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The Constitution of the Normal Child*

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The Problem

Growth, growing up, growing old—it is immaterial what aspect we choose to emphasize—is an orderly process. We must eradicate at once from our minds the defeatism which characterizes so much of current biological thought. We need not approach the subject timidly, contented with something second-rate or at least less than the best. We should not console ourselves with reflections on "fluctuations which must be expected" or "variations within the normal range."

The child is ailing and peevish but Mother "guesses" it is just the teething. The lad is taken off track, because he has, for the moment "outgrown his strength." Or mother herself apologizes for a complexion like aging putty and whites of eyes like hard-boiled eggs by an extenuation "just the change of life you know." Why should every splendid thing we have be dogged by some grotesque shadow of itself like an idiot-twin, misshapen and dismal. That which is disorderly or lacks order is pathological, produced by some defect or deficiency despite the fact that it does not result in any condition which seems to warrant medical interference.

It is not too high a standard for the future to demand that the inherent potentialities of heredity be fulfilled; that growth be preserved from the encroachments and slow deteriorating influence of disturbances in health, of dietetic or respiratory disabilities or dislocations of domestic peace and routine. These unheeded, unacknowledged, or unrecognized maladies may not produce definite and clinically obvious signs but they undermine the constitution.

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Registration of established ill-health in children is a relatively simple task requiring merely the recognition of well-defined symptoms in a definite disease which demands treatment. But the evidence of incipient disorder or subclinical undermining of the constitution requires a more penetrating analysis of minor deviations from physical and mental health. These are to be sought first in variants from the steady progress of developmental growth, secondly in the physical characters of bodily tissues, thirdly in the reactions and behaviour of the child.

Progress in Growth

The study of growth involves two quantitatively measurable features, magnitude and pattern. But into this study must enter a further concept, namely time. A record of attainment of successive levels is not the same thing as a study of progress. It is not enough for us to know that Johnny has arrived: we desire to understand how he arrived.

In 1843 Liebig devised what he called the law of the minimum. He pointed out that, for animals as for plants, a substance essential in nutrition, given in that minimum quantity which will support life, becomes of itself a growth-limiting factor. This means that growth proceeds at that rate or to that extent which will keep the body adequately supplied with that essential substance the ration of which is limited. This law of the minimum appears to hold good for the protein components of the diet but is certainly not true for the mineral constituents. An animal will not grow if it is protein-poor but it will grow calcium-poor.

In some of his experiments in this laboratory Venar fed growing rats on a diet in which calcium salts were replaced by talcum powder (magnesium silicate), which cannot be utilized by the growing organism. The animals continued to grow and, being given plenty of Vitamin D, they were kept free of rickets. But the relative amount of calcium in their bodies steadily declined as the animals grew until at last there was so little calcium in the bones that these would no longer support the weight of the animals and multiple fractures occurred from the simple exertion of moving about. But the fact is the animals continued to grow.

Returning then to our theme, namely the growing child, we see that ratings in stature and weight tell us merely how far the child has fulfilled what may reasonably be considered his full potentiality in growth. They give us no indication of whether his rate of growth is satisfactory. If we measure stature and weight again at the end of a year or such lesser interval as may be convenient we shall learn whether or not the rate of progress is now adequate. It is however perfectly possible that at some time in the

past the child has suffered a handicap which temporarily inhibited growth and although present rate is satisfactory the child's deviations in stature and weight from what may be reasonably expected for his age are really a relic of that defect from which he formerly suffered.

Standard tables of stature and weight have usually been based upon observations made on large numbers of children the health records of whom have not been adequately checked. The multiplication of records on such children will not compensate by their number for defects of health or growth occurring in the sample. Nor will records made of different children at successive ages be proper substitutes for records made on the same children as these become progressively older. For these reasons we, in Cleveland, set up the Inquiry seven years ago, taking as our sample the healthy infants from homes of economic security where the parents were healthy and the children were under efficient medical supervision. We set ourselves to the ambitious task of observing and recording the growth of these particular children as they grew up. We have to date, therefore, the records on one hundred boys and one hundred girls during the first seven years of life and our observations will still be incomplete for many years. But by taking into account our records of the older brothers and sisters who are also under efficient medical supervision we do get some idea of the expectancy in growth of the children of our sample. Until our own records are complete for the entire period of childhood it is obvious that we must be content with the nearest parallel in the literature. This we found in Gray and Ayre's book (Gray, H. and Ayres, J. G., 1931. Growth in Private School Children. University of Chicago Press). Although these authors pursue the time-honored method of utilizing different children at successive age levels the children in their study are comparable with ours in family health, economic status and racial composition. Tables of stature and weight compiled from the records of Gray and Ayres are, therefore, reasonably satisfactory for the time being.

From our own family records, so far as they go, certain generalizations may be made on the progress of stature and weight in childhood.

After increment in weight is stabilized about the second birthday the increment slowly rises in both sexes from five pounds a year between third and fourth birthdays to ten pounds a year between eighth and ninth birthdays in girls, between ninth and tenth birthdays in boys. In girls this ten-pound yearly increment is characteristic from eighth to thirteenth birthday with a sudden peak of about seventeen pounds between eleventh and twelfth. In boys the ten-pound yearly increment is characteristic from ninth to seventeenth birthday with a sudden peak of fifteen pounds between fourteenth and fifteenth birthdays.

Increment in stature is not stabilized until the fourth birthday. Thereafter in both sexes, it remains fairly stationary at about sixty millimeters a year until the thirteenth birthday in girls and the fourteenth in boys. There is in boys only, however, a diminution in increment between tenth and twelfth birthdays to about fifty millimeters a year and another period of diminution to about forty millimeters a year between fourteenth and sixteenth birthdays. After the thirteenth birthday in girls the sixteenth in boys increment in stature dwindles very rapidly to fade out at about the seventh birthday in girls and eighteenth in boys.

The record of progress in these generalizations gives no indication of those spurts of growth which have been postulated first by Brailsford Robertson and Brody as characteristic of the early school age and preadolescent period in children, but that there is something important happening to girls at about the twelfth birthday and to boys at about the fifteenth is evident from the records of weight. This is, of course, the dawn of adolescence concerning which some explanation must be given in the discussion of maturation. It is evident from what has been set down here that whereas ratings made of present stature and weight may bear merely a variable and confusing relationship to actual age, the records made of progress in stature and weight over an interval of time are most valuable in determining whether or not progress is satisfactory. The earlier occurrence of a handicap which formerly inhibited growth may so stamp a child's record that his present ratings are far from those required for his age on any standard tables, but if his progress in a given time interval meets the requirements for healthy increment it is evident that the handicap no longer exists. Thus progress, not status, is the feature which should be emphasized in growth. It is rate of growth, not achievement of a rigid age level in stature or weight, which must be our indicator of health.

Growth is merely the increment in bodily size or bulk: it is one expression of physical development or the growing-up process. One may infer development or maturation from growth, but the progress in development can be ascertained only by the specific evidence of aging. This can, of course, be obtained from certain superficial or skin characters especially about puberty. But for a precise determination of quantitative character recognizable throughout childhood some more precise indicator is necessary. This is found most readily in the skeleton and is ascertained from roentgenograms of the growing ends and epiphyses of the bones. Details of the physical development process in the skeleton are set forth at length in the Atlas of Hand now being published for us by the Mosby Company. Other parts of the skeleton may equally well be used for this purpose but the hand has been

studied by many investigators and, therefore, we use it as the most convenient part of the skeleton for our guide.

In early childhood the appearance of ossification centers in epiphyses can be utilized as indicators of physical development but these are not wholly satisfactory inasmuch as the date of their appearance is so easily influenced by the administration of Vitamin D. Health conditions also govern the dates of appearance of ossification centers. Moreover, these centers are useful over a very limited period of childhood.

In adolescence union of epiphyses gives definite evidence of the progress of physical development but again this evidence is restricted to a relatively limited period of growing-up.

From about the third birthday to puberty neither appearance of bony centers in epiphyses nor the union of epiphyses with the shafts of bones is available for the determination of progress in development. During this major period of childhood we are dependent for our criteria of maturation upon the changes taking place in the bony outline of the ossifying epiphyses. It is true that other workers have attempted to use certain rule-of-thumb methods such as gross increase in area of ossification of epiphyses as seen in roentgenograms but these methods imply merely increment in size. I have already emphasized the fact that increment in size is but one expression of physical development. If this criterion is to be used it would be better to obtain the evidence, not from a roentgenographic record of a small area like the wrist, but from bodily growth itself where the possible error of determination is relatively small. The real usefulness of a roentgenogram is not in the evidence it gives of increase in size of a bodily feature but in the successive changes wrought in the appearance of that feature by the progress of maturation.

We have been apt to imagine that growth in size continues until it is no longer possible owing to union of the epiphyses of a bone with its shaft. But this is not true. In lower mammals, particularly in rodents, growth ceases long before epiphysial union takes place. In primates, however, the length of time elapsing between cessation of growth and union of epiphysis, though not absolutely shorter is, in view of the duration of the period of growing up, relatively shorter than in lower mammals. Epiphyses at the knee begin to unite in girls about the fifteenth birthday and in boys about the seventeenth. Growth at the knee, however, practically ceases a year earlier and is greatly diminished in velocity two years earlier. Growth in stature after the thirteenth birthday in girls and after the fifteenth in boys takes place, at first largely and later entirely, in the trunk. The reason why women as a rule are smaller in stature than men is found in the shorter

time permitted for their growth. It would seem that the changes wrought in the female body about puberty are more intense than those occurring in the male and hence require a shorter period for their completion.

So far as the face is concerned there is little or no post-adolescent growth in girls but a good deal in boys, although this growth is practically confined to the mandibular area.

It is the stage of physical maturity then which determines the increment and locus of growth. Thus the evidence provided by the roentgenogram gives the clue for interpretation and analysis of the growth pattern.

The Physical Characteristics of Bodily Tissues

Criteria of health in the tissues of the body framework can also be found in the roentgenogram. Very little work has as yet been done on this subject which is of great significance for an adequate assessment of health. The body fluids, particularly blood and urine, have, of course, been extensively used in health examinations but investigation of body tissues is still in its infancy.

The tissues, upon the state of health of which the roentgenogram gives evidence, are bone, muscle, intermuscular and subsynovial tissues, subcutaneous tissue and skin.

Bone—The roentgenographic shadow of a bone should show a dense well-defined compacta with a spongiosa in which the trabeculae, especially at the metaphysis near the growing end, are partially obscured by a gray film of labile mineral forming the store from which the blood mineral is replenished. When the demands for mineral are great in consequence of rapid growth, as in infancy and preadolescence, this labile store may be temporarily diminished resulting in a clearer tracery of trabeculae. Children of impoverished constitution, whether from prolonged toxemia, protracted ill-health or inability to utilize mineral, show a more pronounced reduction of the labile mineral with encroachments even on the trabeculae themselves which become thinner or fragmented.

Evidence on mineralization is best ascertained in the antero-posterior roentgenogram of the hand.

Muscular Tissue—The muscle shadows should be dense. Lightness of shadow goes with proneness to fatigue and with poor posture. Evidence of muscular health is most plainly shown in a lateral roentgenogram of the hand where the hypothenar muscles, seen through the shadow of the muscles in the first interosseous space, give a sufficient thickness of tissue for qualitative estimation.

Intermuscular and Subsynovial Tissues—These tissues should be clear with the outlines of muscle and joint well defined. Evidence is most readily obtained from a lateral roentgenogram of the knee.

Subcutaneous Tissue and Skin—Subcutaneous tissue, like intermuscular tissue, should be clear and of reasonable thickness with sharp definition of muscular and cutaneous margins. Evidence is plainest in the antero-posterior roentgenogram of elbow though, with precautions, it can be obtained at the wrist on roentgenograms of the hand. The skin should be of moderate thickness, well differentiated from the subcutaneous tissue, and devoid of the wrinkles which are an expression of cutaneous odema.

Behaviour and Reactions of the Child

There is an orderly progress in both the psychological expansion and the social adjustment of the child as age increases. The sequences evident in these aspects of child development are being established by Dr. Anderson, whose task is more onerous than that of the interpreter of physical pattern because of the difficulties injected into the problem by emotional interference. Dr. Anderson is giving us evidence for the definition of basic principles by which discrimination of these sequences will ultimately provide a correlation of psychological and emotional reactions with physical development and health.

In the foregoing pages I have sought to set forth a brief summary of the methods by which we may obtain reliable evidence on the health of the child as expressed in the progress of growth and maturation as well as in the actual tissues of which the bodily framework is composed. It falls to my colleagues to expound the deviations from these standards of health which are brought about by failure in the maintenance of healthy developmental growth.

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