SCIENCE

VOL. 82 FRIDAY, AUGUST 30, 1935 No. 2122

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

THE BODILY EXPRESSION OF HUMAN GROWTH AND WELFARE[1]

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WITH all the social changes that have swept over us in the past and are scheduled to smite us in the future there are two intensely human traits so entrenched that nothing will ever dislodge them or even rock them in their setting.

The first is the passion for staring. Vision is preeminently a sense bound up with spacial dimensions and we can not see clearly unless our eyes are stationary. To say that a mother's eyes rest upon her child or that a lover gazes fondly at his beloved is but simple truth. Staring is natural to the eyes and we indulge it long beyond the days of juvenile rebuke. Whether we actually see anything or not is quite another matter and even if we do see there may be considerable doubt as to the correctness of the interpretation. Scientists and laymen alike all crave a good look.

> Full many a time and oft
> Have ye climbed up to walls and battlements,
> To towers and windows, yea and chimneytops,
> Your infants in your arms, and there have sat
> The livelong day with patient expectation
> To see Great Pompey pass the streets of
> Rome.

The second trait is the fascination of bones. The history of the whole world abounds in pilgrimages to bones. Whether they be the bones of those we have loved or the bones of those we have admired, their resting place is forever set apart, a hallowed spot, the Garden of the Unforgotten. Personality clings to the framework of our mortality. The vision of Ezekiel in

[1] Public address delivered at the meeting of the American Association of Physical Anthropologists at Philadelphia, Pa., on April 25, 1935.

the valley of dry bones, the sowing by Jason of the dragon's teeth still conjure up a thrill when they are read. Let these dry bones live! So with Ezekiel's cry in our ears we settle down for a few minutes this evening to have a good look at these imperishable records of life's handicap.

Twenty-one years ago, come September, I was engaged in excavating the skeletons of a poor group of Indians from a mound of rubble on Kelley's Island in Lake Erie. All the village had turned out to see the work. It was a humdrum process of gathering bones. There were no pipes, no ornaments, no evidence of culture, but as we laid bare, one after another, these relics of humanity we came upon one skeleton, in the torso of which lay two little heaps of tiny bones. At once a hush fell over the assembled men and women and all gathered close in the growing twilight, warm with the fragrance of surrounding vines, to hear the story of this nineteen-year-old woman of the Erie Nation whose spirit fled before the birth of her twin babes. There was nothing of high mark in this incident—no splendor, no evidence of the working out of destiny on a grand scale, nothing to touch the chords of the human heart but a woman who had met her fate on the very threshold of life.

On a day in the autumn of 1914 a German fleet bombarded the town of Scarborough on the east coast of England. Considerable damage was done and some of the townspeople were killed, but in the course of the engagement a German shell blew up the coast guard station. That served the useful purpose of removing a government building from a place where it had no business to be and permitted, when the war was over, the excavation of a site where generation after generation of British people had maintained a lookout station ever since Bronze Age times. The Romans had constructed an entrenched camp there, the Saxons a monastery, the Normans a fort, the Plantagenets a castle, the Elizabethans a manor house, the Stuarts a farmsteading, the Hanoverians a coast guard station. And now once more, after two thousand years of occupation, the site was free. And there came to work there Eric Simpson, the explorer of Hadrian's Wall, the bulwark of England against the inroads of my own savage forbears. In 1925, through Mr. Simpson's courtesy and the kindness of Sir Arthur Keith, I studied the skeletons of those who had been laid to rest in the chancel of the Old Church and in the neighboring churchyard during the fourteenth century. There were many skeletons of men from thirty to fifty years of age, soldiery and servitors, no doubt; a skeleton of an elderly woman with a crushing fracture of the skull, an old alewife, perhaps, the victim of a tavern brawl, for women under forty were not allowed to serve strong drink in medieval times. The skeletons of these people differed from those of others in the same locality by the character of their bones, which were stout and rugged, and their teeth, which were early worn as though by coarse food. Other skeletons were slender, with teeth far less worn, though the age, indicated by the articular margins and the texture of the shafts, was not less.

It seemed to me at the time that we were dealing with different social grades, but that view could not be scientifically supported for the simple reason that ten years ago we had no criteria of quality by which to judge the bones. Our studies had to be merely quantitative, confined to the gross determination of mortality statistics.[2] Even this was an innovation, for, at that time, the only collection of skeletons the age of whose possessors at death was known lay in the catacombs of Western Reserve University. These skeletons of our fellow townsmen we had gathered from 1913 onwards and carefully preserved with full documentation of all that was known about the owners during life. By studying these we hoped to be able to assess the age at death of skeletons whose origin was unknown. Nowadays Terry has a similar though less extensive collection at Washington University in St. Louis. But so far as I know, these are the only two institutions where complete human skeletons of known age are readily available in large numbers for study.

Perhaps the most easily observed evidence of age is to be seen in the shoulder blades by the method of trans-illumination introduced by Dr. Graves.[3] Whereas the blades of these bones, in young adults, are of uniform translucence, with definitely patterned vascular tracts and no muscular ridges, as age increases the translucence becomes patchy, owing to the thinning of some areas and erratic thickening of others, which mutilates the vascular patterns. The so-called muscular ridges also increase in stoutness and robusticity, so that in old people they become most striking, a period of life, of course, when muscular strength has long been in decline. The full story of age characters in the skeleton as shown in these two great collections has never yet been fully recorded, but it is to be hoped that this will eventually be done for the sake of those who are faced with the practical problems of age determination on skeletal material.

The characters of age between twenty-five and forty-five are largely to be found in the development of beadings or rims to the articular surfaces of bones, though the condition of sutures on the inner surface of the brain case is of material assistance.[4, 5] The

[2] T. W. Todd, *Scientific Monthly*, 24: 481–496, 1927.
[3] W. W. Graves, *Am. Jour. Phys. Anthrop.*, 5: 21–33, 1922.
[4] T. W. Todd and D. W. Lyon, Jr., *Am. Jour. Phys. Anthrop.*, 7: 325–384, 1924.
[5] *Ibid.*, 8: 47–71, 1925.

sutures on the outer surface are not dependable, though they may give accessory information.[6, 7]

After forty-five years of age changes are mainly nutritional in character and depend upon a redistribution of the mineral of the body whereby it is removed from the bones and deposited in joint fringes and articular cartilages. Almost every one over the age of fifty shows this rarefaction, first in vertebral column, ribs and feet, but eventually spreading to all parts of the skeleton, including the skull. Professor Karl Pearson's recent monograph on Oliver Cromwell's head shows the patchy rarefaction, visible in a roentgenogram of the skull-cap like grains of translucent sago, characteristic of a man of about sixty years in poor bodily nutrition.[8]

Essentially the passage of time is recorded in an adult skeleton by the occurrence in corresponding degree of those features which are the inevitable trail of disturbances in health. This means of course that those who have finally succumbed to a long siege of disease will bear in their skeletons the characters usually found only in individuals of much greater age. It is not very unusual to find a skeleton, actually of thirty years, which to the unwary would indicate fifty years. A check of the more youthful features of the articular rims against the more senile features of the bone texture will usually prevent this mistake. Contrariwise, the robust healthy aged are characterized by bone textures far more youthful than the age would lead one to anticipate, whereas the articular margins present undoubted evidence of seniority.

Many days spent together in the catacombs of Western Reserve University in the study of skeletons from men and women whose clinical history we knew has led Dr. Graves and myself to the conception of quality in bodily tissue. It would ill become me to dilate further upon this subject at the moment, for Dr. Graves is engaged in a far more comprehensive statement on those features which have an age incidence, a biological significance and a survival value. We are only at the beginning of the elucidation and, as Dr. Graves insists, must use the age incidence principle until a better means is found.

Quality of tissue is not merely a result of the health or sickness adventures which one meets during one's lifetime. It is expressed in the reaction of the body to onslaught, but is evident at all ages from birth upward, and the origin must be traced back into prenatal life even to the genes which convey to us our inheritance. It is this permanent character of tissue quality which Dr. Graves has so patiently and persistently emphasized.[9] His illustrations have in the main been drawn from shoulder blade form. Quality is already discernible in prenatal life and survival value is vividly portrayed by the finding that in any particular age period there are to be found from one and one-quarter to two and one-quarter times as many convex or "better quality" shoulder blades in healthy as in sick groups.

This does not mean that poor quality must inevitably succumb or better quality survive. Medical science and social hygiene have prolonged the life and usefulness of many an individual who has been unfortunate in his choice of ancestors. But this does not make less laudable our efforts to improve the quality of human inheritance.

So far we have discussed the expression of quality in the adult, but we now see that quality is already established very early in our individual history and we turn therefore to a consideration of quality in childhood.

A few months ago my colleague, Dr. Krogman, wrote a quite fascinating account of two children whose skeletons were recovered from an "Indian Mound" in Missouri.[10] Not only was it possible to give an approximation of stature and age but of health history and the effect of sickness upon the growth pattern.

In the child as in the adult we have tangible evidence of progressive maturity or age characters, but we also encounter the features of growth or increase in dimensions. It is these increasing dimensions which confuse our interpretation. The word growth usually implies both increase in dimensions and progressive maturity, but since we do not apply the term to the adult it is clear that growth does not really include progressive maturity, which may proceed at a totally different rate. Nature is comparatively careless of stature, permitting it to vary within relatively wide limits, but zealously keeps the program of maturation as nearly as possible to schedule. There are circumstances, however, in which the maturation program lags, whereas stature proceeds at usual or even more than usual speed. While disharmony of progress between growth and maturation may, in rare cases, reach pathological extremes it is by no means infrequently observed in more moderate grade. We therefore see children who are tall or short for their age, advanced or retarded in physical development for their years.

Jackson's experiments of many years ago on rats showed that if the animals were underfed in early life they continued to grow but modified their form

[6] *Ibid.*, 8: 23–45, 1925.
[7] *Ibid.*, 8: 149–168, 1925.
[8] K. Pearson and G. M. Morant, *Biometrika*, 26: 269–378, 1934.
[9] W. W. Graves, Scientific papers of the Third International Congress of Eugenics, N. Y., pp. 457–482, 1932.
[10] W. M. Krogman, *Am. Anthrop.*, 37: 92–103, 1935.

so that transverse dimensions lagged more than longitudinal ones. These underfed rats were ultimately a little shorter and much more slender than their controls.[11] This is a very important observation, but it does not necessarily mean that underfeeding directly acts to bring about change of proportions: it means that underfeeding modifies the mechanism of growth control and thus brings about the same end result which might be expected from any form of bodily malnutrition.

During the past twenty years these experiments have been extended, and Jackson now reports further that animals which have survived a period of underfeeding and have then lived a healthy life on a well-balanced diet do recover a normal weight in their internal organs, but not in their skeleton.[12] The organism is restored as a functioning mechanism, but in its framework it bears the scars of misadventure.

I have often mentioned that the work of the Bakwins in New York shows how children, undernourished from gastro-intestinal disorders, present the same slender proportions[13]; and how Boas' classical work on the measurement of immigrants and their children illustrates this slenderness of malnutrition in the face.[14]

That the face is very susceptible to malnutrition from whatever cause is evident from the work of Wharton and myself on the sheep,[15] but the proof of its occurrence in the faces of children has been given by Broadbent.[16] Defective growth of face during the first year of life is by no means uncommon: the astonishing thing is the resiliency of growth and compensatory increase in rate during the period of convalescence by means of which adjustments are made and thus a permanently misshapen form avoided.

Two other features characteristic of early undernourishment are the failure of brain[17] and eyeballs[18] to reach normal size subsequent to the starvation period. These organs alone apparently of all the viscera are specially susceptible to injury of growth capacity from undernourishment.

One would not wish to emphasize too vigorously the lessons taught by these experiments on rats. Two points, however, are significant. First, we may expect the framework of the body to carry in its structural form the scars of misadventure, and secondly, the organ which is most susceptible to injury in early life is the brain with its derivatives, the eyeballs.

If, however, the actual dimensions of the body suffer disturbances of growth capacity and viscera, with the exceptions mentioned, do not, we may well wonder what happens to the maturation progress. Again Jackson has given us important experimental evidence.[19] The nubbins of cartilage on the ends of young bones begin to ossify as early in the undernourished animals as in the normal controls. Maturity pattern runs along with visceral growth and not with dimensions of bodily frame. This is precisely what should be expected, for visceral growth implies functional adequacy to the task, whereas mere bodily size is in no way indicative of bodily efficiency.

Realizing this fundamental principle many investigators have sought to utilize the roentgenographic appearances of the maturing articular ends of bones as indicators of the progress of maturation in the body as a whole. Most have been discouraged by what seem to be marked individual variations and discrepancies. If, however, one will realize that these progressive stages in maturation, obvious enough in bones by roentgenographic methods, have no direct relation to growth but are a measure of metabolic integration and that discrepancies mean functional inadequacy, most of the difficulties of interpretation vanish. Just as there are asymmetries of growth due to inequalities in dimensional increases, asymmetries which may themselves register successful compensations in structural form, so there are discrepancies in maturation progress to be found in different parts of the skeleton of growing children. These discrepancies, when they occur, may make it very difficult to assess the precise stage of maturation to which the child has attained. But that in itself may also be most illuminating and helpful in our effort to interpret or explain the child's behavior pattern. Obviously, a child with an experience characteristic of ten years, with a growth in size average for ten years and the aspirations, interests, cravings and aversions inseparable from a maturity typical of ten years is going to behave in far different fashion from one, whatever his stature, whose experience of ten years is the sole governor of the whims and yearnings typical of a thirteen-year maturity level. Here, then, is one of those causes of turmoil in the young at which we who are older stand in increasing amaze in measure with our encumbering years.

I have given an example from the type of child whose very excellence is his undoing. But there are

[11] C. M. Jackson, *Jour. Exp. Zool.*, 19: 99–156, 1915.
[12] C. M. Jackson, *Anat. Rec.*, 61, suppl.: 28, 1935.
[13] Harry Bakwin and R. M. Bakwin, *Jour. Clin. Invest.*, 10: 370–403, 1931.
[14] Franz Boas, "Changes in Bodily Form of Descendants of Immigrants," 113 pp. Government Printing Office, Washington, D. C., 1910.
[15] T. W. Todd and R. E. Wharton, *Am. Jour. Anat.*, 55: 97–116, 1934.
[16] B. H. Broadbent, "Features of Dento-facial Growth Significant to the Dentist." Am. Dental Assn. Chicago, August, 1933. In course of publication.
[17] C. M. Jackson, *Jour. Exp. Zool.*, 19: 99–156, 1915.
[18] C. M. Jackson, *Anat. Rec.*, 61, suppl.: 28, 1935.
[19] C. M. Jackson, *Jour. Exp. Zool.*, 19: 99–156, 1915.

unfortunately too many whose handicap results not from excellence in one particular but from a growth capacity disorganized by illness, by privation or by economic distress in years gone by. It is an easy thing to tell the age at which a friend with pitted teeth must have suffered from infantile disturbance. It is not yet generally understood that the frequent decay of the six-year molars or of the wisdom teeth could also have been forecast and prepared for years before. These susceptibilities to disease are but the working out of destiny which was already set in earlier childhood. So far we know but little on this most important subject, but the day will come when it will be possible to predict (and budget) for the trials which the growing child is destined to encounter at definite stages of his career.

Time passes or we might enlarge on this subject and press its consideration backward into prenatal life, in which phase of existence, as Dr. Job has recently shown,[20] assaults upon the growth patterns are just as definite and certain in the specificity of their results as are the adventures of postnatal existence.

So far we have considered the individual, child or adult, from the points of view of growth and maturation or differentiation, as Brandt[21] would have us call it. We have not yet taken up the formative influences which loom so large in our hereditary pattern.

Heredity is a little elusive in character. When it is mentioned we are apt to think of fruit-flies or mice, and we console ourselves with the thought that our president's neat experiment involving three hundred generations must be far removed from folk for whom, were it tried, 9,000 years would be necessary.[22] We also perhaps congratulate ourselves that this experiment showed the strength of a stock endowed with what might be called superior quality against the constant sapping from misguided matings.

The most practical way to look at heredity to-day is not in genealogies of feeble-minded or physical defect but in the family growth patterns. Heredity is a broad stream, and these formative influences inherent in our genes allow us plenty of latitude. Hence there are marginal members in most families, outsize or peculiar in gait, habit or attitude, persons to whom a double portion of inheritance has been allotted.

The only practicable way to study these family patterns is by the method of long-term observation, for the characteristic features, though inherited, may not show themselves till late in childhood or even until adulthood. The accumulation of longitudinal records of many family growth patterns in our studies on childhood and adolescence in the Developmental Health Inquiry on which we have been engaged in Cleveland has given us illuminating and suggestive data on this problem. It is not always easy to refer vagaries in the pattern directly to the formative influences of heredity, but when one sees child after child of the same family showing the same peculiar features of the pattern differing only in degree, not necessarily indeed at the same age but always at the same stage of maturation as registered in the roentgenographic records of the skeleton, one must allow that some influence characteristic of that family inheritance is responsible. As Professor Pearl points out[23] it has been learned from animal breeding that the only reliable measure of genetic superiority is the progeny test, the test of the quality of the offspring actually produced. This fundamental truth is the hope of our salvation, for the vast majority of the most superior people in the world's history have in fact been produced by mediocre or inferior forbears. Professor Jennings has been at great pains for many years to emphasize that what one inherits is certain material that under certain conditions will produce a particular characteristic. If those conditions are not supplied, some other characteristic is produced.[24, 25, 26]

Family patterns evident in performance, adaptation and survival are, as Graves insists, the basic formulators of our social life. Fitness problems of the community or the race must ultimately find their solution in the progeny test, the effective moulding of the family pattern. Homogeneous communities are defined by Herskovits[27] as those in which the range of variation falls within the limits of the family pattern.

How great may be the differences of family pattern in heterogeneous communities of complex racial origin or social grade we shall not know until the problem of the family pattern has been subjected to intensive study. For America we have a bare beginning, for other countries none at all. The evidence gathered with painstaking thoroughness by Cobb[28] shows that the bodily features in which the full-blooded Negro differs from the White are chiefly proportions of limbs and torso and of cranial architectural pattern. In fundamental bodily characters and

[20] T. T. Job, *Am. Jour. Anat.*, 56: 97–117, 1935.

[21] Walter Brandt, "Grundzuge einer Konstitutionsanatomie." 382 pp. Julius Springer, Berlin, 1931.

[22] Raymond Pearl, *Science News Letter*, 27: 196, 1935.

[23] *Science News Letter*, 27: 196, 1935.

[24] H. S. Jennings, "Prometheus, or Biology and the Advancement of Man." N. Y., 86 pp. (see p. 43), 1925.

[25] H. S. Jennings, "The Biological Basis of Human Nature." N. Y., 384 pp., 1930.

[26] C. Kirkpatrick and G. Cedarstrand, *Human Biol.*, 5: 371–384, 1933.

[27] M. J. Herskovits, 21st Internat. Cong. of Americanists, pp. 5–12, 1924. See also *Jour. Am. Statistical Assn.*, 30: 380–389, 1925.

[28] W. M. Cobb, *Jour. Negro Ed.*, 3: 340–388, 1934.

developmental patterns the American Negro is identical with other types of modern man. But these are observations made on the end results of growth as found in adults. The only meager documents of the growth pattern itself are found in those records provided by the Brush Foundation for the White House Conference on Child Health and Development in 1930, records which compare the growth patterns of Cleveland White and Negro children, children of American-born parents and of Sicilian-born parents.[29] Hopelessly inadequate though these samples are, they suggest that differences of pattern relate only to proportions and size of body frame-work, not to fundamental pattern of maturation. They bear out Cobb's summary derived from observation of the adult. In the dispassionate consideration of plans for the promotion of human welfare there is but one test of validity. Do they contemplate a cultural system to which man is to adjust himself as best he can or are they the spontaneous outgrowth of the insistent yearnings of human nature, securely rooted in the biological characters of mankind. Our observations to-night point the way to an enchanting study of prime significance for social welfare in a field of work where few have trod and none has set a master furrow. They are but a rushlight in the stormy night of chaotic current social theory, but they illuminate, however feebly, the crucial fact that man's biological nature is so deeply ingrained that political or social schemes which overlook this fact will do so at their peril.

SCIENTIFIC EVENTS

HYDROGRAPHY IN THE BRITISH ADMIRALTY

ACCORDING to the London *Times*, it has been decided that the British Admiralty shall undertake the construction of a magnetic survey ship, which is urgently required to carry out magnetic observations at sea, and provision for commencing the work has been made. The construction of the ship is necessary to determine the secular change in magnetic variation at sea, and thus to provide accurate forecasts of the correction to be applied to the standard, *i.e.*, the magnetic compass, in all ships.

Up to 1929 these observations were made by a ship belonging to the Carnegie Institution of Washington. Unfortunately, this vessel was destroyed by fire in 1929, and the institution has decided not to replace her.

According to the *Times* it is of special importance to Great Britain, as the principal maritime nation of the world, that a vessel should be built to resume the work with the least possible delay.

During 1934 H.M. surveying ships have all been fully employed in making new surveys or resurveys as necessary, the number of ships employed being four at home and four abroad. Of the latter, one has been employed in the Far East, one on the coast of Siam, one in the Persian Gulf and Cyprus and one in the West Indies and on the coast of Labrador. The party left in Labrador during the winter of 1933–34 were reembarked by the *Challenger* in July last, having accomplished a considerable amount of work. Owing to more urgent requirements, the Labrador survey will not proceed for the present.

The tidal stream survey of the British Isles has been continued in collaboration with the French and Netherlands Governments; assistance has also been given by the Fishery Board for Scotland and the Northern Lighthouse Board. Satisfactory progress is being made, and data have been collected at some sixty stations during the year.

Further developments are taking place in both deep and shallow echo-sounding apparatus, which continue to give highly satisfactory results. The development of a boat set has enabled echo-sounding methods to be employed by the motor-boats of surveying ships, and areas to be surveyed can thus be covered in a much shorter time, since echo-sounding does not, as does the use of the sounding machine or the hand lead, involve the stopping of the boats. The development of visual recorders, which enable a trace to be made of the sea bottom, has also been considerably advanced.

THE SECOND DOLAN EXPEDITION OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA

WORD has been received at the Academy of Natural Sciences of Philadelphia to the effect that the second Dolan expedition to West China and Eastern Tibet, led by Brooke Dolan, II, of Philadelphia, which was for several months completely cut off from mail and other ordinary means of communication, had rounded out its first year of exploration and collecting with much new and valuable scientific data and many specimens of rare and unusual birds and mammals for the study collection of the museum.

To secure necessary official permits for work in certain remote areas, Mr. Dolan left the main party and with two Tibetans journeyed from Jyekundo to Sining, through the so-called "Never-never Land" of the nomad tribes who roam these high mountain sources

[29] T. W. Todd, "Growth and Development of the Skeleton," in "Growth and Development of the Child." Pt. II, "Anatomy and Physiology," pp. 26–130. Century Company, N. Y., 1933.