like the dog called the Dachshund. While sitting they are much the same as others, but when they stand on their feet they are dwarfs. Many famous dwarfs in history have been of this type. The grave of one who lived about 1500 B.C., with his figure carved on the tombstone (stele) has been found in Egypt. They occur perhaps once in every 100,000. They are clever and active, and can do all sorts of gymnastic tricks, such as lying on their backs with arms folded and then standing straight up with scarcely an effort.

The adrenal gland, another double gland found just above the kidney, may hasten the growth of sex, a boy becoming a man at 11. Its main use is, however, to provide for emergencies and dangers and to prevent shock. In severe accidents recovery may depend on this organ. It also produces " adrenalin " used by the dentist and surgeon to prevent bleeding by contracting the small blood vessels.

The pancreas is a double gland also. One part produces a juice which helps digestion, but the other part of the gland produces " insulin ", a substance which regulates the use of sugar by the muscles and other parts.

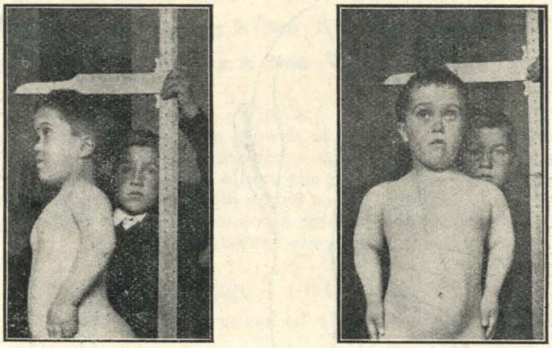


FIG. 10.

Achondroplasia (*a-plasia*, defective growth ; *chondro*, of cartilage) due to pituitary action in early life. These dwarfs are born with the tendency for bones arising from cartilage to be formed too quickly before they can grow to full size. Note the unduly short limbs, especially the arms and thighs. The trunk is of ordinary size, and their sitting height much the same as others. When standing, their short legs make them dwarfs. The Dachshund is a dog similarly affected. The head is large and altered in shape. They are often very clever. This boy of eleven can be compared with his brother of thirteen alongside.

The sex organs produce hormones and play an important part in creating a vigorous healthy body and mind.

Other endocrine organs such as the parathyroid (calcium control), thymus, etc., are recognised.

These various glands have been likened to an orchestra, with the pituitary gland as conductor, the thyroid playing the first violin, and so forth. They are the " chemical control " of the body, and decide the rate and character of growth, not only in height, weight and strength, but also of character and personality. They help to make us what we are.

These glands, endocrines and hormones, are influenced by changes in the world about us, by " environment ", but most of all link up with the growth factors of food " vitamins ".

Produced by the plant, we may eat them direct in fruit and vegetable, or indirectly first eaten and concentrated by the cow and the hen, as milk and eggs ; or by the deep-sea fish as cod-liver oil.

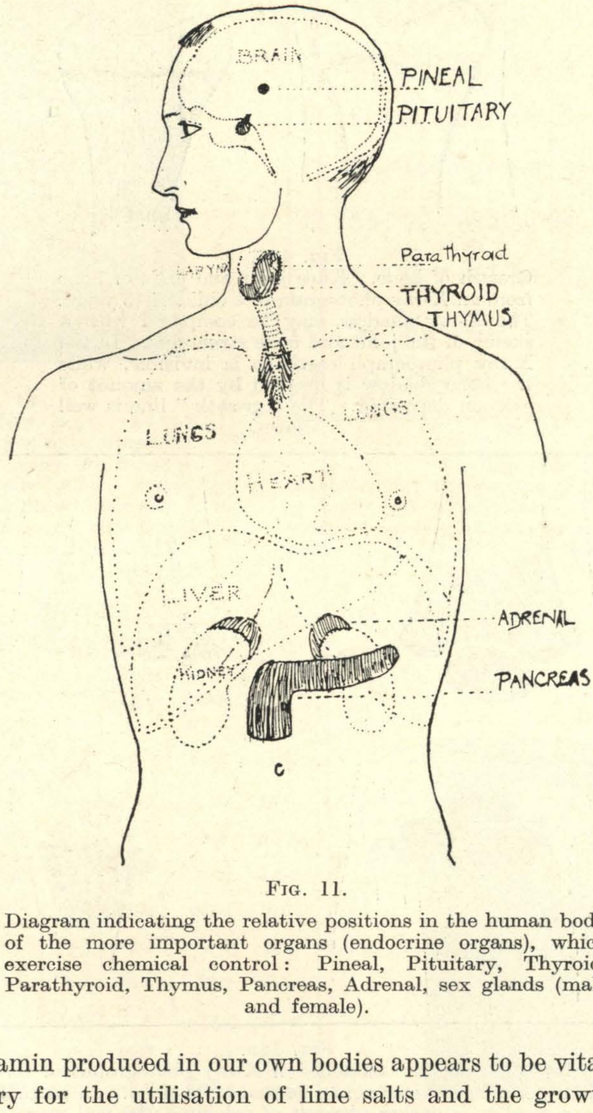


FIG. 11.

Diagram indicating the relative positions in the human body of the more important organs (endocrine organs), which exercise chemical control: Pineal, Pituitary, Thyroid, Parathyroid, Thymus, Pancreas, Adrenal, sex glands (male and female).

The only vitamin produced in our own bodies appears to be vitamin *D* (calciferol), which is necessary for the utilisation of lime salts and the growth of bones, teeth and brain, etc. This is produced by the sunlight acting on the skin fat.

Vitamin *D* is interesting. With the X-rays we can watch its action in depositing lime salts and increasing the stability in the ends of the bones along a line near the joint (the " epiphyseal " or growth line of bone) where the bones grow in length.

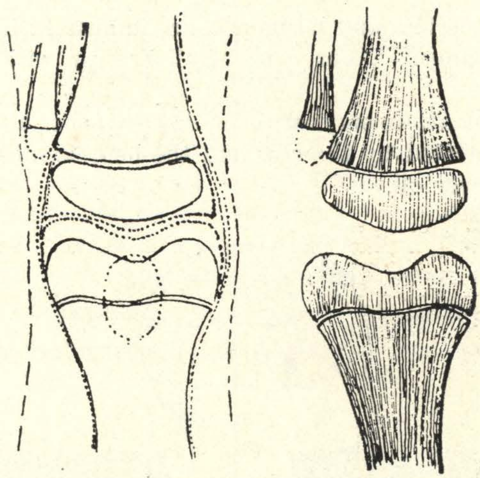


FIG. 12A.
Growth of bone. Knee joint and ends of bone from an X-ray photogram of a child of 13 years. The X-ray shadow may be compared with a sketch of the joint and bone structures. In the X-ray photograph cartilage is invisible, while the bone shadow is decided by the amount of calcium deposited. The "growth" line is well shown.

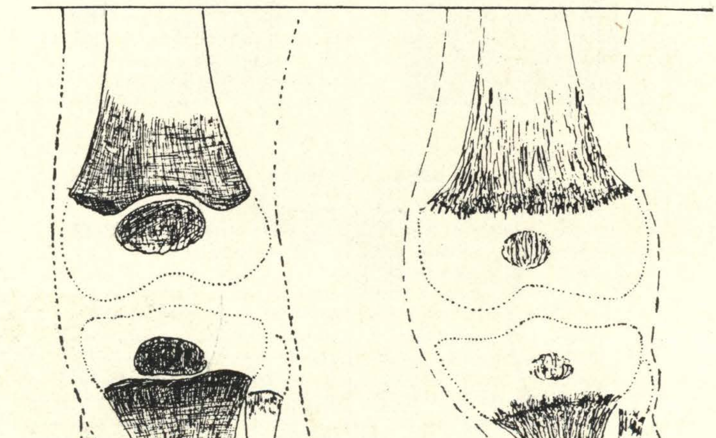


FIG. 12B.
Growth of bone rickets. Sketches of X-ray photographs of the knee joint and bones in rickets (right), normal child (left). In normal bone the bone shadow is darker (deposit of calcium), the end more neatly built, the growth line or epiphyseal line between shaft and end of bone is narrow and clearly defined. The end possesses a larger ossified centre. The dotted line is the cartilage. The bone in rickets is less dark (less calcium deposited). The end of the shaft has mushroomed out, and the centre in the end is less active. The space between these epiphyseal lines has increased.

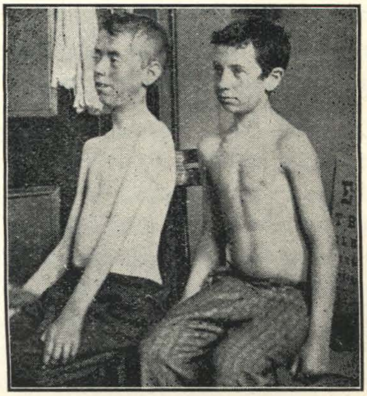


FIG. 13A.
Malnutrition. Two boys, one of normal height and weight, muscular tone good, taller, heavier, and in same school class as the other, whose flabby muscles and chest deformities are the result of early rickets—a definite case of malnutrition.

AGE	MALNUTRITION percentage loss of weight							
BIRTH DAY	HEIGHT INCHES	WEIGHT POUNDS	MALNUTRITION POUNDS	MALNUTRITION PERCENT	HEIGHT INCHES	WEIGHT POUNDS	MALNUTRITION POUNDS	MALNUTRITION PERCENT
6	43·7	43·0	40·7	5·3	43·5	42·4	39·5	7·0
7	45·9	47·3	44·9	5·1	45·3	45·1	43·7	3·1
8	47·7	51·2	48·5	5·3	47·6	50·5	47·5	4·9
9	49·9	56·4	52·6	6·9	49·4	54·8	51·6	6·0
10	51·8	61·1	57·8	5·4	51·1	59·9	56·4	5·8
11	53·4	66·1	62·8	5·0	53·0	64·8	61·3	5·4
12	55·3	72·0	68·3	5·1	55·4	72·9	67·9	6·8
13	57·1	79·7	74·2	6·8	57·8	82·4	75·1	8·8
14	59·7	89·3	84·2	5·6	60·1	92·2	82·5	9·5
15	62·7	104·0	95·4	8·0	61·8	102·4	92·7	9·5
	BOYS		VICTORIA			GIRLS		

FIG. 13B.
Malnutrition. Comparison of the average weights of boys and girls suffering from malnutrition, with the average weights for all children indicates a loss of 5% at earlier, up to 9% at older ages.

VICTORIA Birthday WEIGHTS in pounds 1910-19. 18764 BOYS : 17159 GIRLS						
AGE YEARS	NUTRITION... Boys BAD	NORM	GOOD	NUTRITION... Girls BAD	NORM	GOOD
6	40·0	43·0	47·9	38·8	42·4	45·6
7	44·1	47·3	50·0	43·0	45·1	49·2
8	47·7	51·2	56·3	45·4	50·5	53·9
9	52·1	56·4	62·1	48·9	54·8	59·4
10	55·7	61·1	66·7	55·1	59·9	64·3
11	60·1	66·1	73·4	58·4	64·8	74·1
12	65·4	72·0	79·7	63·7	72·9	80·0
13	71·5	79·7	88·2	72·5	82·4	93·4
14	78·0	89·3	100·9	79·0	92·2	104·4
15	92·4	104·0	117·5	86·3	102·4	113·0
16	100·2	117·2	125·3	92·7	104·2	120·5
BIRTH DAY	BOYS			GIRLS		

FIG. 13C.
Table of weights of Australian boys and girls (Victoria). Increase in growth at each birthday (six to fifteen) is shown for groups of children classified according to nutrition.

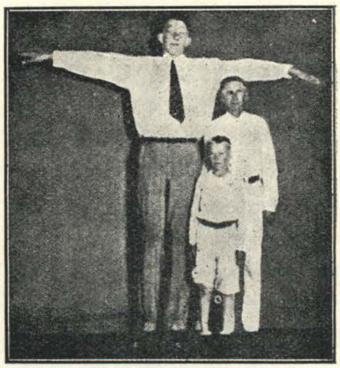


FIG. 14.
A modern giant. At the age of $13\frac{1}{2}$ he easily overtops his father (5 ft. 11 ins.). Compare the ordinary boy of the same age. This lad is now (1936) 8 ft. 3 ins.

Growth in height and weight is primarily inherited. The power of inheritance needs to be accompanied by the circumstances necessary for its full development—sunshine, food, exercise, games, etc. These affect the endocrines and the vitamins, by which growth is decided within the body and make possible their full action. Vitamins, by proper food, we can control readily ; but though the endocrines are steadily being investigated, they certainly have not yet been mastered. Whether H. G. Wells's prediction concerning " the food of the gods " will be realised remains to be seen. The evidence is in favour of an optimum not far off the optimum of today, and suggests that neither giants nor dwarfs are the ideal human beings.