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ANTHROPOLOGY AND GROWTH[1]

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IT would be interesting to review the history of any scientific discipline to its early days when it struggled for a mastery of its subject and note how, while it was still young and insecure, it was seized and held in bondage by a facetious charlatanry which impeded progress and held it up to derision. Chemistry, medicine, astronomy, geography, zoology flash as examples before the mind. Each in turn emancipated itself and the story of its emancipation gives to the thoughtful a thrill of satisfaction at the triumph of earnest effort over dismaying difficulties. It is, however, much more thrilling to watch the actual struggle of a science to free itself from handicap and secure for itself a prestige based upon unimpeachable technique, sound deduction and service to humanity. In physical anthropology that exciting phase has now been reached and to-day we have the privilege of watching the bursting of the entrammeling bonds of political and legislative domination by which it was enslaved during the nineteenth and early twentieth centuries.

It may be impossible to pick out the mind to which, of all others, a science is indebted for its emancipation, or to point to that particular contribution which contains the spark of quickening fire, and I arrogate neither infallibility nor omniscience in this respect. As I write these words my eyes lift to the original photograph, now famous by countless copies distributed throughout the world, of his father taken by Major Leonard Darwin and presented to me as chairman of the Brush Foundation in generous encouragement of Dr. Brush's aim for betterment of the human stock. We do not attribute to Charles Darwin the first conception of evolution nor do we assert that the doctrine set forth by him would serve in its original form for all time, but we do acknowledge his

[1] Address of the vice-president and chairman of the Section of Anthropology, American Association for the Advancement of Science, Pittsburgh, December 28, 1934.

work as a source of inspiration and guidance to biological thought forever.

If then, in gratitude and in acknowledgment of indebtedness which many in this room must share, I single out one mind and one piece of work for mention in my presentation, it must be understood that personal scientific indebtedness and a sense of prophecy for the future find expression in this act of homage.

It seems to me that when Professor Boas described the changes in head form in children of immigrants he set a new furrow in the anthropological field and as it turns out, I believe, a master furrow. So deeply ingrained is the doctrine of predestination which, in its scientific form, is of course the law of heredity, that Boas's announcement was scornfully rejected by some who might have known the value of finding facts first. But that incident is long past and the principle involved in Boas's conclusion has quickly permeated the modern attitude to physical anthropological problems. The adult form of mankind is the outcome of growth enhanced, dwarfed, warped or mutilated by the adventures of life.

I am not decrying heredity. In this chair I follow an able and convincing exponent of its value for mankind. But I do insist that new knowledge gained for anthropology through the study of growth brings hope and confidence where formerly was only the grim figure of destiny.

Now the differences in head form between parents and their foreign-born children on the one hand and their native-born children on the other center in the face and characterize its transverse dimensions. That central European people transferred to the east side of New York should find conditions of life vastly changed needs no emphasis. The difference of paramount significance for the nursing mother and growing child lies in the price of perishable foods, particularly milk and fresh vegetables. Changes in family dietary are inevitable, and while these changes can not affect adult bodily form they do have a profound influence upon the actively growing structures of infancy and early childhood.

That this is no illusion is evident from the careful comparisons of the Bakwins who have shown that undernourished or malnourished children suffer more in the growth of their transverse than of their longitudinal dimensions. And that this distinction characterizes body as well as head merely extends the field of operation of nutritional influences. It does not invalidate but intensifies Boas's original contention.

Years ago Jackson fed very young rats upon a diet which was satisfactory for health but not ample enough to increase the body weight. These animals did not fail to grow. They grew less rapidly than the normal controls and their ultimate size was less. But the striking thing about them was not shortness of body but the deficiency in transverse dimensions. This is not a characteristic of starvation. It results from nutritional defect and is equally well seen in the growing guinea pigs fed by Dr. Zuck on large amounts of thyroid gland.

It is a curious and intriguing fact that the face is extraordinarily sensitive to disturbances of growth. Owing to the kindness of Drs. Sutherland Simpson and H. S. Liddell, of Cornell University, Dr. Wharton and I were given the opportunity to study postnatal physical growth in the sheep following thyroidectomy at about one month after birth. Compared with the growth of normal twin controls these thyroidectomized animals showed a definite interruption of growth in those parts of the face between orbit and mouth the growth of which is most rapid in the early months of the sheep's life. The cretin sheep never grows to the size of its normal control, but this is due to a reduction in velocity of bodily growth whereby, when the period of growth, which we shall later consider somewhat more intently, is over a relatively poor result is attained. The dynamic centers of growth in the face have their maximum activity early in life and, growth being more seriously handicapped at that particular time, they suffer most.

That disturbances of facial growth occur in human childhood is abundantly clear from the work of Broadbent and Hellman. The detailed studies of the former are a part of the program of the Bolton Study, of which Broadbent is director, the Bolton Study being one of the Associated Foundations grouped about my laboratory and engaged in the investigation of the growing child. Broadbent's observations demonstrate in malnourished infants a marked diminution of growth velocity in the dynamic centers of the face. Hellman has shown that during the first five years of life growth is more active in antero-posterior and transverse dimensions of the face, whereas the most vigorous vertical growth occurs after the fifth birthday. It is particularly in transverse and antero-posterior facial dimensions that we must look for the defects of early malnutrition. Recrudescence of growth occurs after the effect of the disturbance is eliminated or compensated, but by then adjustments have taken place and the growth pattern is permanently modified.

Now in emphasizing particularly the effect of malnutrition upon facial growth one must not appear to belittle the heritable factors which plainly direct the general course of growth. We call the expression of this heredity the family line. But any one who has studied families, especially those which represent two or three generations and include growing children, is aware of marginal examples, for the principle of

heredity is one thing and its expression in bodily form is another. We have, among the children studied by the Associated Foundations in Cleveland, many examples of what appears to be a modification in the younger children of family growth pattern as exemplified by the older ones so that it is unsafe to predict the course of growth in successive members of the family. But, whereas most members tend to pursue a common course of developmental growth statistically expressed as regression towards the mean, these marginal individuals occur as examples of intensified family characters, people to whom a double portion has accrued for good or evil.

I shall not dwell further upon marginal individuals but would refer to two other aspects of the heredity problem before I pass on. The first is the ease with which some bodily features can be changed and the stubbornness of others in resisting interference. This theme is well illustrated in hybridization and has its very distinct bearing on the choice and weighting of dimensions used in calculating the coefficient of racial likeness. The American Negro is a good example whose entrenched features I have discussed on a former occasion. The second is the ever-present problem of mental defect. Penrose's recent observations show that the intelligence quotient of the relatives of idiots is higher than that of the relatives of simpletons. There is a rapidly accumulating mass of evidence which indicates that the origin of simple-mindedness lies more in environmental conditions, whereas that of idiocy lies in primary structural defects of the brain. Our solution of the social problems resulting from these two diverse forms of mental inadequacy must therefore be devised on equally diverse lines. The existence of simple-mindedness focuses our attention on the conservation of healthy developmental growth in the prenatal period and in infancy. The problem of idiocy is less insistent because of the family limitation which occurrence of idiocy tends to produce.

This brings us to the contemplation of the constructive social contribution in physical anthropology. Since cumulative anthropological observation shows that hereditary patterns can be modified by conditions of life it ought to be possible to improve the physical status of mankind. Fortunately there is to hand definite evidence of this in the Lanarkshire milk experiment. The free distribution of milk to the school children of this Scottish county has proved statistically that healthy growth can easily be promoted by adequate and appropriate diet. It is significant that the improved growth was most evident in the older children, especially the girls of the family, the inference being that, on a smaller family ration, most of the milk went to the younger children. As far as health is concerned we have Dr. Corry Mann's testimony to the greater irrepressibility of school boys on an adequate milk ration. Following these investigations Sir J. B. Orr makes the plea for regulation of nutrition as the most important of state questions to-day.

Since the statistical survey of growth presents such encouraging conclusions it is incumbent on anthropologists to devise a technique in the long-term quantitative study of growth for the accumulation of data of real social significance. Suggestions for the planning of this study are therefore timely. But as our present information is limited attention may be directed to a few examples.

Long ago Sir Arthur Keith subdivided growth into functional and corporeal concomitants. Any organ, he claimed, must grow to a certain size before it is functionally adequate. Thereafter its growth is merely an increase in size commensurate with increasing bodily dimensions.

That organ of the body which definitely reaches earliest functional maturity is the vestibule, the organ of static equilibrium. Streeter's observations show that the vestibule is functionally active in the 20-mm human embryo, shortly before the appearance of those mass movements which serve to keep the embryo balanced in its water bath of amniotic fluid. Beyond this stage and up to the time of birth the vestibule continues to grow, but this growth exemplifies Keith's corporeal concomitant. After birth there is no further growth: the vestibule is already adult in size.

The observations of Feldberg and Disse demonstrate a growth of the olfactory area of the nose greatest before six months after birth. In later infancy the respiratory part of the nose takes on its increased velocity, but the olfactory area, functionally active at birth, displays but a very small corporeal concomitant. In early childhood it is the middle part of the nose which bears the burden of respiratory growth. In later childhood the inferior part unfolds and growth of this area continues approximately to adolescence.

A tooth, or the occlusal surface of it, has no corporeal concomitant but is already fully grown before the enamel organ first lays down mineral in its cusps and long before eruption converts it into a functionally active organ.

Investigation of the eyeball by Beecher and Williams in my laboratory proves that adult size is reached at about four years, the practical implication of this being that defects of vision, which indicate anomaly of growth, must be corrected far earlier in childhood than is customary to-day.

But the eyeball is essentially part of the brain, and it is not surprising therefore that Loo's examination

of the cerebrum in childhood shows that adult configuration of cerebral pattern is attained between the ages of four and six years when the brain case is at least four-fifths adult size. In other words, we send our children to school when all their mental faculties are potentially present awaiting education to transform them into abilities.

The schedule of differential growth in the head is indeed most illuminating for our present purpose. Brain-case growth is characteristic of infancy and early childhood and with it go the antero-posterior and transverse dimensions of the face, including the zygomata or malar arches. Vertical or respiratory growth of the face attains maximum velocity in later childhood. Vertical growth of the jaws between floor of nose and chin reaches its most vigorous phase at and after puberty.

The sexual differences in facial growth provide the next clue in formulating our plan of study. Brain case and upper or respiratory facial growth are common to both sexes and differ solely by the corporeal concomitant. But lower facial growth, from floor of nose to chin, is much greater in the male than in the female. It is characteristic of anthropoids and man that bodily growth in the female practically ceases at puberty, whereas, in the male, it continues for several years. Hence the majority of women present a relatively small jaw growth compared with that of men. That there are individual differences is less a matter of individual variation than a corollary of modified growth pattern at the cause of which we must glance in a few moments.

The fact that there are periods of maximum growth activity for each organ or area of the body gives an opportunity to analyze the final condition found in the adult and to date growth disturbances which may have occurred in that individual's past. Defective cranial size must have dated from infancy, deficient upper facial growth from childhood, inadequate jaw growth from adolescence. None of course can be utilized to localize a date earlier than that of its own maximum activity.

A relatively simple problem in growth is afforded by stature. Standard tables, say the Baldwin-Wood tables, for boys show a yearly increase in stature of about 50 millimeters from six to thirteen and a half years. Between thirteen and a half and fifteen years the average gain is 100 millimeters in eighteen months. This is the so-called adolescent spurt of growth. But a study of the statistical variabilities by Dr. Lerro and Mrs. Wood on the stature of boys under our long-term observation shows that the so-called individual variation sets in earlier and finishes later than these limiting dates. There are, as Boas has pointed out, two groupings of boys with a smaller number of stragglers intermediate in position. The one group passes through adolescence comparatively early and this accounts for the increased coefficient of variability at the younger level, while the other group passes through adolescence relatively late and accounts for the increased variability at the older level. But a study, by Seymour, not yet published, of individual growth curves analyzed into leg and trunk lengths confirms the conclusion drawn by West, some forty years ago, that adolescent increased velocity of growth in stature is the result not so much of increase in rapidity of growth in leg as in enhanced trunk growth. The relatively long legs and short trunk of some people, who are not themselves tall in stature, is due to defect of trunk growth rather than to increase in leg length. One would summarize this study by saying that maximum velocity in leg length is a function of childhood, whereas maximum velocity in trunk length is characteristic of adolescence. The differential in growth of leg and trunk is clearly marked in achondroplastic dwarfs in whom velocity of leg growth is reduced to approximately half the normal, whereas the growth impulse of trunk suffers much less handicap.

Growth in stature is accompanied by growth in pelvic breadth, but there is evidence in our series of children, evidence which is incomplete as yet it is true, that this pelvic growth takes place in three definite successive stages, necks of femora, iliac blades and sacrum in that order. Analysis of the actual growing pattern in intensive studies of individual children suggests that before long we may be able to carry on a far more penetrating study than is now possible.

Mention of the pelvis reminds us that growth is not merely increase in dimensions. A child grows in size but grows up to adulthood. The development or progressive maturation is even more significant than the increase in dimensions. The control of this maturation is not yet clearly defined and much critical analysis must still be carried out before the discordant claims on growth control are convincingly settled. The appearance of menstruation, however, in most but not in all growing girls gives a clue to the relation between dimensional increase and progressive maturity at one level of developmental growth. Whereas the measuring-rod reveals rapid growth in stature before the menarche it shows very little afterward. But roentgenograms of the growing ends of the bones testify to replacement of a lethargy of progress in maturation before by a period of greatly invigorated maturation afterward. The speed of this process in the girl is a matter of common knowledge not yet scientifically stated in quantitative terms. But we expect shortly to be able to make this quantitative assessment not only for girls but for boys as well.

When, in the light of fuller knowledge, a further analysis of constitutional types is made, it is on the lines of developmental growth that these constitutional types will find their explanation. But one must beware the fascination of using this method to explain, in too facile a manner, differences of race or stock.

Having now sketched the relationships of anthropology to growth and outlined the manner in which intensive long-term studies of individuals may be made fruitful of results which in turn can be applied to the resolution of complex adult patterns it is worth a few minutes' attention to turn to the practical application of anthropology in studies of developmental growth.

By enlarging analytic method to include orthodiagraphic tracings and roentgenograms which record developmental maturation, in addition to the present conventional direct measurement and statistical reduction and by recasting our selection of measurements to cover dynamic foci of growth rather than dimensions offered by chance, by ease of determination or by sheer obviousness, physical anthropology can be transformed from a static study of structural form into a kinetic study of structural progress. The recognition of periods of maximal velocity of growth and of developmental maturation for particular organs and areas will clear many a confused problem. It is evident, for example, from Bolk's investigations, that if sutural union occur precociously in the cranium it takes place before the age of seven years. But we have seen that this coincides with the limiting date of maximal velocity of growth in the brain. Irregularity in date of sutural union in human skulls is therefore probably a function of its undue delay and the problem is not to be consigned to the dragnet of individual and meaningless variation.

In application to eugenics the study of structural progress gives a detailed insight into the characteristic features of family lines with their various expression in different members of the family and the development of marginal individuals.

In physical education the investigation of developmental maturation by roentgenographic methods, added to the regular routine physical measurement of dimensional growth, completes the study essential to a wise application of compulsory athletics and solves many a problem of undue fatigue, of muscular tone, of inadequate heart or of deficiency in speed, power and grace.

In scholastic education the anthropologist's wisely used record of differential maturity combined with that of differential growth throws light on vagaries of emotion, on problems of social adjustment, on failure in promotion and the host of problems that beset the teacher of the preadolescent grades four to six.

Lastly in application to clinical medicine determinations of progress in physical maturation qualifying those of growth in stature and weight differentiate the outsize child, the subnormal child, the superior child of advanced physical development, the physical impress of malnutrition, of respiratory allergic disorders such as hay fever and asthma, of the disharmonically progressing child who is a problem to himself as well as to those responsible for his guidance and health.

The serial study of developmental growth is a function of the physical anthropologist not of the physician whose attention is sufficiently occupied with problems of health, but whose effectiveness of management is enhanced by the record of progress made by the anthropologist when this analysis is based on trustworthy determinations of growth and of physical development.

To the newly arisen discipline of orthophylactics or correct child guidance the psychologist and clinician have devoted their energy. When the anthropologist has enlarged his understanding to include progress in physical development as well as progress in physical growth he will have before him an opportunity for responsible constructive effort in an unexplored field which provides a career of usefulness and of immense social significance for, as Dr. Cyril Norwood claimed in a recent address, the first qualification of our children for citizenship is health and physical fitness, a body that can be trusted to do what the will commands.

SUMMARY

(1) The adult physical pattern is the outcome of growth, along lines determined by heredity but enhanced, dwarfed, warped or mutilated in its expression by the influence of environment in the adventures of life.

(2) Of all parts of the body the face appears to be specially sensitive to disturbances of growth. It is particularly in transverse and antero-posterior facial dimensions that we must look for the defects following malnutrition in infancy and early childhood.

(3) Studies of growth in the several children comprising the family indicates that whereas most members tend to pursue a common course of developmental growth statistically expressed as regression towards the mean, marginal members occur as examples of intensified family characters.

(4) Long term quantitative studies on child growth by families promises data of real social significance.

(5) In such studies the record of development or progressive maturation is even more important than the record of dimensional increase.

(6) The serial study of developmental growth offers a new field of endeavor to the anthropologist, with practical applications of great value in eugenics, in physical and scholastic education and in clinical medicine.