WHITE HOUSE CONFERENCE
ON CHILD HEALTH AND
PROTECTION

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PRESIDENT HOOVER

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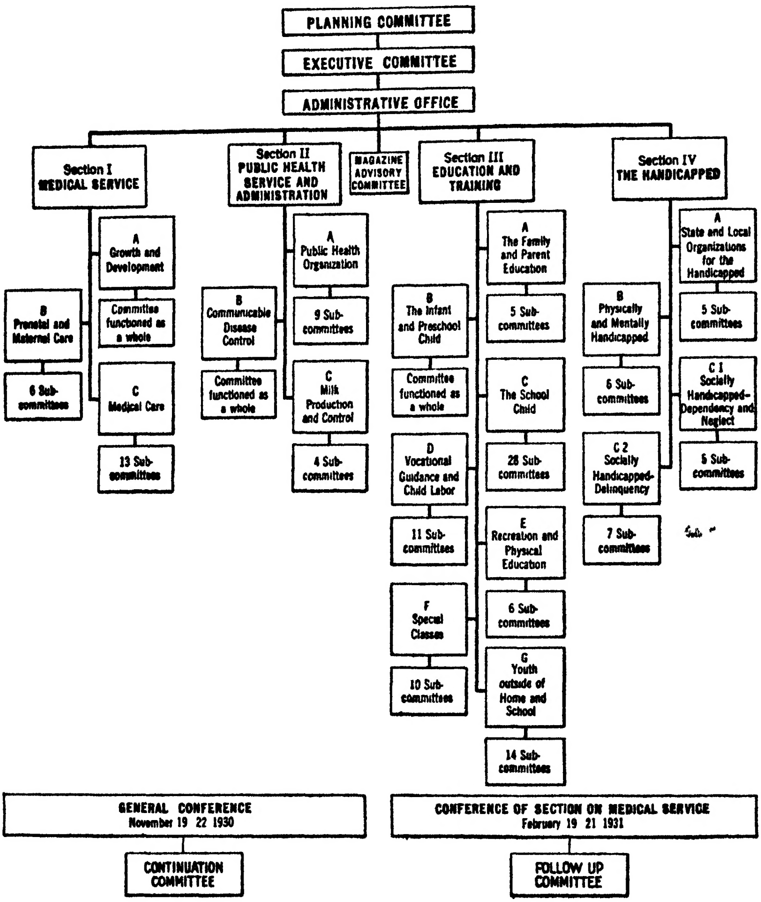

Section I—MEDICAL SERVICE

Samuel McC. Hamill, M.D., *Chairman*

Committee on

GROWTH AND DEVELOPMENT

Kenneth D. Blackfan, M.D., *Chairman*

V For every child health protection from birth through adolescence . . .

From The Children's Charter

GROWTH AND DEVELOPMENT OF THE CHILD

Part IV
APPRAISEMENT OF THE CHILD

GROWTH AND DEVELOPMENT OF THE CHILD

REPORT OF THE COMMITTEE ON GROWTH AND DEVELOPMENT

KENNETH D. BLACKFAN, M.D., *Chairman*

GROWTH AND DEVELOPMENT OF THE CHILD

PART IV
APPRAISEMENT OF THE CHILD

I. MENTAL STATUS
II. PHYSICAL STATUS

REPORT OF THE COMMITTEE ON
GROWTH AND DEVELOPMENT
KENNETH D. BLACKFAN M.D., *Chairman*

WHITE HOUSE CONFERENCE ON
CHILD HEALTH AND PROTECTION

THE CENTURY CO.
NEW YORK LONDON

PRINTED IN U.S.A.

Dedicated to

THE CHILDREN OF AMERICA

WHOSE FACES ARE TURNED TOWARD THE LIGHT OF A NEW DAY AND WHO MUST BE PREPARED TO MEET A GREAT ADVENTURE

SECTION I

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GENERAL INTRODUCTION

THE main objective of the Committee on Growth and Development has been to appraise the existing knowledge descriptive of the growth and development of children from conception to maturity. But we have undertaken, in addition, to point out the obstacles to normal growth and development which may be imposed by disease and socio-economic circumstances; also to indicate the places where our data are lacking, inadequate, or discontinuous and to suggest fruitful pathways to follow in the approach to fuller knowledge. In so far as is possible, we have endeavored to evaluate the significance of these facts and to view them in a proper perspective from the standpoint of the health and protection of children.*

The report of the Committee is much more than a mere collection of individual opinions. After each topic had been drawn up in tentative form, the Committee met together for free discussion and criticism of the facts and opinions presented by each member. When each section had been written in the light of this discussion, it was then sent to other members of the Committee for further criticism, so that the ultimate publication is, as far as it is possible to make it, a committee report representing the consensus of expert opinion.

In formulating the report the laboratory scientist and the practicing physician were equally and fully represented. Facts have been considered both from the point of view of their strict scientific accuracy and from the point of view of their

*This General Introduction appears in each of the four volumes of the Committee on Growth and Development inasmuch as it represents a key to the procedure followed in gathering and interpreting the material embodied in the reports.

significance and importance in practical questions of the care and guidance of children. We feel that this union of the laboratory specialist and his more practical colleague has been one of the valuable achievements of the Committee, and that it is through just such a union of different points of view that the most valuable and significant additions to our knowledge may be found.

Early in its deliberations the Committee found it necessary to answer a number of important questions. Among them were: "What is meant by *growth* and by *development?*" and "What does the term *normal* imply?" It was also essential to determine the kinds of knowledge upon which we might properly base conclusions concerning the growth and development of children.

GROWTH AND DEVELOPMENT

We use the two terms, growth and development, advisedly as there is a useful and significant distinction between them. By growth we mean increase in size. As opposed to this, development implies an increase in complexity, such as we see in the formation of the four-chambered heart of the infant from the simple pulsating tube of the embryo. It is possible in many instances to have considerable development with very little growth in size. This obviously occurs during the first days following the fertilization of the ovum, before implantation has occurred, and almost as clearly in certain cases in which the growth of a child is checked by some pathological condition such as rickets. The size of the individual may remain at a standstill, and yet, judged by other standards, the child has progressed more or less according to the usual expectations for his age. It is in just such cases as this, where growth and development do not take place in their usual association, but where one or the other is retarded, that the distinction between the two is of greatest assistance in giving a clear analysis of the situation.

On the other hand, in the field of mental development it is impossible to make any clear distinction between growth and development. We may say that the mind grows, but we can just as well say that the mind develops. In practice the terms are used quite interchangeably. The situation here is different from that in which we have something we can measure with a yardstick or weigh on the scales. The mind is expressed only in terms of its activities. Increasing complexity of function and the appearance of new patterns of behavior are characteristic of mental growth. Any attempt to distinguish between increase of size and increase in complexity is meaningless in this case, and may actually hinder progress by suggesting that we know more than we actually do as to the nature of the mind. Our knowledge of the relation of the mind to the brain is still woefully inadequate.

THE NORMAL

In considering what constitutes normal growth and development, we have found it necessary to consider carefully what is implied by the term normal, and in what sense it may properly be employed. It does not mean simply the usual or the average, and neither does it mean the best, although it ordinarily carries a connotation of all of these ideas. The most important meaning which we wish to attach to it is the *absence* of ill health or incapacity. If we find that a child shows indications of an incipient disease which does not yet cause outspoken symptoms, the child cannot be described as normal until the disease has been cured. This use of the term focuses attention upon *practical considerations of functional performance.* At the same time, it is impossible to avoid entirely the use of the term normal when we mean average, typical, or standard. We recognize, when we examine any group of individuals, that they differ one from another to a considerable degree, and the question is: What range of variation shall we consider as normal?

It is now clearly recognized that such variations are always to be expected in any group, and the statistician speaks quite appropriately of "the normal distribution curve," which expresses just this variation. Many of the individuals who differ from the average or mean must be thought of as normal. Great variations, however, often involve some interference with function, and it is convenient to recognize such deviations as abnormal; and we also consider as abnormal any very extreme and unusual variation. If a certain degree of divergence from the average seems to be frequently associated with imperfect function, we may set this arbitrarily as the limit of normal. The separation is essentially arbitrary, but the conception of the normal, as including a certain range of variations, becomes of great significance when we attempt to set up standards. A single value in itself is inadequate as a standard. It must be accompanied by some indication of the range of variation which it is expected to include.

We must recognize that each individual is endowed by his heredity with certain possibilities of growth and development. These potentialities may be a little more or a little less than the average. Our practical problem is not so much to determine whether the child conforms to a standard representing the average of a group, but whether or not he realizes to the fullest possible extent his own inborn potentialities.

The Committee on Growth and Development has made no attempt to set up new standards or to improve those already in use. One reason why we have taken this position should be apparent. We simply do not possess the information necessary to state the range of variations which should be regarded as normal in each case; and there is always a danger that any standard which is set up may be applied too rigidly to individual cases. We are all familiar with the tables which show the usual relation between the weight and the height of children of different ages. These have been used to determine whether any child is "up to normal weight," with the implication that the child who is found to be underweight is probably undernourished. The work of this Committee shows that deviations from these standards very frequently depend upon differences in the skeletal proportions of the child. The underweight child very frequently is simply the child who has a slender chest or narrow hips. We are not ready to set up more complete standards which would take such differences into accounts; but quite apart from this practical difficulty, we wish to emphasize the danger involved in uncritical acceptance of these as standards.

METHODS OF ATTACK

The information upon which our knowledge concerning the growth and development of children is based has been obtained by a great variety of methods. One of these has been the observation and measurement of a large number of individuals of different ages. Such observations have given us a general idea of the course of growth and development. The possibilities of this method are by no means exhausted, particularly if the results are analyzed by modern statistical methods. Furthermore, the development of the roentgen ray has enormously increased their powers, allowing the anatomist to make observations and measurements on a living subject which would be utterly impossible without it. The extended use of this method in future studies should yield much valuable information concerning normal growth and development, and also many aspects of disease.

A somewhat different avenue of approach is that of clinical observation. The pediatrician, while studying disease in children of different ages, has found himself forced to study the normal healthy child as a standard of comparison against which to recognize the picture of disease. His observations have usually been less systematic and complete than those of the anatomist and physiologist, but more and more he is subjecting his ideas to properly controlled tests in the clinic. He has also gained a vast fund of information of a sort which has not yet been formulated in precise laws and rules. It is in the clinic that the information which we have already acquired concerning growth and development will be most usefully and directly applied. The clinic will also continue to be an important source of knowledge; but a great opportunity will be wasted unless medical schools recognize to the full the importance of study of the normal child. Too often the attention of the student is focused upon disease and its manifestations, while the normal growth and development of the child and the best means of fostering them are neglected.

In the laboratory, animal experimentation has proved to be an indispensable tool. Without it we should today be ignorant of the whole subject of vitamins and of many other important phases of nutrition, and our knowledge of the sciences of physiology, bacteriology, and immunology would be only rudimentary. Inquiry into the fundamental processes of growth, which take place so slowly in the human as almost to escape detection except over periods of months, may be attacked with prospect of success only in rapidly growing animals. The theoretical limitations imposed by differences between species are slight as compared with the tremendous advantages offered by animal experimentation in the attack upon otherwise inaccessible problems.

Statistical methods for securing information regarding growth and development have been employed increasingly in recent years. If we are seeking the relation between two variables such as height and weight, and the issue is clouded by the influence of a variety of other factors, statistical methods are essential for obtaining the desired information from the data. The study of the variations among the individuals constituting a group is likewise a statistical problem. In such situations there is no substitute for this method; but it has certain dangers and limitations. We must remember that the results arrived at by statistical methods are no sounder than the original data themselves. The original observations must mean what they purport to mean, and must be obtained under known conditions, if the conclusions drawn from them are to be valid. Furthermore, although statistical analysis may show a relationship between two variables, it does not tell which is cause and which is effect, or even whether there is any direct causal relation whatever between them.

In the evaluation of work in certain fields the Committee has often found that investigations are of no value because of failure to recognize such limitations. These questions are discussed in the separate sections of the report, but we must here emphasize the point that uncritical use of statistical methods involves a real danger because of the false impression of authority given by results mathematically expressed. Its misuse may even go so far as to bring the method into disrepute.

Another line of approach to the problems of growth and development has been recognized only recently for its true worth. That is the type of study which follows an individual over a long period of time, making systematic tests and measurements at regular intervals, and gathering all kinds of relevant information about him. Observations made on large groups of individuals, even when analyzed by statistical methods, tell us only of general trends. Certain observations which have recently been completed indicate that the acceleration of growth at puberty is usually much more sudden than the customary group methods had led us to believe. The suddenness of the spurt of growth was masked by the fact that it does not occur at the same age in different individuals, so that the composite curve for the whole group shows only a gradual rise through a period of years. This is only a single illustration of the type of information which may be obtained by such individual studies. The development of physiological functions, the reactions of an individual to various diseases, and much of the story of mental development can be adequately obtained only in this way. The careful study of a relatively small number of individuals, continued over a period of years, seems to be the most promising method of attack upon the majority of unanswered questions in the field of growth and development.

Not all periods of growth and development are equally well understood. The stage of maturity, the end product of the process of growth and development, has quite naturally been most extensively studied. The baby and the young child have been fairly extensively studied from many points of view. There is an important gap in our knowledge, in that the newborn infant and the infant during the first few weeks of life are much less well understood than the older child. This is particularly unfortunate, because growth and development are most rapid at this period, and, in terms of maturity, small differences in age become very important. Perhaps the very rapidity of change and the instability of physiological adjustments account to some extent for our lack of knowledge concerning this period. The prenatal development of the infant is more or less inaccessible to study, and it is not surprising that we are in relatively gross ignorance of many important aspects of the subject. The other period for which our knowledge is most defective is that of adolescence. It is not generally recognized what profound changes are taking place in the individual both physically and mentally during this period. Not only is there a sudden spurt in growth, but a certain instability in the relationships of the various organ systems appears at this time. However, because of the comparatively large size of the boy and girl at this age, physicians have usually thought of them as practically mature, and have treated them very much as adults. Such information as we now possess clearly shows that this point of view is unsound and that further studies of the period of adolescence are essential to complete our knowledge.

APPRAISEMENT OF THE CHILD

How are we to deal with the problem of the evaluation and appraisement of the individual child? If we encourage parents to bring their children to physicians for examination to find out what, if anything, is wrong with them, the physician in turn must take the responsibility of making a complete and thoroughgoing examination. He should not only pass judgment on what is wrong with the child, but also make practical positive recommendations as to how to improve the situation. The physician should be prepared to employ all of the methods now available so far as circumstances permit. For example, the roentgen ray should not be regarded as something to be used only as a last resort and after extensive consultation, but, like the microscope, it should be recognized as a tool available to every physician. The information afforded by it in properly trained hands is so important that its use should be widely encouraged.

There is a growing recognition of the fact that in dividing the study of the child among various specialties, we have been in danger of losing sight of the child himself. To examine the child's tonsils or to weigh and measure him is better than nothing at all, but no consideration of the child can be complete which does not include a recognition of all parts of his body, his mental development, his emotional life, his family background and heritage; or, in other words, a consideration of the child as a whole. Furthermore, we are thinking more and more of each child as an individual. No two children are exactly alike, and we should not expect them to be exactly alike. Some children of the same age tend to be larger than others, some are more fortunately endowed with mental faculties, and all do not develop at exactly the same rate. Each child has his own past experiences and has formed his own habits. These individual differences must be given due weight, particularly in regard to our attitude toward so-called normal standards of both development and achievement. No fixed and rigid arbitrary standards can be set.

Physicians must be as well acquainted with the healthy child as with the sick child. Their standard of comparison must be one of positive health, and not merely one of relative freedom from disease, and they must learn the importance of asking themselves the question, not only, "Is the child well?" but also, "Is the child happy?" for the truly healthy child is also a happy child.

The Committee on Growth and Development of the White House Conference had hoped to find in the data already available adequate material on which to base conclusions as to the influence of race, locality, and economic circumstances upon the growth and development of children. A careful survey of existing material showed this to be impossible. In order to make such comparisons it will be necessary to obtain additional data in different parts of the country, taking care that they are obtained under comparable circumstances and by similar techniques. If studies are to be made on the neonatal and adolescent periods of life, careful thought should be given to the possibility of so planning these studies that they will at the same time yield the much needed information as to the influence of these other factors to which reference has been made. Time spent in planning such studies in advance, not only with respect to their soundness and completeness, but also with regard to their coordination with other studies carried out at other times, and in other places, will be richly repaid.

To advance our knowledge of normal growth and development, the line of attack which at present seems most fruitful is the careful and extensive study of a relatively small number of individuals, carried over a long period of time. The statistical studies based upon large numbers of individuals have in the past yielded much valuable information, but by their very nature they tend to submerge individual differences in the rate of growth and maturation.

It will take time to solve many of the fundamental problems which are suggested in the various sections of this report. For the present we must deal with the practical problems of the child's health and protection, on the basis of our *best* knowledge at the moment. This is a difficult task, as we are often forced to make temporary judgments on the basis of incomplete data and tentative theory. We must continually test our conclusions as we proceed, and be prepared to modify our methods as further knowledge accumulates.

KENNETH D. BLACKFAN

I. MENTAL STATUS

MENTAL GROWTH IN INFANT AND CHILD

THE mental welfare and the physical welfare of childhood cannot be considered altogether apart. The whole tendency of the modern sciences is to bring mental and physical factors into closer relationship. The general plan of study adopted for the study of growth and development gives equal status to problems of physical and of mental growth. At present the scientific literature dealing with physical development far exceeds that on mental development, but with the recent expansion of the biological sciences there has been a significant increase of knowledge concerning the psychological aspects of early development. This knowledge is still incomplete and rudimentary, but it serves to place the problems of mental growth in coordinate relation with those of physical growth. The present statement deals with general principles which underlie the study and the supervision of mental growth in the infant and child.

THE NATURE OF MENTAL GROWTH

The mind grows. However difficult it may be to establish a satisfactory definition of either mind or growth, it is certain that mental growth is a valid scientific and medical concept. Physically, growth expresses itself in changes of dimension, bulk, and form. Mentally, growth expresses itself in changing patterns of behavior. Long before birth, the life of the organism manifests itself in defined modes of reaction and response. These behavior characteristics, usually called reflexes, are based upon maturing neuro-muscular and biochemical mechanisms, and they constitute the early developmental psychology of the individual. They are as much a part and parcel of his make-up as are his anatomical organs.

Like his physical structure, they too have form and undergo progressive patterning. As the infant grows new patterns of reaction constantly emerge, determining his posture, locomotion, prehension, manipulation, language, and adaptive and social behavior. Viewed in this light, the mind becomes as real as the body, and need not be too sharply distinguished from the physical expressions of growth. The mind also becomes tangible enough for orderly study. The growth of the mind may be followed by inventory and by measurement of significant behavior patterns in relation to age and to physiological or anthropological factors. Indeed the behavior of the infant is probably the most inclusive, and consequently the most basic, indicator of developmental status.

The term *mental* is here used in a broad sense to include the total psychical life. Sometimes this term has been restricted to intellectual functions, but from a biological and from a medical standpoint it is best to follow the broadest usage. The study and the protection of mental growth begins long before intelligence in the ordinary sense is in evidence. The terms *growth* and *development* will be used interchangeably in the present discussion. It is impossible, in the field of behavior, to limit the word growth to dimensional changes on the one hand, and development to changes involving differentiation. The two kinds of change are inseparably associated. The genetic advance of behavior always proceeds by alteration of pattern and not by purely linear increase.

THE CYCLE OF MENTAL GROWTH

The cycle of behavior development begins long before birth. Even in the embryonic stage the organism is not altogether inert. Slow movements of arms and legs have been observed as early as the second month of gestation. A large number of varied tactile-motor and postural reflexes become established by the middle of the fetal period. So complete is the behavior equipment of the fetus that even the infant born eight weeks prematurely has a fair chance of survival. Behavior development proceeds apace in the postnatal period. Weekly and even daily increments of behavior occur in the first flourishing months of life. During early infancy up to approximately forty weeks reckoning age on a postnatal basis, or eighty weeks reckoning age on a postconceptional basis, the patterns of perception and prehension and manipulation undergo a high degree of organization. During later infancy, up to the age of two years, locomotion and language development are very prominent. The period of early childhood from two to six years is marked by fundamental acquisitions in every field of behavior—motor, language, adaptive, and personal-social. The first permanent molar erupts at about the age of six years, punctuating the beginning of school life and later childhood. Adolescence comes with the teens and is of variable length. Full physical and mental maturity is not achieved until after eighteen years. In a psychobiological sense, mental growth phenomena extend throughout the life span. There are important individual and possibly racial differences, in the form and the extent of the cycle of early and of late mental growth.

It is, of course, recognized that there are no sharp lines of separation between adjacent periods. The successive stages of development merge with each other almost imperceptibly and it is difficult to establish uniform criteria for any stage of childhood or of maturity. Statistical norms and descriptive specifications are none the less very important to define the individual differences which do exist. With our present inadequate data, however, it is undesirable to oversimplify the problem of mental maturity or the possibilities of mental diagnosis. The concept of adult age presents many difficulties.*

* The army data represent the widest and most random sampling of mentally tested adults. The average mental age of drafted men, equated with the Stanford-Binet Intelligence Scale, is between thirteen and fourteen years. But the category *drafted men* excluded the officers and probably many men of superior intelligence, as well as many mentally unfit. It may not represent the male population fairly. The Stanford-Binet Scale assigns the *average adult* to the sixteen-year level and does not measure above the eighteen-year level which is termed *superior adult.* Few college intelligence tests attempt to measure beyond this age level. Pintner comments: "It would seem, therefore, that the kind of ability demanded by the army tests is such that it does not increase much, if at all, beyond the age of thirteen or fourteen in the average individual." Spearman holds that the growth of "G" (a mental energy factor

All of the developmental periods are of importance from the standpoint of child protection. The periods of infancy and preschool childhood are of peculiar medical significance because the behavior organization at this time is rapid, is fundamental, and tends to project itself into the later sectors of the life cycle. It is a favorable time for preventive hygiene. With mental growth, as with physical growth, it is in a broad sense true that the older the child, the longer it takes him to achieve a definite proportional amount of growth. In early infancy, therefore, it is necessary to give due respect to small units of duration. The younger the organism, the more potent is a given unit of time in the economy of its development. The younger the organism, the more swift and intense its growth tends to be. In the period of the germ and embryo, hours and days count; in the period of the fetus, weeks; in infancy, months. The intense compression of development in the early sector of the life cycle is so great that age, by virtue of some kind of relativity, assumes an augmented importance, which must be reckoned with in diagnostic procedure.

NORMS AND INDICES OF BEHAVIOR DEVELOPMENT

The scientific problems of mental growth are highly comparable to those of physical growth. Although mental growth is in a sense more elusive, it is not less lawful. Behavior tends to fall into tangible patterns ordered by the age and maturity of the infant. Even in the neonatal period, behavior is not utterly random. So consistent are the laws of emergence and sequence that behavior patterns may be systematically studied to elucidate the nature of mental growth. For convenient illustration of this general statement, consider the reactions of the infant to a small red block, a one

comparable to general intelligence) "does not continue to any appreciable amount after the age of fifteen or sixteen and perhaps even ceases some years earlier." Thorndike investigated the learning ability of adults experimentally and by testimony. He found that "the facts are in flat contradiction to the doctrine that childhood is the period for easiest learning to read, write or understand the hearing of a language, and that the early teens are the next most advantageous"; and that the curve of learning is one of slow decline which is no greater for inferior than for superior adults between the ages of twenty-two and forty-two years.

inch cube. The four months old infant gazes at the block placed before him, but fails to pick it up. The five months old infant can pick it up on contact. The six months old infant seizes the block with executive directness and puts it to the mouth; the nine months old infant bangs it against a cup in combining play; the one year old subject unwraps it from a paper covering; the eighteen months infant stands on his own feet and builds a tower of blocks; the two year old assembles a row of blocks with deftness; the three year old builds a bridge of three blocks; the four year old, a more difficult gate, and the five year old reproduces from memory a complicated stairway model of ten blocks. This progressive gradation in the child's reactions to the small red blocks shows how the patterns of his performance tend to keep lawful step with the maturity of his nervous system. Closely scrutinized and critically interpreted in relation to age norms, the behavior with the cubes furnishes a tangible objective evidence for estimating developmental status.

Just as the cubes can be used as an objective device for determining the patterns of prehension, manipulation, and adaptive exploitation, so can other psychological materials and situations be used to define characteristic forms of behavior. When these behavior forms or patterns are precisely formulated in relation to age and other associated factors, they become indices for the measurement and interpretation of mental growth. It is not assumed, of course, that all normal individuals pursue exactly the same lines of development, nor is it assumed that growth can be measured with the same absolute directness with which physical length and weight are measured. But it may be safely assumed that the course of individual development is neither whimsical nor fortuitous.

POSSIBILITIES OF DEVELOPMENTAL DIAGNOSIS

The laws which govern the sequence and the variation of behavior patterns are so fundamental that scientifically established norms may be used as diagnostic indices to determine the tempo, the trend, and the configuration of individual mental growth. Normative formulations of infant behavior pattern are still in a rudimentary stage of development and all present available normative criteria must be used with clinical caution. It is certain, however, that the construction of norms will yield to statistical and experimental improvement, and that they will become increasingly serviceable for the diagnosis and even the prediction of behavior development.

A complete developmental diagnosis of an infant or a child would embrace a survey of his anthropological, physiological, and psychological characteristics. At the present stage of scientific knowledge, it is not feasible to make such a comprehensive examination, and psychological estimates must be undertaken with due qualifications and reservations. When supplemented with clinical judgment, it is nevertheless possible with present techniques to make a diagnosis of many cases of mental defect, of mental superiority, mental inferiority, and of conduct deviation in early life. From a medical point of view, the diagnosis of behavior development is more than an estimate of general intelligence. A comprehensive behavior diagnosis should be descriptive and analytical, attempting to characterize, as far as possible, the whole child. This would include statements of postural and locomotor behavior, language, and adaptive and social behavior. Such statements can be based on systematic normative formulations. A single simplified mental rating becomes misleading unless interpreted in terms of the child's total individuality and his previous developmental career. It should be emphasized that the accuracy and the hygienic value of developmental diagnosis are greatly increased by periodic and follow-up examinations. Too much confidence must not be placed in a single developmental diagnosis or a single inventory. The estimate of the individual's make-up and his growth potencies should be determined by a series of examinations in which each new examination becomes a check upon all the preceding. After all, it is not the status at a given moment, but the growth characteristics of the individual career which are important from the standpoint of child health and protection. Periodic diagnosis then becomes the basis for developmental supervision.

The application of norms of behavior need not be restricted to the diagnosis of maturity status as such. Behavior is also a subtle and sensitive index of physiological or dynamic status. Accordingly, behavior signs constitute an integral part of medical symptomatology, and behavior norms may become the criterion for discovering and supervising conditions of health and disease in infancy. Maldevelopment is frequently an expression of disease, and, conversely, diseases are frequently reflected in deviations of behavior development. Clinical anthropology and physical diagnosis supply many keys to an understanding of developmental status; but often the child's behavior is of chief importance. For this reason, the scientific study of infant behavior from the standpoint of symptomatology becomes an important phase of preventive pediatrics. In spite of its ordered stability, the growth complex is, to an undetermined degree, alterable. The behavior signs of significant deviations must be sought and found early.

Departures from general health and from optimal nutrition, the onset of disease, and the course of illness and of convalescence all tend to express themselves by more or less distinctive behavior signs. The skilled clinician is aware of a host of them. He utilizes his knowledge in his judgments of diagnosis, of prognosis, and of treatment. Scattered, casual references to such behavior signs abound in the literature. It can scarcely be said, however, that behavior symptomatology has attained a systematic status in clinical pediatrics. At any rate, there appears to be abundant opportunity for a behavioristic type of clinical investigation. Behavior symptoms figure more or less prominently in every syndrome. Diseases do not have pathological entity in the anatomical and physiological sense alone; they may have pathological entity in the sphere of behavior. Behavior signs, which are correlated with the peculiarities of prodromal, active, and resolving phases of disease processes, would yield to exploration. The field is one of importance and great fertility. It would undoubtedly serve the advancement of clinical pediatrics if systematic studies of behavior were more frequently undertaken at hospitals where selected cases are under extended observation and treatment. Many of these cases now scientifically wasted provide an almost experimental opportunity for the elucidation of laws of child development. Harvey's observation still holds: "Nature is nowhere accustomed more openly to display her secret mysteries than when she shows traces of her workings apart from the beaten path."

THE PROTECTION OF EARLY MENTAL GROWTH

The above general considerations are of special importance from the standpoint of preventive medicine and, particularly, of preventive and supervisory pediatrics. Development, quite as much as disease, falls within the theory and practice of pediatrics. Historically, development has been chiefly studied from the standpoints of morphogenesis and of physical anthropology. It may be studied also from the standpoint of function or of behavior. The physiology of human development cannot be investigated or understood apart from behavior. In this sense, the pediatrician has a vested interest in the whole problem of infant behavior. In terms of the major objectives of this study, it becomes necessary to inquire how the diagnostic and supervisory approach to problems of infant behavior can be incorporated into the present provisions for child health and protection.

THE ORGANIZATION OF DEVELOPMENTAL SUPERVISION

The supervision of nutrition in infancy is, and will doubtless remain the central concern of pediatrics, and here the pediatrician maintains a balanced interest in disease and in normal growth. His attitude and his technique in this field constitute perhaps the most tangible advance which has been made on a large scale in preventive medicine. The problem of nutrition is so fundamental that by implication, and often by actual exigency, it includes the psychological and functional aspects of the individual's growth. The protection of the nutritional health of the child thus becomes the natural stage for a broader and equally continuous type of developmental supervision. The technique of this developmental supervision will be slowly evolved, but it will come to include the mental as well as the bodily economy of the child's total growth. It will include his behavior patterns and his behavior trends, for they are part and parcel of his entire, indivisible growth.

Although at first glance this seems like an expansive and abstract concept of the province of pediatrics, such an extension of scope is almost inevitable if pediatrics continues its present position as a regional specialty converging the resources of general medicine and biology upon infancy. The whole tendency of modern science is toward concepts which stress and preserve the unity of the individual. Among the biological sciences, there is an increasing hyphenation of related disciplines which reflects this tendency. Embryology is becoming physiology; the physiology of development is incorporating basic problems of behavior; anatomists are making experimental researches of immediate importance to psychology. The complexity of this whole situation, regarded from the standpoints of clinical science and of preventive medicine, places an increasing premium on the integration of the activities of the clinic and of the laboratory. The status of pediatrics as a correlating nucleus of general medicine becomes reinforced. It is impossible to see how pediatrics can avoid a fundamental reckoning with the problems of human behavior. A large part of the work of the practicing pediatrician is already concerned with relatively normal infants, not suffering from acute illness but presenting problems of hygiene, of posture, of habit formation, of behavior deviation, and of behavior disorder. Even in the field of nutrition he is not perplexed so much by dietary requirements as by such "psychological" phenomena as loss of appetite, food intolerance, faulty feeding habits, and the conspiring influences of the child's total behavior day and of the family situation. Indeed, infant hygiene cannot be reduced to purely physical terms. In the final analysis many of the primary factors of feeding, sleeping, exercise, rest, energy, and metabolism reduce themselves to forms of behavior, subject to laws of habit training and of emotional conditioning. Basically, these problems in infant hygiene find an ultimate reference in the personality of the infant and in the infant-parent relationship.

For every age group and for every individual there are, therefore, ascertainable *norms* of behavior which must enter into an estimate of his mental and physical health. Any full inquiry into the status of his health must give systematic heed to these behavior conditions and bring them into the scheme of developmental supervision.

Periodic health examinations will then become developmental inventories, and the child's behavior assets and liabilities will be entered into a continuing biographical record. Each examination is a check on another. The physician becomes an adviser with respect to the child's behavior health even during the first year of infancy, and takes a preventive interest in symptoms of mental welfare. The more complex and exacting problems of mental diagnosis and treatment will naturally be referred to the psychiatrist; but the problems of mental hygiene are too numerous and too ubiquitous to be assigned to any specialty. The child's hygiene, at least, remains indivisible. It is not assumed that every pediatrician will become an expert in mental medicine. Neither, however, can it be assumed that the vast field of mental hygiene should be undertaken by an additional and supplementary mental service. Applied forms of educational psychology are penetrating into the preschool levels of childhood, and they have important contributions to make; but programs of infant training cannot be well undertaken apart from the safeguards, the technique and the traditions of medicine. Looking well into the future, the responsibility and the participation of pediatrics in a progressive organization of developmental supervision seem established.

Periodic health examinations and a periodic normative survey of behavior patterns can be brought into association in a supervisory type of developmental pediatrics directed toward the early recognition and more timely control of growth conditions. The demand for this type of pediatrics is becoming clearer, in the fields both of private practice and of public health. Systematic health supervision is only in its beginning, but in principle a revolutionary increase in medical and social control has already been achieved. How this supervisory service in infant and mental hygiene will actually be organized no one can, of course, predict. The methods of developmental pediatrics will naturally take shape slowly, but probably with the same steady and sound growth which has marked the advances of preventive pediatrics in the supervision of infant nutrition.

Research in child development and research in the behavior aspects of pediatric problems will contribute to the definition of diagnostic and supervisory technique. But almost equally important are forms of medical education, both preprofessional and postgraduate, which will emphasize the psychological or the psychobiological aspects of individual development. Toward this end curriculum and clinical training alike will have to deal more systematically with the characteristics of the normal infant and with the norms of typical, optimal mental development. This will entail fundamental attention to the developmental aspects of child psychology and to the genetic aspects of neuropsychiatry. The multiplication of special courses and lectures in adult psychiatry, mental hygiene, and psychopathology can scarcely meet the situation. Purely supplementary instruction in these fields might even operate to retard the desired correlation of mental and physical hygiene. What is most needed is a developmental approach which will focus on the central concept of growth from the outset, and will bring health and abnormality in both psychical and physical spheres into organic relation. Only in this way can the psychological outlook be assimilated into the biological point of view of the medical student, and only in this way likewise can a scientific outlook of mental hygiene become assimilated into the attitude of the physician.

INTELLIGENCE TESTS

NEED FOR SCIENTIFIC METHODS OF ESTIMATING INTELLIGENCE

EVERYONE knows that human beings differ greatly in mental ability. At one extreme is the idiot who cannot learn to speak or to care for his bodily needs, while at the other extreme are the Aristotles, the da Vincis, the Galileos, the Goethes, and the Einsteins, who create science, art, and all that goes to make civilization. The range between these extremes is continuous through the moderately feeble-minded, the dull, the average, the superior, and the very superior. The importance of intellectual differences, as well as previous training in habits and other factors, as determiners of behavior is universally recognized. All of us, consciously or unconsciously, pass frequent judgment upon people with respect to their intelligence, insight, or understanding. Teachers so judge their pupils, employers their employees, and friends and acquaintances one another.

That estimates based upon ordinary observations are extremely unreliable has been sufficiently demonstrated. If thirty individuals are rated for intelligence by several judges who know them well, the ratings so obtained will show radical disagreements. In fact the ratings of two judges rarely correlate more than .50 with each other. Different persons have different ideas with respect to what intelligence is and how it is revealed. One person may judge a child's intelligence by his general mastery of school subjects, another by the adaptability he shows in play or other social activities, and another by his breadth and variety of interests. Apart from the many different conceptions of what intelligence is, there are still other sources of error in its estimation. The teacher usually underestimates the intelligence of children who are shy and reticent, and overestimates the intelligence of forward and talkative children. Estimates are even influenced by the mobility of facial expression, and are especially likely to be influenced by mannerisms and peculiarities of personality. Finally, errors are often caused by the lack of suitable standards of comparison. Teachers and parents who know only bright children tend to rate them as average, while those who know only dull children tend to rate them also as average. The task of the psychologist who would devise improved methods for rating intelligence is thus twofold: he must define the concept of intelligence, and he must make his methods so unambiguous and objective that the types of error mentioned will be eliminated or reduced in extent.

WHAT IS MEANT BY INTELLIGENCE

No definition of *intelligence* has been formulated that is universally accepted by psychologists. Some prefer to think of it as ability to adapt to new situations, others as ability to learn, others as ability to perceive relations, others as the sum of innumerable special abilities, and others as capacity for conceptual thinking. Such definitions have much in common; they differ chiefly in the direction in which emphasis is placed. The contention sometimes voiced, that psychologists should not undertake to test intelligence until they can agree on what intelligence is, is unreasonable. There is nothing in the universe the ultimate nature of which is known. The physicist does not hesitate to study the properties of matter because he does not know what matter is, the chemist to investigate molecular compounds because he does not know the ultimate nature of the elements which compose them, or the physiologist to investigate the properties of living matter because he does not know the ultimate nature of life. In each case it is necessary to begin with tentative hypotheses and to proceed by refining these in the light of investigational data. Similarly in the case of intelligence, we must begin with a tentative hypothesis and depend upon the results of research to make the concept more definite.

It is generally agreed that the possession of intelligence in high degree enables one to adapt his responses to complex situations, to solve difficult problems, to acquire an extensive command of thought and behavior symbols in the form of language; in short, to see meanings and to think in terms of abstractions. This is considered general intelligence of the sort which affords the major distinctions between the imbecile and the genius.

We must not, however, ignore those abilities and talents of narrower scope which exist more or less independently of general intelligence and which are commonly designated as special abilities. Examples are musical ability, mechanical ability, computational ability of the kind shown by lightning calculators, artistic ability, and many others. Some of these, such as discrimination of musical tones, or mechanical and computational ability, are but little dependent upon general intelligence; others, as poetic and mathematical ability, much more so. It is only for convenience that the term intelligence has come to be used by psychologists in a sense which excludes the more specialized abilities. No harm will be done by this conventional restriction of the term provided its arbitrary nature is always kept in mind. No one denies that musical, mechanical, and artistic ability make important contributions to our civilization, or even that such special abilities as those which enable one to perform prodigious feats of memory or of motor coordination may have some social value. The fact remains, however, that common usage of the term *intelligence* would not deny one the use of the adjective *intelligent,* when considering persons who are tone deaf, or color blind, or manually clumsy, or devoid of athletic ability. The person who could not advance beyond the second school grade or adapt to the ordinary demands of life well enough to keep out of an institution for the feeble-minded, however, would not be regarded as intelligent. Misapprehension will be avoided by giving separate treatment to tests of special abilities; here it is important to note that special abilities exist in considerable variety and that they range all the way from those who are almost entirely independent of general intelligence to those which are rather highly saturated with it.

The fact should also be mentioned that there are psychologists who regard what we have called general intelligence as less "general" than Binet, Spearman, and others have believed it to be. Those who take this view consider general intelligence, as we have defined it, to be a "group factor" rather than a general factor. The dispute is partly a matter of terminology, and hinges upon the question how pervading a group factor must be before it should be called a general factor. General intelligence as above defined certainly plays a leading rôle in the vast array of the most important thought processes, and is even involved in some degree in many aptitudes commonly thought of as independent of it.

BEGINNINGS OF INTELLIGENCE TESTING

The idea that mental abilities can be tested by formal procedures is more than two thousand years old. It was suggested explicitly by Plato as a means of identifying those who were fitted by nature to become rulers. It was not until the seventies of the last century, however, that the first crude experiments in mental testing were performed by Galton, when he compared the memory span of feeble-minded and normal subjects. In the eighties experimental work on this problem was begun in Germany, and in the early nineties in France and America. Pioneers after Galton in the movement were Kraepelin and Ebbinghaus in Germany, Binet and Henri in France, and Cattell in America. It was Cattell who first used the term *mental test.* This term is of course much broader than the term *intelligence test,* for it includes also tests of emotional, volitional, and all other non-intellectual mental traits. The intelligence test is but one type of mental test.

Intelligence tests as we now know them have gradually emerged from mental tests of a rather planless sort. The earliest tests by which individual differences were studied have little resemblance to those in use today, for they were limited almost entirely to tests of the more elemental functions such as sensory discrimination, perception, reaction time, rote memory, and motor coordination. Methods had not been found for bringing the more complex mental processes under experimental control, and it was not then known that the most important differences between persons would not be detected by tests of the elemental functions. Thus Binet, to whom we are most indebted for methodological progress in intelligence testing, experimented assiduously for fifteen years with numerous types of tests before he attempted to formulate a scale for differentiating grades of general intelligence. Among the tests extensively experimented with during the decade 1890 to 1900 by Binet, Cattell, Jastrow, Muensterberg, and others, were tests of visual, auditory, touch, kinesthetic, and pain discrimination, perception of time and movement, reaction time, rate of tapping, various motor skills, color naming, perceptual illusions, counting letters or dots, simple addition, bisecting lines, locating a sound, reproducing letters or other visual material after brief exposure, memory for musical tones and nonsense syllables, and mental imagery.

It was Binet who first clearly appreciated the futility of tests of the elemental processes as a means of differentiating intelligent from unintelligent subjects. He therefore abandoned for the most part tests of this type in favor of tests of imagination, attention, comprehension, suggestibility, logical memory, language functions, common information, and ability to discriminate concepts, detect absurdities, and solve problems. The shift from the old to the new type of test was made almost simultaneously by Ebbinghaus. Whereas the earlier tests had largely failed of their purpose, the new proved successful beyond expectation. The old tests had brought out large individual differences, but they were differences which correlated but slightly or not at all with intelligence as judged by ordinary criteria. The new tests, on the other hand, yielded scores which correlated to a greater or less degree with any reasonable criterion of intelligent behavior. It only remained to assemble a suitable battery of such tests to put the method on a practical footing. This was first done by Binet,[1] * who published in 1905 his serial arrangement of thirty tests covering the wide range of intelligence from infancy to maturity. The tests of this scale were shortly afterward increased in number, arranged

* Superior numbers in text refer to list of references at end of sections.

in age groups, and published in 1908 as the first age-grade scale. Adaptations and imitations of Binet's 1908 scale have since come into general use throughout the civilized world.

An important practical advance in the decade 1910 to 1920 took place in the development of group tests; that is, tests that could be administered to many subjects simultaneously. This was a development which had not been foreseen by Binet, who had characterized his own scale as *une méthode de luxe* that required too much time and skill in its administration ever to be applied universally in the schools. Tests of the Binet type are the main reliance in the intensive study of individual subjects, as in the case of delinquents, the feeble-minded, the backward, and the gifted, but in the testing of extensive school populations group tests are necessarily employed. The feasibility of such wholesale testing was first demonstrated in 1917 to 1918 when nearly two million American soldiers were given the army mental tests. Now every year millions of school children in the United States are given intelligence tests.

PRINCIPLES AND TECHNIQUE

Testing a Method of Sampling. Galton likened the mental test to the assaying of minerals. Just as the value of a mineral deposit may be estimated by samplings of ore, so the abilities of a person may be estimated by properly chosen samplings in the nature of test performances. One's total vocabulary, for example, may be fairly accurately estimated by definitions given to a random sampling of one hundred words; one's memory span, by a few series of digits; one's ability in arithmetical reasoning, by twenty or thirty properly chosen problems, and so forth. In order to be of any use, the sampling of mental ability by means of tests must fulfill two conditions: (1) It must be adequate in extent so that the test will give consistent (*reliable*) scores, and (2) it must be a sampling of processes which really involve intelligence, that is, the test must be *valid*. A test is reliable if it tests accurately whatever it tests; it is valid if it actually tests what it purports to test.

Reliability. This is measured in terms of the coefficient of reliability, which is computed by giving two comparable forms of the test, or the same test twice, to a group of subjects, and correlating the two sets of scores thus obtained. For use in individual diagnosis it is generally considered that an intelligence scale should have a reliability of .90 or preferably .95. The reliability of a test score is also measured in terms of its probable error. That is, we must distinguish between the *found* score and the hypothetical *true* score that would result from a similar test of very great length. If the probable error of a score is 4 points, this means that the chances are even that the true score, if it could be ascertained, would not deviate from the found score by more than 4 points. The more reliable the test, the smaller is the probable error of its score, but no tests have been devised which are so reliable that the probable error of its scores can be ignored safely. Factors making for high reliability are length of the test (extensive sampling), homogeneity of the items of the test, suitable instructions in setting the tasks, and objectivity of scoring.

Validity. The validity of an intelligence scale is more difficult to determine, for it necessarily involves a comparison of the scores earned in the test with intelligence as estimated against other criteria which are themselves fallible. Criteria that have been used for this purpose include ratings by teachers or other acquaintances, scholastic marks, rate of progress in school, social and occupational success, and so forth. Tests have presumptive merit as tests of intelligence if they differentiate between normal subjects and inmates of institutions for the feeble-minded, between accelerated and retarded school children of a given age, between officers and privates in the army, between skilled and unskilled laborers, or between any other groups that are believed with good reason to differ in their average intellectual calibre. No one of these criteria taken alone is entirely dependable. Some children are retarded because they do not study; some unskilled laborers are more intelligent than some lawyers; and subjective ratings of intelligence are influenced, as we have seen, by facial looks, verbal fluency, timidity, personal mannerisms, and an indefinite number of other factors. The usual procedure, therefore, is to use not one criterion of validity, but several.

Validity of Tests as Indicators of Native Capacity. At best, intelligence tests are capable merely of appraising the intelligence that an individual has actually developed. They do not directly measure one's native capacity to become intelligent. Any pronouncement on a subject's inborn intelligence rests necessarily upon inference. The subject who tests as imbecile may have been well endowed by heredity, but may have become afflicted by meningitis. Similarly, a child reared in complete isolation from human contacts might test as feeble-minded even if he were a potential Newton. The latter statement implies that an intelligence test does not indicate present potentiality except by inference, to say nothing of inborn potentiality. What it registers is actual performance under the conditions of the moment. A child reared in complete isolation and testing as feeble-minded might conceivably test as a genius after he has been educated. To what extent intelligence test scores actually are influenced by various physical and environmental factors can only be determined by investigations planned for this specific purpose. The problem will come up later, but the point to be noted here is that the value of intelligence tests does not hinge upon their complete freedom from environmental influences. Indeed, the tests themselves are capable of supplying the most dependable evidence as to the importance of those influences. The maker of tests tries to select items to which the responses will be as little as possible affected by the ordinary differences among people in educational and cultural opportunity, but his success at best can be only relative. If he had time and money to validate every test item with large numbers of subjects, of whom every one had been pushed by education to the uttermost limits of his natural capacity, the resulting intelligence scale would approximate the ideal much more closely than any now available.

The Formation of Test Batteries. Assuming that valid test items in great number and variety have been devised, the next problem is to select the best possible combination to use as a scale or battery that can be administered in reasonable time, say an hour or less. One of Binet's most important contributions in this connection was his idea of pooling a great variety of brief tests, each tapping a different aspect of intelligence, instead of testing separately a number of supposedly independent ability. It was Binet who first clearly assumed the existence of a general intelligence which is not the mere arithmetical sum of a host of independent functions. Another principle generally followed in the assembling of tests in a scale is that the scale as a whole should test power, rather than the total number of tasks that can be performed on a single level, or the speed with which they can be performed. It is on the whole more useful to know how difficult a thing one can do than how many easy things one can do. Between power and speed the correlation is only moderately high, and much of the success of the Binet scale is due to the fact that it tests power rather than speed.

Standardization of Procedure. An essential characteristic of the test method is the requirement of a standard procedure in both the administration of the test and the evaluation of responses. Every task must be presented according to a prescribed formula, and every response must be scored according to definite rules. This is the first thing that the beginner in psychometrics must learn. Departures from the standard procedure are sometimes necessary, but it is only the rigidly trained and experienced examiner who can be trusted to make them. Departures that would appear immaterial to the inexpert examiner may grossly distort the results. Even though the standard procedure is rigidly carried out, the personality of the tester remains an uncontrolled variable which is particularly significant in the matter of gaining the cooperation of the subject.

The Necessity of Norms. However meritorious an intelligence scale may be, the results it yields are practically meaningless until they are interpreted with reference to norms. Without such possibility of comparison even the most competent psychologist could have only a vague idea of the significance of a subject's performances. Several kinds of norms are in use, each possessing its peculiar advantages and disadvantages. Among the most indispensable when we are dealing with children are those based upon age. The ten year old child can be fairly compared only with the average performance of ten year olds in general; and so with children of any other age. A subject whose score equals that of the average child of ten years is said to have a mental age (or better, intellectual age) of ten years. Such a score may of course be earned by bright subjects much younger than ten, or by inferior subjects much older.

Mental age, as the term is used, indicates the level of intellectual development which has been reached. It does not indicate brightness until it is interpreted with reference to actual age. When this is done, by taking the ratio of mental age to chronological age (MA:CA) we have the intelligence quotient (I. Q.). The child of eight years who tests at ten has an I. Q. of 125; a child of ten years who tests at eight, an I. Q. of 80. In reckoning the I. Q. of older subjects, chronological age above fifteen or sixteen is usually ignored on the ground that intelligence as measured by available tests has pretty well ceased its development by that time.

The I. Q. as an index of brightness is to a certain extent decidedly useful, especially when we are dealing with children, but its limitations should not be overlooked. Its validity does not extend beyond the validity of the intelligence scale upon which it is based. It gives no clue to important special abilities, and does not even give a total picture of general intelligence. Depending on the nature of the test employed it may put a premium on certain abilities, such as verbal fluency or ability in reading and writing. Like any other mental test score, it always has a probable error that must not be ignored. Its value lies in the fact that it is more readily understood than most other indices of brightness (sigma or "Z" scores, for example), and that in the large majority of cases it maintains a fair degree of constancy through the period of mental growth. As maturity is approached, however, the I. Q. loses its significance.

Whatever intelligence scale is employed, the use of age norms can hardly be avoided. This is just as true of the so-called *point scales* as of the scales of the Binet type that are scored immediately in terms of mental age. If a child of ten years makes a point score of 45, for example, this means little or nothing until we know the distribution of scores for unselected ten year olds. The chief danger in the use of age norms comes from reading more meaning into a mental age score than it is intended to carry. When a subject is assigned a mental age of ten years this means merely that his numerical score on a particular test is equal to that of the average child of ten years; it does not mean that there may not be important qualitative differences in the intellectual performances of two children who have earned the same numerical score. No intelligence scale adequately samples all of the abilities that may reasonably be classed as intellectual, and when we speak of a mental age we should therefore designate the scale of tests on which it is based. Moreover, when we are dealing with adults who are not intellectually inferior, age norms cease to have meaning and must be replaced by average scores for specifically defined groups. For example, the mean and the variability of scores for "unselected whites of European descent and of the age range of 20 to 30" may be taken as points of reference for evaluating the intelligence scores of other groups of adults, although it is difficult in practice to find a truly "unselected" group. The question whether there should be separate norms for the sexes and for the different racial and social groups is not an important issue. Inter-group comparisons will be made in any case; they are merely made more difficult by a multiplicity of norms.

At present it is impossible to measure intelligence in terms of any absolute scale whose units are of equal value, and since this is the case it is not strictly legitimate to speak of measuring intelligence at all. Binet explicitly rejected the term so far as his own scale was concerned, claiming merely that it reveals the "hierarchy of intelligences" and locates the individual subject in relation to this hierarchy. It should be borne in mind that the growth of intelligence from childhood to maturity involves pattern differences and not mere linear increase.

TYPICAL RESULTS OF INTELLIGENCE TESTING

For detailed summaries of the results of intelligence testing, the reader is referred to such books as those by Freeman,[4] Pintner,[15] Spearman,[19] Terman,[21] and Yerkes and Yoakum.[30] Space permits only the briefest possible exposition here.

Sex differences are very small with respect to mean scores, but boys appear to be slightly more variable than girls. American Negroes and Indians average much below the white standards, but this may be in considerable part owing to differences in educational opportunities and cultural backgrounds. Second generation Chinese and Japanese in California approximate the white standards. Children of superior social status average considerably above children of inferior status.

The best tests indicate scholastic aptitude fairly accurately. Children of Binet I. Q. below 60 rarely go beyond the third or fourth school grade, those below 80 rarely reach the eighth grade, and those much below 100 are not often able to graduate from high school. A majority of college students are above the 115 or 120 I. Q. class. Gifted children of 140 I. Q. or above usually make very superior to brilliant school records. Occupational success is only roughly correlated with intelligence; a particular occupation requires a certain minimal intelligence for success, but beyond that amount success depends largely upon other factors. Subjects who test as low as 60 I. Q. are usually feeble-minded—and so are some who test as high as 75. Naturally, many other factors than intelligence help to determine one's social competence, and feeble-mindedness, in the sense in which the term is ordinarily used, is essentially a lack of social competence. Delinquent children average below unselected children, but low intelligence as a cause of delinquency has been greatly overstressed.

The relation of intellectual development to physical development is considered in a separate section. On the whole the former proceeds at a fairly steady pace, spurts and resting periods being the exception rather than the rule. The various specialized abilities, however, do not all develop strictly *pari passu*. The question as to when intelligence ceases to develop can be answered only in terms of particular tests, and for these only very roughly. It appears that Stanford-Binet scores increase very little after the age of fifteen or sixteen, though there may be slight increases to seventeen or eighteen. Individual children, however, may show a considerable increase in mental age after fourteen years. Group tests of the markedly verbal type in common use show appreciable increase in scores at least as far as eighteen or twenty years. If there were a test that adequately measured the wisdom that comes from experience in life, its scores might conceivably show increase to the age of sixty or later. From present evidence it appears that ability to deal with novel situations has pretty well reached maturity by the late teens. The low average mental age of American soldiers (13.7, but often misquoted as 12), can be explained in part by faulty standardization of the tests, in part by the unsatisfactory conditions under which the army tests were given, and perhaps in part by factors operating in the selection of the draft quotas. It is possible that one reason for this low average mental age of adults is the inadequacy of the tests to do justice to the kind of change which characterizes this later age period.

EVALUATION OF INTELLIGENCE TESTING

Tests of general intelligence and of special abilities are among the most valuable tools that psychology has given to the world. In the schools they are useful in the classification of children for instruction, in deciding doubtful cases of promotion, in vocational guidance, and in the study of problem children. In the study and treatment of subnormal, delinquent, and gifted children they are obviously indispensable. In industries they have a limited usefulness in the selection and placement of workers; limited, because so many special abilities and so many non-intellectual factors enter into one's fitness for a given type of work. In sociology they are useful in affording comparative norms of intelligence realized by different racial, national, and other social groups. Their usefulness in research is perhaps the most significant of all.

The above values are genuine and important, notwithstanding the fact that intelligence tests do not and cannot test pure native capacity for intellectual accomplishment. These very tests supply the method by which the relative importance of nature and of nurture can be evaluated. They are capable of telling us whether the kind of intelligence which the tests measure is or is not modified by malnutrition, adenoids, superior or inferior school instruction, regularity of school attendance, intensive training in infancy, bilingualism, living in a cultured home, being an only child, or being of one race rather than another. Nearly all of these possible influences on intelligence scores have been investigated to some extent, but none of them has yet been adequately measured.[26] Psychologists do not at present agree in the interpretation of such investigations and further researches are urgently needed.

It is believed that the data so far available suggest that scores on tests of the Stanford-Binet type are not greatly influenced by malnutrition, adenoids, or other common physical defects; by the loss of a month or two of schooling annually; by the difference between the best and the poorest teachers in an ordinary city school system; by attendance at a nursery school, or by being an only child. He believes that the detrimental effects of bilingualism on Stanford-Binet test scores are relatively negligible after the first three or four years of school life. For example, children of immigrant Germans, Swedes, and other north European groups yield high average Binet scores after three or four years in school, which means that the low average scores of children of certain other immigrant groups can hardly be attributed to bilingualism. He believes that living in a home of the cultural grade of an average unskilled laborer will depress the I. Q. a few points below what it would be if the home were distinctly superior, but that all of the cultural and environmental influences combined do not go very far in accounting for the enormous intellectual differences one finds among the intelligence quotients of a thousand ordinary school children, a range that usually extends from 50 to 150 I. Q.

The question of genuine race differences in intelligence remains an extremely controversial issue. How much of the apparent inferiority of Negroes and Indians in the United States, just noted, is merely the reflection of a backward cultural environment and of inferior educational advantages, no one at the present time can say. The same uncertainty exists with reference to the lower intelligence scores made by the children of south European descent. In view of the ambiguity of the data on race differences it is wisest to suspend judgment until crucial large-scale experiments have been made. Experiments capable of answering the question would be costly and difficult, but they are feasible and will assuredly sometime be made. It would only be necessary to divide at birth pairs of identical twins born into poor environment and of supposedly inferior race or family stock, leaving one member of each pair to live on in its poor environment but removing the other member to an environment that would develop all the intellectual capacities to the uttermost, and then check the development of both groups from time to time by the use of intelligence tests. One hundred pairs so treated might tell us how much of the apparent differences between the Negro and the white are genuine; another hundred pairs might answer the same question for any other two groups.

Investigations to date which have attacked the problem most directly are the numerous studies of twin resemblance and the Chicago University and Stanford University studies of foster children.[26] An interpretation of these studies is that the large excess resemblance of identical twins in intelligence as compared with that found for fraternal twins is due chiefly to native endowment, and that the very superior foster home probably raises the I. Q. of the foster child adopted in infancy by less than 10 points in the average and rarely by as much as 15 or 20 points. That some influence is exerted by various environmental and cultural factors is universally admitted, and changes of even the modest order indicated (10 or 15 points) are far from trivial.

In the case of group tests of the markedly verbal type commonly used in schools, it appears that the scores are very greatly influenced by educational opportunities; it is therefore unsafe to compare two individuals on the basis of a test of this kind unless they have had equal amounts of schooling and other formal training.

NECESSARY CAUTIONS IN THE USE OF TESTS

Inexpert administration as a source of error has been mentioned earlier and deserves emphasis. Even when the test has been properly administered, arithmetical errors may occur in computing the score. Preferably every test should be scored twice and every computation should be checked. Test procedure may be correct in the sense that all the stated rules and formulas are observed, but the results may be distorted by failure to secure the subject's wholehearted cooperation. The difficulty of establishing satisfactory rapport is especially great with young children. While most intelligent persons can be taught in a few days to administer and score the simpler of the group tests correctly, extended and meticulous training is necessary for the administration of Binet and similar tests for individual examination. Coaching and practice effects must be guarded against.

But it is in the misinterpretation and misuse of test results that the greatest danger lies. Tests are useful in classifying children for school instruction, but it should go without saying that such classification ought never to be based solely upon test scores. Arbitrarily diagnosing a subject as feeble-minded on the sole evidence of an intelligence test is thoroughly unsound in the wide range of border-zone cases. It is especially important to remember that no intelligence test samples the entire range of mental abilities, and that even the sampling taken is never extensive enough to make the test score an entirely reliable measure of what it measures. The ubiquitous probable error should be kept in mind. A found score of 70 I. Q. does not really mean 70, but 70 plus or minus a probable error, or even plus or minus two or three probable errors. Accordingly, the test score should not be thought of as a final verdict, but only as a point of departure for further observation and study. When an important decision is involved, the test should if possible be repeated. It should be supplemented by case history data, and by tests of educational accomplishment. Viewed in the light of such additional information the intelligence score becomes much more significant.

As we have seen, there are many kinds of intelligence tests and no two are the exact equivalent of each other in the sense of testing precisely the same intellectual functions. Moreover, the different tests have not been standardized upon the same subjects, so that the mental ages and intelligence quotients which they yield are not equivalent. The various tests differ greatly in reliability. Every test has an optimal range above and below which its scores lose significance. The numerical scores are deceptive in their appearance of simplicity and definiteness.

The lesson to be drawn from this formidable list of inadequacies and dangers of the test method is not that intelligence tests should be used less, but that they should be used with more care and where possible be improved. The intellectual domain covered by each test or battery of tests should be more exactly defined. The important special abilities should be identified and separately measured. The fact that definitely stated rules for giving and scoring tests sometimes tempt the incompetent is no argument for abandoning rules and returning to haphazard procedures; that numerical scores sometimes mislead is no argument in favor of reverting to subjective appraisal of performance; that the content of every intelligence scale is more or less arbitrary and open to criticism is no argument in favor of each examiner's improvising his own method of interview. Nothing but chaos can come from any of these alternatives. The test method is indispensable because the totality of a subject's possible responses can never be adequately examined; samplings must be used, and tests are nothing but samplings taken by plan instead of by whim, and interpreted by standards which have been freed from personal bias.

DESCRIPTION OF LEADING TESTS

Some of the more important intelligence tests of each type in use in the United States have been selected for brief description. There are many other tests of considerable merit in one respect or another, but the selection here given as representative, and without pretense of completeness, is based upon a careful examination of all available sources of information.

It should be emphasized that data are not available for a really satisfactory comparison of the merits of the intelligence tests in use. A thorough and just comparison could only be based upon data derived by giving to the same group of subjects all of the intelligence tests usable in that group. The data at present available are only roughly comparable. Correlation coefficients yielded by intelligence tests are very greatly influenced by the range of ability in the subjects tested. If several ages of grades are thrown together, both reliability and validity coefficients will be so increased over what would be found for a single age or grade group that even a very poor test may make what to the uninitiated would seem to be a good showing. This, however, is a common practice among those who have reported their findings. It is true that the coefficient for a single age or grade can be roughly estimated from that found for a wide range of ages or grades, but sometimes the author fails to give any information at all about the range used. Moreover, in comparing coefficients of correlation on the same tests from different authors, one occasionally finds discrepancies so large as to justify suspicion of computational errors.

It should further be emphasized that the merit of a test depends upon one's purpose in using it and the circumstances under which it must be given. If the results are not to be used in passing judgment upon individual subjects, but only for comparing very large groups of subjects, one may safely use a brief, inexpensive test of such low reliability and validity as to be entirely undependable for individual diagnosis. Most of the tests here selected for description, with exception of the nonverbal and performance tests, are believed to have sufficient reliability and validity to warrant their cautious use in individual diagnosis as well as in group comparisons.

Finally, the choice of tests will naturally also be influenced in many cases by such considerations as the cost in money and time, the ease of giving and scoring, the types of norms provided, and the aspect or aspects of intelligence about which information is sought. For these and other reasons it is not feasible to attempt to give a single list of intelligence tests in order of merit.

I. TESTS FOR INDIVIDUAL EXAMINATION

American Versions of the Binet Tests

For the clinical examination of individual subjects who have no gross handicap in the matter of language, some form of the Binet scale is almost universally preferred. The chief advantages of tests of the Binet type are that they cover a wide range of ability and tap many aspects of intelligence, rank high in reliability and validity, and give an unexcelled opportunity for qualitative observations on the subject's mode of response. Their chief disadvantages are that much training is required for their correct use and that they are so time-consuming. These disadvantages, however, are common to all worthwhile tests for individual examination. Coaching effects must be guarded against. The standard versions of the Binet scale are not usable with deaf or blind subjects, or for illiterates above the mental age of seven or eight years.

The Stanford-Binet. Range, age three to superior adult level; one form; time, forty to sixty minutes; scoring time, five minutes; norms, age and intelligence quotient; publisher, Houghton Mifflin Company.

This is by far the most widely used of the Binet revisions to date, both in the United States and (through translations) in other countries. Numerous reliability coefficients have been reported for single age or grade groups, nearly all of which are between .90 and .95. Thus, for 149 first grade children the reliability was .92; for 57 twelve year olds, .93; and for 180 adult prisoners and unemployed men, .93; and for 108 eight year olds, .92. The probable error of the Stanford-Binet I. Q. is between three and four points. The probable error of the mental age score is about three months at the six year level and six months at the twelve year level. The correlation of test with retest, even after an interval of two or three years, is seldom below .80 for a single age group. With a good composite criterion the Stanford-Binet test usually yields a validity coefficient between .60 and .80, which is probably not exceeded by any other intelligence test.

Samuel P. Hayes has prepared a special adaptation of the Stanford-Binet for use with blind subjects.

The New Stanford Revision. This test, which is intended ultimately to replace the original Stanford-Binet, has been in process of construction since 1927 and will not be completed before 1932 or 1933. Its range will extend both lower and higher than the present Stanford-Binet, it will be much more thoroughly standardized, and its reliability and its validity will both be higher. The new revision will be made up in two alternate forms, each composed of about twice as many tests as are in the original Stanford-Binet. The variety of tests will be greater, but the average time for giving each will be somewhat less, so that the total time for administration will remain about the same. The alternative forms will give the new Stanford-Binet important advantages, especially in the avoidance of coaching effects and in the study of mental growth by repeated tests of the same subjects.

The Kuhlmann Revision and Extension of the Binet-Simon Scale.[12] Range, from three months to fifteen years; one form; time, fifty to eighty minutes for subjects above age five or six; scoring time, approximately five minutes; norms, mental age and I. Q.; publisher, Warwick & York.

This is one of the most carefully worked out of the Binet revisions, and is especially valuable because of the tests for the early years. The test requires more time and also more skill for its administration than the other Binet revisions. Little information is available on reliability and validity, but in both respects the scale is probably about as good as any other version of the Binet scale thus far published. The Kuhlmann-Binet tests for children of preschool age have been subjected to critical study and evaluation by Goodenough,[5] who found retest reliabilities as follows for single age groups of 100 cases: two year olds, .76; three year olds, .87; four year olds, .82. These are fairly good reliabilities, considering the difficulties encountered in testing young children, but are not high enough to predict the future status of a subject as accurately as is possible in the case of older children.

The Herring Revision of the Binet-Simon Tests. Effective range, from about five years to average adult intelligence; one form; time, thirty to fifty minutes; scoring time, five minutes; norms in terms of point scores translated into Stanford-Binet equivalents; publisher, World Book Company.

This test resembles considerably the Stanford-Binet, but it contains fewer tests and the tests are not grouped by age level. Fewer rules are laid down for its administration, which makes the procedure appear simpler to learn but hardly favors accuracy of results. Its reliability is not given for single age or grade groups, but is probably not very far below that of the Stanford-Binet. The same is probably true of its validity, although it includes a smaller variety of tests than the Stanford-Binet and is on the whole considerably more verbal. L. S. Hollingworth [8] has shown that its mental age and intelligence quotient scores tend to run considerably below those of the Stanford-Binet in rating very bright children.

The Yerkes-Bridges Preadolescent Point Scale, Foster Revision.[29] The Yerkes-Bridges scale, as revised by Foster, includes three scales: one for infants, one for preadolescents, and one for adolescents and adults. Only the preadolescent scale will be described here, as the other two are admittedly in a very tentative form. Range: age four or five to adult level; one form; time, thirty to forty-five minutes; scoring time, approximately five minutes; age norms; publisher, Warwick & York.

The Yerkes-Bridges-Foster scale is an adaptation of the Binet scale, considerably briefer, and lacking the age grouping of the tests. It is scored in terms of points, but as these are interpreted in terms of age norms and converted into intelligence quotients the result is not essentially different from scales of the Binet type. The authors have given no reliability or validity data. In these respects, because of the smaller number of tests included, the scale is probably somewhat inferior to the Stanford or Kuhlmann revisions. The special advantages claimed by the authors for the point scale method have not sufficed to bring this scale into general use.

Scales for Individual Examination of Preschool Children

Mention has already been made of the tests for preschool children in the Kuhlmann-Binet and in the forthcoming new revision of the Stanford-Binet. Two additional sets of tests for young children remain to be described: one arranged by Stutsman, the other by Gesell. The testing of young children presents extraordinary difficulties. The manifestations of different aspects of behavior are not easy to identify or their significance for later development easy to establish. Standardized samplings of behavior are difficult both to obtain and to evaluate when obtained. However, substantial progress has been made in recent years and a vastly important field of research is rapidly being opened up. Both medicine and education are naturally much interested in the possibility of diagnosing mental defect and superior promise at an earlier age than has hitherto been possible.

The Merrill-Palmer Scale. Range, two to six years; one form; time, thirty to fifty minutes; scoring time, approximately five minutes; norms in terms of percentiles and standard deviations of age groups; publisher, World Book Company.

This is one of the most carefully worked out scales for the individual examination of preschool children, possibly the best thus far published. Its high reliability has been established by the author, Doctor Stutsman, on extensive data.[20] The tests are on the whole of a type that command the attention of young children.

The Gesell Developmental Inventories. Gesell's developmental inventories for children from earliest infancy to school age represent the most thoroughgoing attempt ever made to establish norms of psychomotor growth during the preschool period. The author has not attempted to measure *intelligence,* but instead presents separately the norms for motor development, the development of language, adaptive behavior, and personal-social behavior. Numerous tests are given for estimating the stage of development which a subject has reached in each of these major fields. Although their purpose is primarily to bring out qualitative changes as growth progresses, rather than to measure growth in quantitative terms, it is possible by their use to make a rough appraisal of what some would wish to call the subject's general developmental age. These inventories are of such outstanding importance as to justify more detailed standardization of the procedures for giving and scoring the individual tests. Until this has been done even competent psychologists will find it extremely difficult to use them with assurance.

An Equal Unit Scale

Thorndike's[23] *CAVD.* Range, age two to very superior adult; forms, one; time, varies greatly; scoring time, approximately ten minutes; age, grade, and other scores in terms of hypothetically equal units; publishers, Teachers College, Columbia University.

The CAVD represents the most important attempt to derive a scale of absolutely equal units. The equality of the units is open to question, but the test affords a fairly dependable measure, over a wide range, of the functions tapped by the test, which are completion ability, analogical association, vocabulary, and ability to follow directions (designated respectively as C, A, V, and D). The test is time-consuming, but has high reliability and correlates well with the usual criteria. The functions tested by CAVD are those concerned with abstract or conceptual thinking, largely those involved in scholastic success. In the upper ranges the test may be used as a group test.

Performance Scales for Individual Examination

Performance scales attempt to test intelligence by giving the subject things to do rather than by asking questions or setting problems that call for verbal responses. Some of the tests in the various versions of the Binet scale are more or less of this type, though most of them presuppose the use of language by the examiner in setting the tasks. The advantages of performance tests are of two sorts: (1) They sometimes sample abilities of a kind not adequately sampled by the verbal tests, or even by the usual nonverbal tests and paper tests. (2) They are more valid than verbal tests with subjects who are deaf or handicapped by a foreign language. Their shortcomings are also chiefly two: (1) their lower correlation with the best outside criteria of intelligence; and (2) the difficulty of devising tests of this type which discriminate grades of ability in the adolescent and adult levels. Great numbers of form boards, peg boards, picture puzzles, mazes, and so forth, have been separately standardized, but the value of such tests has been limited by the difficulty of combining the scores obtained from separate tests into a single score. Taken alone each is too restricted and unreliable to have much significance. Two serious attempts have been made to derive a composite scale of performance tests, one by Pintner and Paterson, the other by Kohs.

The Pintner-Paterson [16] *Performance Tests.* Range, four or five to fifteen years; one form; time approximately 120 minutes; scoring time approximately ten minutes; norms, age and percentiles; publisher, D. Appleton and Company.

This is a group of fifteen individual performance tests, standardized separately and also as a composite. Norms are given for each test and for the composite. The authors give no reliability or validity data, but a correlation of .84 with Binet mental ages was found in the case of 260 American-born soldiers, and .70 in the case of 61 foreign-born soldiers. The entire battery of tests is extremely time-consuming, but an abbreviated version was worked out in the army which gave high correlations with the composite scores of the fifteen tests.

The Kohs [11] *Block-design Test.* Range, four to fifteen years; one form; time, fifty to eighty minutes; scoring time, approximately five minutes; norms, age and percentiles; publisher, The Macmillan Company.

This test is based entirely upon the matching of block-design patterns, and thus provides a much narrower sampling of mental ability than the Pintner-Paterson battery of tests. Its correlations are for the most part rather low both for reliability and validity. With a single age or grade group it correlates about .60 with the Stanford-Binet, and the author reports a correlation of only .23 with teachers' estimates of intelligence. Although the test does not have very much in common with the tests of the Binet type, and gives little information about scholastic aptitude, it is a valuable test for supplementary use because of its nonverbal character and its careful standardization.

The Goodenough[6] *Test of Intelligence by Drawings.* This ingeniously worked out test is described among the group tests for kindergarten and primary children. Here it is only necessary to call attention to the fact that for the age range of four to nine years it is one of the most valuable brief performance tests ever devised.

II. GROUP TESTS OF INTELLIGENCE

The group tests will be treated under five headings: (1) kindergarten and primary tests, (2) tests for the intermediate grades, (3) high school tests, (4) college tests, and (5) nonverbal tests of various ranges. The merits and shortcomings of group tests in general already have been mentioned. The method of individual examination requires extensive training for its proper use, while the procedure for group tests is usually so simple that it can be learned by any intelligent person in a few hours. The method makes it possible to test millions instead of thousands. It cannot be emphasized too strongly, however, that the interpretation of a group test score requires just as much psychological expertness as the interpretation of a Binet score. If there is any difference the latter is the simpler. Much complaint has been made about the unskilled use of Binet tests, but the misuse of group tests is even more common. The scores which they yield are so easily obtained that the need for psychological training for their interpretation is likely to be overlooked.

Kindergarten and Primary Group Tests

Group tests at this level have not proved very satisfactory, largely because of the difficulty of making the tasks understood and of securing maximal individual cooperation of the children. A high score on the better tests of this type is significant, but a low score may be caused by many factors other than inferior intelligence. Their chief merit lies in the possibility of securing a rough idea of a child's ability immediately upon entrance into school.

The Pintner-Cunningham Primary Mental Test. Range, kindergarten to grade three; one form; time, thirty to forty-five minutes; scoring time, five minutes; norms, age and intelligence quotient, with percentiles; publisher, World Book Company.

This is probably the best of the group tests of intelligence for this range of ages. Its reliability for two groups of kindergarten children of 22 and 23 pupils respectively is reported as .88 and .93. These are very high for group tests at this age. For three small groups of kindergarten children (17, 20, and 19 cases) the correlations with Stanford-Binet were .55, .71 and .82. For second-grade pupils a correlation of .66 with the Otis Primary test is reported. For four groups the correlations with teachers' ratings ranged from .64 to .78.

Otis Group Intelligence Scale, Primary Examination. Range, kindergarten to grade three; one form; time, thirty to forty-five minutes; scoring time, five minutes; norms, age and I.B. (index of brightness) with percentiles.

This test has been well standardized and has a fairly high reliability for a primary test. Two different investigations have given this test a first place among primary tests in respect of correlation with Stanford-Binet; namely, .66 for grades two and three combined. This low figure shows how little even the best of primary group tests have in common with the Binet.

The Dearborn[3] *Group Test of Intelligence, Series I.* Range, grades one to three; forms, one; time, forty-five to sixty minutes; norms, age; publisher, J. B. Lippincott Company.

This test is rather more difficult to give and score than most other primary tests, but it has the advantage of being interesting to young subjects. Reliability data are not available. Root reports correlations of .79, .40, and .72 with Stanford-Binet in grades one, two, and three taken separately.

Haggerty, Delta I. Range, grades one to three; forms, one; time, thirty minutes; scoring time, five minutes; norms, age and I. Q. with percentiles; publisher, World Book Company.

A reliability of .78 was found, based upon retests of 100 pupils of grade 1A to grade 2A. Reliability of .60 to .70 for single grade groups is reported, which must be regarded as unsatisfactory. As for validity, a correlation of .53 with teachers' ratings has been found, and correlations of .28 to .71 with Stanford-Binet in grades one, two, and three taken separately.

The Goodenough[6] *Test of Intelligence by Drawings.* Range, ages four to nine or ten; forms, one; time, ten minutes; scoring time, three to five minutes; norms, age, grade, and I. Q., with percentiles.

This is a performance test which can be used either for a group or for individual examination. Its great advantages are that it is so easy to give and score, that it is not influenced by the factor of language, and that it compares favorably with the best of the primary group tests in both reliability and validity. The reliability, computed on 194 first grade children, is .93. The average reliability for ages five to ten, taken separately, is considerably lower; namely, .77. Its average correlation with the Stanford-Binet, for ages four to ten, taken separately, is about .74. It correlates on an average .44 with teachers' estimates of intelligence in the first three grades.

Group Tests for the Intermediate Grades

The National Intelligence Tests. Effective range, grades three to eight; two scales (A and B), each in five forms (three thus far published); time, thirty-five minutes for either scale A or B; scoring time, five minutes for either scale; norms, age and grade; publisher, World Book Company.

These are perhaps the best tests available for the range they cover. They were devised by a group of five persons, Haggerty, Terman, Thorndike, Whipple, and Yerkes, and are the result of an extensive research in which twenty different types of tests were tried out. They are convenient to give and to score, and the norms are based upon large numbers of subjects. The reliability of each scale for a single grade range is about .75; of scales A and B combined, about .86. It is evident, therefore, that both scales must be given to secure a satisfactory reliability. The correlation of either A or B with Stanford-Binet, for a single age range, is in the neighborhood of .75 to .80.

Haggerty, Delta II. Effective range, grades three to eight; forms, one; time, thirty-five minutes; scoring time, three to four minutes; norms, age and grade; publisher, World Book Company.

The reliability of this test has not been reported for single age or grade groups, but Kelley's [10] estimate of .60 for a single grade is probably too low. For grades three to nine, taken separately, Root found correlations with Stanford-Binet of .62, .69, .58, .60, .82, .79, and .44. Franzen found its average correlation with a composite of thirteen other tests to be .73, which was exceeded only by the Terman Group Test and the National Intelligence tests. Unfortunately, the test has no alternative forms.

The Dearborn [3] *Group Tests of Intelligence, Series II.* Effective range, grades four to eight; forms, one; time, 100 minutes; scoring time, twelve to fifteen minutes; norms, age and grade; publisher, J. B. Lippincott Company.

This test is less verbal than most of the group tests for school children. It is rather time-consuming to give and score, but is more interesting to children than most of the tests designed for this range. No data on reliability have been reported. Franzen showed that it has little in common with the composite of thirteen other well known tests, and that it yields relatively low correlations with school marks and teachers' ratings.

Otis Self-administering Tests, Intermediate Examination. Effective range, grades four to eight; forms, two; time, forty minutes; scoring time, two to three minutes; norms, age and grade, with percentiles; publisher, World Book Company.

This test is exceptionally convenient to give and score. Data on reliability and validity are not available for single age and grade groups.

Group Tests for Junior and Senior High School

The Terman[22] *Group Test of Mental Ability.* Effective range, grades seven to twelve; forms two; time, thirty-five minutes; scoring time, eight to ten minutes; norms, grade and Stanford-Binet mental age, with percentiles; publisher, World Book Company.

This test is unique in that each individual item contained in its two forms was selected by tryout against an outside criterion. In all the comparative studies which have been made of tests covering a similar range, this one has been given first place. A reliability of .89 was found for 132 ninth grade pupils. Franzen found that it ranked first in correlation with the composite score of thirteen tests. It is exceptionally easy to administer.

Otis Group Intelligence Scale, Advanced Examination. Effective range, grades six to twelve; forms, two; time, sixty-five minutes; scoring time, eight to ten minutes; norms, age and grade, with percentiles and index of brightness (I B); publisher, World Book Company.

This was one of the first successful group tests of intelligence to be devised and remains one of the best, although rather time-consuming to give. The norms have been carefully worked out. Reliabilities based on scores of Form A against Form B average around .85 for single grade groups. It correlates highly with a composite of other intelligence tests. Colvin found high correlations with scholarship, mostly above .60 for separate grade groups.

Otis Self-administering Test of Mental Ability, Higher Examination. Effective range, grades seven to twelve; forms, one; time, forty minutes; scoring time, two to three minutes; norms, age and grade, with percentiles and index of brightness; publisher, World Book Company.

The special merit of this test is the ease with which it can be given and scored. The reliability is fairly high, but in validity it ranks below the Otis Group Scale, Advanced Examination.

Army Alpha. Effective range, grades six to thirteen; forms, five; time, fifty minutes; scoring time, ten minutes; norms, letter ratings reprinted by Stoelting (Chicago).

This, the most famous group test ever devised, was given to nearly one and three-quarter million soldiers during the World War. It is of the markedly verbal type and has time limits which make it to some extent a speed test. The reliability of Alpha for a single age or grade group is ordinarily between .80 and .90. Its correlations with scholastic marks are usually rather low. The test is now chiefly of historical interest.

Group Tests Primarily for College Students

The College Entrance Examination Board Scholastic Aptitude Tests (devised by Brigham). Effective range, grade twelve and up; new forms each year; time, 150 minutes; norms, in terms of percentiles of various college groups; released by the College Entrance Examination Board.

This is the best test available at the college level, much labor and expense having been devoted to its preparation. It is used only as a part of the college entrance examination board examinations, and copies cannot be privately obtained.

The Thorndike[28] *Intelligence Examination for High School Graduates.* Effective range, from grade twelve up; new forms issued yearly; time 180 minutes; scoring time, thirty minutes; norms, percentiles for college freshmen; released by the author, E. L. Thorndike, Teachers College, Columbia University.

This test has long been widely used by colleges and universities in rating applicants for admission. Its reliability and validity are only fair, considering the great length of the test, and it is expensive. For unselected freshmen students reliabilities have been found ranging from .70 to .85, which are of course lower than would be found for a strictly unselected group of eighteen year olds. Numerous correlations with scholastic success have been reported, ranging chiefly between .30 and .60 and averaging in the neighborhood of .45 and .50.

Other Group Tests for the College Level. One of the best of the numerous other tests devised for college students is that prepared by L. L. Thurstone for the American Council on Education. The Ohio

State University Test is widely used in Ohio and other states. The Otis Group Intelligence Scale (Advanced Examination) and the Terman Group Test of Mental Ability are sometimes used in rating college applicants, but neither is to be recommended for the purpose; they are not sufficiently difficult and they can be too easily obtained for coaching.

Nonverbal Group Tests of Intelligence

The group tests which have been described, all of them predominantly verbal, are unsuited to the examination of subjects who have not had reasonably normal educational exposure or who have a language handicap. Much ingenuity has been expended in devising nonverbal pencil-and-paper tests for group use. The best of these are valuable when verbal tests cannot be used, but they are all lower in validity than the verbal tests; they yield lower correlations with school marks, with personal estimates of intelligence, and with most other criteria. The trouble is not that they have low reliability, but that the abilities they measure are less *intellectual,* as we usually understand the term, than those which enter into verbal tests. Another fault of the nonverbal group tests is that it is extremely difficult to devise any which discriminate very effectively between the mental levels above that of the average adult.

Army Beta. Range, age seven to somewhat inferior adult; forms, one; time, forty minutes; scoring time, ten minutes; norms, letter grades, also Alpha equivalents; republished by Stoelting, Chicago.

This is the companion test to Alpha, having been devised for illiterate or foreign-born soldiers. It may be administered entirely in pantomime. Its retest reliability is rather low, about .75 to .80 with pupils of a single school grade. Its correlation with the Stanford-Binet, for four groups of unselected soldiers, was .74, .64, .76, and .66. Its correlation with Alpha for unselected soldiers was .81. In the case of school children its scores yield low correlations with scholastic success.

The Pintner[15] *Non-language Tests.* Range, grades four to eight; forms, one; time, forty minutes; scoring time, five minutes; norms, age and grade with sigma indices; publisher, Teachers College, Columbia University.

This is one of the best tests of its type for the range covered. Its reliability for pupils of a single school grade is between .70 and .80. Tests of 50 policemen yielded a correlation of .72 with the Stanford-Binet. Correlation with the National Intelligence Tests for pupils of a single grade are very low, namely, .25 to .40. Its correlation with school marks is also low.

The Thorndike Non-language Test. Range, age eight to average adult level; forms, thirteen; time, sixty minutes; scoring time, twenty minutes; norms, age, also Alpha equivalents; publisher, Teachers College, Columbia University.

In reliability and validity this test is probably not excelled by any of the non-language pencil-and-paper tests. The probable error of a score is given as about 6 or 7 per cent of any score above .70. A correlation of .77 is reported with a composite criterion of school marks plus subjective ratings. It is better than Army Beta in the lower ranges, but, like most tests of this type, it is inadequate in the upper ranges. The test is rather expensive to give and score.

Dodd's International Group Mental Tests. Range, age five to adult level; forms, one; time, three to four hours; scoring time, very excessive; norms, age; publisher, Princeton University Press.

This test is the result of an extended and costly research conducted for the purpose of devising a method of testing which would be as nearly as possible independent of cultural influences and therefore usable in comparative studies of races. All other nonverbal group tests require the use of a pencil for checking responses, while this one merely requires the subject to rotate a disk in such a way as to indicate the response. It covers a wider range than any other nonverbal test, whether for group or individual examination. Its retest reliability for sixth-grade orphan children was .78. It is doubtful whether it is much more valid for the study of race differences than some of the other nonverbal tests. Its correlation with the Stanford-Binet for 100 feeble-minded subjects was .80. It is extremely difficult to give and score.

III. TESTS OF SPECIAL APTITUDES

It is by no means easy to isolate a special ability for separate measurement. The result is that tests devised by different psychologists to test the same special ability are often found to have very little in common. This is especially true of tests of musical ability and of mechanical aptitude. Other special abilities which psychologists have attempted to measure are artistic appreciation, literary comprehension, motor skill, and scientific aptitude. For lack of space only brief mention can be made of some of the better known tests of special aptitudes.

Tests of Musical Ability. The best known tests of musical capacity are those of C. E. Seashore.[18] These are supplied in the form of Columbia phonograph records which test sense of rhythm, tonal memory, consonance, sense of intensity, and sense of pitch. Norms are in terms of percentiles for age groups. The tests are applicable to subjects above the age of six or seven years and may be given to groups. The reliabilities of the five tests have been found to be rather low (.35 to .70), but investigation shows that the test as a whole has considerable value in predicting the possibility of educating a subject in music. They are widely used in public schools. The other tests in the field of music are tests of achievement rather than of capacity.

Tests of Mechanical Aptitude. Among the best known tests in this field are those devised by Stenquist. These are performance tests which require the subject to manipulate mechanical appliances, but a pencil-and-paper adaptation of the test also has been made. Both the performance and the paper test can be used as a group test over a wide range (grades five or six to twelve). Percentiles by age are given. The reliability of both tests is low, averaging only .67 for fifteen classes taken separately. It possesses more or less validity as a measure of what is commonly called mechanical ability, but its possibilities for predicting ability to master particular mechanical trades have not been fully explored. The paper test is supplied by the World Book Company, and the apparatus for the performance test by Stoelting.

The MacQuarrie Test for Mechanical Ability (published by Stanford University Press) is entirely a pencil-and-paper test. It is designed for grades six to twelve. Its reliability is far higher than that of the Stenquist tests, but its validity appears to be decidedly lower. As a matter of fact, it has little in common with the Stenquist tests in respect of functions measured.

However, by far the most valuable tests in the field under discussion are the Minnesota Mechanical Ability Tests, devised by Paterson, Elliott, and their associates.[13] These are the result of one of the most extensive and thoroughgoing investigations in the entire history of the testing movement. The battery consists of seven tests requiring, altogether, about two hours for administration. All but one are of the "performance" type. The reliabilities of five are in the neighborhood of .90 or better and those of the other two in the neighborhood of .80. Great care was exercised in their validation and the validity coefficients compare favorably with those of the best intelligence tests. The scores earned appear to be very little influenced by environmental factors. The Minnesota tests are applicable from the seventh grade to the college level and deserve wide use in connection with educational and vocational guidance. A certain amount of special training is necessary for giving and scoring them.

Tests of Mathematical and Scientific Aptitude. Agnes Rogers has devised group tests of aptitude for mathematics taught in the first year of high school which have good reliability and moderate validity. They have at least some value in the sectioning of first year high school classes for mathematical instruction. The tests are published by Teachers College, Columbia University.

The Zyve Test of Scientific Aptitude (published by the Stanford University Press) is intended primarily to measure aptitude in the physical sciences. It has high reliability, only moderate correlation with general intelligence, and very high correlations with estimates by university professors of physics, chemistry, and engineering of the scientific aptitude of their graduate students. It is probably one of the most useful tests of special aptitude thus far devised. It can be used as a group test in high school and college and is fairly easy to give and score.

Tests of Artistic Ability. The C. E. Seashore tests of artistic appreciation (supplied by the University of Iowa) promise considerable usefulness. A group test of artistic aptitude of the performance type has been devised by the Research Department of the Los Angeles public schools. The latter appears to have value in identifying pupils in the intermediate grades who have artistic talent.

Tests of Literary Aptitude. The test deserving special mention in this connection is the Burch test of literary comprehension. It is a group test designed for junior and senior high school students and is published by Stanford University. Volume III of Genetic Studies of Genius (Stanford University Press) presents a scale devised by Doctor Dortha Williams Jensen for estimating the merit of literary juvenilia. The Abbott-Trabue test of poetic appreciation (supplied by Teachers College, Columbia) has not proved particularly useful.

Tests of Motor Skill. The best battery of tests for measuring motor skills has been devised by Robert Seashore. It is a performance test, for individual examinations. Each of the tests composing the battery has a rather high reliability, and there is reason to believe that the test as a whole will be of value in vocational guidance after its predictive values have been explored. The apparatus is supplied by the designer, from the University of Oregon.

SUMMARY

Intelligence tests have proved themselves a useful means of correcting and supplementing the more subjective methods of estimating human abilities. They have thrown important light on the rate of mental growth and on the problems of individual differences generally. They are indispensable tools

in the study of exceptional children, and have considerable value as a partial basis for educational and vocational guidance. Their shortcomings, which have been pointed out by their authors as well as by their critics, should not be lost sight of. It is not claimed that they test every aspect of mental ability, that they are an infallible measure of original capacity, or that the scores they yield are equal units in the sense that units of physical measurement are equal. It is recognized that apart from general intelligence there are special abilities and various combinations of personality traits which contribute very significantly to any individual's social value. Some of the more important tests, both of general intelligence and of special aptitude, have been briefly described, but there has been no attempt to include in these descriptions all of the useful tests that have been devised. In considering the use of any test it is important to take account of all the available evidence as to what the test measures, and how reliably it measures what it purports to measure. It is especially important not to be misled by the apparent definiteness suggested by the numerical scores of tests.

References

1. Binet, Alfred, and Simon, T. *The Development of Intelligence in Children.* Translation by Elizabeth Kite. Vineland, New Jersey, The Training School, 1916. 336 p.
2. Bronner, Augusta; Healy, William; Lowe, Gladys M.; and Shimberg, Myra E. *A Manual of Individual Mental Tests and Testing.* Boston, Little, Brown & Company, 1927. 287 p.
3. Dearborn, Walter F. *Intelligence Tests; Their Significance for School and Society.* Boston, Houghton Mifflin Company, 1928. 336 p.
4. Freeman, Frank N. *Mental Tests; Their History, Principles, and Applications.* Boston, Houghton Mifflin Company, 1926. 503 p.
5. Goodenough, Florence L. *The Kuhlmann-Binet Tests for Children of Pre-School Age; A Critical Study and Evaluation.* Minneapolis, University of Minnesota Press, 1928. 146 p.
6. —— *The Measurement of Intelligence by Drawing.* Yonkers-on-Hudson, N. Y., World Book Company, 1926. 177 p.

7. Gesell, Arnold L. *Mental Growth of the Preschool Child.* New York, The Macmillan Company, 1925. 447 p.
8. Hollingworth, Leta S. *Special Talents and Defects.* New York, The Macmillan Company, 1923.
9. Hull, Clark L. *Aptitude Testing.* Yonkers-on-Hudson, N. Y., World Book Company, 1928. 535 p.
10. Kelley, Truman Lee. *Interpretation of Educational Measurements.* Yonkers-on-Hudson, N. Y., World Book Company, 1927. 363 p.
11. Kohs, S. C. *Intelligence Measurement; A Psychological and Statistical Study Based upon the Block-design Tests.* New York, The Macmillan Company, 1923. 312 p.
12. Kuhlmann, F. *A Handbook of Mental Tests; A Further Revision and Extension of the Binet-Simon Scale.* Baltimore, Warwick & York, Inc., 1922. 208 p.
13. Paterson, Donald G., Elliott, Richard M., and others. *Minnesota Mechanical Ability Tests.* Minneapolis, University of Minnesota Press, 1930. 586 p.
14. Peterson, Joseph. *Early Conceptions and Tests of Intelligence.* Yonkers-on-Hudson, N. Y., World Book Company, 1925. 320 p.
15. Pintner, Rudolf. *Intelligence Testing; Methods and Results.* New York, Henry Holt and Company, 1923. 406 p.
16. —— and Paterson, Donald G. *A Scale of Performance Tests.* New York, D. Appleton and Company, 1917. 213 p.
17. Ruch, G. M., and Stoddard, George D. *Tests and Measurements in High School Instruction.* Yonkers-on-Hudson, N. Y., World Book Company, 1927. 375 p.
18. Seashore, Carle E. *The Psychology of Musical Talent.* New York, Silver, Burdett and Company, 1919. 288 p.
19. Spearman, Charles E. *The Abilities of Man; Their Nature and Measurement.* New York, The Macmillan Company, 1927. 454 p.
20. Stutsman, Rachel. *Mental Measurement of Preschool Children, with a Guide for the Administration of the Merrill-Palmer Scale of Mental Tests. Measurement and Adjustment Series.* Yonkers-on-Hudson, N. Y., World Book Company, 1931. 368 p.
21. Terman, Lewis M. *The Intelligence of School Children.* Boston, Houghton Mifflin Company, 1916. 317 p.
22. —— *The Measurement of Intelligence.* Boston, Houghton Mifflin Company, 1916. 362 p.

23. Thorndike, Edward L., and others. *The Measurement of Intelligence.* New York, Bureau of Publications, Teachers College, Columbia University, 1926. 616 p.
24. Wells, F. L. *Mental Tests in Clinical Practice.* Yonkers-on-Hudson, N. Y., World Book Company, 1927. 315 p.
25. Whipple, Guy Montrose. *Manual of Mental and Physical Tests.* Vol. 1. *Simpler Processes,* 1914. 365 p. Vol. 2. *Complex Processes,* 1915. 336 p. Baltimore, Warwick & York, Inc., 1914–1915.
26. Wood, Ben D. *Measurement in Higher Education.* Yonkers-on-Hudson, N. Y., World Book Company, 1923. 335 p.
27. *Twenty-Seventh Yearbook of the National Society for the Study of Education: Nature and Nurture.* Part I. "Their Influence upon Intelligence." 465 p. Part II. "Their Influence upon Achievement." 393 p. Bloomington, Ill., Public School Publishing Company, 1928.
28. Yerkes, Robert M. Editor. "Psychological Examining in the U. S. Army." *Memoirs of the National Academy of Science,* Vol. 15, Washington, D. C. Govt. Print. Off. 1921. 890 p.
29. —— and Foster, Josephine C. *A Point Scale for Measuring Mental Ability.* Baltimore, Warwick & York, Inc., 1923. 219 p.
30. Yoakum, Clarence S., and Yerkes, Robert M. *Army Mental Tests.* New York, Henry Holt and Company, 1920. 303 p.

MENTALLY SUPERIOR CHILDREN

INTRODUCTION

THIS section is concerned with the intellectual, physical, and personality traits of mentally superior children; their social origin, their development from childhood to maturity, and their scholastic and occupational accomplishments. Problems of training will be touched upon only incidentally, as these are given detailed treatment in another publication of the White House Conference.*

We may distinguish two types of mentally superior children: (1) those whose superiority is particularly noticeable only in a single special field, such as music, art, lightning calculation, chess playing, or mechanical skill; and (2) those who are superior in a much wider range of intellectual activities. That is, there are children who are characterized by superior general intelligence, and others who are outstanding because of some special ability. For convenience we may designate these two groups as the intellectually gifted and the specifically talented.

INTELLECTUAL SUPERIORITY

A discussion of intellectually gifted children is possible only on the assumption that we know something about what intelligence is, and on the further assumption that grades of intelligence can be measured or estimated. Intelligence involves the ability to think in abstract terms. The higher degrees of intelligence, if utilized, enable one to solve difficult problems, to adjust to complicated situations having novel elements, and to acquire an extensive command of thought or behavior symbols in the form of language. In the discussion of intelligence tests it has already been stated that

* *Special Education.* New York, The Century Co., 1931.

intelligence bears little relation to sensory acuity or to such psychomotor functions as simple reaction time or accuracy of muscular coordination. Many of the lower animals excel man in one or another of these elementary functions. The relationship of "general" intelligence to numerous other more or less specialized abilities, although it has been extensively investigated in recent years, has not been fully clarified.

For the present purpose it may be said that the intellectually superior child is one who rates high on the best available tests of general intelligence, or on a composite of several such tests. Inasmuch as there is an indefinite number of grades of mental superiority, the discussion may be further limited to those children who are rated by the best intelligence tests as among the most intellectual five or ten in an unselected population of one thousand children.

Whether children who are intellectually gifted, by this definition, retain their relative superiority as adults, and whether intellectually gifted adults were in all cases correspondingly superior as children, are questions with which the definition is not concerned. These are matters of fact to be determined by investigation.

TYPES OF STUDIES AVAILABLE

Studies of intellectually gifted children are of four main types: (1) general descriptive reports, usually made by persons who are not psychologists; (2) clinical reports on a single case or on a small number of cases, utilizing psychological methods; (3) statistical studies based upon psychological and other measurements of groups of subjects, and (4) studies of the childhood of geniuses.

An example of the first type is the book by Pastor Witte on his gifted son, entitled *The Education of Karl Witte.* Less detailed and less dependable accounts of gifted children have appeared from time to time in the various popular magazines. Reports of this kind are interesting, but are usually lacking in scientific value.

Some excellent examples of studies of the second type have been reported by Leta S. Hollingworth in Chapter IX of her book, *Gifted Children.*[9] Here are found not merely descriptive case histories, but also measurements of numerous physical and mental traits. The results of such a clinical study give a fairly complete picture of the gifted child in terms that are objective and psychologically meaningful. Clinical studies of individual gifted children are extremely valuable and too many of them can never be collected when they are competently done. They do not, however, tell all one wants to know. The individual case may be typical or atypical. It is only when data have been secured for a large number of cases selected in such a way as to give representative results that any generalizations can be made regarding what is true of intellectually gifted children as a class.

Small groups of superior children have been studied by Hollingworth,[9, 10] W. T. Root,[11] Dorothy Yates,[13] and others. The only searching investigation thus far conducted with a large group is that described in *Genetic Studies of Genius*, Vol. 1 [12] and Vol. 3.[1] As the data of these two volumes give the most comprehensive picture available of the typical gifted child, they will be summarized here at some length.

A fourth method which deserves mention is the biographical study of the childhood of persons who have made notable accomplishments in adult life. This method has been applied by Catherine Cox,[5] and is one which yields interesting and instructive results, but it suffers from two serious limitations: the biographical information is always incomplete, and the method tells nothing about intellectually gifted children who did not later achieve eminence.

The characteristic traits of intellectually gifted children as they appear in the investigation of a group of one thousand cases will be considered first.

FINDINGS ON ONE THOUSAND SUBJECTS

Method of Selection. A school population of approximately a quarter million children was sifted by a rigidly uniform method for the purpose of locating the thousand who were the most gifted intellectually. There was a three fold sifting; first on the basis of teachers' judgments, secondly by group intelligence tests of those who were most accelerated or who were judged by the teachers to be among the brightest, and lastly by Stanford-Binet tests of those rating highest on the group tests. The thousand children finally selected for study included those of I. Q. 140 or above, that is, the mental age in each case was 40 per cent or more above the chronological age. Accordingly, the results to be reported on this group may be accepted with considerable confidence as valid for children in general of I. Q. 140 or above.

Origin and Family Background. The group showed a notable excess of Jewish parents, a considerable excess of parents of native parentage, and a marked deficiency of Latin and Negro ancestry. Nearly a third of the fathers belonged to the professional classes, and a half to the semiprofessional or higher business classes. Less than 7 per cent belonged to the semiskilled laboring classes. The average family income at the time the study was made (1921 to 1922) was about $3,300. Most of the homes rated very high on the "Whittier Point Scale for Home Grading." Both the parents and the grandparents had far more schooling than the average of the general population. There were 82 families that yielded two or more subjects, which is about 1,200 times as many as would occur by the laws of chance. Eminent relatives were extremely numerous. The stock from which the children came was superior physically as well as mentally. The birth rate of this stock has decreased by about 50 per cent in the last generation, so that at present the stock is not maintaining itself. There is no correlation between the brightness of the child and the age of the parents. More gifted boys than gifted girls were found, the ratio being about 7 : 6 in the first eight grades and more than 5 : 2 by the senior year of high school. The excess of boys does not appear to be attributable to the method of selection used and is difficult to account for on the basis of facts at present available. Possible explanations are greater variability of the male and the earlier physiological maturation of the female.

Physique and Health. Thirty-seven different anthropometric measurements showed that the group was superior to average American children in height, weight, lung capacity, muscular strength, and other important physical traits. Nutrition was in general superior, and both ossification and sexual maturity were somewhat advanced. Each child was given a one-hour medical examination by a pediatrician, and medical histories were secured from parents and school physicians. In birth weight these gifted children exceeded the norm. Walking, talking, and dentition tended to be slightly precocious, especially talking. With one exception, physical defects were less common than in general school population. The exception was vision, which is probably accounted for by excessive reading. The traditional belief that intellectually superior childen tend to be undersized, weakly, or sickly thus is definitely overthrown.

Educational Accomplishment. Seven out of eight gifted children are accelerated in their progress at school. On the average the acceleration amounts to one seventh of the age of the child. Even so, a large majority of the group were in a grade at school far below that corresponding to their mental development. A three-hour test of educational accomplishment (Stanford Achievement Test) showed that a majority of the children had already mastered the subject matter from one to three grades above that in which they were located. Their lessons did not tax their mental capacities. The achievement tests showed all-around superiority, in that scores for the various school subjects were almost uniformly high. The belief that children who are strong in certain subjects are especially likely to be weak in others, seems to be disproved. Gifted children do not tend as a class to be one-sided. In exceptional cases, however, unevenness in accomplishment is found, perhaps largely as a result of unevenness in interest and application. Arithmetic, handwriting, and spelling are the subjects in which a child is most likely to rate higher or lower than he does in other work at school, which may be interpreted as showing that these subjects involve special abilities as well as general intelligence. The subjects which were rated by the gifted children as the easiest and the most liked are those which may be described as predominantly abstract, such as arithmetic, literature, grammar, debating, ancient history, and so forth. These are the very subjects which average children find hardest and like least. Half of the group had learned to read before starting to school; many of them before the age of four years and several before three. One, who probably holds the world's record, could read as well at twenty-five months as the average child at the end of the first grade. Reading is usually learned with little or no formal instruction. Record was kept of the reading of each child over a period of two months, and an analysis was made of the material read. The typical gifted child of seven reads more books than do unselected children at any age up to fifteen. At nine, the number of books read is three times the normal. The quality of books read is correspondingly superior at all ages.

Special Interests. Gifted children have more hobbies and other enthusiasms than average children. They make more and larger collections, especially collections of a scientific or historical character. A test of knowledge of games showed that the typical gifted child of ten knows more about plays and games than the average child of thirteen. His interest in play is hardly less intense, though he plays slightly fewer hours a week than the average child. Application of Doctor Wyman's test of intellectual and social interests and those concerned with physical activity, showed that the gifted child rated very high in intellectual and social interests, and only a little above average in interests involving physical activity. The belief that gifted children as a class have fewer wholesome interests than average children is false.

Character and Personality Traits. Application of the Cady-Raubenheimer batteries of character tests showed the gifted group to be vastly superior to unselected children in freedom from objectionable interests and objectionable social ideals, in freedom from boastfulness, and in trustworthiness in the face of temptation to cheat. In character development the typical gifted child of nine has, in fact, reached the norm for the age of fourteen. In the Moss test of social intelligence and in the Goodwin Watson test of fairmindedness the gifted child of sixteen years equals the average score of college freshmen. The Stanford test of masculinity-femininity of attitudes and interests shows gifted boys just at the norm of masculinity, while the gifted girl is distinctly more masculine than the norm for her sex. The Woodworth-Cady test of psychopathic tendencies showed both sexes far above the norm for unselected children in respect to emotional stability. The Laird test of introversion-extroversion shows that the gifted child is slightly more introverted than children of average intelligence, though this need not be interpreted as an unfavorable finding.

The above results are not all in harmony with traditional views, but they are borne out in almost every detail by ratings secured from the parents and teachers of the children on twenty-five character and personality traits. The findings given may be accepted as final so far as central tendencies are concerned with respect to the traits that are measured by the various personality tests applied to these subjects. In this connection, however, it is necessary to call attention to the fact that personality testing is in its infancy and that exactly what some of the tests measure is still in dispute. The reliabilities of those used in this investigation are fairly high and the results are unquestionably significant in comparing one group with another as we are doing here. In leadership and social adaptability, traits in which gifted children are commonly thought to be especially deficient, the record for the group is far above that for children of the general school population. Gifted children more often than others lead in extracurricular activities, and are more often elected to class offices and to other honors in school and out. In athletic competition, however, their record is less outstanding, doubtless because of a handicap in age which averages about two years.

Exceptions to the Rule. Thus far gifted children have been described in terms of what is usual or typical. Such generalizations are extremely valuable as showing what may ordinarily be expected of such children in comparison with the usual run of children. This particular combination of traits gives on the whole an extremely favorable picture. Gifted children as a class are not sickly, nor one-sided, nor psychopathic, nor emotionally immature, nor socially maladjusted, nor deficient in wholesome interests of any kind. Plans for the special training of gifted children may safely be based upon the generalizations as they have been stated. It must not be supposed, however, that all children of superior intelligence conform to the description given. Exceptions to the rule are found in regard to every trait. Some gifted children are below par physically, some are one-sided in their interests, some do inferior school work, some are unstable, some are socially maladjusted, and some are downright delinquent or psychopathic. Every unfavorable trait that can be found among unselected children can be found also among children of superior intelligence; the only difference is in the fact that the incidence of unfavorable traits is less in the gifted group.

Do Gifted Children Deteriorate? A more recent follow-up of the gifted children studied in California, with retests after a period of six to eight years, showed that the group as a whole is holding its own well. The mean intelligence quotient of the gifted boys remained practically unchanged, but that of girls decreased by eight or ten points. As this sex difference was evidenced in the scores of four different intelligence tests and also, though to a somewhat lesser degree, in the composite score of extensive batteries of achievement tests in the school subjects, it is probably real. It is possible that gifted girls reach the limit of mental growth a little earlier than do gifted boys. The difference, however, if it exists at all, is not great enough to prevent the girls from excelling the boys in scholastic grades in almost every subject.

The later school record of both sexes is extraordinarily good. Failures in high school subjects are practically unknown, more than half the marks earned being of A grade. There is practically no elimination below high school graduation, and between 80 and 90 per cent of the high school graduates go to college. In college, because of more severe competition, the marks earned drop below the earlier high record, but still greatly exceed the norm. Members of the gifted group in college earn far more than their proportionate share in scholarships, fellowships, graduation honors, and student offices. More than half remain for graduate work. Several of the older members of the group have taken advanced degrees and a few of them have already won considerable professional recognition. One is an internationally known musical composer. One is a nationally known scientist. One graduated from a university at sixteen and one at seventeen. At least seven before the age of sixteen composed poems that compare favorably with the best juvenilia produced by eminent poets at corresponding age. One of the seven is among the most prolific juvenile authors on record, much of her work being of high merit.*

It may be concluded that mentally superior children tend to remain superior, and usually to about the same degree. Again, however, there are exceptions to the rule. Some show significant increase of superiority and some show significant decrease. The writer has even found cases previously testing above 140 I. Q. who later regressed to a position not very far above the average, without discoverable cause so far as health, training, or environment was concerned. Although deterioration of this degree is rare, it is important to bear in mind that it sometimes occurs.

Pseudo-deterioration. Most cases of apparent deterioration of gifted children are found on investigation not to be genuine. Usually they are children whose scholastic accomplishments or social adaptability suffer because of defects in personality. The intelligence score remains high, but the subject is lazy, lacks ambition, is emotionally unstable, is poorly adjusted to his environment, or is cultivating interests remote from his school work. Cases could be described illustrating the influence of all these factors. Not a few gifted children, after making a brilliant record in high school, deliberately decide on entering college to cultivate other interests and so go out for athletics, school politics, feminine society, or anything that will rescue them from the odium of reputation for brilliance. The average teacher, however, does not discriminate in judging such students, and classes them together as examples of an intellectual precocity that has burned out. As has been already emphasized, it is im-

* For a comparative study of the juvenilia of California's gifted children and of eminent authors, see *Genetic Studies of Genius,* Vol. 3, Part III.

portant to bear in mind that the highest intellectual gifts may fail of realization because of factors that have nothing at all to do with intelligence.

The numerous studies that have been made by repeated intelligence tests of the same subjects agree fairly closely in showing that in the large majority of cases the I. Q. undergoes only minor fluctuations from early childhood to maturity, and that the mentally superior child usually becomes the mentally superior adult. The section which follows offers additional evidence on the question of I. Q. constancy.

THE CHILDHOOD OF GENIUS

The investigators of historic geniuses and of other eminent groups of adults offer many interesting parallels to the study of living children selected on the basis of high intelligence quotient. The subject was opened to science by the epoch-making work of Francis Galton,[7,8] in 1869, whose findings have been in the main confirmed by the researches of Ellis,[6] Cattell,[3] Castle,[2] Clarke,[4] and others. These studies have sufficiently established the fact that geniuses come chiefly from the middle to superior social classes, that they are far more likely than the average person to have eminent relatives, and that the families from which they come tend also to be superior in moral and physical traits. These facts taken alone do not prove that heredity is the sole or necessarily even the main factor in the production of genius, since the factor of superior educational opportunity has also entered. Although investigators do not always agree as to the relative weight to be attached to nature and nurture, the facts point strongly to the conclusion that while nurture factors probably play a rôle far from negligible, heredity is extremely influential. That the proportion of eminent women is only about a twentieth as great as the proportion of eminent men is attributed both to the less marked variability of women in natural ability and to the physical, social, and occupational handicaps under which they live. The investigations mentioned offer little if any support to the view of Lombroso, Grasset, and others, that genius is allied to degeneracy.

The studies of genius referred to have given but little systematic attention to the childhood characteristics of individuals who later achieved eminence. Lombroso long ago popularized the belief that many geniuses were as children exceptionally backward and unpromising. Ellis and others, however, have presented evidence to show that a large proportion were characterized by extreme intellectual precocity. It remained for the extensive research of Catherine Cox to prove beyond doubt the falsity of the Lombrosian theory. Her investigation dealt with the childhood traits of three hundred of the most eminent geniuses born since 1450, selected on an objective basis. With the help of assistants trained in child psychology she assembled from several thousand biographical references all of the available information that threw any light on the heredity, health, education, intellectual development, and early traits of personality of these three hundred subjects. Particular attention was given to evidence bearing on the course of mental development, such as age of learning to read, age at which given school grades were reached, types of books which were read at given ages, school honors won, reputation for intelligence among school fellows, quality of letters, compositions, poems that have been preserved, and indications as to the direction and intensity of interests.

The material so collected, comprising some six thousand typed pages, was next analyzed and evaluated independently by three psychologists whose training and experience had given them exceptional familiarity with the norms of accomplishment and behavior for the various age levels of childhood. On the basis of evidence available each of the three psychologists estimated for each subject the lowest childhood I. Q. *that could reasonably be held to account for the facts given.* The average of the three judgments was taken as the final I. Q. estimate of a subject. While the resulting data cannot be regarded as comparable in reliability with results of actual mental tests, they represent the nearest approximation to the facts that it is possible to secure. The fact that in a large majority of cases there was fairly close agreement among the three psychologists who made the estimates is evidence of the validity of the method. It appears that the true average childhood I. Q. of the group was not less than 160, and that few cases were below 140. The very geniuses mentioned by Lombroso and others as notable for a lack of early promise were without exception found to have given evidence of high I. Q.'s during childhood. Among these were Lord Byron, Sir Walter Scott, and Charles Darwin, with estimated I. Q.'s of 150, 150, and 135 respectively. Among those rated as above 180 I. Q. in childhood were Goethe, John Stuart Mill, Leibnitz, Macaulay, Pascal, and Grotius.

The childhood traits of this group of geniuses resemble closely the traits of the group of gifted children studied in California (page 68). However, the average true I. Q. of the genius group during childhood was undoubtedly higher than that found by test for the California children, and the genius group almost certainly possessed on the average a more favorable combination of personality traits, particularly initiative, perseverance, and intellectual zeal, since without these supporting qualities even high intellectual gifts may fail of fruition. Other points of similarity between the two groups include the following: the infrequency in both groups of such traits as "queerness," emotional instability, one-sidedness, and lack of social adaptability; the presence in each group of individuals whose superficial traits caused them to be grossly misunderstood; lack of evidence that the intellectual superiority in either group was primarily the result of forced culture; and evidence that the direction of later achievement is likely to be foreshadowed by early preoccupation of interest.

CHILDREN OF SUPERIOR SPECIAL TALENT

It is well known that ability in music, drawing, painting, arithmetical computation, or feats of memory is by no means perfectly correlated with "general" intelligence. Feebleminded subjects can be found who rate above the average normal person in any one of these abilities. Among the numerous lightning calculators who have been studied by psychologists, some had high general intelligence and superior mathematical gifts while others belong to moron grade of mental deficiency. The same is true of those capable of prodigious feats of memory. There is no case on record, however, of a feeble-minded person who was an accomplished artist or an accomplished musician (either performer or composer). All the great musical composers and the great artists were gifted in intellect and imagination. In the writer's investigations of gifted children an extraordinary effort was made to locate children of only average I. Q. who were outstanding in these special abilities. In a school population of a quarter of a million only twenty-six were found who showed any promise, and follow-up of these subjects showed that the early promise was not fulfilled in any case. We may conclude that without superior general intelligence special ability in music and art inevitably falls short of really great achievement. All of the young musicians and artists of genuine accomplishments whom the writer has studied have without exception high intelligence quotients.

Exceptional ability in such fields as mathematics, science, literary composition, or linguistics is of course still more intimately bound up with general intelligence, although it is undoubtedly true that among children of a given (high) intelligence quotient some degree of specialization in one or more of these lines may be present. In such cases it is important to discover the direction in which greatest ability lies and to give it appropriate encouragement. Tests have been devised for the measurement of special aptitude in music, art, mathematics, science, mechanics, composition, and literary appreciation. Although measurement in this field is still largely in the experimental stage, some of the tests have already demonstrated their practical value. One can confidently look forward to the time when standard tests of the more important special aptitudes and special interests will be universally applied in the schools. To make the most of a child's resources of talent it is first necessary to determine where they lie and in what wealth they are present.

CONCLUSION

Intellectually superior children are products of heredity, but nature and personality determine in large measure the extent to which they achieve. Geniuses have practically all shown unmistakable signs of superiority in childhood, but not all gifted children become geniuses. Other causes than deterioration of ability usually explain the failure of those who do not. To make the most of the capabilities of such children, improved methods of training are necessary. The researches above summarized have given a solid foundation of fact with respect to the physical and intellectual traits of gifted children, and on this foundation educational experiments can be planned intelligently. Systematized effort in behalf of such children must replace the present general neglect and also the ruinous methods of prodigy-making which have been sporadically attempted.

References

1. Burke, Barbara S., Jensen, Dortha W., and Terman, Lewis M. *Follow-up Studies of a Thousand Gifted Children. Genetic Studies of Genius,* Vol. 3. Stanford University, California, Stanford University Press, 1930. 508 p.
2. Castle, Cora Sutton. "A Statistical Study of Eminent Women." *Archives of Psychology,* No. 7, 1913, p. 90.
3. Cattell, James McKeen, Editor. *American Men of Science.* New York, The Science Press, Appendix of edition 2, 1910, and edition 3, 1921.
4. Clarke, Edwin Leavitt. *American Men of Letters; Their Nature and Nurture.* New York, Columbia University Press, 1916. 169 p.
5. Cox, Catherine Morris. *The Early Mental Development of Three Hundred Geniuses. Genetic Studies of Genius,* Vol. 2. Stanford University, California, Stanford University Press, 1926. 842 p.
6. Ellis, Havelock. *A Study of British Genius.* London, 1904, 300 p. New, revised and enlarged edition. Boston, Houghton Mifflin Company, 1926.
7. Galton, Francis. *Hereditary Genius.* (First published in 1869.) New York, The Macmillan Company, 1914. 379 p.
8. —— *English Men of Science; Their Nature and Nurture.* (First published in 1874.) New York, D. Appleton and Company, 1890. 206 p.
9. Hollingworth, Leta S. *Gifted Children; Their Nature and Nurture.* New York, The Macmillan Company, 1926. 374 p.

10. ——*Special Talents and Defects.* New York, The Macmillan Company, 1923.
11. Root, William T. *A Socio-Psychological Study of Fifty-three Supernormal Children. Psychological Monographs.* Princeton, N. J., Psychological Review Co., 1921. 134 p.
12. Terman, Lewis M., and others. *Mental and Physical Traits of a Thousand Gifted Children. Genetic Studies of Genius,* Vol. 1. Stanford University, California, Stanford University Press, 1925. 648 p.
13. Yates, Dorothy Hazeltine. *A Study of Some High School Seniors of Superior Intelligence.* Bloomington, Ill., Public School Publishing Co., 1922.

INFERIOR MENTAL DEVELOPMENT *

IN previous sections the concept of mental growth has been outlined and the problem of the nature of intelligence has been considered. In view of the wide variety of meanings attached to the term *intelligence,* it is well to repeat that it is here employed in the sense of a general capacity for adjustment which is reflected in varying degrees of complexity, variety, and facility of behavior. This capacity is assumed to increase with age, both in a qualitative and a quantitative sense; that is, there is an increase both in the number of different types of behavior and in the complexity and variety of each type.

It has also been pointed out that intelligence can be measured only in terms of actual performance and that the degree of intelligence which an individual is presumed to possess may be inferred from his performance on one or more reputable intelligence tests. Mental development properly includes more than mere improvement of performance on such tests, and any given individual may develop unequally in different directions. For example, his ability to think in terms of verbal abstractions may lag behind his aptitudes with concrete situations and materials or his powers of social adjustment, and this situation gives rise to much difficulty when we face the practical problem of determining whether or not a child is feeble-minded, or of evaluating the importance of intelligence tests for purposes of education and training. For the sake of simplicity, however, we shall consider intelligence as a general capacity which increases

* Other Committees of the White House Conference deal with mental subnormality. See reports found, for example, in various Subcommittees of Section IV, Committee B, Physically and Mentally Handicapped, and *Special Education,* a Publication of the White House Conference, New York, The Century Co., 1931. No attempt is made here to indicate the relation of mental inferiority to other types of mental and physical handicaps.

with age, and attempt to give an account of certain details, such as the rate of development of intelligence, the level which is ultimately attained, and certain pathological variations from the normal.

It is obvious that there are periods in mental development during which one or another mode of adaptive expression predominates. Thus the principal manifestations in early childhood are motor, at a later period the development of language is the outstanding feature, and still later the power of reasoning in terms of abstractions assumes the major rôle. It seems impossible to measure the growth of intelligence in terms of a single function throughout the life span, and, as previously shown in detail, we must resort to intelligence tests which measure a variety of functions and lay due emphasis on those characterizing particular periods of growth. These tests are then standardized in terms of the mean performances of large groups of children of successive ages. Inferior mental development implies a low performance in terms of expectation for age on such tests.

MENTAL MATURITY

With such scales as generally have been employed, it is found that mental development reaches what we may term a *maturity level* at sometime during the second decade of life. The exact age at which this level is reached seems to depend somewhat upon the type of test employed, but most current tests agree in showing a marked slowing or cessation of development during this period. The problem is complicated by the difficulty of obtaining unselected subjects in this age group, and also by the fact that in many individual cases development may proceed to a considerable extent beyond the age at which it ceases for the average person. The actual age at which the maturity level is reached has been variously placed at fourteen to sixteen years, or even higher, as an average for the general population. This level has been found to vary, however, with social status, race, and color.

TYPES OF INFERIOR MENTAL DEVELOPMENT

Inferior mental development implies that the average maturity level of the general population is never reached, but that development ceases at some lower level. There are two opposing views as to the usual way in which this lower level is approached. One of these recognizes that different individuals, and perhaps also certain groups of individuals, tend to develop at different rates. There is not merely one normal type of growth but several. When compared with the average for the total population one type may show an early retardation and a later acceleration, another group just the opposite, and so on. Each individual develops at what is for him the "normal" rate and stops at his own "normal" level. The inferior individual, according to this view, usually reaches what is for him his final stage of mental development at an earlier age than does the average normal child. This view is in accord with what seems to be a general principle in biology, that the duration of infancy or immaturity lengthens in proportion to the ultimate level of mature development of a species. In other words, the higher the stage of development the longer is the period of infancy. This general principle as applied to the mental development of various human races is developed at length by Briffault [1] from the anthropological point of view, but it is contrary to the position commonly held by most anthropologists and psychologists. Further experimental research on this problem is urgently needed.

In contrast with Briffault's position, Terman [2] concludes that the rate of mental development, as determined by the Stanford-Binet test, tends to be constant throughout the developmental period. This implies that children who ultimately turn out to be mentally inferior show a relative retardation in the early years. Gesell [3] has formulated a similar tentative conclusion from his experience with children of preschool age. On the other hand, the writer's experience with hereditary strains and pathological varieties of mental inferiority strongly suggests that such children may develop during early infancy at a rate which much more closely approximates the normal curve of mental growth than would be expected from the ultimate mental inferiority. Likewise, mental tests during later development show a decreasing rate of mental development with advancing years, which indicates that the children must have been more nearly normal in infancy than at maturity.

It is now generally recognized that mental inferiority may be transmitted from parent to child as a familial characteristic. If both parents show a decidedly low mentality, the chances are very large that their children will not rise far above the parental level. Mental inferiority may also be due to individual pathological variations which will be described later in greater detail. Comparative study of these two groups shows that children and adults who are deficient because of their heredity tend to resemble children at earlier stages of normal development. The course of their mental development tends to be normal, except that it proceeds at a slower rate and ceases at a lower level. Their resemblance to the normal is more complete than is the case with the pathological varieties, and, broadly speaking, the lower degrees of mental inferiority (that is, idiocy and low grade imbecility) are relatively infrequent among families showing hereditary mental inferiority.

Pathological Mental Inferiority. There is good reason to expect *a priori* that the mental development of pathological types would be more uneven and less predictable than that of normal children or those showing a hereditary mental inferiority. The irregularities are related to the specific nature of the abnormality in each particular case. The mental deficiency of Mongolian idiocy, for example, seems to present a syndrome of a definite anatomical and physiological nature which predetermines the course of development. Nevertheless Mongolian mental deficiency ranges from complete idiocy through imbecility to the lowest moron grade.

Traumatic mental inferiority is a variable condition whose seriousness depends upon the nature and extent of the trauma as well as on the age at which it occurs. Thus, children seriously injured at birth may never develop beyond the initial stages of helpless infancy or, on the other hand, may develop even to the superior limits of the normal, depending upon which portion of the nervous mechanism was damaged and to what extent. Injury sustained comparatively late in childhood may produce a sudden arrest of mental development or perhaps a progressive decrease in the rate of development.

Hydrocephalus as a pathological condition may be progressive or arrested, and the degree of mental development in this condition will vary accordingly. Microcephaly, on the other hand, occasionally permits continuous mental development in a most unexpected fashion, but in other cases there is practically no development beyond simple motor functions.

Generally speaking, pathological mental inferiority requires the consideration of each case in its clinical aspects, and the course of mental development is determined by the initial hereditary endowment, by the nature and extent of the pathological lesion, and by the age at which it occurs.

Degenerative States. The degenerative mental states, such as epilepsy, epidemic encephalitis, and the degenerative psychoses, represent another type of inferior mentality. These conditions may occur early in life and thus interfere with normal development. They may cause deterioration of previously normal individuals and they may also be engrafted upon an original predisposition toward inferiority. It is important to emphasize that these conditions do not necessarily produce an inferior intelligence. Thus epilepsy, although usually associated with some degree of deterioration, does not necessarily lead to serious mental inferiority, and this is also true of the other degenerative states.

THE BORDER ZONE

The distribution of intelligence in the general population closely follows the "normal distribution curve." The various degrees of mental inferiority described above all fall within the lower range of this curve; more specifically, they fall below the mode by more than one standard deviation. This limit may be otherwise defined as corresponding to the fifteen-percentile grade. Mental inferiority associated with feeble-mindedness falls within this range but includes probably not more than two per cent of the total distribution. The remaining 13 per cent includes a condition of mental subnormality which is sufficiently serious in degree to constitute a practical problem. This group does not show the same qualitative differences which are recognized in the more extreme cases. Such children are essentially normal in mental constitution but rank as definitely subnormal on intelligence tests of a verbal character. They tend to be relatively less subnormal on other types of test, and are relatively successful socially and economically. These border-zone cases are easily confused with feeble-minded children, if the decision is based on verbal intelligence tests alone. When a variety of tests is employed and when such data are supplemented by a consideration of the developmental histories and the social adjustments of these dull children, the distinction between low grade normal and actual feeble-mindedness becomes apparent. The term *feeble-mindedness* definitely implies social maladjustment or economic incompetence. The border-zone group are not feeble-minded, but they are definitely handicapped in school work because of their relatively low intelligence as measured by verbal tests. Their inferiority becomes apparent fairly early, as indicated by difficulties in the early school grades and by their inability to progress much beyond the sixth school grade. The majority of them become successful wage earners in unskilled or semiskilled pursuits, and they differ from the feeble-minded in that they do not require social supervision.

The border zone at the lower limit of the normal includes several groups of children. There are the potentially feeble-minded, that is to say, those whose mental development ceases at a low level but whose early development proceeds at a nearly normal pace and shows no evident early inferiority. There are the slightly inferior children who might be classified either as a very low grade of the normal or as within the upper limits of inferiority. There are children who are definitely subnormal in certain respects but not in others; their proper classification is a matter of considerable difficulty. There are likewise children showing retarded mental development who may lag seriously behind the normal early in childhood but who later reach a normal level of mature development as the result of a continuation of development beyond the age when it ordinarily ceases.

These various conditions are important from the standpoint of classification and of prognosis. These children must be thought of as individuals rather than as members of a group or type. Their total number is sufficient to warrant special attention to the problem which they present, but as yet relevant scientific data are too limited to permit any generalization other than recognition of the irregularity of individual development among these border-zone children.

Even in normal children the individual growth curve may show a departure from the normal rate of development at any time in early childhood. The retardation may be gradual or sudden, depending upon the nature of the underlying cause. From the practical point of view these conclusions are rather discouraging. It would be most useful if we could in each individual case make as definite predictions about future mental development as we can for large groups; but if there is any one conclusion which stands out clearly from all of the work on inferior mental development, it is that the future course of development in individual cases cannot yet be predicted with any high degree of certainty.

References

1. Briffault, Robert. *The Mothers; A Study of the Origins of Sentiments and Institutions.* New York, The Macmillan Company, 1927.
2. Terman, Lewis M. *Measurements of Intelligence.* Boston, Houghton Mifflin Company, 1916, 362 p.
3. Gesell, Arnold. *Infancy and Human Growth.* New York, The Macmillan Company, 1928, 418 p.

DEVELOPMENT OF MOTOR SKILLS IN THE PRESCHOOL YEARS

THE development of control of movement of various parts of the body occupies a large part of the time of the infant and preschool child. Movement is the avenue through which most of his contacts with the world are initiated, and through which many of his experiences are gained. At no other stage of life is it so vital and important to general development. Nevertheless, the aspects of motor ability that may be studied are considerably restricted at the younger ages. Garfiel [1] has listed five aspects of motor ability in adults: speed of voluntary movement, accuracy (that is, coordination) of voluntary movement, control of involuntary movement or steadiness, strength, and motor adaptability (that is, capacity to "solve" motor situations and to make a new coordinated movement accurately). As we go further and further down the age scale, these aspects less and less characterize the motor behavior, until in infancy none of them is applicable. It is impracticable in infants to attempt to separate voluntary and involuntary movement. The measurement of steadiness, even in later infancy, becomes impracticable because of the necessity for comprehension of instructions and a desire to carry them out. This lack of response to the expressed desires of others has so far greatly limited all of the studies of infants. Below the age of about four years speed of voluntary movement cannot be studied satisfactorily because of the lack of a concept of time.

The behavior of the newborn infant has been classified [2] into mass activity, or those movements that involve the whole organism, and specific movements, or movements of a part or segment of the organism. Mass activity is strikingly characteristic throughout the first few days of the infant's life, probably as a consequence of the neurological immaturity of the newborn infant. Infants engage in an enormous amount of activity; the total number of movements recorded for ten days varied from 10,357 to 22,752 in four infants. Much of the activity comes as the result of internal rather than external stimuli, very probably localized in the alimentary canal. The amount of activity varies with the different hours of the day and with the proximity of excretory and nursing periods. During the period of the first ten days after birth there is an increase of dominance of movements of the anterior segments of the body (head and arms) over the posterior segments (toes, feet, and legs). Instead of the reflex being an elementary form of behavior out of which more complex behavior evolves, the reverse seems to be true. Complex behavior is characteristic of the infant, and what are usually designated as reflexes appear to be an outgrowth from the more complex mass activity. This point of view is developed at greater length in the section dealing with the development of reflexes.

A very considerable amount of work has been done on the reflexes and behavior patterns of infants.* The results obtained by the different investigators vary as to the presence or absence of a particular reflex and the age at which it is manifested. Recent work seems to indicate that the reflexes are so variable in the infant that they have not the great diagnostic value they assume in the adult.[3] The deep and superficial reflexes may be present at birth, but their absence does not necessarily indicate disease.[4] It is still an open question whether the reflexes occurring after birth occur in any regular order. While certain of the reflexes drop out as the infant develops, others come in. The suggestion [5] that further investigation may lead to an age scale of reflexes similar to the Binet-Simon scale, does not seem hopeful in the light of the results of other investigators.

A periodicity in the breathing curve, an alternate accelera-

* Among the many reflexes that have been studied are the plantar, abdominal, cremasteric, pupillary, Babinski, pelvic, grasping, Achilles, chin, Landau, labyrinth righting, neck righting, knee, Brundinsky, Rossolimo, Bechterew-Mendel, Mayer, Chaddock, Moro, neck, spine, clasping, scapular, biceps, triceps, scapulohumeral, genital, ankle, clonus, Gordon, Oppenheim, anal, opisthotonic, and compensatory adjustment to tilting of the head.

tion and retardation of breathing peculiar to infants, has been noted.[6] The periodicity apparently results from insufficient coordination of the sympathetic and parasympathetic nervous systems. Periods of acceleration in breathing are accompanied by movements of the head and hands and turning of the body. It has recently been demonstrated that conditioned reflexes may be established as early as the fourth day. The particular response that has been successfully conditioned is sucking in response to the sound of a buzzer.[7]

MOTOR BEHAVIOR AT VARIOUS AGES

Considerable information has been accumulated as to the motor behavior that may be expected of the infant and preschool child at the various age levels. So rapid is development during the first year of life that Gesell has presented his results for intervals of a month. The following items indicate the general progression in abilities. They should not be used in connection with any particular case, except with full reference to the conditions under which the results of the investigators were obtained. The items as given here represent average attainment, and do not show the amount of variation that may normally be expected at a given age. These items have been combined from different sources: below one month they are taken from Blanton,[8] from one month to twelve months from Gesell,[9] and from twelve months to thirty-six months from Gesell and Cunningham.[10]

Under one month:

1. Follow slowly moving hand with eyes (few minutes after birth)
2. Turn head when on face (few minutes after birth)
3. Hold head up when upright (two days on)
4. Erection of penis (few days after birth)
5. Spread and close hands (birth)
6. Grasping (few minutes)
7. Creeping (seven days on)
8. Kicking (continuous after 15 to 30 minutes)
9. Turn over (seven days).

One month:
1. Lift head from time to time when held to the shoulder
2. Make crawling movements when laid prone on flat surface
3. Lift head intermittently, though unsteadily, when in this prone position
4. Turn head laterally when in prone position.

Two months:
1. Hold head erect for a short time when held to the shoulder
2. Lift head when suspended dorsally (the head being momentarily unsupported to test the compensatory postural adjustment)
3. Lift the chest a short distance above the table surface when in the prone position
4. Make vertical arm thrusts in random play when in the dorsal position.

Three months:
1. Hold head erect and steady when held to shoulder
2. Rotate body from dorsal to side position
3. Push or elevate self by arms in prone position.

Four months:
1. Hold head steady when carried or when swayed
2. Lift head and shoulders in dorsal position as an effort toward sitting
3. Sit with resistant body posture when supported by pillows
4. Hands no longer predominantly clenched, but frequently open.

Five months:
1. Roll from back to stomach
2. Sit with slight prop
3. Pick up cube from table on contact.

Six months:
1. Sit momentarily without support, if placed in a favorable leaning position
2. Grasp with simultaneous flexion of fingers
3. Retain transient hold of two cubes, one in either hand.

Seven months:
1. Tend to unilateral reaching and manipulation
2. Rotate wrist freely in manipulation
3. Secure pellet with raking or scooping palmar prehension
4. Pick cube deftly and directly from table.

Eight months:

1. Sit momentarily without support
2. Raise self to sitting position
3. Pick up pellet with partial finger prehension.

Nine months:

1. Sit alone
2. Oppose thumb in seizing cube
3. Make a locomotive reaction in prone position.

Ten months:

1. Pull self up to standing position
2. Pluck pellet with precise pincer prehension.

Twelve months:

1. Walk with help
2. Lower self from standing to sitting position
3. Hold crayon adaptively to make stroke
4. Remove a paper cap from head
5. Stand, supporting self
6. Tap a small bell
7. Remove feet from box, baby seated on floor
8. Take hoop off of neck
9. Obtain a toy from the second step
10. Crawl out of a hole in a board elevated 5 in.

Fifteen months:

1. Stand alone
2. Walk alone.

Eighteen months:

1. Climb stairs or chair
2. Throw ball into box
3. Scribble spontaneously and vigorously
4. Get off inverted box, infant seated on a box 6 in. high
5. Obtain a toy from step three
6. Get off stool, infant seated on stool 19 in. high
7. Climb over long obstacle
8. Climb three steps
9. Roll a bowling ball 8 ft., ball weighing 10 lbs., 10 oz.
10. Climb upon low box
11. Slide or back down three steps.

Twenty-one months:

1. Walk attended on the street
2. Walk backward
3. Differentiate between stroking and circular scribble.

Twenty-four months:

1. Run
2. Pile tower of six blocks with good coordination
3. Imitate vertical or horizontal strokes
4. Get off chair, height 13 in.
5. Climb upon chair, height 17½ in.
6. Roll a rubber ball half way up an incline, 3 ft. 8 in. long with 6 in. elevation
7. Throw a bean bag into a 12 in. hole after practice
8. Roll a bowling ball 9 ft. and over a small obstacle.

Thirty months:

1. Go up and down stairs alone
2. Pile seven or eight blocks with coordination
3. Try to stand on one foot
4. Copy vertical or horizontal line
5. Throw a bean bag into hole at 3 ft.
6. Walk up 8 foot flexible plank elevated 8 in. at upper end
7. Roll a ball up an inclined board 3 ft. 8 in. long
8. Walk upon two parallel 4 x 4 x 4 in. beams, 6 ft. long, placed 8 in. apart, without stepping off
9. Walk between straight parallel lines painted on floor 8 in. apart
10. Step into three 8 in. hoops without stepping out or on hoop
11. Roll a bowling ball 10 ft. and over obstacle
12. Walk on double diverging beams without stepping off, beams 4 in. apart at one end and 12 in. at the other
13. Walk between converging lines not stepping out more than once.

Thirty-six months:

1. Roll a rubber ball up an inclined board
2. Throw a soft ball into a basket from a distance of 3 ft., elevation of basket 3 ft.
3. Walk between converging lines without stepping out
4. Walk up steps without support
5. Jump with both feet from 8 in. elevation

6. Walk down steps without support, alternating steps not expected
7. Roll bowling ball 11 ft.
8. Throw hoop onto rod from distance of 3 ft. rod elevated 3 ft.
9. Start to run within two seconds of signal
10. Walk on alternating block 3 x 6 x 6 in. without stepping off, blocks placed 12 in. apart in each row
11. Walk on a 4 x 4 x 4 beam without stepping off more than twice.

Too difficult for thirty-six months:

1. Walk on separated blocks without stepping off more than twice, blocks placed in one row 5 in. apart
2. Run and stop within two seconds of signal
3. Jump with two feet over hurdle 2½ in. high
4. Hop on one foot.

The following items are included in a scale of motor development for ages four and older by Oseretzky.[11]

Four years:

1. Stand fifteen seconds on one leg with eyes open; for two minutes on both legs
2. Hop three times, both feet lifted together
3. Climb ten stairs, 12 to 15 cm. high, without help of rails, alternating feet
4. Climb downstairs, same conditions
5. Wrinkle forehead
6. Wash face: scoop water in palms of hands, take it to face.

Five years:

1. Hop on one leg with open eyes, distance 5 m.
2. Walk on tiptoe, distance 3 m.
3. Dress self alone
4. Run up ten steps, 10 to 15 cm. high
5. Throw ball at a fixed goal 25 cm. sq., 1 m. away.

In addition to the above summaries, a wide range of other motor skills has been tested in children from two to six years of age, the results of which have been expressed in terms of degree of accomplishment rather than in terms of success or failure. Among them are included punching out perforated holes in sheets of paper, tracing a paper or metal maze, thowing a ball at a target, tapping, walking on boards of different widths, steadiness of hand, dynamometer and strength of grip, motor rhythm, fitting cubes in a box, buttoning, ring toss, cancellation, and cross-line tests. The results of researches on motor skills at these ages during the past three years have been critically and ably reviewed by Anderson.[12] Many other tests involving motor coordination in connection with discrimination of form, size, and color have been reported, particularly by Baldwin and Stecher,[13] and Stutsman.[14] An inventory of the motor habits to be expected between the ages of two and four years has been prepared by Andrus.[15]

Most of the work that has been done with preschool children has been with children of average and superior mental development and coming from homes somewhat above average in economic status. More studies are needed to round out the picture for less privileged children.

Although much attention has been paid to norms of development and one or two scales have been built up, we still are far from having a satisfactory motor index. It is not known whether motor precocity at a later age can be predicted from motor precocity at an earlier age. This can only be ascertained from repeated consecutive measurements of the same individuals. We do not know whether certain samplings of abilities can be used to indicate the total motor development of an individual at a given time. What evidence there is concerning the interrelationship of different types of motor abilities seems to indicate a positive relationship. Very few results have been presented, however, where the relationships have been determined within a small range of age. The use of partial correlations to factor out the influence of chronological age is not particularly satisfactory here. It is quite possible that further work will reveal a common motor factor at these ages running through all of the specialized capacities.

In many studies comparatively little attention has been paid to the reliability of measurements. It is extremely important when dealing with young children to know whether the results can be depended upon, whether the same or entirely different results would be obtained if the test were repeated. Much more attention should be given to the details of testing conditions. We find in the literature, for instance, many explanations regarding the greater ease of movements toward the body compared with those away from it, on the basis of whether the movement is important for the survival of the race, fixed by heredity through selection, more primitive and useful, and so forth, when the explanation might have been found in the testing conditions. By changing the sequence in which movements are tested with young children, one can change also the accuracy of a given movement, regardless of whether it is inward or outward. Intelligence test scores of preschool children, and hence the judgment as to a child's mental level, can be changed greatly by changing the conditions under which the testing is done. Correlations between early and later intelligence quotients can be raised as much as thirty points without reducing the variability, by testing the child somewhere between two weeks and two months after he has entered a preschool group instead of before enrolment.[16] In other words, a much truer picture can be obtained of what a child's later I. Q. will be if one waits until he has made some adjustment to his new surroundings. This fact has an extremely important bearing on any study which is attempted to find out whether preschool attendance changes the mental level of the child.

More information is needed about the influence of such conditions on the results of the tests of motor development. Generalizations from one set of conditions to another become precarious. Little is known at present about differences in motor behavior due to differences in background, previous experiences, home influences, personality, and general development of the child, or about variations in motor behavior dependent upon how, where, when, and by whom attempts to elicit a given behavior are made. It is known that a child's behavior is likely to change under changing conditions. The problem becomes that of carefully defining what constitutes changing conditions. Probably much of the conflict in results with infants can be traced to inadequate techniques, such as lack of control over duration or intensity of a stimulus, lack of appreciation of the fact that internal stimuli are potent factors in infant behavior, and ignorance of the fact that an infant's receptivity for, and response to, external stimuli vary with the time of day, and the nearness of the feeding and excretory periods.

Up to the age of five years, few sexual differences in motor ability have been reported. The pupillary reflex seems to be present at an earlier age in boys in 100 per cent of the cases.[17] There is a possible superiority of boys in throwing a ball or rope ring and in maze learning, although this is not adequately determined, and a possible superiority of girls in the age at which walking is first accomplished.

Handedness

Although much has been written on handedness, particularly in relation to learning to write, little is known regarding the nature of handedness or its prevalence in young children. Where observations have been made of the preferential use of the hand in a specified situation, up to about five months both hands have been used with equal frequency. From then on, there is a gradual increase in the use of the right hand. In one investigation[18] 70 per cent of the children studied at one year of age used the right hand. Other investigations show that between 85 and 96 per cent of preschool children use the right hand in preference to the left. There seems to be an indication, however, that the preferential use of the hand is specialized. When children from four to twelve years of age were tested on strength of grip, steadiness, tapping, and throwing a dart, only 25 per cent of the individuals were consistently righthanded in all four tests.[19] Very few tests have been made to determine the relative degree of control of the same child over his right and left hands. A comparison of scores for the right and the left hand on accuracy of keeping between two printed lines, shows that three year old children did practically as well with the left hand as with the right, but the differences between the scores for the two hands became increasingly greater as age increased, up to six years.[20]

The evidence on the relation of handedness to the dominance of one eye over the other is not clear as yet. For a more thorough understanding of the nature of handedness, we need more actual tests of skill with both hands, as well as more complete studies of preferential use of the hands in a variety of situations; more thorough studies of the structural concomitants; and a more adequate appreciation of the setting of handedness in the total development of the individual, including a better definition of what constitutes handedness.

In spite of a definite relationship between chronological age and most motor skills, there is a wide range of degrees of motor ability at a given age level which may still be called normal. Without ample understanding of this condition and allowance for it, the use of means or norms such as those presented in the outlines of development on the previous pages becomes dangerous. Two children, both normal and healthy, may be as much as four or five months apart in age when at the same stage of locomotion. Detailed studies, such as are being made of prehension,[21] will aid us in determining some of the conditions which accompany these normal variations.

Effects of Practice

It is a matter of common observation that, once a motor skill is accomplished, it is retained over a period of years, and even after disuse can be regained with much less effort than is expended on its acquisition as a new skill. During the past few years several studies have been initiated bearing on the effects of practice in a given skill versus maturing of the organism. Results on throwing a ball at a target, tapping, climbing stairs, and ring toss have shown that for the given ages and under the given environmental conditions, practice was relatively ineffective. The practice groups did gain in ability, but not significantly over the nonpracticed groups. It is quite conceivable, however, that a good general environment does facilitate the maturation process, and that one explanation for lack of differences between practice and control groups may be that both groups were in superior environments. Does maturation take place adequately in very restricted environment, and what are the elements that constitute a good environment? One element of good environment affecting performance of motor skills may be access to sufficiently varied play apparatus. There seems to be a positive relationship between the amount of activity a child engages in on play apparatus and his ability at certain motor tasks, even within a group of children having equal opportunity at the apparatus. It is apparently possible to correct the posture of infants by certain systematic gymnastics.[22] It seems possible, also, that climatic conditions may affect the age at which children learn to walk. There probably comes a time in the child's life when practice at the skills just mentioned does become effective. It is highly important in education to know when is the most economical time for training and practice in any given skill. The results of repetition of a given task show that children profit by previous experience, so that they do better at the second experience, even a year later, than do other children of the same ages to whom it is a first experience. When is the body sufficiently matured so that practice becomes effective? Little is known at present about the transfer effect from one motor skill to another.

Motor Behavior and Nutrition

The few careful studies that have been made of the effects of nutrition upon motor behavior lead us to the conclusion that malnutrition probably has much less effect than might be expected.[9] Rachitic children perform as well in motor tests as nonrachitic children. Although Feldman finds that breastfed infants show an earlier decrease in the Babinski reflex and that premature infants give the response longer, he does not find any relation between the reflex and rickets. Premature infants retained the Babinski longer because of lack of myelinization of the pyramidal tracts. Gesell, however, found little effect on the trend or tempo of development from premature postnatal environment or protracted uterine environment. Information as to the effects of different types of feeding on the motor skills of preschool children is almost entirely lacking. Disease, unless extreme, apparently makes little change in the motor behavior of the individual.

Under conditions of known success and known failure preschool children exert more energy in a motor task of the dynamometer type than they do under conditions of performing the task without knowledge of results and without comments from the experimenter. Praise, reward, reproof, and punishment all serve to raise the scores also. Children who were successful in throwing a rope ring over a peg tended to overthrow on the following trial. Better throws were made at a moving target immediately after a successful hitting of the bull's eye, but the trial immediately preceding the success was also higher than the child's general average. Whether these represent the influence of knowledge of success or simply more effective motor organization is not known.

Motor development has, in general, been found to be positively related to general intellectual development. The degree of relationship depends upon the particular combination of traits used and the particular conditions under which the relationships are obtained. Since both mental and motor development take place so rapidly at these younger ages, it would be desirable to know more about the relationship between these two abilities within a very narrow age range. The determination of the true relationship is hampered at present, because motor acts are intrinsic parts of the measures of mental development. It is a question whether at the very youngest ages it will be possible or even desirable to attempt an absolute separation. The capacity to acquire a motor skill may at these younger ages be much more symptomatic of general intellectual qualities than it is at the older ages. It is very difficult to devise a motor test for young children that is independent of mental factors, partly because comprehension of the task is in itself significant of mental development. Children are capable of making the movements necessary to draw a line between two lines long before they can perform the task successfully under instruction. Similarly, children are able to make the fine coordinations involved in writing long before they can accomplish writing itself. While good motor and mental ability are likely to occur together, they are not completely interdependent. Children with a marked motor disability, such as in brachial palsy, may show normal or superior mental ability.

Comparatively little is known about the relationship between physical growth and motor skill. Ultimately, this approach may be the most helpful prognostically and for our understanding of the composite growth of the child, but practically it involves a wide number of studies of a variety of both physical and motor growth traits. Such studies as have been made have used largely the correlational technique, with too wide an age range for any conclusive results. The application of other statistical measures within smaller age ranges may prove a more helpful technique than the correlational method. Does the rate of physical growth affect the child's motor coordination? Is it possible for a child to grow so rapidly that he becomes too large and weak? Is motor control interfered with during periods of very rapid growth or does it progress at the same rapid pace? All of these questions remain unanswered at present.

Of the relation between personality traits or the mental hygiene aspects of childhood and motor development, we know very little. Of what significance is it to the child's mental health that he does or does not have good control over his movements? What effects do certain personality trends have on the efficiency of motor coordination?

From the foregoing review, it will be seen that problems concerning the motor development of infants and preschool children are many and varied. Some of them are solved, but more are unsolved. For each additional finding in an investigation, there seem to be uncovered a number of unanswered questions. Through the remarkable strides in our knowledge during the past few years, a substantial background of information has been furnished, upon which more refined conclusions may be built. Rather than to simplify behavior, the findings of the past few years have served to emphasize the complexity of the child's development and responses.

References

1. Garfiel, Evelyn. "The Measurement of Motor Ability." *Archives of Psychology,* No. 63, 1923, p. 47.
2. Irwin, Orvis C. "The Amount and Nature of Activities of Newborn Infants under Constant External Stimulating Conditions during the First Ten Days of Life." *Genetic Psychology Monographs,* Vol. 8, 1930, p. 1.
3. de Angelis, F. "Reflexes of the Newborn." *American Journal of Diseases of Children,* Vol. 26, 1923, p. 211.
4. Burr, Charles W. "The Reflexes in Early Infancy." *American Journal of Diseases of Children,* Vol. 21, 1921, p. 529.
5. Schaltenbrand, George. "The Development of Human Motility and Motor Disturbances." *Archives of Neurology and Psychiatry,* Vol. 20, 1928, p. 720.
6. Denisova, M. P., and Figurin, N. L. "Periodic Phenomena in the Sleep of Children." *Novoe o Refleksologii i Fiziologii Nervnoi Sistemy* (*Reflexological and Neuro-Physiological News*), Vol. 2, 1926, p. 338. Abstract, *Psychological Abstracts,* Vol. 2, 1928, p. 117.
7. Postle, Dorothy. Unpublished investigation, at State University of Ohio. Columbus, Ohio. n.d.
8. Blanton, Margaret Gray. "The Behavior of the Human Infant during the First Thirty Days of Life." *Psychological Reviews,* Vol. 24, 1917, p. 456.
9. Gesell, Arnold. *Infancy and Human Growth.* New York, The Macmillan Company, 1928. 418 p.
10. Cunningham, Bess V. "An Experiment in Measuring Gross Motor Development of Infants and Young Children." *Journal of Educational Psychology,* Vol. 18, 1927, p. 458.
11. Oseretzky, N. I. "Eine metrische Stufenleiter zur Untersuchung der motorischen Begabung bei Kindern." *Zeitschrift für Kinderforschung,* Vol. 30, 1925, p. 300.
12. Anderson, John E. "The Development of Motor, Linguistic, and Intellectual Skills in Young Children." In *Report of Third Conference on Research in Child Development,* 1929, Part I. "Critical Reviews." Washington, D. C., Committee on Child Development, National Research Council, Vol. 14, 1929, p. 144.
13. Baldwin, Bird T., and Stecher, Lorle I. *The Psychology of the Preschool Child.* New York, D. Appleton and Company, 1925. 305 p.

14. Stutsman, Rachel. "Performance Tests for Children of Preschool Age." *Genetic Psychology Monograph,* Vol. 1, 1926, p. 1.
15. Andrus, Ruth. *A Tentative Inventory of the Habits of Children from Two to Four Years of Age.* Contributions to Education No. 160. New York, Bureau of Publications, Teachers College, Columbia University, 1927. 50 p.
16. Updegraff, Ruth. Unpublished investigation at the Iowa Child Welfare Research Station, Iowa City, State University of Iowa. n.d.
17. Nakaoji, M., Kuhara, M., Inamatsu, S., and Imoto, T. "The Pupillary Reflex in Infants." *Journal of Pediatrics* (Tokyo), No. 339, 1928, p. 1337. Abstract, *American Journal of Diseases of Children,* Vol. 30, 1928, p. 1302.
18. Lippman, Hyman Shalit. "Certain Behavior Responses in Early Infancy." *Pedagogical Seminary,* Vol. 34, 1927, p. 424.
19. Heinlein, Julia H. "A Study of Dextrality in Children." *Pedagogical Seminary,* Vol. 36, 1929, p. 91.
20. Wellman, Beth. "The Development of Motor Coordination in Young Children; An Experimental Study in the Control of Hand and Arm Movements." Iowa City, *University of Iowa Studies, Studies in Child Welfare,* Vol. 3, No. 4, 1926, p. 93.
21. Halverson, H. M. "An Experimental Study of Prehension in Infants." Abstract, *Proceedings and Papers of the Ninth International Congress of Psychology,* Princeton, N. J., Psychological Review Co., 1930, pp. 208, 209.
22. Schoedel, J. "Bewegung des Säuglings und Säuglingsgymnastik." *Jahrbuch für Kinderheilkunde,* Vol. 123, 1929, p. 316. Abstract in *Child Development Abstracts,* Vol. 4, 1930, p. 12.

DEVELOPMENT OF MOTOR SKILLS IN THE EARLY SCHOOL YEARS

THE earlier investigators of motor development of school children used tests of relatively simple and supposedly fundamental motor abilities, involving primarily finger, hand, and arm coordinations, such as tapping, steadiness of hand, target aiming, and tracing tests. Their primary concern was, in general, to discover whether motor control improves with age and whether it is related to mental ability. Since their work was done before intelligence tests came into vogue, their measures of mental ability were tests of selected specific capacities or estimates of general mental ability. Another group of investigators attempted to find out whether there is a general motor capacity. A few investigators have been interested in tests of manual dexterity, such as sorting pegs or cards into compartments and assembling nuts and bolts. Recently a great deal of attention has been paid to the measurement of physical achievement, including such tests as the fifty-yard dash, basketball throw, hop and jump, and chinning. The interest here has been largely in planning an adequate program of physical education; consequently the emphasis has been on physical rather than mental aspects. Scales or series of tests of motor achievement or physical achievement on a large number of children have been presented by a number of workers.[1-9]

Increases in motor control and physical achievement with age have been well established by a large number of investigations. Growth curves showing the rate of growth of a particular individual followed over a period of years are, however, lacking. The low interrelations between different motor tests, the lack of an adequate motor index comparable to mental age or intelligence quotient, and the administrative difficulties in following the same children for a number of years probably account largely for this lack. There seems to have been less emphasis on whether motor skill at one age can be predicted from skill at an earlier age, than upon whether motor skills can be used to predict success in industry.

On the basis of the low intercorrelations between different motor tests of children and of adults, both Muscio [10] and Perrin [11] concluded that there is no general motor capacity. Gould [12] found only low correlations between the same tests given at the beginning and end of the school year to two groups of seventh and eighth grade boys, one having shop work training and the other academic subjects only. His highest correlations were for the three-hole test, .689–.07 and .606–.07. However, Gould did not find improvement in the tests from the beginning to the end of the school year. It is possible that one of the reasons for the low intercorrelations usually found between different tests is that a given test does not correlate highly with itself over any length of time. Information on this point is scarce. Muscio found that practice increases the intercorrelations between motor tests only in the early stages. Hollingworth [13] had previously found that practice increased the intercorrelations between mental tests of adults but he did not separate his mental and motor tests. Muscio, taking Hollingworth's three motor tests, choice reaction, three hole, and tapping, found that the average coefficient of correlation on the first trial was –.017, that it increases to .293 on the fifth trial, and did not then increase to the eightieth trial. By the two hundred and fifth trial it had reached .403.

Sexual differences in motor control of school children seem to be specific. In most tests of physical achievement boys excel. In steadiness [14–16] girls seem to excel. Burt and Moore [17] concluded that boys were superior in simple mechanical movements, but that girls were markedly superior in compound and controlled movements.

Although many workers have reported a relationship between handedness and disturbances of speech, and handedness and eyedness, recent findings seem to indicate that these conclusions must be accepted with some caution. Fletcher [18] from a review of the literature on the disturbances of speech of children who are left-handed and have been trained to be right-handed in writing, did not find much support for the view that there is a causal relationship between transfer of handedness in writing and disturbances of speech. Ojemann,[19] from an experimental approach to this problem, came to the same general conclusion. He found that a single test cannot be used to differentiate accurately between the various unimanual handedness groups, but that a combined score from several tests does result in a bimodal curve. The relationship between handedness in unimanual activities and in bimanual activities varied with the type of activity. When Brenn [20] asked children from six to fourteen years of age to trace a figure with the eyes closed, he found that the functional equivalence of right and left hands for this new unpracticed motor activity was retained until after the fourteenth year. Jones's [21] results on the detection of handedness by means of physical measurements have not been substantiated by the findings of Beeley [22] and others. The recent work of Cuff [23] and others throws considerable doubt on the contention of Parson [24] that handedness is related to the dominance of one eye over the other. The whole question of handedness is one of great interest and practical significance, and deserves careful investigation in the future.

From a thorough study of the motor activities required in writing, including analysis of motion pictures for speed, pressure on the pen, position of hand, fingers, and arm, Freeman [25] found that good writers organize their movement more clearly into units of speed. They have a looser grasp of the pen, hold the finger below the thumb, and divide the movement into a series of units. Little relation has been found between mental age or chronological age and writing ability. Diffusion of motor activity is characteristic in the early stages of learning to write [26] as in other motor activities of the young child.[27]

Talent in drawing apparently does not presuppose a general motor superiority,[28] and practice in drawing does not seem to affect scores of motor control.[29]

While mentally normal children have been found to be superior to mentally defective children [30, 31] in motor control and physical achievement, little relationship has been found to exist between mental and motor ability within the normal and upper ranges of mentality.[32–34]

The need for a more systematic study of the motor development of the same individuals over a period of years is indicated from a survey of existing knowledge. There is practically no information available as to whether later achievement on a specific test can be predicted from achievement on that same test at an earlier time. Those interested in prediction have heretofore turned their attention almost exclusively toward the problem of predicting industrial achievement by means of a series of motor tests. Such attempts have not met with much success. It might be more fruitful now to turn the attention to a study of the reliability of the measures, to the influence of various conditions of testing, to the influence of training upon motor achievement, and to the development of a motor index that will express the individual's general relative position based on a sampling of a number of specific abilities.

References

1. Atkinson, R. K. "A Motor Efficiency Study of 8,000 New York City High School Boys." *American Physical Education Review,* Vol. 29, 1924, p. 56.
2. —— "A Study of Athletic Ability of High School Girls." *American Physical Education Review,* Vol. 30, 1925, p. 389.
3. Bliss, James G. "A Study of Progression Based on Age, Sex, and Individual Differences in Strength and Skill." *American Physical Education Review,* Vol. 32, 1927, p. 85.
4. Brace, Davis Kingsley. *Measuring Motor Ability; A Scale of Motor Ability Tests.* New York, A. S. Barnes & Co., 1927. 138 p.
5. Jenkins, Lulu Marie. *A Comparative Study of Motor Achievements of Children of Five, Six, and Seven Years of Age.* Contributions to Education, No. 414. New York, Bureau of Publications, Teachers College, Columbia University, 1930. 54 p.
6. Judelsohn, Samuel J. "A Study of the Physical Ability of Men-

tally Retarded Children." *Mind and Body,* Vol. 31, 1924, p. 296.

7. Maroney, Frederick W. "Motor Ability Tests." *American Physical Education Review,* Vol. 30, 1925, p. 311.
8. Oseretzky, N. I. "Eine metrische Stufenleïter zur Untersuchung der motorischen Begabung bei Kindern." *Zeitschrift für Kinderforschung,* Vol. 30, 1925, p. 300.
9. Zwarg, L. E. "The Influence of Age, Height, Weight, and Weight-per-Inch Upon Motor Ability of High School Boys." *Mind and Body,* Vol. 33, 1927, p. 456.
10. Muscio, B. "Motor Capacity with Special Reference to Vocational Guidance." *British Journal of Psychology,* Vol. 13, 1922, p. 157.
11. Perrin, F. A. C. "An Experimental Study of Motor Ability." *Journal of Experimental Psychology,* Vol. 4, 1921, p. 24.
12. Gould, Russell L. "Manual Accuracy in Prevocational-School Boys." *Journal of Educational Psychology,* Vol. 8, 1917, p. 439.
13. Hollingworth, H. L. "Correlation of Abilities as Affected by Practice." *Journal of Educational Psychology,* Vol. 4, 1913, p. 405.
14. Hancock, John A. "A Preliminary Study of Motor Ability." *Pedagogical Seminary,* Vol. 3, 1894, p. 9.
15. McHale, Kathryn. *Comparative Psychology and Hygiene of the Overweight Child.* Contributions to Education No. 221, New York, Bureau of Publications, Teachers College, Columbia University, 1926, 123 p.
16. Woolley, Helen T., and Fischer, Charlotte R. *Mental and Physical Measurements of Working Children.* Princeton, N. J., Psychological Review Company, [1914]. (The Psychological Monographs, Vol. 18, No. 1; Whole No. 77, Dec., 1914.)
17. Burt, Cyril, and Moore, Robert C. "The Mental Differences Between the Sexes." *Journal of Experimental Pedagogy,* Vol. 1, 1911, pp. 273, 355.
18. Fletcher, John Madison. *The Problem of Stuttering; A Diagnosis and a Plan of Treatment.* New York, Longmans, Green & Co., 1928. 362 p. (Pages 53 to 88.)
19. Ojemann, Ralph H. "Studies in Handedness. I. A Technique for Testing Unimanual Handedness." *Journal of Educational Psychology,* Vol. 21, 1930, p. 597.
    II. Testing Bimanual Handedness. III. Relation of Handedness to Speech. In preparation for publication.
20. Brenn, R. "Untersuchungen zur Frage der Rechts und Linkshan-

digkeit und zum Gestalterkennen aus der Bewegung bei Kindern." *Archiv für Psychiatrie,* Vol. 86, 1929, p. 255. Abstract, *Psychological Abstracts,* Vol. 3, 1929, p. 360.
21. Jones, Wallace Franklin. *A Study of Handedness.* Vermillion, South Dakota University Bulletin No. 14, Series 17, 1918, p. 80.
22. Beeley, Arthur L. "An Experimental Study in Left-Handedness; With Practical Suggestions for Schoolroom Tests." *Supplementary Educational Monographs,* Vol. 2, No. 2 (Whole No. 8), 1918.
23. Cuff, Noel B. "The Interpretation of Handedness." *Journal of Experimental Psychology,* Vol. 11, 1928, p. 27.
24. Parson, Beaufort Sims. *Left-Handedness; A New Interpretation.* New York, The Macmillan Company, 1924. 185 p.
25. Freeman, Frank N. "The Handwriting Movement; A Study of the Motor Factors of Excellence in Penmanship." *Supplementary Educational Monographs,* Vol. 2, No. 3 (Whole No. 9), 1918.
26. Judd, Charles H. "An Experimental Study of Writing Movements." *Philosophische Studien,* Vol. 19, 1902, p. 243.
27. Wellman, Beth. "The Development of Motor Coordination in Young Children; An Experimental Study in the Control of Hand and Arm Movements." Iowa City, *University of Iowa Studies, Studies in Child Welfare,* Vol. 3, No. 4, 1926.
28. Manuel, Herschel Thurman. *A Study of Talent in Drawing.* Bloomington, Ill., Public School Publishing Co., 1919. 152 p.
29. Tildesley, M. L. "Preliminary Note on the Association of Steadiness and Rapidity of Hand with Artistic Capacity." *Biometrika,* Vol. 12, 1918, p. 170.
30. Judelsohn, Samuel J. "A Study of the Physical Ability of Mentally Retarded Children." *Mind and Body,* Vol. 31, 1924, p. 296.
31. Kelly, Robert Lincoln. "Psycho-Physical Tests of Normal and Abnormal Children; A Comparative Study." *Psychological Reviews,* Vol. 10, 1903, p. 345.
32. Goll, R. W. "A Comparison of Mental Ability, Physical Ability, Height and Weight." *Mind and Body,* Vol. 30, 1923, p. 311.
33. Kiefer, Frieda A. "Manual Motor Correlation in Superior Children." *Journal of Applied Psychology,* Vol. 13, 1929, p. 357.
34. Monahan, Jane E., and Hollingworth, Leta S. "Neuro-muscular Capacity of Children Who Rest Above 135 I. Q. (Stanford-Binet)." *Journal of Educational Psychology,* Vol. 18, 1927, p. 88.

MOTOR SKILLS IN LATER YOUTH

INDIVIDUALS differ greatly in the speed, strength, and precision of their muscular coordinations. This observation seems to hold equally well for all types of performance from the simplest or most delicate movements of the hand or vocal cords to the strenuous athletic performances in which nearly every part of the body is actively involved. Furthermore, many of these skills can be reliably measured, and the differences between individuals are found to be relatively stable. Regardless of whether or not the differences in skill are hereditary in origin, their magnitude and their persistence over long periods of training are sufficient to make them of first importance to the individual himself and to the teacher, coach, or employer who attempts to secure more skillful performers. One of the main problems concerning the development of motor skills is therefore to analyze the extent to which various motor skills are determined by physique or bodily build, by functional variables such as speed of nerve and muscle response, by the adoption of favorable methods of work, and by various types of training.

Recent studies by motor tests on men and boys in the field of physical education have sought to determine the influence of height, weight, and the strength of various groups of large muscles upon athletic skills. A separate consideration is necessary for the "fine" muscle skills, or those which involve relatively small and precise movements, on account of differences which appear to exist between these and the grosser coordinations. By each of these two approaches attempts have been made to classify individuals in terms of a "general motor ability," or perhaps a number of group factors which might be called "basic motor capacities." A third hypothesis considers the possibility of analyzing differences in complex skills into elements of speed or precision in simpler component activities or even to a neuromuscular basis.

For the purposes of this study the term *motor skills* will be used to denote those types of sensory-motor coordinations in which the variables of speed, accuracy, or strength of muscular activities are emphasized. According to this point of view there are all degrees of skill in a given activity, and these degrees may be measured objectively by the number of units of work done correctly per unit of time. This measure is in terms of a single integrated score rather than of separate scores for output, accuracy, or time. An alternative definition of skill is of the type suggested by Pear,[1] who emphasizes the ease or efficiency of a highly integrated performance where rate is constant. He thus limits the term *skill* to the higher degrees of coordination.

There are continuous gradations between intellectual, sensory, and emotional measurements and those which are called *motor.* For instance, a test of visual serial discrimination may emphasize the sensory aspect by employing very fine or very complex differences in the stimulus while requiring a simple type of discriminative response, or it may emphasize the motor aspect by making the differences in the stimulus clear cut and by increasing the rate or difficulty of the muscular responses to be made. A type of test which might be called either a motor test or an intellectual test is that of learning to trace a complicated path in a finger maze with one hand while blindfolded. In this case a few persons do seem to learn the patterns by a rote method of repetitive practice, but most persons adopt some verbal system of counting visual imagery for learning the sequences of movements to be made.

Since all of these variables, intellectual, sensory, and emotional, are present to some extent in any motor test, it is necessary to hold them constant by using (1) standardized simple directions with full knowledge of procedure and results; (2) relatively clear cut differences in the stimuli, and (3) approximately constant motivation. It may again be emphasized that the term *motor* refers merely to one aspect of all behavior and that we must guard against considering it as a sort of separate factor appearing only in a few types of work such as mechanical and athletic skills. Spoken language and writing are also highly developed motor skills, as are many of our other daily activities.

Practically it is important to know whether there are certain fundamental aptitudes which determine the probability of a child's attaining a high degree of motor skill. If so, the child may be advised either to work along certain lines in the motor field or perhaps to avoid lines of work for which he is not fitted. The possibility of giving such advice rests upon an adequate knowledge of the ways in which individuals differ in their motor characteristics, so that we may be able to classify (1) the individual's motor characteristics, and (2) those motor characteristics which are likely to be necessary in various practical activities.

GENERAL MOTOR ABILITY

Nearly all experimenters have started with the hypothesis that there probably is some general motor ability which would be basic to success in acquiring various practical motor skills. Bovard and Cozens [2] have traced the history of the various types of indices which have been suggested as measurements of this general factor. Beginning with the early anthropometrists, we have had successive emphasis on bodily proportion, strength tests, endurance tests, cardiac and other organic efficiency measurements, and, finally, the development of batteries of performance tests whose scores are to be averaged for a general index. No one of these measurements has been found to be sufficient by itself, although each of them seems to be important in extreme cases. For example, there is no characteristic build for a good sprinter, except that certain overweight or very "spindly" persons will be slow. Similarly, there does not seem to be a very close relationship between the efficiency of normal heart action and success in athletic performances, except perhaps in long endurance contests.

The most recent line of work, that of assembling a battery of tests of physical ability for the classification of individuals for work in physical education and athletics, has been more successful than the others and is the one with which we are principally concerned. Examples of this type of procedure are the studies by Rogers on physical ability of boys, and by Cozens on athletic achievements of college men.

Rogers [3] built up a battery of six "physical capacity" tests which included such things as vital capacity, strength of grip of right and left hands, strength of back and legs as measured by dynamometers, push-ups on parallel bars, and pull-ups in chinning on rings. The composite weighted score on these tests constitutes the *strength index*, and the ratio between an individual's strength index and the average index for all boys of the same age and weight is termed the *physical fitness index*. Rogers makes practical use of these indices in classifying junior and senior high school boys according to the types of physical activity best suited to the individual. This basis of selection corresponds more nearly to athletic ability than selection by height and weight, but even these are preferable to age or scholastic advancement. When the results of the separate tests are compared, it is found that a high score in one, such as vital capacity, will be fairly indicative of a high score in another such as strength of legs. For this reason it is permissible to combine these scores from separate tests and to speak of a strength index. The tests are objective, and repetition during the school year shows that they are also reliable. The indices correlate quite highly with scores made on a battery of tests of athletic ability including such events as the 100-yard dash, broad jump, high jump, shot put, baseball throw, and so forth. The practical usefulness of the strength indices obviously depends on this correlation.

However, on the theoretical side, there are still a number of criticisms which should be met. In the first place, Rogers's groups of boys had a very wide range of age, height, and weight. The coefficients of correlation as calculated are therefore unduly high, and in order to determine the real relationship between strength and athletic ability the study should be repeated upon groups which are more nearly homogeneous in height and weight. We may anticipate that there would still be a fair degree of correlation, but the principal interest in such a study would be to determine whether or not the relationships of these activities of large muscle groups really differ from the relationships which seem to hold for the finer types of skills such as manual activities, or whether the relationships at present apparent are due merely to the large ranges of talent which have been measured.

Cozens [4] found that his groups of athletic tests for college men were reliable and corresponded well with instructors' ratings of athletic skill. He also found that the scores in various tests correlated moderately well with one another, tending to support the hypothesis of a general athletic ability.

SPECIFICITY OF SKILLS

In contrast to the results of these studies on activities involving the large muscles, experiments on skills involving the coordination of small muscles, or the so-called *fine muscle skills,* tend to show quite uniformly a high degree of specificity of skills. If we compare simple activities, such as speed and precision of hand movement, we find in most cases that we are unable to predict success in one type of performance above that in another. The failure to demonstrate a general ability often has been attributed to uncertainties of measurement and other unknown factors. As a test case R. H. Seashore [5] assembled a battery of eight tests of motor ability designed to sample a large number of the principal abilities which psychologists have considered essential for success in complex performances. The tests ranged from measurements of steadiness of posture to coordinations of hand with eye and hand with ear. As a criterion for which prediction on the basis of the results of the test was to be attempted, there was included one performance similar to an ordinary industrial packing operation. Due consideration was given to matters of reliability of tests, practice, motivation, and so on. The differences between the performances of various individuals in any one test were found to be quite large and consistent. The interrelations of the scores of various tests were almost exactly the same as those of earlier workers, and indicated that each test measured a rather specific skill unrelated to the others. No single test was found which would predict success in the industrial packing operation with any degree of accuracy, and even the optimal weighting and combination of all scores by multiple correlation yielded only a very moderate prediction from the tests as a whole. Thus it would seem that the term *general motor ability* is not a useful one, since a person may rank very high in one motor test and very low in another. Certain individuals may rank high in a large number of these tests, but such cases may be most accurately described by saying that they possess a large variety of specific skills.

BASIC MOTOR CAPACITIES

The hypothesis has been advanced that, underlying the more complex performances which are usually examined, there may be certain fundamental capacities. It is usually assumed that these basic capacities would involve serial rather than single movements, that each group would be only slightly related to other groups, that they would be found essential for success in activities involving complex coordination. The tests just described bear directly on this question, for they were selected as representative examples of these so-called *basic motor capacities*,* so that the evidence may be fairly interpreted as weighing against this hypothesis of fundamental capacities. For example, three tests of the pursuit type were given. One of these was slightly related to the other two while these other two were only moderately related to each other. It thus seems either that there is no basic capacity underlying the activities involved in eye-hand pursuit tests, or that there must be different basic capacities for each of the three tests.

Speed in serial discrimination of stimuli presented either visually or by ear might be expected to represent a basic factor in muscular coordination. However, Hansen[6] found

* Postural stability, speed of hand movements, serial discriminative responses, eye-hand pursuit movements, and ear-hand motor rhythm coordination were all included.

that it made a very considerable difference in the scores on such tests whether the stimuli were presented by sight or by sound. R. H. Seashore [7] found that the accuracy with which one individual kept time in following different rhythmic patterns was by no means consistent. On the other hand, when the same pattern was followed by different groups of muscles, including the right hand, left hand, right foot, left foot, and jaws, it was found that each individual tended to rank about the same for accuracy on all of the groups of muscles. The two hands and likewise the two feet showed a slightly higher degree of relationship between themselves, but all of them were quite consistent.

In a study by Campbell,[8] the observers moved a baton in a square before them according to the position of lights which flashed on the sides. These movements were executed by either hands or feet, and it was found that the particular group of muscles employed had little influence on the individual's ranking. These studies might suggest that there is some basic rate of neuromuscular function common to all of the muscles of the body, but there are other possible interpretations. Changing the stimuli from one sense field to another, such as from visual to auditory, has a considerable effect upon the relative ranking of individuals on motor tests, and in at least one test a change of pattern within the same sense field was sufficient to produce marked changes in ranking. It apparently makes little difference which group of muscles is used if the sensory pattern remains constant and if there has not been any great difference in the amount of training of the different groups of muscles.

Another possible general capacity might be speed of performance. It has been suggested that the speed of a complex performance is determined principally by the speed of the various simple components of movement which go to make up the entire performance. Here again the experimental evidence is equally definite and equally negative. For example, in four different studies in which the simple reaction time for pressing a telegraph key in response to a signal was compared with the speed attained in tapping a similar key for five seconds, it was found uniformly that there was no general speed factor for the right hand. The two types of movement are almost totally unrelated.

A study by S. H. Seashore [9] showed that for reaction time, as for accuracy of motor rhythm, the particular group of muscles employed had practically no effect upon the ranking of the individual in the group. There were absolute differences between the reaction times for hands, feet, and teeth, but this did not alter the rank of the subjects relative to one another. Kidwell [10] showed that reaction time, measured by depressing a key in response to a flash of light, is practically unrelated to the speed of response due to an auditory stimulus, although the same muscular movement is employed in each case. Furthermore, if the movement by which response is measured is one of considerable amplitude, differences in the speed with which the muscular movement is carried out may quite submerge the differences in the promptness with which the response began. Likewise, it is found that people do not perform at a consistent rate in complex activities.

In a number of studies the simple reaction time has been compared with scores in intelligence tests on the theory that both of them might depend in some way upon the speed of neural conduction. The results in all cases in which large numbers of individuals have been studied have uniformly shown that there is no relationship between these two functions. An apparent positive relationship which was reported to exist between the speed of reflex action, such as the knee jerk, and intelligence has since been shown to be an error.[11, 12]

In the matter of steadiness the results are a little ambiguous, but a recent study by Stephenson [9] showed that there was a very moderate positive correlation between the amount of postural sway while standing with the eyes closed and the steadiness of holding a stylus at arm's length or of moving the stylus down a narrow path. Spaeth and Dunham [13] were able to predict rifle marksmanship fairly accurately from scores on a steadiness test. There may be some slight general factor present in these measures of steadiness, but we must await further evidence.

A study of the development of these individual differences in specific skills has recently been undertaken by R. H. Seashore. It seemed possible that a child might start out with a relatively even development of all of his skills and that the later specificity might be due to differences in motivation and to the influences of training. Preliminary studies, however, have shown that at the ages of ten,[14] fifteen,[15] and eighteen,[16] the finer motor skills, as measured by the Stanford Motor Skills Unit,[17] are just as specific as they are in adults. These results show that we must begin testing at a still earlier age in order to check the validity of these theories, and this project is to be carried out during the next two years in the Oregon Laboratory. The early appearance of specificity suggests that it may not be due so much to the total amount of previous training as to the particular methods of attack adopted by the individual for each type of performance.

PRACTICAL MOTOR SKILLS

In contrast to the field of physical education, in which it would seem both possible and profitable to classify individuals according to their attainments, we might conclude that there would be little hope of accurate prediction of complex, practical motor abilities of the finer types on account of the very high degree of specificity which is involved. The possibilities of predicting industrial skills have been put to the test in at least two experiments in which many of the difficulties of previous trials had been ruled out. It should also be mentioned that certain tests of ability in various directions, including manual dexterity, have been devised on a purely empirical basis, and are employed to advantage by certain industrial firms in guiding prospective employees to the type of work in which their chances of success are greatest. O'Connor [18] gives an account of certain tests and of the relationships which he has been able to establish between them and certain types of industrial activity.

R. Y. Walker [15] carried out under experimental conditions a study of seventy high school boys approximately fifteen years old. They were given six tests of the Stanford

Motor Skills Unit at the beginning of the second year. After seven months of training in typing, they were given a series of standardized speed tests. In spite of reasonably high reliability of both motor tests and typing tests, the rate of typing could not be predicted from the motor test scores.

The second industrial study of an experimental character was carried out by S. H. Seashore [16] in a large knitting mill. A group of sixty male apprentices averaging eighteen years of age were given the same tests of the Stanford Motor Skills Unit and the scores were compared with their output after three months of training. In the particular industrial operation involved the production is almost entirely a function of the speed of the operator in handling the machine. No relation whatever could be found between the motor test scores and the industrial output. Further studies were made in an attempt to check up on the underlying factors involved. For example, the five fastest machine operators and the five slowest operators were timed for speed in tying the weaver's knot on the machine, which is one of the most difficult parts of the operation. On this and other speed tests requiring approximately twenty to forty seconds it was found not only that the poorest operators could equal the time of the faster performers but that they actually exceeded them slightly. Further analysis by means of slow motion pictures proved impossible as the pictures were so nearly identical that an observer could not tell which were the fast and which the slow operators. The startling results of this comparison of brief tests with the production rate over a longer period suggest that we may have found one of the reasons for our inability to predict practical motor skills. If individuals do not maintain their maximal rates of work, we are essentially attempting to predict the rate of work which the individual selects for himself on the basis of a maximal rate of work measured under experimental conditions.

THE INFLUENCE OF TRAINING

Even if we do not find that complex motor skills depend on any general motor ability or on fundamental factors such as speed or steadiness, and although the analysis of complex activities proves extremely unsatisfactory, we may still investigate the effects of training. It has been suggested that the individual differences shown by various tests may be due to different amounts of previous training. Not only might there be direct effects, but there might also be some transfer from one type of training to another activity. It is generally recognized that practice and training improve motor performances. Most investigators have supposed that there is a limit which each individual approaches in the course of training but cannot surpass, and that this limit differs markedly from one individual to another. However, the great changes in world's record typing speed, almost doubling in twenty years, might be cited as an example of a complex motor skill in which "physiological limits" were accepted prematurely.

The general findings as to the amount of transfer from one type of performance to another are that there is usually very little carry-over even when there are a number of apparent similarities in the two types of work. Transfer does sometimes appear, however, where there are elements or methods of procedure common to the different performances. Furthermore, if we emphasize in the training such things as efficient methods and relationships of materials, it may be possible to produce transfer of training from one performance to another as is shown by Woodrow's experiment [19] on the memorizing of different forms of material.

Certain work in the field of educational psychology seems to show rather large effects of transferred training related to motor phenomena when the individuals were markedly deficient in some respect at the start of the training. The relationship of stuttering to right-handedness and left-handedness, and the improvement in speech in such cases which may follow intensive training in the use of one hand, seems to be a case in point. There are indications that children who are changed over from left-handedness to right-handedness at an early age may suffer a rather severe disturbance for a number of years, but that this is eventually overcome to a very large extent. Another example is the case of persons who are very deficient in reading ability. Many of them can greatly improve their rate of reading by a "kinesthetic approach." This consists in having the subject trace out the letters in a series of large movements at the same time that the word is pronounced very clearly. The attempt is thus made to supplement the visual cues by all the other available sense fields, particularly hearing and kinesthesis. Improvement under this method of training suggests that we may here have an example of transfer the basic mechanism of which is still unknown.

METHODS OF WORK

A number of psychologists and industrial engineers have studied methods of work very intensively in an attempt to eliminate unnecessary tiring movements. Taylor was an engineer who developed this type of work analysis under industrial conditions and obtained significant improvement in performance even in such heavy unskilled labor as loading pig iron. He was one of the first to show the importance of pauses for rest in increasing productivity in industry. Numerous other workers have extended his methods and have usually found it possible to make considerable improvement in the methods in use by workers in any line of work. The outstanding analysis of this sort was made by Gilbreth,[20] whose classic work was on reducing the number of movements in laying a brick from eighteen to four. He developed a fine photographic technique for accurate timing and analysis of finer movements, and directed his efforts to finding "the one best way" of doing each operation. Many arguments have been proposed both for and against such standardization of movement. Apparently there is considerable justification for it in operations which are repeated over and over again, provided that alternative sequences are arranged so as to rest one group of muscles by employing others.

All of these studies show that the timing of movements is extremely important. This explains in part why we cannot predict the speed of a serial response from the separate times of its component movements, since one movement is often started before the preceding one is completed. Likewise, we cannot predict the accuracy of a complex movement from the accuracy of its component parts since timing may be far more important. For instance, the time of release of a ball thrown from the hand is one of the major factors in the accuracy of the throw.

Instruction in activities which involve groups of small muscles and fine coordinations therefore involves, first, directing the performer through the series of movements, then eliminating wrong or useless movements, and finally securing the optimal timing of the several components. In more complex skills, such as typing, Book [21] has shown that the movement series is progressively condensed by grouping into words, phrases, and sentences. He also shows the necessity for motivation in trying for higher levels and in cutting out useless movements. His approach to this practical skill offers a starting point for similar studies, both theoretical and practical. One of the principal difficulties of instruction is the fact that muscular movements are often so fast or so complex as to be very difficult to analyze in detail. Slow motion pictures may be of great utility in making such an analysis. Analysis is usually essential because very often a person who is highly skilled in some performance cannot describe verbally the way in which he achieves his skill, although he may recognize it after it has once been pointed out to him.

SUGGESTIONS FOR FURTHER RESEARCH

It may be profitable to point out some of the more promising lines of research which may be expected to supplement our present knowledge. The method of comparison of individuals at successive ages should throw some light on the origin and nature of individual differences. It is still possible that there may be a differentiation of specific skills in the very early years.

The mechanism underlying the "kinesthetic approach" for the improvement of poor readers should be of considerable importance if it can be analyzed. Even though it is not completely understood, it is very likely that useful, practical results could be obtained by its extension to other fields.

In the field of physical education, we already have a procedure by which to select for individuals the type of work which will be most beneficial to them, but further refinements of the selective tests may eventually give us cues for extension of these principles to the fields of finer motor coordinations in which selection is at present impracticable.

Apparently success in the fine motor activities is determined more by the method of work which is adopted than by the motor characteristics of the individual. This implies that such activities can probably be greatly influenced by efficient methods of training, and points to the importance of improving the techniques for studying and analyzing movements both theoretically and practically.

Further study is greatly needed on the relative significance of aptitude and training in industrial problems. The relative efficiency of verbal as against visual instruction has been but little investigated. We should also inquire as to what extent our visual and verbal directions should best be distributed over a period of time and interspersed with actual practice.

A fundamental description of what takes place in the simplest type of learning is still lacking. Recent neurological studies have tended to destroy some of our favorite theories and as yet have given us little of a positive nature in their place. It may be necessary for psychologists to devote a considerable portion of their time to investigation of these principles before turning to the question of their application to specific problems.

References

1. Pear, T. H. "Skill." *Journal of Personnel Research,* Vol. 6, 1927, p. 15.
2. Bovard, J. F., and Cozens, F. W. *Tests and Measurements in Physical Education, 1861–1925.* Eugene, University of Oregon, Physical Education Series, Vol. 1, No. 1, 1925. 94 p.
3. Rogers, F. R. *Tests and Measurement Programs in the Redirection of Physical Education,* New York, Bureau of Publications, Teachers College, Columbia University, 1927. 166 p.

4. Cozens, F. W. *The Measurement of General Athletic Ability in College Men.* Eugene, University of Oregon, Physical Education Series, Vol. 1, No. 3, 1929. 92 p.
5. Seashore, R. H. "Individual Differences in Motor Skills." *Journal of General Psychology,* Vol. 3, 1930, p. 38.
6. Hansen, C. F. "Serial Action as a Basic Measure of Motor Capacity." *Psychological Monographs,* Vol. 31, 1922, p. 320.
7. Seashore, R. H. "Inter-muscular and Inter-pattern Relations in Rhythmic Auditory-Motor Precision." 1930. Not yet published.
8. Campbell, M. "Individual Differences in the Speed of Serial Reaction of Large Muscle Groups." Thesis not yet published. University of Oregon Library, 1930. Abstract, *Psychological Bulletin,* Vol. 27, 1930, p. 639.
9. Seashore, R. H., Seashore, S. H., Stephenson, D., Walker, R. W., and Wickersham, R. "The Personal Equation in the Field of Motor Performances." Study not yet published. Eugene, University of Oregon, 1930.
10. Kidwell, P. *Sense Modalities and Extent of Movement as Determinants of Individual Differences in Speed of Simple Reactions.* Study not yet published. Eugene, University of Oregon, 1930.
11. Travis, L. E., and Hunter, T. A. "The Relation between Intelligence and Reflex Conduction Rate." *Journal of Experimental Psychology,* Vol. 11, 1928, p. 342.
12. —— and Young, C. W. "The Relations of Electromyographically Measured Reflex Times in the Patellar and Achilles Reflex to Certain Physical Measurements and to Intelligence." *Journal of General Psychology,* Vol. 3, 1930, p. 374.
13. Spaeth, R. A., and Dunham, G. C. "The Correlation between Motor Control and Rifle Shooting." *American Journal of Physiology,* Vol. 56, 1921, p. 249.
14. Merrill, Marion. *The Specificity of Motor Skills of Boys at the Age of Ten Years.* Study not yet published. Eugene, University of Oregon, 1930.
15. Walker, R. Y. *The Validity of Serial Motor Tests for Predicting Typewriting Proficiency.* Thesis, University of Oregon Library, 1930, 62 p. Abstract, *Psychological Bulletin,* Vol. 27, 1930, p. 655.
16. Seashore, S. H. "The Aptitude Hypothesis in Motor Skills." To appear in *Journal of Experimental Psychology.* Abstract, *Psychological Bulletin,* Vol. 27, 1930, p. 653.
17. —— "Stanford Motor Skills Unit." *Psychological Monographs,* Vol. 39, 1928, p. 51.

18. O'Connor, J. *Born That Way.* Baltimore, Williams & Wilkins Company, 1929.
19. Woodrow, H. "The Effect of Type of Training Upon Transference." *Journal of Educational Psychology,* Vol. 18, 1927, p. 159.
20. Gilbreth, Frank B., and Gilbreth, Lillian M. *Fatigue Study.* Second edition, revised. New York, The Macmillan Company, 1919. 175 p.
21. Book, W. F. *Learning to Typewrite; With a Discussion of the Psychology and Pedagogy of Skill.* New York, Gregg Publishing Co., 1925.

THE DEVELOPMENT OF LANGUAGE

IN the process of evolution, the increase in relative size and complexity of the cerebral hemispheres is correlated in behavior by a greater variety of response, and the response which distinguishes man from the lower animals is found in the development of the ability to understand and express oneself in speech. The animal can make a variety of sounds but he does not develop the ability to use words as concepts; whereas the normal infant within the first year produces and reproduces imitatively the sounds necessary for speech, and in a relatively short time has developed the linguistic response by which he can communicate abstract ideas. It is customary to locate the control of the mechanism of speech in the lower frontal convolution of the left hemisphere, hearing in the temporal lobe, vision in the occipital lobe, but there is no clear evidence of a localized area upon which the development of language depends. One can only assume, on rather scanty and conflicting evidence, that the number or type of cortical cells bears some relationship to the apperception of sensory impressions, and that the increase in relative size of the frontal and more particularly of the prefrontal lobe bears some relation to that essentially human characteristic, "the ability to carry on abstract thought."

The establishment of well-baby conferences, nursery schools, and preschool laboratories in the past ten years has provided an opportunity for systematic study of the development of language in large numbers of children under more or less controlled conditions. In addition to the records of spontaneous language, definite methods of stimulating linguistic response have been devised. In varied situations dealing with objects, pictures, and questions, a mass of data has been secured. In an individual case the estimate of the size of vocabulary and the ability to deal with words as concepts may then be compared to the characteristic response of groups of children at stated age intervals. On the basis of these studies, the following generalizations have been made.

Preliminary Stage

The cries of the infant are ascribed to hunger, pain, fatigue, fright, loneliness, and impatience; while a different type of vocalization, characterized as cooing, crowing, gurgling, and laughing, arises under conditions assumed to be pleasurable. Although many writers believe that the various cries can be differentiated, under controlled experimental conditions, the sounds were not sufficiently characteristic for an observer to recognize them without knowledge of the conditions of stimulation. The order in which the phonetic elements of speech appear varies greatly with different children. In the first months modification of the vowel sounds, particularly the vowel *a* with its various shadings, is present. Ordinarily by six months the consonants *g*, *p*, *d*, *b*, *m* are being combined to make the first syllables. The two consonants which usually appear late are *r* and *l*. These letters, which are difficult for the child to produce, are frequently reported as significant in disorders of speech.

Most writers report the tendency to imitate sounds during the second six months of life, and nearly all writers have observed among the first words the reduplication of syllables. It is believed that the child imitates only the sounds which have already occurred in his spontaneous utterances and that no purely new sounds are added by the process of imitation. This period of repetition of syllables whether produced by itself or stimulated by another person is often referred to as the babble stage. In these early months it is probable that no one sound is used as a response to one set of circumstances that is not used at some time for quite different conditions; such sounds, therefore, cannot be considered as words. A prolonged sound, "maa," stimulated by discomfort, and the short explosive "da" produced under pleasurable stimulation, when repeated in this babble stage may be readily conditioned to a definite association with the two persons most eager to believe that the child is talking. Associated sounds have been produced experimentally in very young infants. If an object is presented when a sound is made, a connection may be formed between vocal effort and a definite reward, but these attempts to stimulate speech are unavailing if the child has not reached the babble stage of spontaneous vocalization. The natural belief that "mama" and "dada" are definitely associated words makes the age at which the child began to talk a very difficult period to determine. It accounts in part for the wide age range for "first words" reported by various investigators and it is a most deceptive item to evaluate when attempting the study of delayed speech. On this basis, many a child had apparently begun to talk and then stopped. It is of interest to know that the child had reached the babble stage, but some other word than the variations of "mama," "dada," and "nana" must be used as reliable evidence of the beginning of speech.

The Development of a Vocabulary

Between twelve and eighteen months, there is usually a mastery of a few sounds with increasing specialization of use, so that a child by eighteen months has a vocabulary of half a dozen or more definitely associated words. Between eighteen months and twenty-four months, along with the rapid increase of words the child shows a marked increase in the facility with which he repeats words and uses his growing vocabulary. A study of the vocabularies of 47 children at twenty-four months showed a range of 5 to 1,212 words, with an average of 328 words. Ordinarily the child by twenty-four months combines words quite freely in two and three word sentences and can be persuaded to name familiar objects and pictures in test situations. These simple sentences have, however, a parrot-like inflexibility of phrasing; they are characteristically the direct repetition of words heard under similar conditions. It is a step in originality of thought when the child changes the form of the sentence by the use of pronouns. In the early stage of single words, the names of objects and persons are used in relatively large numbers. The verbal element by the third year assumes almost equal proportion, and by thirty-six months pronouns are usually used correctly, while relative pronouns and subordinating and connecting words are acquired with difficulty. This conversation of the young child deals largely with his own activities and experiences and is heard most frequently when he is engaged in physical activity. The stimulus of active play to language has raised the question whether delayed speech may result if a child is deprived of physical exercise. The type of child who will probably show marked intellectual interests begins early to ask questions; he is probably demanding information by a constant "What's that?" by the time he is two years old. Such questions as "What is it?" and "When?" are admittedly earlier than "Why?" A few observers have noted that between the fourth and the fifth year there is a rapid development in the use of abstract terms. Genuine argument and collaboration in abstract thought, according to Piaget, do not ordinarily appear until the age of seven. Without attempting to define steps in abstraction or the age of appearance, the most striking difference in the development of language between the young child, the school child, and the adult, and between the normal and feeble-minded at any comparable age, is shown in the ability to use abstract terms.

RELATION OF LANGUAGE DEVELOPMENT TO OTHER PHASES OF DEVELOPMENT

The aspect of mental development which is best described as intellectual (to avoid the controversy over the meaning of intelligence) may be defined as "the ability to carry on abstract thought." Whether speech (oral or sign language) is essential for advanced development in this ability has not been proved, but that speech is a major asset in the communication of ideas can hardly be denied. Mothers frequently say that although the child does not talk, "he understands everything," not realizing that without the intercommunication of ideas through language, she has limited her conversation with him to the needs of the immediate situation, and the situation by itself frequently supplies the necessary meaning to her tones and gestures. Normally the understanding of language and the use of language develop together. In large groups of cases it has been shown that the age at which speech developed has a high correlation with intellectual development.

In these studies the estimate of mentality is usually made by the Stanford-Binet Scale, which weighs heavily the child's knowledge of the meaning and use of abstract terms. According to this estimate, it was found that the median age of talking was 16.6 months for normal boys and 15.5 months for normal girls; whereas for the feeble-minded, the age was 35.7 months and 30 months respectively. The sex difference which many persons have found in the age of beginning to talk and in size of the early vocabularies, according to several investigations disappears by three years. Of the single tests in the Binet scale, the vocabulary test has the highest correlation with the total score. Even in a group of three-year children the correlation between a picture vocabulary test and the mental age, according to the Kuhlman-Binet, was .68. There are also many studies to show that the age of walking and talking are closely correlated and motor control has a low positive correlation with later intellectual development. These group tendencies are often misleading, however, in the individual case; it is well known that an idiot who never learns to talk, may have walked within normal limits, and the child who did not talk until he was six years old may show superior intellectual ability in high school and college.

In a number of studies it has been shown that children of different economic status differ in the extent and use of their vocabularies. There is a striking difference in this respect between children in the ordinary home and in institutions, and between children in private nursery schools and in day nurseries. The factor of inheritance rather than the difference in the breadth of experience is probably responsible, as there is a high positive correlation between the parental occupations ranked according to the intellectual demands and the intelligence of the children even in the nursery school ages.

DISORDERS OF SPEECH

Disorders of speech may be classified from the descriptive standpoint as follows: (1) delayed speech, (2) defective speech, and (3) stuttering, which includes stammering.

Delayed Speech. In a group of studies dealing with normal children the time of the observed appearance of the first word varied from the eighth to the seventeenth month. Among the standard tests for twenty-four months, we find the expectation that the child can name familiar objects and pictures, repeat words readily, ask for what he wants in simple sentences of two and three words, obey simple commands, and most important of all he is rapidly increasing the size and type of word in his vocabulary. Consequently one may say that speech is definitely delayed if the child by twenty-four months has no intelligible word (other than "mama" and "papa"). In the majority of cases of delayed speech the delay is probably due to a general mental retardation due to maldevelopment of the brain. If the child shows the characteristic attention defect of the feeble-minded, a lack of social response and the inability to imitate, training in speech will be ineffective. Another obvious but less common factor which influences the development of speech is deafness. If the child is totally deaf, the problem of detecting the sensory defect is relatively simple, but there is no way of adequately estimating partial deafness in the young child. The audiometer which is used successfully in the school requires too great concentration for most children under six years.

In addition, the problem of auditory aphasia in children has hardly been recognized. Occasionally one finds a report of a child who hears sounds but for whom words have no apparent meaning, although he adjusts intelligently to many types of situations. If recognized, these children presumably could be trained to talk as one trains the deaf child. Whether these children are otherwise normal is not clearly established. Prolonged illness during infancy may be an important factor, but the studies reported are not conclusive. In the individual case studies one often finds that emotional factors are given as cause of the delay; a negativistic mutism is occasionally produced by overstimulation; a lack of initiative or dependence on infantile means of expression may result when oversolicitous adults supply all that the child desires without effort on his part. Although delayed speech is frequently a symptom of general mental retardation, a parent should be informed of these other factors and should also realize that some children talk early and others late, without any cause as yet established.

Defective Speech. Oral inaccuracy is an ineffective method of producing sounds of speech. In 218 children between five and seven years, 49 per cent did not give the sound of "th" correctly but only 12 per cent showed marked defects of articulation. Incorrect sounds were chiefly "ch," "k," "l," "r," "s," and "sh." Although defects of speech are common in feeble-minded children, none of the children in this group was so classified and 2 received a high ranking as to mental ability. Practically none of the sounds was corrected from hearing a correct sample. Twenty-eight children were given training in speech. At the end of three weeks' training, all but 4 were able to give the sounds correctly. Surveys of school children report from 2.4 per cent to 13 per cent of the children with defects of speech. In six years of testing speech at Mt. Holyoke College, an average of 16 per cent of the class each year has been classified in the group given corrective training in speech because of difficulties, mild to severe. The girls in this group were more subject to disturbances in personality, low scholarship, and other forms of maladjustment than the girls in the group having superior speech, but there was nothing on the records at the time of college entrance in regard to difficulties of speech or personality. Corrective work in speech, however, is increasingly a part of the progressive school program and many public school systems have remedial classes.

Some children with cerebral palsy have extreme disabilities in speech. Occasionally one finds children who cannot control the tongue and lips sufficiently to make the consonant sounds; nevertheless through the modification of the vowels they can have a limited form of communication with persons familiar with the defect in pronunciation. The disorganizing defect on speech of injury in the left hemisphere is fairly well established, but the relation of hemiplegia due to birth injury or congenital defect to speech is not known. The large number of left-handed children who have defects of speech strongly suggests that there is a close relationship between handedness and disorders of speech. Certainly if an infant shows marked preference for the left hand, one should not insist on the use of the right hand. To insist that a child write with his right hand, as is the custom in some school systems, is an equally doubtful procedure.

Stuttering. Many surveys in this country and abroad show that one half of one per cent to one per cent of school children stutter, with four to six times as many boys as girls. A survey of college students shows that the child does not ordinarily outgrow the stutter. In 1,400 entering students, one per cent had a marked stutter and one per cent a mild stutter. In the history of a number of stutterers one finds such physical factors as tetany in infancy, dietary disturbances, convulsions, and habit spasms. The child may be either dull or precocious; he is usually very sensitive. In fact, it has been stated that the emotional life of stuttering children always reveals some of these defects: timidity, strong feeling of inferiority, overdependence on the parents, and feelings of inadequacy. An outstanding characteristic of the stuttering child is a keen sensitiveness to social situations. Although speech is not inherited, there is some evidence that a congenital weakness of the muscles of speech sometimes exists; but on the other hand if a member of a family stutters, the disorder is readily imitated. Often some emotional shock seems to be the precipitating cause and when the cause has been discovered, faced frankly, and explained, the stuttering disappears. Whereas stuttering is extremely difficult to cure in an adult and lapses often occur, the prognosis is considerably better in the case of a child.

The relationship of speech to the disabilities in reading which are found in various degrees of severity in a high per cent of school children is worth discussing. It is quite generally believed that in the development of speech and writing, one of the cerebral hemispheres is primarily concerned, or dominant, in the coordinations or associations made. There is an increasing amount of data to show that to avoid difficulties in reading and writing (and possibly in oral speech) one should be either left-eyed and left-handed or right-eyed and right-handed and preferably the latter, although the relation of handedness to eye dominance cannot be regarded as positively established. Difficulties appear most frequently in children who have been "changed over" in handedness or whose one-sidedness or lateral dominance has never been well established. In writing and reading (in the English language) the movement of hand and eye are dextrad, the natural movement of the right-handed person away from the center of the body. Left-handed and left-eyed children have a preference for the other direction, a preference which not infrequently is so strong that it produces the striking appearance of mirror writing. In reading they confuse the reversible letters *b* and *d*, *p* and *q*, or reverse the sequence of letters. A right-handed child may also be a mirror writer and later show the same form of disability in reading. These letter reversals and mirror words are usually so obvious they are recognized early and are readily checked by the teacher.

When lateral dominance has not been established the trouble is more insidious. There is uncertainty about the correct sequence of letters, because of conflicting tendencies of hand and eye. The difficulty in establishing the correct sequence in the visual field is sometimes associated with similar confusion in maintaining sequence of sound; it produces characteristic misreadings, difficulties in spelling, even in repetition of digits and may be one of the causes of stuttering. In a recent investigation on a large number of school children, the highest percentage of disorders of speech was found among the mixed types or "crossed sinistrads" where lateral dominance of hand and eye had not been established on the same side or had been interfered with and weakened. What the factors are which complicate and make the adjustment difficult in some cases and not in others is not clearly defined. The time when the change is made in relation to the establishment of habits of speech may be one of them; a nervous constitution which reacts unfavorably to the strain and annoyance of relearning or shifting from the use of the preferred hand, and the method employed, may be of varying importance in different children. Undoubtedly many children are "changed over" for writing and other acts of skill without any observable defect in oral speech or in reading or writing, but there is sufficient evidence that some are affected detrimentally so that one must proceed with caution, bearing all of these factors in mind.

The various devices by which one may train the nonreader to maintain correct sequence of sound and letter and establish correct visual movements, have produced marked improvement in a large number of cases, provided the child had good, but not necessarily superior, intelligence. An explanation of the disability and the assurance that it can be overcome may bring about a striking change in the emotional response. It is probable that many of the nonreaders in the past were sent to schools for the defectives. A psychological examination to make an analysis of the child's abilities and disabilities should prevent such a mistake.

Our knowledge of the development of language needs supplementing in every direction. As a basis for comparison, one needs more information on sound production and intonation of young children. What is the relation of babble to the basic sounds in the language? How does the child learn to modify his vocalizations? What constitutes the normal development of speech? Why are some children slow and some fast in learning to talk? What are the best methods of stimulating speech? How can we prevent disorders of speech? How early can we detect them and correct them should they arise?

References

1. *Twenty-Eighth Yearbook of the National Society for the Study of Education. Preschool and Parental Education.* Part II. "Research and Method." Chapter III. "Studies in Language Development." Bloomington, Ill., Public School Publishing Company, 1929. 875 p.
2. Gesell, A. *The Mental Growth of the Preschool Child.* New York, The Macmillan Company, 1926. 447 p.

3. McCarthy, D. *The Language Development of the Preschool Child.* Minneapolis, University of Minnesota Press, 1930.
4. Oates, D. "Lefthandedness in Relation to Speech Defects, Intelligence, and Achievement." [London.] *Forum of Education,* Vol. 7, 1929.
5. Orton, S. T. "Word-blindness in School Children." *Archives of Neurology and Psychiatry,* Vol. 14, 1925, p. 58.
6. Stinchfield, Sara M. *Speech Pathology with Methods in Speech Correction.* Boston, Expression Co., 1928. 266 p.

BEHAVIOR IN NORMAL CHILDREN AND ADOLESCENTS

UNDER the heading here adopted, certain aspects of behavior which develop, and certain problems of conduct and control which arise as a normal child grows from infancy to maturity, are to be considered. Only a few of the more conspicuous manifestations of development can be brought to attention and these but briefly, because of the necessary space limitations.

INFANT ACTIVITIES

Probably no other approach gives as vivid a picture of the growth and development of children as a consideration of their behavior. The activities of an infant are markedly different from those observed in childhood, although the transition is gradual, on the whole, from infancy to maturity. The period from birth to about six years of age is characterized by rapid change, great activity, and a tremendous learning. If one compares the initial squirmings and apparently unorganized movements of the newborn infant with the child of six, it will be realized that motor development and the multitude of experiences have had a powerful effect on the life of the child.

As an infant, he has learned to focus his eyes, reach for objects, hold them, coordinate and balance his body so that he can roll over, sit, creep, stand, walk, and run. He has learned to differentiate what he sees, hears, feels, and tastes, as well as to control some of the sounds he makes. During this whole progress, he has learned to respond appropriately to favorable and unfavorable stimuli in his surroundings. At birth the infant already has reflexes, which continue to increase postnatally and make possible the ability to respond appropriately. Early behavior has an important influence in shaping later conduct. Few people realize how many impressions a young baby is subjected to in even the simplest environment. He comes from an environment in which he is protected almost completely against external changes. After he is born, every element of his new environment affects him. Light, sound, and all physical contacts cause him to respond. It is the combination and sum of all these various elements that really form the stimulus to which he is responding at any given moment. The more complicated and variable this combination is, the more variable should we expect the resulting behavior to be. If one is trying to establish certain associations or habits in regard to eating or sleeping, the associations will not be clean cut or rapidly established if some elements in the surroundings are continually being changed. If the situation remains simple, one may then expect the child's behavior to become a definite response to each situation; for example, he will go to sleep when he is put into his bed after each feeding.

The development of behavior is influenced by the organization of reflexes and of motor and mental development. All of these are counterparts of each other and progress together toward forming definite new patterns. This early period is extremely important because behavior patterns persist to such an extent that the formation of later habits is easy or difficult, depending on the degree of harmony between them and the early background. The subject of training in habits is outlined in the section by that title. During the period of infancy there is a definite progress in control of function such as eating, elimination, sleeping, and so forth, all of which are taken up in detail in other reports.

DEVELOPMENT OF SOCIAL BEHAVIOR

Growth in social behavior depends upon learning methods of communication. The development of language has been discussed. From the cry of the newborn infant to the ability to understand language and gradually to use it, to understand facial expressions, gestures, and movements of those about him, making known his own needs and desires, the observable changes in behavior take place by leaps and bounds. Concomitant with the increase in control of communication is another aspect of social behavior, which is recognized as play. At first this social behavior is only an apparently casual interest, but it soon becomes active enough to cause the baby or small child to desire proximity to other children. With other children near, it is evident that he watches more and more in detail what they are doing. Eventually he begins to find himself in the midst of the other children's activities, trying to take a part. His play is clumsy, so much so that the other children are unable to understand his interference. It is at just this point that the small child, undergoing experiences both pleasant and unpleasant, develops a conception that other children have feelings, desires, and wants like his own. Feelings of fear, anger, affection, loneliness, and joy, are emotions which exert an influence on social behavior. During the early stages, the problems of physical harm, domination of one child over another with subservience as a counterpart, taking turns, sharing, and cooperating, become important as social behavior progresses. As children learn to play together, guidance by adults, whether intelligent non-interference or an explanation at just the right time, exerts one of the most important influences for the development of desirable behavior.

The first six or seven years, therefore, seem to be ones in which a child, building on the first established reflexes, acquires the foundation for later social behavior. Play, an aspect of social behavior in the child, begins to progress more and more definitely toward the development of a personal-social attitude which by this age is rather clearly outlined. The desire for independence becomes obvious and seems to be increasingly manifest along with motor control. Emotions are intricately linked up with this independence and control of conduct.

GROWTH OF INTELLIGENCE

In order to discuss conduct and control, it is well first of all to consider the growth of intelligence incidental to both. Inteliigence tests, or norms for proving the various degrees of intellectual development, have been considered in another section. Throughout the period of immaturity there is a steady, gradual increase in powers of planning, of abstract thinking, and of expression. The typical child of six years is capable of very primitive planning only, can generalize very little from what he observes about him, and has a limited vocabulary for expressing his ideas. By the time he approaches adolescence, gradual daily change has brought him to a point where he can evolve comparatively complicated plans, can generalize from one incident to another, and can understand the meanings of abstract nouns, such as kindness, charity, and justice. He can express his ideas relatively well, both orally and in writing. At the end of the teens, he can do what would be expected of the ordinary adult. The increase of intelligence is one of the fundamental factors underlying the accumulation of experience. Other considerations are the nature of environment and the simple extension of time. By living in any environment, with a growing intelligence, for sixteen or seventeen years, innumerable experiences are gained, which in themselves may also determine subsequent behavior. It will be clearly impossible to enumerate them all, but some of the more influential may be pointed out.

LEARNING REAL VERSUS UNREAL

The young child often pretends in his play. He may pretend that a stick is a horse, that a tree is a person, that a dog is a lion. He may carry this pretense even further and have imaginary playmates, and construct imaginary worlds. The young child tries by pretense to supplement his environment, or to make up for his lack of control over the events taking place therein. Habits of pretense by which he may have built for himself a very satisfactory world may sometimes persist into later childhood. Among the important distinctions which are gradually learned are differences between the real and the unreal. For instance, there are the illusions of time, space, and substance which can be overcome by experience only. One who has watched an infant grasping at the moon, or a child trying to brush shadows from a porch with a broom, will be brought to reflect upon the extent to which illusions may dominate the mind of the child. The confusion of real and unreal and the habits of pretense lead to what seem like lies and "tall stories" to the adult. Children's lies arise from many different motives, but it is always well to bear this explanation in mind. Between the early years of childhood and maturity, the child abandons his pretenses. Pretense does not often persist much beyond early adolescence, and life in the imaginary country ceases before maturity, in the course of normal development.

UNDERSTANDING KINSHIPS

Another set of facts, gradually accumulated and vital in the child's psychology, are those concerning kinships. That kinships are fixed by birth and cannot be altered is not realized by the young child. He tries to determine his kinship at will, saying to this one, "You be my sister," and to another, "You be my uncle." Grievous disappointment may result if the child is told that this is impossible. The psychology of the child in regard to kinships has not been well studied. From common observation of children it is evident, however, that kinship is an important matter to the child by the age of six at the latest, probably earlier. The accumulation of correct knowledge as to what kinships are, or how they come about, and that they are fixed, is influential in shaping conduct and in creating or solving problems of development. It might be well here to bring out the fact that the child may develop an unusual attitude toward older people as a group if his ideas of kinship in his own family are not clear. The mother cares for the child during infancy. In childhood a close bond exists between the mother and child. Such a bond may be established with the nurse, father, grandmother, or whoever has continuous care of the child. Where such care is inconsistent, or changes continually from person to person, a child may feel a very definite lack of security and an unsatisfied need in his life.

The mother-child relationship is probably the closest bond of affection in a child's life during the early years. Anything that disturbs this relationship is of deep consequence later on in life. If this bond becomes overemphasized, is exclusive of other relationships, an overemotional dependency develops. Even during these early years a certain breadth of affection will insure greater stability. Where father, sister or brother, nurse, aunt, or grandparent is gradually given certain responsibilities for the care of the child, affections will gradually be built up on an increasingly widening scale. Such a plan simplifies the adjustment which must be made when the mother goes away or the child enters school for the first time. The absence of a feeling of security from a lack of affection, overdependency of the child on anyone, the use of affection as a means of obtaining obedience, subservience, and the like, are some of the problems which may arise in the emotional development of a child, and become a definite underlying factor of emotional immaturity when the child becomes an adult.

SOCIAL ADJUSTMENTS

From the beginning of a small child's first contacts with other children in their play, he learns from many favorable and unfavorable experiences the fact that other people have thoughts and feelings. Sympathy and tact are founded on this knowledge and for this reason it is readily understood why the very young child normally lacks sympathy and tact to a marked degree, as compared with the adolescent and adult. Another item of experience which may be mentioned is learning the arrangement and customs of social groups, what occasions are to be celebrated, what is approved in manners, and so on. This experience is largely a development of the years constituting "school age." Certain problems normal to everyone arise out of this inextricable mixture of intellectual growth and accumulated experience. In the first place, all the problems of institutional adjustment may be noted. The child has to adjust his own desire to the restrictions of constituted authority, first at home, then at school and in the community. The great problem here is to learn necessary conformity to social requirements and cooperation with others, without being crushed as to initiative and normal self-assertion. As intelligence develops and experience accumulates, this adjustment to authority should become more and more a matter of appeal to reason, and less and less a matter of arbitrary command, on the part of parents and guardians. The ideal aim of education here is to bring it about that when the person has become an adult, control from external forces will be unnecessary, self-control being fully substituted for external control. This is a matter of development of good habits and control, as the child grows more capable.

SELF-SUPPORT

Problems of self-support are implicit in the developmental process. *Self-support* may be defined broadly as the power of caring for oneself. This means that self-support begins during the first year of life, so that a child of six should have achieved it in large measure. Financial self-support is not allowed in society until fourteen to eighteen years, differing with locality, and is not imposed legally until twenty-one years of age. In the meantime it is the duty of parents and teachers to require that the child attend to his own needs in so far as he may be able at any given time. Feeding himself, dressing himself, crossing the street alone, helping to choose his own clothing, and the like are here involved. Students of child development have not studied these problems of self-support in any systematic manner. Such study is now in the initial stages. If asked by a parent at what age the average child should be able to cross a given city street alone, experts could not answer. Yet this is an important question of self-support. No one knows at what age a normal child should be expected to put himself to bed, to take his bath alone, or to become responsible for his own pocket handkerchief. The evils of expecting too much and of expecting too little of the child are, perhaps, equally great. These matters can and should be determined, in order to reduce the numbers of persons who arrive at the legal age of mature responsibility full of cradle habits and of emotional dependence upon parental support of all sorts.

Vocational problems typically begin to arise at the age of puberty. The question is, what shall the child be? What work of the world shall he do? This question grows more and more complicated for the average person as we become more civilized. Differentiation of work has progressed to a stage where more than twenty thousand distinguishable occupations are listed in the census. The majority of these occupations call for more or less formal preparation, and entrance upon one of them tends to be irrevocable. How can it be determined what occupation will be suitable and possible for a given adolescent? The crude trial-and-error struggles of adolescents and their parents to find vocational adjustment are quite wasteful. The work of the world is now so complex that even an expert in vocational guidance can hardly approximate an understanding of it. Vocational guides gradually are being developed in connection with education, but it will be a long time before the vocational guidance of youth will be conducted scientifically.

SELF-ORGANIZATION

Problems of self-organization begin to appear as such in adolescent years, as a result of development and experience. The young child becomes vaguely conscious of his individuality and begins using the word *myself*. The concept of the life span gradually becomes established in young human beings. The age at which the average child comes to a realization of the fact that all must die, and that human life is limited within a rather definite span of years, varies with circumstances. Probably the average young child has few and vague ideas about the life span. This concept, with its profound influence over plans, grows in the period under discussion. Religious problems do not usually arise in childhood, because intelligence is not then sufficiently developed to formulate the questions. At about a "mental age" of thirteen years, questions as to the fate of the "ego" begin to rise and press insistently for answer. These questions are often met by the adoption of a religious faith. When religious conversion takes place, it is found to occur most frequently during the adolescent years. The primary reason for this is undoubtedly that during adolescence intelligence first becomes sufficient to formulate definite abstractions. Highly intelligent children feel these needs in earlier years, because they achieve a "mental age" of thirteen or more while they are still little children.

Personality may be thought of as depending upon an organization of various sets of habits. These habits may be considered in terms of the most important biological and social functions. At the end of the period of immaturity, each aspect of the personality, such as the religious, the philosophical, the sexual, and the vocational, incorporates its own complex of habits and ideas. In the well matured personality all these various sets of habits work together, and are organized into a single unit, harmonizing each with the requirements of the other. During the years of adolescence, one of the fundamental, persistent problems is to bring about this organization. Some may call it *finding the self*. When this has been accomplished, emotional poise and balance automatically result. Adolescent instability arises from the difficulties and conflicts which inevitably characterize every struggle toward self-organization.

PROBLEMS OF SEX

The development of the sexual drive, which grows with the maturing of the sexual organs, brings with it many problems upon which the well-being of the person depends. It is now quite generally agreed among students of human nature that the sexual life of the child begins at birth and very gradually develops with the growth of the total organism. The idea formerly held, that the little child was altogether uninfluenced by sex, and that sexual interest suddenly "dawned" at puberty, is now understood to be erroneous. Previous to puberty, the child's longings for human contact have been vague and unlocalized. His affections have been attachable to persons of either sex rather indiscriminately, as a rule. The period of puberty marks no abrupt transition, but is simply the time when the slow, antecedent development emerges and takes specific form in behavior. Special problems arise, sometimes rather acutely, particularly in the sphere of sexual behavior.

With the maturing of the sexual organs, and their power to reproduce, it is important that emotional discrimination should be well enough established for attraction to be felt toward members of the opposite sex, who are normally the most potent stimuli to sexual activity. Such emotional discrimination is called heterosexuality. To establish this attitude in a normal manner is one of the problems faced by human beings under the conditions of modern culture. In order to maintain what is usually called *the standard of living,* it is necessary for highly civilized peoples to postpone mating long beyond the age at which it becomes biologically appropriate. Thus strenuous efforts are made by parents, and others who have the duty of maintaining social order, to bring about inhibition of sexual drive in the young. This inhibition must be effective, if possible, until the young person can achieve not only self-support, but also a surplus for the support of offspring. As the standard of living rises, mating is automatically postponed to a later time. Many of the most difficult problems of normal development thus arise, about some of which no clear and certain generalizations can be offered at the present time.

A few suggestions for guidance may be attempted, however, on the basis of common observation coupled with principles of psychology. The four or five years following puberty, roughly from fourteen to twenty, are the best that the person will ever have in which to establish firmly a definite and healthy attitude of interest in the opposite sex as such. If an emotional attitude of free, wholesome contact with members of the opposite sex can be established during these crucial years, it is by far the greatest safeguard for later conduct. If it is not established then, it can hardly thereafter come to pass in a normal way, but only, if at all, by long and expensive processes of re-education, undertaken to relieve that illness and suffering which result when mind and body are out of step with one another. As an instance of psychologically inept attempts to create inhibitions in the young, the effort to force upon the boy an attitude of overidealization of womankind may be mentioned. The fiction is presented to him that women are to be thought of as nearly holy, fine, fair, and almost too delicate to touch. Added to this is the attempt to teach him that he should think of women and act toward them only in terms of mother and sister. Now this is to think and act in terms of unreality, so that a boy who becomes emotionally convinced by such teachings will find himself involved in impractical attitudes. Happy and suitable mating may be rendered permanently impossible for him. He is likely to become fatally confused in conduct. Similarly, there is the attempt to set up inhibitions in the girl by inculcating the unhealthy idea that men are dangerous, and mysteriously charged with "ruin." There is talk of "protecting oneself" and of "being protected" without clear explanation of just what calls for protection. A girl thus emotionally convinced of the sinister nature of man is forever defeated in the struggle to achieve emotional maturity and the complete use of the biologically mature organism.

'ENLIGHTENMENT'

The first principle of rational control in this phase of development is the principle of "enlightenment." For the majority of adolescents, enlightenment of the kind that comes through valid information, given by respected persons, is a prime preventive of human ills in this field, as in others. A second principle is that of habitual contact with reality. Close acquaintanceship during youth with a large number of actual persons who may be considered as potential mates is healthy, and this is one of the reasons why coeducation is more in accordance with mental hygiene than is segregated education. Youth spent in a world cut off from the presence of proper potential mates is not likely to culminate in successful mating. In English-speaking countries the consummation of sexual attraction in marriage is no longer typically an event of adolescence. The average age of marriage for both sexes lies beyond twenty-one years. It is the learning of normal attitudes toward members of the opposite sex, and the formation of wholesome acquaintanceships of all kinds, that belong under existing economic conditions to the period of immaturity.

Normal growth of emotional control has not yet begun to be established by objective, verifiable criteria, as is being done by research on the problem of *normal growth in physique* and intelligence. Little or no progress has yet been made toward setting up norms of emotional maturation. One states vaguely that a person is "emotionally immature" or "emotionally mature," but upon close questioning little can be said as to the basis on which such a statement is made. Offhand, one knows that there is a course of development of emotional control, just as there is a course of growth of the intellect, but psychologists have not charted the former as they have the latter, because emotion is more difficult to gauge quantitatively. The fact of a typical development in emotional control may be exemplified by a concrete illustration. A two year old who weeps and wails if his hat is blown off is regarded as behaving normally, and no one uses any special term in describing his actions. He is merely behaving like a baby. The six year old who does the same thing is regarded less complacently, and the special term "cry-baby" may be used to classify him. It is scarcely accurate to say merely that he behaves like a six year old. Let a nine year old now bellow in the same situation, and we are likely to use a term denoting deviation and say that the child is "spoiled." A twelve year old so acting will be designated as a "problem child," while a twenty-five year old will be called "hysterical" or "insane" if such unrestrained emotional reactions occur when his hat blows off.

WHAT IS "CHILDISH"?

Emotional control grows with the years, partly by increments of power from within, partly by habits of meeting restraint. The question is, what are the signs that one is no longer as "childish" as he was? And what are the signs that one is no longer "childish" at all? The answers to these questions cannot now be given in any form which could be generally agreed upon. Nevertheless, naïve peoples, living under conditions of savage life, have formulated certain tests which they apply in their coming-of-age ceremonies, which might be considered at least extremely suggestive as criteria. This is not the occasion for considering in exhaustive detail all these suggestions. One only will be cited here, as a sample of the possibility of seeking norms for emotional maturity. This is the test of the solitary journey; the test of ability to go alone. This test of ability to go alone has been frequently applied by savages in their public ceremonies. For instance, among the primitive Omahas, living on the plains of Nebraska, when the boy's mind "became white" (that is, could obviously comprehend and remember relatively well) he had to undertake a solitary journey, as part of the proof of manhood. For four days and nights he had to go alone, singing a prayer in lonely places.

It might be possible to elaborate this test of the solitary journey into stages appropriate to various ages from infancy to maturity. The first stage might be when the baby leaves the mother's lap to sit and play alone upon the floor. Later stages might be the first step taken without holding on to someone's hand; the first time the child enters an adjoining room in the dark alone; the first time the child sleeps away from home; the first journey without guardians to a neighboring town; the prolonged visit among unrelated persons; the journey to a foreign country, and so forth. Norms could be established to determine at what various ages these stages of the journey alone are normally appropriate to psychological progress. Under modern conditions, where these things are left to parental enterprise, almost anyone can think of persons thirty and forty years of age who are incapable of all but the initial steps in the test of the solitary journey. Their emotional dependence is still that of the child.

Many other tests in the ancient public ceremonials might well engage the attention. To maintain silence for long periods, to sit still, to endure pain quietly, to suffer heat and cold without complaining, to sit before tempting food without eating—these and many other capacities mark the adult as distinguished from the child, in the sphere of emotional maturity. Those who fail in these tests fail to be recognized as adult in the tribes employing them ceremonially.

Still other clues for determining what is to be expected at various ages in emotional control are derived from the observations of psychologists. It has been suggested that the power to remain calm under emotional stimulation or, in other words, to delay in the motor phase of emotional response, might be considered a criterion. This obviously could be scaled for various degrees. Another suggestion relates to gradation of response. The younger the child, the more normal is the all-or-none response, the sign of psychological progress being that the individual becomes more and more capable of suppressing his response in part, of keeping his emotion "within bounds," as it were.

At the end of the period of immaturity, the progress of behavior has reached a definite goal. Habits appropriate to the early years of childhood have gradually been modified and merged into others characteristic of adolescence and mature development. The normal adult is one whose behavior has successfully carried him through childhood and adolescence, from the pretense life of the little child to an independence of coddling, to an independence in controlling his emotions, and to the ability to be considerate of people's opinions. His behavior shows him to be one who has attained self-support, a heterosexual attitude, and a philosophy of life which are to stand him in good stead as he engages in the trials of maturity and old age. Throughout growth and development, if the native intelligence can pursue its course aided by normal progress in behavior, it will serve to complete a harmoniously adjusted mechanism including mind and body.

Among students of the insane the idea is constantly gaining ground that much of the mental invalidism in the world is simply persistent childish behavior. Individuals thus afflicted remain permanently irresponsible, and must live like children under the supervision of others. Thus childhood psychology is fundamentally related to psychiatry and mental hygiene. What "childishness" is must be clearly defined, and then every effort must be exerted to foster normal progress toward maturity in behavior in all its phases. Further study is needed in every phase of this subject.

TRAINING IN HABITS

DISCUSSION of the rôle which habit plays in the health of childhood involves a large acreage of departmental knowledge. The mechanisms of the formation of habit, what habits children can be expected to achieve, and what constitutes desirable behavior toward which habits should be directed, are aspects of the subject that demonstrate its complexity; not to mention the wealth of ethical concepts associated with the word *habit*. Section III of the White House Conference, Education and Training, has the bulk of this contribution to make in its discussion of Parent Education, The Infant and Preschool Child, and The School Child; Section IV of the Conference has a large and important contribution in The Training of the Handicapped. The present discussion will be confined to the rôle that habit plays in the mental health of childhood. An attempt will be made to deal with the subject of habit as the physician, whether general practitioner, pediatrician, or public health officer, needs to consider it.

The formation of habits is recognized very early in the life of an individual. The persistence of habit has a profound influence upon the growth and development of a child, yet the habits of an individual are relatively unamenable to any standardization or measurement. They constitute a most variable and uncertain element in the appraisal of growth and development, as compared with such measurements of physical endowment and growth as are evaluated by weight, height, and hemoglobin content of the blood. Even intellectual equipment is more amenable to criteria of measurement when forms of intelligence tests, and various estimates of ability which psychologists have provided, are used. Nevertheless habits are among the important fundamental considerations in the growth and development of a human being, and have almost unlimited possibilities in influencing behavior. Science and popular thought have passed through a long period of conviction that the greater part of man's behavior, both physical and mental, was due to this equipment of inheritance. It was only when science abandoned the methods of philosophy, and began to deduce theories as a result of experimental observation, that progress in the study of behavior was made. As a result of about fifty years of such procedure, more and more evidence is being produced to show that the extent to which man can be influenced by training is tremendous, and that behavior is primarily dependent upon the results of early environment, inclusive of education and social contacts.

The human being in action is such a finely integrated mechanism that it is impossible to study his functioning in separate divisions of mind and body. It is with the behavior of the organism as a whole that we must work in any sphere of departmental knowledge. We have learned that the purely intellectual processes are but servants of the energies and impulses invariably found at the springs of human action, and that the possibilities of training in habits during the growth and development of children as yet have hardly been realized.

Normal habits may well be thought of as the cementing substance which holds in structural form the equipment of intellect and personality, muscular and nervous coordination, and wholesome physiological functioning of every detail of bodily organization. Without their harmonizing influences even genius becomes a behavioristic caricature. Parents, teachers, and physicians long have recognized their importance in the hygiene of the body and in the educational preparation of the child and adolescent to meet the exacting requirements of business, professional, and industrial activities. But we have not as yet come to appreciate the great educational rôle of habit as a preparation for adjusting ourselves to the job of living. Achievement of a well balanced life is not the simple matter which former generations believed it to be when they divided an individual neatly into mind and body. Mind is obviously something more than the expression of one's intellectual faculties. Mind is the being in action. This action is started by a wealth of factors about which we are just beginning to learn a few things.

INHERITED VERSUS ACQUIRED TENDENCIES

In studying the determinants of human behavior, we find that they can be grouped together roughly under two headings: determinants associated with ingrained, inborn, or inherited tendencies, and determinants which have to do with learned or acquired characteristics developing from environmental influences and cultivated through training. It would be simple if we could make the distinction between native and acquired equipment by such observations as those which indicate that the color of the eyes is an inborn characteristic, and calluses on the hands are acquired characteristics. A good deal of evidence has been collected which indicates that certain factors fundamental to intelligence are largely hereditary. At least it seems that the relative level of ability which a child shows in these lines early in life is maintained throughout his development. Education and practice will improve the performance of an individual on any test, but will never make a feeble-minded boy normal, or create genius from mediocrity. Behavior, on the other hand, seems to be much more extensively determined by training and early experiences. Even if we cannot completely overcome or prevent certain pathological extremes of behavior which rather clearly have a hereditary basis, we can at least be certain that environmental influences are of the utmost importance in determining the future course of conduct. Nature may have the upper hand in determining an individual's potentialities, but training and habit primarily determine his everyday conduct and the use to which he will put his potentialities. Biologists and psychologists have discussed and roughly classified for us the native equipment of the newborn infant, with reference to the fundamentals of organic function, motion, and sensation, together with their regulating mechanisms provided in the lower nerve centers of the spinal cord and brain stem.

When considering inherited tendencies, it is important to keep in mind the highly developed reflexes present at birth, and the behavior which results. Hand in hand with these inborn tendencies are such behavior or reactions as are concerned with the getting and managing of food (sucking, chewing, and so forth) and the reactions having to do with the resistance to unfavorable stimuli (squirming, coughing, sneezing, and the like). In addition to this group of natural reactions, which are evident in behavior, there are the conscious states called emotions, which are fully as important. Fear, anger, pleasure, lie ready-made in the infant and constitute powerful impulses to early activity. Every impulse carries with it some emotion, and this combination furnishes the only motive force of much consequence to the individual and society. "Instincts" and emotions of fear, anger, sadness, pleasure, with their counterparts of hatred, jealousy, sensitiveness, pessimism, self-pity, and longings and cravings of which we may not even be aware, constitute by far the most powerful drives of our behavior as individuals and our behavior as crowds and groups. Moreover, it has been shown that these "instincts" and emotions are intimately associated with every physiological system in the body. Under the influence of sadness and depression the heart beats slower, and the blood pressure falls, just as under the influence of anxiety and excitement the heart beats faster, the breathing is more rapid, and the sweat glands are more active.

TEACHING AN INFANT GOOD HABITS

Determinants having to do with learned or acquired characteristics develop from environment and are cultivated through training. The "instinctive" equipment must be recognized as an adequate and organized material for training from birth. A good start in the formation of habits is just as essential to the adaptive equipment of infancy as are clean birth and good nutrition. The first part of the native equipment of the newborn infant to be put into use is his respiratory outfit. As soon as he can breathe he can cry. For the first few days this cry is a response to a new environment. If the cry of an infant were nothing but this, one could always expect to find him motivated by the changes in his physical surroundings such as wetness, changes in temperature, and so forth. But often within the first week of life the mother or nurse realizes that the cry is no longer always motivated by these physical surroundings, but has become associated with other factors of the environment and is obviously an expression of a desire for something else: to be held, walked with, rocked, or fondled. It is a demand for attention. Some may call this an "instinct of self-assertion," "ego drive," manifesting its presence in no uncertain terms even before the infant can raise its head or turn over. If, having made certain that the baby is not hungry, wet, or in pain, the nurse or mother puts him back into a comfortable bed, it will not be long before crying is given up as a means of getting attention. Such treatment for this behavior acts as a definite stimulus to which the baby responds. The repeated stimulus in the form of the same treatment produces the same response. Habit is then developed. In this case it is a desirable habit.

If, on the other hand, the child were pacified each time he cried, by rocking, patting, or tossing him up and down, the result would be different. The child, subjected to inconsistent treatment, would develop an erratic behavior. Time would eventually prove that such treatment, satisfying a baby's momentary demands, is the foundation of bad habits. Unbridled emotional response develops along with erratic behavior because he has learned to attain his ends by such outbursts. If this kind of treatment is continued, a child at three years of age will inevitably be subject to an accumulation of faulty habits, such as eating all the time, having no daily naps, refusing to go to bed without father or mother, insisting upon sleeping in the bed or in the room with his parents, or crying in the night to be taken into the parent's bed. The behavior during the day time will bear the earmarks of the same self-assertion and will extend disastrously into every other field of childish activity. There may be tears and kicking when the slightest wish is denied, and fighting and screaming with playmates who have their own ideas as to what they want to do. By five years of age such a child would seem more fit for reform school than kindergarten.

By this time a young individual who is thoroughly unequipped to get along with other people may be thrust into an environment where he cannot make good unless he can get along with other people. His intellectual capabilities may be supernormal, his physical assets may receive a similar rating, provided his native physical equipment was hardy enough to survive the hygienic abuses to which it has been subjected, but all of his impulsive and emotional reactions are unorganized. The self-assertion, initiative, and sturdy energy associated with an excellent intellectual endowment will have been trained to only one form of expression. His ideas of social responsibility are contained in but one concept: "What I want and what I like, that I must and will have."

The fact is again emphasized that whether a baby or a child is guided or not, habits develop. The environment acting upon the child, whatever his complex make-up happens to be, will determine largely what sort of habits are formed. In the environment to which he is accustomed a child may become blocked emotionally when an attempt is made to establish good habits, for the simple reason that a fortuitous set of habits has been permitted to develop. Such a condition of affairs occurs in the neglected child whose habits are a jumble of activities expressed outwardly in aimless behavior and a continuous emotional instability. Affluent families have such children in their midst quite as often as poor families. In the former the child spends most of his waking hours with well paid attendants whose training in the care of babies and children is largely concerned with accomplishing a daily routine. As yet there is no training given for an intelligent guidance of children into good habits through ordinary routine and play. The attendant, or even the mother, who understands such fundamental needs of growth and development as are expressed by happiness, an even disposition, and an active curiosity about everything that takes place, is extremely rare.

The infant growing into childhood must be guided in useful choices and patterns of control. Long before these choices and methods of control become the subject of reasoning, the young child can be given an excellent start in wholesome forms of behavior by those who supervise his life situations when he is still a subject chiefly for the observation of biological activities. As has been outlined, it is known empirically that an acquired mode of behavior becomes habitual by repetition, and the more frequent it is repeated the stronger becomes the habit. Extensive as is the native equipment of man, with its manifold sensations and movements and emotions and interests, it would make a very small showing in an inventory of the whole equipment of the adult. Seldom, except in the internal workings of the body, does one perform a purely "instinctive" act. Previous learning usually gives a modified form of behavior. One acts as one has learned to act. Interests are activities which one has learned to enjoy; and dislikes concern those things which one has been taught to dislike. Yet it would be a great mistake to suppose that the adult has lost his native equipment and has built up for himself an entirely new outfit by means of which he carries on all his rational activities as an adult. The native equipment, or most of it, remains in use and is built up into the more complex and specialized mechanisms of activity which have been learned.

WHO IS RESPONSIBLE FOR HABIT TRAINING?

This process of building up the native equipment of response or behavior of an individual is not so simple as many people would lead one to believe. Apparently it is to be supposed that this job is the exclusive province of systematized education, and that somehow or other the science of pedagogy should have a monopoly of the technique of molding the behavior of childhood. "I'm waiting until he goes to school to see what that does for him," is the common remark of mothers whose children are untractable for any reason. The general practitioner and the pediatrician, when consulted about difficulties of behavior of young children, were formerly wont to reply; "Don't worry about that; wait until he goes to school and he'll outgrow it." Many physicians, with all their concern for public health and child welfare, seem to have neither time, patience, nor interest to inquire into the aspects of mental hygiene in the practice of medicine and discover for themselves what results an intelligent management of the situation will bring forth.

In the medical treatment of adults the effect of family strains and domestic relationships is considered, but in the treatment of children one is likely to feel that their mental health is the business of the father, mother, and teachers. There is no instinctive preparation for parenthood. The day is past when intelligent people believe that the production of offspring is invariably accompanied by wisdom concerning the development and training of that offspring. Provision for adequate education of children in their homes involves a thorough evaluation of the mental health of the parents who make these homes. Children copy at least as much as they inherit in the matter of responses of habit. The child who is brought up on the parental dictum, "Do as I say," is quite likely to be found doing as the parents do.

On the other hand, there are parents whose one aim is to train the child to good habits, and who do such a perfect job that the child becomes overhabituated. The child responds to routine, does always what is expected of him, and is perfectly obedient. If the child is observed closely, his health may seem to be robust but he will lack the "spark" and carefree, joyful, childish manner. Habits forced upon him by keeping him in a set routine for years rob him of the chance to be spontaneous. He becomes a machine, and more closely resembles the institutional child. Obedience has been secured but his set of habits has guided him into a routine apart from his own life. The habits were formed to obtain obedience to others. He thus does not become an independent individual, absorbing experience, learning by mistakes and success to judge and think for himself. The road of progress toward constructive living was not open to him.

A child's adjustment to the period of school should also be a matter of interest to the physician. The failure of formal education to adapt its training to the needs of individual children is one of the commonest factors in the nervous instabilities of childhood, and educational mismanagement occurs in even the best of private schools. Physicians are apt to look with the suspicion of ignorance upon material coming from the fields of psychology and psychiatry and are blind to, or unwilling to see, its great application to the needs of the medical profession. Habit clinics (such as Massachusetts has established in the Mental Hygiene Division of its Department of Mental Disease), nursery schools, and child welfare research stations are all discovering and treating factors of vital importance to the mental health of generations to come. The rank and file of the medical profession are completely oblivious to the productions of these great laboratories of child health. Hygiene, as the science of health, must concern itself with every factor contributing to the growth, development, and personal welfare of a human being. These factors take the physician into the home, with its economic strains, its social strivings, its harmonies and disharmonies of parental relationship; they take him into the neighborhood with its opportunities for recreation and social contacts; they bring the intimacies of family life into his office. Surely here are matters which medical science must take into consideration and evaluate if it is to minister intelligently to the health of childhood.

The origin and the proper handling of these "instinctive" and emotional endowments have been, and still are, the subject of a great deal of psychological study and discussion, from which have come facts of vital importance to the welfare of childhood. The mental health of childhood should be the active concern and intelligent interest of parent, physician, teacher, psychologist, clergyman, psychiatrist, social worker, public health nurse, and every other constructive force of social organization that comes in contact with the welfare of children. If these people are to be interested, they must be guided by a well trained medical profession.

How shall the training of psychiatrically intelligent internists, pediatricians, obstetricians, gynecologists, orthopedists, and so on be accomplished? The safest guide in approaching the mental health of childhood is a good general background in the field of medicine, which includes training and a practical working knowledge of the integrated mental and physical functioning of a normal human being. The student would be greatly aided if every medical school would place psychiatry on exactly the same basis in the curriculum as physiology and internal medicine. Rotating hospital services should include periods of resident training in psychopathic wards and in psychiatric dispensaries. Medical schools should also teach the future pediatrician to awaken in the parents of his small patients a realization of the importance of training in habits. Under his guidance parents could learn to be consistent in maintaining the good habits acquired in the wholesome routine which the pediatrician established during infancy. The physician with such a background of training in medical school and hospital would then be equipped not only to treat the health of the child as a whole with a feeling of reasonable security, but he would also be able to utilize and correlate a wealth of helpful contributions from the broad fields of education, psychology, sociology, and psychiatry.

PARENTAL EDUCATION FOR THE TRAINING OF CHILDREN

IN the training of a child the task is probably not so much one of the parents' managing the child as of their being in a position to evaluate factors in the environment which influence the child's growth and development. Oftentimes the failure of parents, and of the physician as well, to recognize the importance of the child's personal relations to his environment, and the ill effects these relations may have upon the future welfare of the child, is due to the fact that the attention has been too closely focused upon symptoms and resulting incapacities, and the child himself has been excluded from the picture. The physician will often find the answer to what appears to be a baffling medical situation if he thinks of the child as an individual struggling to make an adjustment between his own instinctive strivings and the limitations set up by the family and society.

THE PHYSICIAN'S RESPONSIBILITY

If the physician is to fulfil wisely and well the function of guiding the child, he must be concerned not only with the child's physical well-being but with his intellectual equipment, his emotional stability, and the degree of completeness and satisfaction with which the child as an individual is meeting the demands of his environment. If he fails to do this, he will be unable to cope with the varied problems continually arising as the child grows up. He will fail to recognize the psychological basis in many cases in which the symptoms are obviously of a physical nature.

In the past twenty years the physician has been held more rigidly accountable, not only to his patient but to the public in general, for the welfare of the individual and the community. The public is no longer satisfied with a diagnosis at the terminal stage of a chronic disease; it is demanding that incipient symptoms be recognized and that adequate measures for treatment be instituted early. These demands, whether or not they are consciously recognized by either the community or the medical profession, are the real force behind preventive medicine. It is essential that the physician who is to be held responsible for the growth and development of the child keep in mind that this immature human organism is affected directly and indirectly by many environmental situations which frequently pass unobserved by the parents. He must remember that as a physician he not only stands in a position where he can recognize situations, relationships, and conditions as being both harmful and incapacitating, but also by virtue of his relation to the family he is already endowed with authority which makes him the logical person to educate and influence the parents to meet their problems with reason and judgment rather than emotion. Malnutrition, rickets, and focal infections do not help to lay a sound foundation for good physical health. An oversolicitous mother, a stern, rigid, uncompromising father, or an interfering, dominating grandmother does not contribute to the emotional stability and the ultimate mental health of the child.

In dealing with a child whose mother complains that "he fatigues so easily," one may discover that the most important element producing fatigue is a highly neurotic, unstable, nagging, overaffectionate mother. Sleeplessness, terrifying dreams, and subsequent fatigue, in another situation, may be due to the child's being overstimulated just before retiring. *Jack the Giant Killer* or *Jack and the Beanstalk* may be altogether too realistic for a child with a vivid imagination.

Anorexia and subsequent loss of weight may bear very little relation to any physiological disturbance of the gastrointestinal tract. This is particularly true if the mother is oversolicitous and firmly convinced that the welfare of her child depends upon his eating a certain number of calories of a particular kind of food at exactly the same time each day.

Enuresis may continue over a long period of time and defy ordinary methods of treatment if one overlooks the fact that it may be the one means that the child has of gaining the mother's attention after the birth of another child. Here it should be stressed more openly that the child in himself may be all right, and the mother's attention should be directed to the fact that unconsciously she has been neglecting her older child. Above all, the child's attention should not be drawn to the enuresis.

Physicians are well aware that illness and accidents are often followed by marked changes of personality in children, yet comparatively little is done by the physician to enlighten the parents on the part that is played by environment in developing undesirable traits of personality during a prolonged illness, and how they may be avoided. Without minimizing the effect which illness itself has upon one's feeling toward life, the fact cannot be overlooked that oversolicitude of the parents is an important factor in producing the undesirable traits of personality as well as undesirable mental attitudes toward life. Too often these are attributed to the illness itself. The child's entire relation to the parents and to other children is radically changed. He finds himself occupying a place of undue importance in the life of the family. It is not surprising that he relinquishes with much reluctance the position which he has been permitted to attain.

In dealing with so-called *unstable children,* those who are extremely sensitive to all internal stimuli as well as to environment, and who are subject from time to time to varied types of acute manifestations (asthmatic attacks, convulsions, mannerisms, night terror, and other fears), one must always keep in mind that these attacks may be precipitated by an emotional situation between parent and child. It is not uncommon to find young children capitalizing the allowances made for them by oversolicitous parents and utilizing their peculiarities to attain special privileges or avoid responsibilities.

On the other hand, there are cases in which the parents neglect to supervise the habits and health of their children. These parents permit the children to eat as and what they choose, and to have all the sweets they want. They even take small babies to "movies." Many parents who have nurses to take charge of their children may not set aside time to impress upon the children their love and interest in their activities, thoughts, and ideas. The effects of this neglect are as profound, subtle, and permanent as the effects of oversolicitude and domination.

PARENT AND PHYSICIAN SHOULD COOPERATE

The foregoing examples are perhaps sufficient to make it clear that it is highly important for parent and physician to work closely and harmoniously together in helping the child to avoid the shoals upon which so many personalities have been wrecked. The satisfactory integration of the child's personality depends upon an intelligent and harmonious relationship among the members of the family in the home. Cooperative effort between physician and parent is valuable in maintaining this relationship at all times. Each must contribute from his particular position and special knowledge that which will be most constructive in the growth and development of the child.

From the physician's point of view, parental education and child training are not concerned with handing out dogmatic techniques to meet particular situations, but are directed to the task of helping the parent place the child and the problem in proper perspective. All too frequently the child is entirely obscured by the problem. This leads inevitably to treating the symptoms and ignoring the cause. Under such conditions the treatment is dispensed hurriedly and emotionally, and is often lacking in the intelligence that comes from careful premeditation. Frequently the physician will find it necessary to look outside of the home in order to understand some situation which defies the ordinary therapeutic measures applied on a physiological level. Exploration into the life of the child at school and on the playground, his relationship with the gang, with individual companions, and with relatives, and into all other personal contacts will invariably bear fruit, and the time spent in an effort to interpret the child's behavior in terms of his past experiences will be worth while.

Such investigations are desirable in all cases in which growth and development show evidence of retardation or in which there is a tendency to deviate from the normal, either physically or mentally. Many of the most obvious and harmful relationships may pass by quite unobserved even by parents who are well endowed with intelligence. This, of course, is owing to the fact that often their own emotions are directly involved with the child's maladjustment. In such a case it is necessary for the parents to meet their own conflicts, which they may have been avoiding for years. When such parental conflicts exist it will not be sufficient simply to inform the parents that their planning for the child is faulty and inadequate. The parents must be shown why they react as they do to the child and his difficulties. It may be that they have refused to admit that a problem exists, or they may admit the existence of the situation but deny that it is a problem. Perhaps, and this is even more common, the parental reaction to the child's problem is one of undue concern. It is here that the physician can treat the child wisely and well by considering the parent as well as the child.

Parental education might be looked upon as a branch of preventive medicine. Parental training should be utilized not so much in treating specific problems as in helping to establish a happy, healthy relation of parent to child, which will tend toward the development of such habits, patterns of conduct, and mental attitudes in the life of the child that he will attain independence and normal control of his own emotions and habits.

References

1. Thom, Douglas A. *Habit Training for Children.* New York, The National Committee for Mental Hygiene, 1924. (This is a series of nine leaflets dealing with the practical management of common wholesome habit formation.)
2. Child Study Association of America. *Habits—What Are They?* New York, Child Study Association of America, 1930.
3. Fillmore, Eva. *Habit Formulation in the Preschool Child.* Iowa City, Iowa Child Welfare Research Station. n.d.
4. Thom, Douglas A. *Child Management.* Washington, U. S. Children's Bureau Publication No. 143, 1928.

MEDICAL ATTITUDES TOWARD THE SEXUAL EDUCATION OF CHILDREN

THERE is probably no force or energy in human beings which gives parents, teachers, physicians, social workers, and society in general so much concern and perplexity as the activities arising from sexual instincts and urges. These activities are usually thought of as conduct to be judged, rather than as behavior to be interpreted. In the animal world the sexual instinct is known as a great biological force, next in importance to self-preservation in the activities of animals. In the lower forms of animal life the instinct is seen only in its primitive rôle of preservation of the race; in the higher forms, it is seen expanding to desire for mating and the maternal instinct. It is in human beings that one sees the inclusive possibilities of the sexual instinct. In more civilized races the ultimate object of reproduction becomes more and more disguised; it appears vague and inchoate beneath mother-son and father-daughter monopolies; and masquerades in the guise of devotion to dress and personal appearance, gallantry, the desire for conquest and supremacy, and in many other characteristics of everyday life for which society has need.

It is to the physician that parents naturally turn for guidance in the wise management of this great biological and psycho-biological energy of childhood and adolescence. Unfortunately the average medical mind has taken little interest in the rôle which sexual life plays in the growth and development of a human being. The physician has joined with others in smoothing over this whole topic with a certain amount of embarrassed repression, and in treating in a more or less mechanical manner concrete issues that arise in the form of auto-erotism (masturbation), illegitimacy, promiscuity, and many other sexual conflicts. Consequently, parents and teachers have been obliged to go to psychology, psychiatry, and research in the study of children for aid in understanding a sphere of behavior which may give rise to poor health. Material from these sources is often ridiculed and condemned without study or consideration of what can be offered in its place. The average physician is apt to treat symptoms and not causes of symptoms. In no sphere of his activity is this principle better illustrated than in his attitude toward the sexual life of his patients.

CHILDREN'S CURIOSITY ABOUT SEX

Here is a form of energy that exists from infancy throughout life, expressing itself in complexities of behavior that are as natural as the expression of any other instinct. What are some of the common issues of the sexual life of the human organism as it grows and develops from infancy? Curiosity precipitates many such issues during the early years. Interest in the body of himself and others in the nursery is an early and common expression of curiosity in the child. The possibilities of bending the legs and putting the toes in the mouth, and the mystery of fitting foot to stocking and shoe to foot are regarded as evidences of intelligence and acumen, but when a little girl expresses curiosity as to the difference in the method of voiding between herself and her baby brother, often one is aghast at the inquiry and begins to instill lessons of sexlessness. Many children are early confronted with the situation of new brothers and sisters. Where do they come from? Too often an attempt is made to satisfy this natural curiosity by the well known fairy tales. The child feels that he has made a fool of himself and has not been taken seriously. He senses the fact that he has been deceived, and often the first link in the relation of confidence between parent and child is broken, never to be repaired. To frown on these early curiosities does not stop them, but piles up trouble for parent and child later on. The child should be given a simple, direct answer to each question as it arises, one that will keep his confidence and may be expanded from time to time, but need never be retracted. The more the biological aspects of life are taken naturally and without embarrassment by parents, nurse, and teacher, the less likely is the child to grow up with distorted ideas about these matters.

THE PHYSICIAN'S OPPORTUNITY

The family physician, more than any other member of society, has a chance to lead parent education sanely in problems of this sort. To do so he must extend the boundaries of his thoughtfulness and interest through reading and study, combined with time and patience in investigating the behavior life of his patients. Boys and girls are brought to him who, out of a quiet existence, have suddenly behaved in a manner which shocks their parents. On a visit to playmates the child has been found participating in episodes of mutual exposure, masturbation, or peeping. The parents are sure that he has been taught this by his playmates. Here is the physician's chance. He should treat the situation with intelligence and sympathy. He should find out what has led up to such behavior. The next step is to calm the parents and give them courage to face realities. Very frequently this overflow of energy is associated with insufficient outlets in the way of play and recreation. Naps prolonged to six or seven years of age often give the child too much time he does not need for rest, and furnish unhealthy opportunities for day-dreaming. This day-dreaming is often accompanied by the discovery that certain manipulations of hands and thighs upon the genitalia produce pleasurable sensations.

In common with the rest of the grown-up world, many physicians have been horrified by masturbation. The child's hands have been tied, and often he has been placed in a steel frame to sleep. Children and parents have been told that the practice will cause the body to deteriorate, and in all probability will result in feeble-mindedness or insanity. There are absolutely no scientific facts to support such statements. It is true that auto-erotism is openly practiced by individuals unbalanced enough to require institutional care. But these same individuals are also seen spitting on the floor, taking off their clothes in public, and eating with their fingers. Such behavior is interpreted as a symptom of the unbalance, not as a cause. In exactly the same way autoerotism is a symptom, not a cause, and as such must be treated intelligently. To worry a young child by scolding and watching him every minute is poor policy, and may serve merely to associate the activity with a wealth of fears that he carries with him through life.

Parents should be made to realize that the practice is very common, and is by no means fatal to the child's future mental and physical development. Treatment must be directed toward diverting this energy into proper outlets of play and other interests. Games and toys should be suited to the child's developmental progress. It is a poor policy for any child always to play alone, even with the best equipped playroom or yard. He needs somebody to talk to, to compete with, to enter into his imaginative fancies. It is on solitude that auto-erotism thrives. See that the child goes to bed thoroughly tired from happy play. When he wakes in the morning let him get up and play in his nursery until someone is ready to help him dress. In other words, reduce as far as possible opportunities for the continuance of the practice, but avoid associating it with fear, shame, or sense of guilt, If attention is not focused on the habit, other activities and interests will compete successfully with it and it will be abandoned as the child grows older.

There is another aspect of the early appearance of the sexual instinct, and that is the objects which the child loves. He first learns affection, or strong attraction with pleasurable sensations, for his parents. It is rare for a child to be equally fond of both parents. The boy may be attached to the mother, and the girl to the father. To the one parent each goes for sympathy and comfort. These attachments of child to parent are not insignificant things. They are often unconscious ideals that follow on through life, and the husband or wife chosen is often the prototype of the father or mother, to be judged by the parental standard, possibly with resulting sorrow and disappointment. And after marriage there may be so strong a pull between the old home and the new, the first attachment and the second, that the young woman or man is well nigh wrecked in a matrimonial career.

From the parents, the child's affection radiates to other objects of love: brother and sister, pets, servants, or playmates. The love may remain fixed or fluctuate, according to the child's temperament and the response of the object loved. With love are associated the corresponding characteristics of hate and jealousy, springing up on interference with the child's affections. The child's problems must be given serious attention, and not be treated as a source of amusement in the family. It is important that the parents should not unwittingly foster these attachments by pouring out complaints or criticizing and nagging each other. Such situations give the child a chance to side with one parent against the other. Interparental loyalty cannot be too carefully cultivated.

Time and patience spent in giving a child intelligent guidance in his biological life are an invaluable preparation for puberty. Coincident with the maturing of the gonads, a variety of impulses and emotional urges arises, concerned with interest in personal appearance, in companionship with the opposite sex, and in the stimulation of excitements. The parents and the family physician feel that the time has arrived for enlightening the boy or girl about "the mysteries of life." By the time they have braced themselves for an embarrassed revelation, the adolescent has usually acquired, and sometimes experienced, the equivalent of a graduate course in sexual activities.

The period from puberty to twenty years of age is apt to be one of floundering in petting, crushes, random promiscuity, and elopements. Obstetrical services, clinics for venereal disease, juvenile courts, and correctional institutions for delinquents bear witness to the number of adolescents passing through their channels. Physicians work energetically in these places attempting to stem the tide of human needs as it rises daily, but are likely to give little time and thought to the mismanaged childhood preceding the adolescence, and still less thought to the social implications of the adolescent sexual life. Again, the real therapeutic objective is finding ways and means of directing this great dynamo of energy. Logically the guidance of these great issues of social health belongs in the hands of the medical profession, but it will be placed there only when physicians expend time and thought on the psychological and social implications of sexual problems.

References

1. Blatz, William E., and Bolt, Helen. "Sex Training." *Parents and the Preschool Child.* New York, William Morrow & Co., Inc., 1929. (Chapter VII.)
2. Emery, E. Van Norman. *Revising Our Attitude Toward Sex.* New York, The National Committee for Mental Hygiene. Reprint No. 223.
3. Thom, Douglas A. "Sex Instruction." *Child Management.* Washington, D. C., U. S. Children's Bureau Publication No. 143, 1928, pp. 29–33.

EDUCATION AND MENTAL DEVELOPMENT

THE chief problem of this section is the question of how far children's mental development may be influenced by their education, both formal and informal; and how far, on the other hand, their mental development is limited by their inborn characteristics. This question is a highly controversial one. Opinions of competent students of the subject range all the way from belief that the child's mental development is entirely determined by inheritance, and will neither suffer from educational neglect nor profit by unusual educational opportunities, to the belief that all normal children are alike by nature and that the differences between adults are wholly due to education. This wide contrast in opinion would be incomprehensible if it were not for the ambiguous character of most of the evidence on the question. All but a very few of the studies of the relation of environmental influences to mental development are open to a double interpretation. It is common therefore for scientists to draw opposite conclusions from the same study according to their several predilections. The relation between heredity and environment is considered at length in the section on "Heredity."

The types of evidence or of scientific studies can be described only very briefly. One method of attacking the problem is to study the biographies of eminent persons. The most elaborate biographical study is the one by Cox,[1] dealing with 282 geniuses. There are three kinds of facts relating to the lives of eminent persons which may have a bearing on the cause of their superiority. These facts concern, first, their heredity as indicated by the character of their ancestors; second, their early educational and cultural advantages, and third, evidences of superior endowment as indicated by rapid learning and unusual attainments during childhood. The indications of such facts are usually so interrelated as to leave their interpretation entirely ambiguous. This interrelation may be brought out by an analysis of the ways in which heredity, early education, and superior childhood attainment may bear on the problem.

SUPERIOR ANCESTORS VERSUS SUPERIOR ADVANTAGES

Consider, first, the individual who possesses superior ancestors, is given unusual early training, and exhibits exceptional mental powers as a child. Such a case is illustrated in the lives of John Stuart Mill and Francis Galton. Neither the early nor the later attainments of such men can with any assurance be ascribed to either native endowment or to superior education, since these two factors are both present. Either, or both together, might account for the result.

Consider now the opposite type of case in which there is no evidence of superior heredity, of superior early education, or of superior endowment exhibiting itself in early attainments. Abraham Lincoln seems to exemplify this conjunction of factors. If the cases of Mill and Galton embarrass us by too rich a set of explanatory factors, the case of Lincoln embarrasses us by not exhibiting any adequate explanation of his greatness. Perhaps it was due to some obscure hereditary strain, or, in part, to circumstances of his early life which have not been recorded.

Certain men impressed their associates during childhood by their intellectual superiority, and were given encouragement, but no striking superiority is to be discovered in the near ancestry. Daniel Webster was such a man. He seemed to be inherently superior, for though he had early advantages, these appeared to be given in response to the call of powers demanding expression and fulfilment.

What shall we say of Benjamin Franklin, who was superior as a child but possessed neither superior ancestors nor favorable advantages; or of Charles Darwin, who had superior ancestors but ordinary education and showed no special powers as a boy? The study of biography evidently reveals such various combinations of factors and such contradictory types of cases that it is of little value as a means of estimating the effectiveness of education and environment in furthering the child's mental development.

The cases in which special care has been taken to accelerate the early mental development of children by unusual methods of education deserve attention. John Stuart Mill belongs in this class. He began Greek at three, read Plato at seven, and studied higher mathematics at nine. He attributes his scholarly achievements to his early training rather than to superior endowment, but this opinion cannot be given great weight. Another renowned scholar whose precocious mental development was attributed to very special early education was Karl Witte.[2] Witte received the degree of doctor of philosophy at the University of Leipsic at the age of thirteen. He taught law at the University of Berlin, became a renowned Dante scholar, and lived to the age of eighty-three. Other historical examples are William Thomson (Lord Kelvin) and his brother James Thomson. It appears probable that the training these men, and others like them, received in early childhood had some influence on their attainments, but it is also probable that they were favored by superior heredity. It is reasonable, however, to believe that special training may have had some influence on the degree of superiority, and to conclude that it would be desirable to give children in general a more stimulating intellectual environment than commonly surrounds them. Before enlarging on this conclusion, we may turn to other lines of evidence.

We have been considering children who have had educational advantages far above the ordinary. The effect of unusually meager education may also indicate how far intelligence is affected by environment. A number of cases have been reported of children who lacked the usual advantages of schooling and home surroundings characteristic of contemporary civilized countries. For example, Terman in *The Measurement of Intelligence*[3] describes a girl called Gypsy Mary who had been stolen by the gypsies at four years of age, had lived with them continuously with no schooling until the age of sixteen, and yet had an I. Q. of 100 on an intelligence test. Other individual children with very meager advantages have been found to test even higher. Individual cases such as these show that the child's level of intelligence is not wholly dependent on his schooling or environment, but they do not prove that it is wholly or even mainly independent of them. We do not know what these children would have been like if they had had superior or even average advantages. For more conclusive evidence we must study large groups of children or note the effect on individual children of radical changes in their surroundings.

EVIDENCE FROM STUDIES OF TWINS AND SIBLINGS

Another type of evidence is found in the facts of familial resemblance in mental abilities. The method is to find the correlation between the abilities of parents and children, of brothers and sisters, or of more remote relatives. One mode of interpretation has been to compare the correlation in mental abilities with the correlation in physical traits, on the assumption that the latter is to be ascribed to overlapping in heredity. A relationship of special interest is that of twins, identical or monozygotic twins on the one hand, and fraternal or dizygotic twins on the other hand. While rather intricate, involving the association between the factors of heredity and environment, these comparisons yield some evidence on the problem. The bearing of the facts of familial resemblance on the problem is this: the resemblance between parents and children or between brothers and sisters may be due to the fact that they have in part the same inheritance or to this fact plus the fact that they live in the same general environment.

One method of analyzing familial resemblances is to compare the resemblance of siblings (brothers and sisters) who are brought up together in an orphanage, with siblings who are brought up in their own homes. If pairs of siblings who had spent all of their lives in an orphanage were no more alike than were pairs of children picked at random in the orphanage, we should conclude that the greater resemblance of siblings under ordinary circumstances is due to the home environment and not to the common inheritance. If the resemblance of siblings in an orphanage is greater than that between random pairs but less than that of siblings in their own homes, we may attribute part of this latter resemblance to environment. The correlations which have been made to test this point are thus far somewhat contradictory, but their general trend indicates that the correlation between the abilities of siblings is slightly reduced as a result of life in an institution. Further studies are necessary to make the evidence conclusive.

Another method is to find the correlation between the abilities of siblings who have been separated during a considerable portion of their childhood, to see whether it is less than that of siblings brought up together. This was done in the case of about one hundred and twenty-five pairs of siblings who had been placed in separate foster homes. The correlation between the I. Q.'s of siblings reared together is usually found to be .50 or above. The correlation between the I. Q.'s of these siblings, who had been separated at an average age of five years, was found to be only about .30. Children separated early and those in widely different grades of homes were less alike than those separated later or living in homes of similar grade.

A final comparison may be made between the resemblance of siblings in mental abilities, which conceivably are influenced by the environment, and in physical traits, which may be affected by environment in a lesser degree or not at all. The coefficient commonly accepted as representing the correlation between physical traits of siblings is .50. This has been recently checked by finding the correlation between the number of finger ridges as observed in the finger prints of fraternal twins. The biological relationship of these twins corresponds to that of siblings. The correlation was found to be almost exactly .50. The correlation in mental abilities varies somewhat in the different studies which have been made. Thorndike in a careful study estimates the correlation on an intelligence test to be .60. In the study of fraternal twins mentioned above the correlation of I. Q.'s was found to be approximately .70. If we assume that the resemblance due to heredity is equal to that in physical traits, these correlations suggest that the resemblance in intelligence has been increased by the similarity in home environment. If heredity alone produces less resemblance in mental abilities than in physical traits, we must ascribe more of the resemblance in intelligence to environment.

The comparison between races has been drawn upon in the discussion of this problem, but the factors in racial differences are so involved that the student of racial differences has more to learn from the student of mental development than the other way round.

Many studies have been made of the relation between mental abilities or mental development and environmental conditions, such as social surroundings, occupation of parents, place of residence (one state *vs.* another, or city *vs.* country), nationality, or amount of schooling. In all of these comparisons marked correlations have been found, and the natural interpretation would seem to be that favorable environmental influences produce higher mental development than others. This is probably a reasonable interpretation, but it is not the only one possible. For example, the child with more schooling may also be superior, not solely because his schooling made him superior, but because he was superior by nature, and this enabled him to meet the demands of the school and to remain in it until he reached the later grades.

INTELLIGENCE VERSUS SCHOOLING

A few examples of the relation between intelligence and these circumstances may be given, not because the interpretation of the facts is clear, but because they have frequently been interpreted in misleading fashion. The average scores on the Army Alpha Scale of recruits from forty-four of the states in the Union were correlated with the standing of these states on certain indices of culture, for example, the Ayres School Index, which sums up the status of the public school system of a state. The correlations were high, .83 to .87 in the case of the Ayres Index. But whether good schools are the cause or effect of intelligence is not indicated.

Somewhat similar is the relation between amount of schooling and intelligence. In the report of the army tests, for example, the mean scores of men classified according to the amount of their schooling are given. For the men of the native white draft the averages are as follows:

School Grade Completed	0–4	5–8	High school	College	Beyond college
Average Score on Army Alpha	22.0	51.1	92.1	117.8	145.9

This progression suggests that an increase in the amount of schooling produces an increase in intelligence, but it may be interpreted to mean that the more intelligent are able to progress farther in school than the less intelligent.

An interesting suggestion of interrelation between native ability and schooling comes from a comparison between officers and enlisted men. Officers, of course, make much higher scores than do enlisted men, and also they have had more schooling. This fact alone throws little light on our problem. By searching among the officers, however, the army psychologists found a number who had had a meager education, none of them having gone beyond the eighth grade. These men made scores intermediate between the enlisted men as a whole and the officers as a whole. Apparently their native ability raised their scores above those of the privates, while their lack of schooling depressed their scores below those of the other officers. Again, a group of privates was found, all of whom had attended school beyond the eighth grade, and had therefore had more schooling than the majority of privates. These men also made an average score which was intermediate between those of the privates and of the officers in general. We may infer that their excess of schooling raised their scores above those of their fellow privates, while their lesser native ability kept their scores from equaling those of the officers.

Another circumstance which is found to be related to differences in mental ability is the vocation of the individuals who are tested or the vocation of their parents. Members of the professions or their children make the highest scores, while day laborers commonly make the lowest. The distinction between persons in different vocations is complicated by differences in education, but this is not so true of their children. To what extent persons who enter the various occupations are sorted out to begin with according to their native ability, and to what extent the occupations themselves, the preparation for them, and the circumstances surrounding them mold the intellectual abilities of their members, we do not know.

City children regularly make higher scores than do children in towns and villages, and these in turn excel rural children. Again, immigrants who have been in the United States for a longer period excel those who have come more recently. Since, in both cases, those excelling in the tests have had superior educational advantages, these facts might be cited as evidence of the effectiveness of education in raising the level of intelligence; but in both cases it is quite possible that the differences between the groups may be chiefly native and not acquired.

Again, the comparative constancy of the intelligence quotient has led some to the conclusion that mental development is determined by innate constitution; but since the individual's environment is usually about as constant as his I. Q., the fact might just as well be taken as proof of the influence of environment. We are driven by all these difficulties in interpretation to seek more crucial evidence. To secure such evidence we must in some fashion disentangle the effect of hereditary differences from the effect of educational or environmental differences. If two persons differ in heredity and also in training, we cannot tell what to attribute to the one and what to the other factor.

One method of seeking to separate these factors is to find groups of children whose heredity is, so far as may be judged, not seriously inferior, but whose educational advantages have been seriously lacking. Gordon found two such groups in children brought up on canal boats and children with physical defects which kept them from getting the usual schooling. In both types of cases the intelligence quotient was found to be low, and increasingly so as the children grew older. The parents of the canal-boat children are engaged in an occupation demanding at least average intelligence, so that it is not probable that the children's inheritance is below the average. The marked increase in the gap between the intelligence of these children as they grow older and the average intelligence of children in general seems to be rather conclusive evidence that they suffer from the lack of the usual educational advantages. Confirmation of Gordon's findings is found in Baldwin's [8] study of the intelligence of young children in two counties of Iowa. The inhabitants of the two counties were very similar in racial or national stock; and the counties were similar in the character and value of the farms and in the economic condition of the inhabitants. The people of the two communities differed markedly, however, in their social and civic spirit, in the degree of social organization they had developed, in their interest in education, and in the extent to which the children took advantage of their opportunities for higher education. The tests of young infants in these two counties revealed no significant difference in mental ability, indicating that their native capacity was about the same. As they grew older, however, the children of the superior county drew away more and more from those in the less favored community. This progressive divergence very strongly suggests, if it does not prove, that the difference in education and in cultural advantages is responsible for the superiority of the favored children revealed by the intelligence tests employed. In nonverbal tests the two groups were about equal, indicating that the influence of the superior community was manifested chiefly in those abilities which involve the use of language.

Another method is to give repeated tests to one group of children who have special educational advantages, as in a nursery school, with another group which does not have these advantages. This comparison of gains instead of comparative status enables us to attribute the differences to the educational conditions or attendant circumstances. Some of the studies made by this method are positive and some negative, but the burden of the evidence is positive.

EFFECTS OF VARYING HOME ENVIRONMENT

The final method to be cited is to study the effect of diverse home environments on the mental development of children when there is no hereditary relation to complicate the comparison. Such a condition is found in the case of foster children. Two rather extensive studies of the general success and social adjustment of foster children give evidence of the effect of improved environment on behavior. Two other studies involve an elaborate series of tests given to about two hundred and four hundred foster children respectively. In both of these studies an appreciable correlation was found to exist between the mental development of the children and the character of the homes. The inference drawn was that the children in superior homes had been stimulated to a higher degree of mental development than had those in the relatively inferior homes. This general comparison was supplemented in one of the studies by a variety of other comparisons which gave further evidence of the influence of the home on mental development.

While the whole problem is a very complicated and difficult one to attack, and while many of the attempts to solve it have been inconclusive, improved methods of investigation are now being developed. The slowly accumulating evidence indicates that the mental development of the child may be enriched and accelerated to a very material degree by the application of the most effective methods of instruction. The possibilities of development are limited, however, by the child's individual, inherited nature as well as by the common human nature. If educators and social workers keep these limitations in mind and have due regard for those differences in ability which a reasonable interpretation of mental tests indicates to be the result of native constitution, they may confidently hope, by extending those educational advantages which now exist to children who do not enjoy them, and by constantly improving the methods of education, to raise materially the level of intellectual performance of both children and adults.

References

1. Cox, Catherine M. *The Early Mental Development of Three Hundred Geniuses. Genetic Studies of Genius.* Vol 2. Stanford University, California, Stanford University Press, 1926. 842 p.
2. Witte, Karl. *The Education of Karl Witte.* Translated by Leo Wiener. New York, Thomas Y. Crowell Company, 1914.
3. Terman, L. M. *The Measurement of Intelligence.* Boston, Houghton Mifflin Company, 1916. 362 p.
4. *Twenty-Seventh Year Book, National Society for the Study of Education: Nature and Nurture.* Part I. "Their Influence upon Intelligence." 465 p. Part II. "Their Influence upon Achievement." 393 p. Bloomington, Ill., Public School Publishing Company, 1928.
5. Freeman, Frank N. *Mental Tests: Their History, Principles, and Applications.* Boston. Houghton Mifflin Company, 1926. 503 p.
6. Sidis, Boris. *Philistine and Genius.* Third edition, revised. Boston, Richard G. Badger (The Gorham Press), 1917. 122 p.
7. Dolbear, Katherine E. "Precocious Children." *Pedagogical Seminary,* Vol. 19, 1912, pp. 461–491.
8. Baldwin, B. T., Fillmore, Eva A., and Hadley, Lora. *Farm Children.* New York, D. Appleton and Company, 1930.

THE RELATIONSHIP BETWEEN SOCIO-ECONOMIC STATUS AND MENTAL TRAITS

BECAUSE of its theoretical significance for the general problem of "nature versus nurture," the relationship between social factors and mental development has attracted much interest during recent years. Less attention has been paid to the significance of such relationships as factors affecting the technical adequacy of scientific studies of child development and behavior. Nevertheless, it is true that, in so far as relationships between social background and mental characteristics exist, they must be taken into account in all studies dealing with the traits in question. The technical error introduced by failure to make the appropriate allowance for an existing difference between groups is equally great, however the difference has been brought about. In this section, therefore, no attempt will be made to review the rather extensive literature dealing with efforts to evaluate the relative effects of hereditary and environmental factors upon mental traits. The discussion will be confined to those studies which show the existence or nonexistence of relationships between the social background and various aspects of mental and social behavior in children.

The discovery that children from better homes make higher scores on tests of the Binet type than do those from the poorer districts was made almost as soon as Binet's 1908 scale was published. Decroly and Degand[1] gave the tests to 45 children in a private school attended only by children from the upper social classes. They found that among these children none rated "below age" while 80 per cent were classified from one to three years "above age." This led them to question the accuracy of Binet's norms. In reply, Binet[2] pointed out that the social status of the children was so far superior to that of the public school children used in standardization, that it might well constitute an adequate explanation for the difference in the findings. The consistency of the findings from later investigations has furnished rather conclusive evidence as to the soundness of Binet's hypothesis, in spite of the fact that the methods used for classifying social status have varied considerably from one investigation to another. The earlier studies made use chiefly of general descriptive terms or ratings such as good, medium, and poor neighborhoods, children from private or public schools, and so forth. Growing realization of the relationship between socio-economic factors and other characteristics of the individual has led to a number of attempts to develop more objective methods of classification. The earliest of these were the Williams scales for rating homes and neighborhoods.[3,4] The scale for homes includes five items, each rated on a scale of 1 to 5: necessities, neatness, size, parental conditions, and parental supervision. Significant, though rather low, relationships between the total home index and children's scores in intelligence tests have been found. The mean difference between the home ratings of delinquents and those of unselected children is large, but there is much overlapping of the individual scores.

At an early period in the study of the factors related to performance in intelligence tests, it was found that occupation and test standing are associated to a significant degree. This association is to be noted not only among adults actually engaged in the occupations under consideration, but also in the test scores earned by their children. Among adults, this relationship was most evident in the findings from the army tests. A somewhat different method of social classification is thereby suggested, which has certain advantages over the methods previously used in that it is simple, fairly objective, and is easily obtained, thus making it suitable for use in large-scale investigations for which any method requiring an individual check-up of the homes would be out of the question. An additional advantage of the occupational classification lies in the fact that reliable comparative data for any community or for the country as a whole are available from the census reports.

At least three occupational classifications have been proposed: the Barr Scale,[5] the Taussig industrial classification,[6] and a modification based upon both of these, devised by Goodenough at Minnesota.[7] The last named is now undergoing an extensive revision.

PATERNAL OCCUPATIONS VERSUS MENTAL TRAITS

Some of the most outstanding findings as to the relation between socio-economic status, as indicated by paternal occupation, and the mental traits of children may be summarized as follows: Using the Taussig industrial classification, Haggerty and Nash[8] found the mean intelligence quotients of 6,688 children in the schools of New York State in grades three to eight, and 1,433 children of high schools from the same communities, distributed themselves as shown in Table 1. The Haggerty group test (Delta II) was used. Results obtained by Dexter[9] for 2,782 children in grades one to eight by the use of the Dearborn and the National Intelligence tests, and by Dickson[10] for 150 children in the first grade using the Stanford-Binet are given for comparison.

TABLE 1

MEAN I. Q.'S OF CHILDREN CLASSIFIED ACCORDING TO PATERNAL OCCUPATION (TAUSSIG SCALE)

	OCCUPATIONAL CLASS					
	I Profes-sional	II Busi-ness	III Skilled labor	IV Semi-skilled	V Farmer	VI Unskilled labor
Haggerty and Nash 6,688 children, grades 3–8	116	107	98	95	91	89
Ibid. 1,433 high school children	121	112	111	108	108	106
Dexter 2,782 children grades 1–8	115	105	99	92	...	89
Dickson 150 first grade children	Classes I and II combined 112.5				Classes V and VI combined 82.5	

r^a I. Q. with occu. class = +.48.

[a] r stands for correlation coefficient.

It is apparent from Table 1 that the differences found are most evident in the groups in which selective elimination has been least operative. Thus, in the Haggerty and Nash data, the difference in intelligence quotient between occupational extremes is 27 points for the grade school children but only 16 points for the high school children. That the difference is due chiefly to selective elimination among the lower classes is shown by two facts: (1) The mean intelligence quotient for the children of the professional group in high school is only 5 points higher than that for the corresponding group in the elementary school, while in the unskilled labor class the difference between the means of the elementary group and the group in high school is 17 points. (2) In the elementary school the professional class makes up 5.07 per cent of the total, and 14.02 per cent in the group in high school; while the unskilled labor class comprises 11.14 per cent of the group in elementary school and but 3.77 per cent of the group in high school. Among the children in the first grade studied by Dickson, the difference between occupational extremes is even more pronounced than among the older children, though the greater reliability of the test used may in part account for the more complete segregation.

That the differences found antedate the period at school, has been shown by Goodenough,[11] who reports results from two successive administrations of the Kuhlman-Binet tests to the same group of 380 children ranging in age from eighteen to fifty-four months. In this study the Minnesota occupational classification [7] was used, which divides occupations into six groups ranging from "professional" (Group I) to "unskilled labor" (Group VI). For comparison with the scores of the preschool children, the Alpha scores earned by the draft army sample,[12] the Haggerty and Nash data for elementary school children, and the Barr Scale theoretical values, using the frequencies reported for the city of Minneapolis in the 1920 Census, were selected. All scores were transmuted into standard x/σ scores.

It is evident that differences between occupational classes are quite as well defined among preschool children as at later ages. None of the empirical curves shows as steep a slope as the theoretical standards set by the Barr scale, but this is quite to be expected since the actual occupations would include many "misfits" which would tend to flatten the curves. It is also possible that the judges, upon whose ratings the Barr scale is based, tended to exaggerate the differences between the occupations rated. The fact of significance is that no appreciable change takes place in the mean standing of children from the various occupational groups from the age of two years up to the close of the period of elementary schooling.

LANGUAGE OF CHILDREN IN DIFFERENT GROUPS

In her study of the development of language of children of preschool age, McCarthy[13] found differences between children of different social groups to be even more pronounced than the corresponding differences between their total performances on mental tests. This finding has been corroborated in Day's study[14] of the development of language of preschool twins, and by Goodenough and Shapiro[15] in a study of the qualitative differences in the test performances of preschool children separated on the basis of mental rather than chronological age. It was found that the children from the upper social classes showed a consistent superiority over those from the lower classes on tests of language while those from the lower classes were relatively superior on motor tests when the performance on the total test was held constant for the two groups. Similar results have been reported from several European countries. Probst,[16] using a group of 100 children from kindergartens selected to constitute a representative sampling of the population of Minneapolis, found that differences between social classes in the amount and kind of general information possessed by children between the ages of five and six years are very clearly established. The differences between the upper and lower halves of the occupational distribution was 4.9 times its standard error, a divergence which would occur by chance only about once in a million times. Differences were most clearly shown in items dealing with natural science and simple mechanics.

Similar results have been reported by many other writers both in this country and abroad. Among the foreign studies may be mentioned particularly those by Duff and Thomson [17] on children of Northumberland, McDonald [18] in the Isle of Wight; and Sirkin [19] in Charkow, Russia. It has also been found that children from the upper social classes make significantly better progress in school than do those from the lower classes, and that this remains true even when the factor of intelligence is partialled out.[20] Contrasted with these studies are certain others, dealing with tests of the so-called *performance* type in which verbal elements are absent or are reduced to a minimum. Goodenough [21] gave the Wallin Peg Board Series to the same group of preschool children that were given the Kuhlman tests previously mentioned. The two tests were given at the same sitting. No difference between socio-economic classes was found for the peg-board tests in spite of the large differences shown by the same children on the Kuhlman test, for which the average correlation with the peg-boards for single year age groups was .507. Likewise Furfey [22] reports a zero relationship between social status, as measured by the Sims score card,[23] and the scores earned by 300 infants under one year of age on the Linfert-Hierholzer scale. Among older children Paterson and Elliott [24] find a zero relationship between the scores earned on the Minnesota Mechanical Ability Tests and social status as measured by an objective scoring card for the home which was developed especially for this study. It does not appear safe, however, to say that the explanation for the lack of relationship between home status and test standing in these cases lies purely in the nonlinguistic character of the tests, since Atkins,[25] using her Object Fitting Test, which is completely nonverbal, found almost exactly the same differences between occupational classes as were found by Goodenough on the Kuhlman tests. Further investigation is needed before it can be stated with certainty what types of mental performance are most closely bound up with social status, or what factors in the home background exert the most profound influence upon the development of mental traits.

If the question of the so-called personality and character traits is considered, the evidence is much less clear cut than in the case of the more purely intellectual characteristics previously discussed. This is not surprising when the difficulties involved in securing adequate measurements or even descriptions of the characteristics to be studied are realized. The task of measurement is still further complicated by the fact that in place of trying to ascertain the limit of ability to perform certain tasks (as in the case of most of the standard mental and educational tests), an indirect method is sought by which the child's *most typical* reactions to situations which can rarely be reproduced in the laboratory may nevertheless be predicted.

That certain factors in the social background of children appear to be closely related to the adjustments of personality in later life, seems evidenced by common observation as well as by an extensive body of clinical data regarding persons whose failure to achieve satisfactory adjustment has brought them in contact with some correctional agency. The difficulty of reducing these clinical observations to quantitative terms is, however, very great, and interpretation of such quantitative data as have been assembled from these sources is rendered both difficult and hazardous by the subjective character of much of the evidence, by the lack of adequate control data, and by failure to differentiate between negative items and omissions, all of which tend to accentuate the effects of personal bias on the part of the investigator. For these reasons and because of space limitations, no attempt can be made to review the mass of material on this subject which has been derived from clinical sources. Instead, the results obtained in the recent studies by Hartshorne and May [26] will be considered, which, while open to all the criticisms to which attempts to predict behavior by means of paper-and-pencil tests are necessarily subject, nevertheless have the virtues of comparative objectivity and experimental control.

Hartshorne and May have dealt with three major aspects of "character," namely, deceit, service, and self-control. Each aspect has been studied by means of a comprehensive series of "tests" designed to classify individuals with respect to the trait under consideration. Hartshorne and May have also used a variety of different methods of defining and classifying the social background of the subjects. Their findings may be summarized briefly as follows: Deceit, as measured by actual amount of cheating done under various conditions, is negatively correlated with intelligence-test performance, that is, the children testing highest cheat on the average somewhat less than others of less ability. When intelligence-test scores are held constant by partial correlation techniques, there remains a small but significant negative correlation between deception and socio-economic status as measured by the Sims score-card.[23] This is true of all forms of deception studied, whether the opportunity to cheat was given at school, at home, or at parties. Negative correlations between cheating and knowledge of social etiquette, and between cheating and an "apperception" test designed as an indirect approach to the cultural standards and family relationships in the home background, were also secured. Surprisingly enough, a simple four-level classification of paternal occupations showed a somewhat closer relationship to cheating in these tests than did any of the more elaborate devices tried. A combination of the various socio-economic measures showed a more significant relationship to cheating than did any one taken separately. After surveying all the results, Hartshorne and May make the following comments: "We are not as yet in a position to make as satisfactory a prediction of the true relation between deceptiveness in general and the cultural background as we have made in the case of the relation between intelligence and deception, and it is hazardous to guess, since the data are insufficient. Pending further information, however, we give as our present judgment the r of —.45 as expressive of this relation, and estimate that, with intelligence constant, this r will be reduced to —.30." Comparison of the resemblance of siblings in deception with that of orphans leads them to assume that a biological factor accounts in part for individual variations in deceptiveness. Cultural and economic status show only a slight relation to persistence, but social relationships within the home and school exert marked influence upon tendencies to be of service and to cooperate with others.

It seems evident, therefore, that in spite of our present crude methods of classification, a considerable degree of relationship exists between the cultural background from which children come and their mental and social characteristics. It is probable that as more adequate methods of defining and describing social status are developed, further relationships not yet apparent will be established. Probably many of the discrepancies in the literature on mental growth may be attributed to inequalities in the social status of the subjects used for investigation. With more adequate analysis and control of the social factor, many of these inconsistencies would disappear. However the relationships may have come about, their existence has been so clearly established as to render it essential that socio-economic status be taken into account in all studies on the development and behavior of children, and particularly in those for which the results are expected to have normative value.

References

1. Decroly, O., and Degand, Mele, J. "La Mésure de l'Intelligence chez des Enfants Normaux d'après les Tests de M. M. Binet et Simon." *Archives de Psychologie,* Vol. 9, 1910, pp. 81–108.
2. Binet, Alfred. "Nouvelles Recherches sur la Mésure du Niveau Intellectuel chez les Enfants d'Ecole." *L'Année Psychologique* (Binet), Vol. 17, 1911, pp. 145–210.
3. Williams, J. Harold. *A Scale for Grading Neighborhood Conditions.* Whittier, California, Whittier State School, Research Bulletin No. 5, 1918.
4. ——*A Guide to the Grading of Homes.* Whittier, California, Whittier State School, Research Bulletin No. 7, 1918.
5. Barr, F. E. *A Scale for Measuring Mental Ability in Vocations and Some of its Applications.* Master's thesis, Stanford University, 1918. Described in *Genetic Studies of Genius,* Vol. 1. *Mental and Physical Traits of a Thousand Gifted Children,* by L. M. Terman and others. (Chapter 55.)

6. Taussig, F. W. *Principles of Economics*. Second revised edition. New York, The Macmillan Company, 1915.
7. Goodenough, Florence L. *The Kuhlman-Binet Tests for Children of Preschool Age; a Critical Study and Evaluation*. University of Minnesota, Institute of Child Welfare Monograph Series No. 2. Minneapolis, University of Minnesota Press, 1928. 146 p.
8. Haggerty, M. E., and Nash, H. B. "Mental Capacity of Children and Paternal Occupation." *Journal of Educational Psychology,* Vol. 15, 1924, pp. 559–572.
9. Dexter, Emily S. "The Relation between Occupation of Parent and Intelligence of Children." *School and Society,* Vol. 17, 1923, pp. 612–614.
10. Dickson, V. E. Unpublished Master's thesis, Stanford University. Results given in *Intelligence of School Children,* by L. M. Terman. Boston, Houghton Mifflin Company, 1919. (Chapter IV.)
11. Goodenough, Florence L. "The Relation of the Intelligence of Preschool Children to the Occupation of their Fathers." *American Journal of Psychology,* Vol. 40, 1928, pp. 284–294.
12. *Psychological Examining in the United States Army.* "Measurements of Intelligence in the United States Army." Memoirs of the National Academy of Science, Vol. 15, 1921, Part 3, pp. 547–877.
13. McCarthy, Dorothea. *The Language Development of the Preschool Child.* University of Minnesota, Institute of Child Welfare Monograph Series No. 4. Minneapolis, University of Minnesota Press, 1930.
14. Day, Ella J. *The Development of Language in Twins.* Unpublished Ph.D. thesis, University of Minnesota, 1929.
15. Goodenough, Florence L., and Shapiro, Gertrude. "Performances of Preschool Children of Different Social Groups of the Kuhlman-Binet Tests." *Journal of Educational Research,* Vol. 18, 1928, pp. 356–362.
16. Probst, Catherine. *A General Information Test for Kindergarten Children.* Unpublished Master's thesis, University of Minnesota, 1928.
17. Duff, J. F., and Thomson, G. H. "The Social and Geographical Distribution of Intelligence in Northumberland." *British Journal of Psychology,* Vol. 14, 1923, pp. 192–198.
18. McDonald, Hector. "The Social Distribution of Intelligence in the Isle of Wight." *British Journal of Psychology,* Vol. 16, 1925, pp. 123–129.

19. Sirkin, M. "The Relation between Intelligence, Age, and Home Environment of Elementary School Children." *School and Society,* Vol. 30, 1929, pp. 304–308.

20. Chauncey, M. R. "The Relation of the Home Factor to Achievement and Intelligence-test Scores." *Journal of Educational Research,* Vol. 20, 1929, pp. 88–90.

21. Goodenough, Florence L. "The Reliability and Validity of the Wallin Peg Boards." *Psychological Clinic,* Vol. 16, 1927, pp. 199–215.

22. Furfey, P. H. "The Relation between Socio-economic Status and Intelligence of Young Infants as Measured by the Linfert-Hierholzer Scale." *Pedagogical Seminary,* Vol. 35, 1928, pp. 478–480.

23. Chapman, J. C., and Sims, V. M. "The Quantitative Measurement of Socio-economic Status." *Journal of Educational Psychology,* Vol. 16, 1925, pp. 380–390.

24. Paterson, D. G., Elliott, R. M., and others. *Minnesota Mechanical Ability Tests.* Minneapolis, Minn., University of Minnesota Press, 1930.

25. Atkins, Ruth E. *The Measurement of the Intelligence of Young Children by an Object-fitting Test.* University of Minnesota, Institute of Child Welfare Monograph Series. Minneapolis, University of Minnesota Press. In press.

26. Hartshorne, Hugh, and May, Mark A. *Studies in the Nature of Character.* I. "Studies in Deceit." II. "Studies in Service and Self-Control." New York, The Macmillan Company, 1928. 720 pp.

PERSONALITY TESTS

DEFINITION OF PERSONALITY

PERSONALITY is usually defined in a very inclusive fashion. Morton Prince defined it as the "sum total of all biological dispositions, impulses, appetites, tendencies and instincts of the individual, and all the acquired dispositions and tendencies." Most writers stress an integrative rather than merely an additive combination. Thus McDougall says: "Personality is the integrated product of different dispositions, instincts and sentiments." Gordon expresses this concept clearly in defining personality as "the emergent synthesis of the bodily and mental attributes of the individual in relation to the environment in the most comprehensive sense." Some writers, however, have emphasized special aspects of this totality as being especially relevant to personality. Bagby stresses the emotional associations, whereas Allport considers the social implications as most important. Thus Allport says: "Personality is preëminently the social aspect of the individual. It is the individual's characteristic reaction to social stimuli and the quality of his adaptation to the social features of his environment."

These samples suffice to emphasize the general concept that personality is the totality of many vague attributes, few of which may be measured objectively. The term itself may be used to convey any one of three distinct meanings. It is used, first, in the sense of *selfness,* that is, the peculiar distinguishing features of the individual as distinct from someone else; second, in the sense of the sum total of the individual's characteristics, behavior, or descriptive traits, mental, physical, and social; and, third, in the sense of disposition or characteristic moods, attitudes, or temperament.

Because of this variety of meanings we shall avoid as far as possible the use of the term personality, at the expense of brevity but for the sake of accuracy. Much controversial discussion in this field might be avoided if words always conveyed the same meaning to each individual. Clarity of concept and precision in definition are as essential here as in any other branch of science. Where the term *personality* is used, it will be primarily to designate what is measured by the various tests which have been devised. We may discuss, on their own merits, the results of such tests, and likewise may consider various *types of personality,* without ever raising the question of whether the sum total of all of the qualities which are tested really is the *personality* in the sense of the self. If types are clearly and objectively distinguishable, and if tests yield reproducible results we have fit material for scientific treatment, while if we stray from such facts we soon become lost in philosophical speculation.

TYPES

One common attempt to study personality has been based upon the concept of *types.* Hippocrates began with four: the sanguine, the melancholic, the choleric, and the phlegmatic. In Addington's *Book of Characters* over five hundred types appear. The difficulty is that in one sense every individual is a type, distinguishable from all others, and no general types have been described into which all persons may be divided. Some people, for example, appear to be "schizophrenic," others, "cyclothymic," in temperament, but the great majority of persons have patterns of behavior too varied to fit these categories. Most persons withdraw in certain situations and dominate in others, and this is one reason why the concept of introversion and extroversion has proved so inadequate. An introvert by one set of tests becomes an ambi-vert or even an extrovert when other tests are applied. Studies of the behavior of boys in camp have shown no tendency for various introvert traits to be associated in the same individuals.[4] In a series of a thousand or more cases the occurrence of introvert traits produced the familiar curve of normal distribution, only the extreme suggesting a *type.*[1] Just as with physical types, so types of personality turn out to be the extremes of curves of distribution.

TRAITS

Even the trait seems to be largely fallacious as a description of personality. Investigations of the behavior of children under fifteen years of age have shown that the correlation between one act of deception at school and another act of deception at home is no higher than the correlation between an act of deception and an act of selfishness or poor self-control.[3] Many persons tend to be speedy about some things and deliberate about others. A boy who is lazy and slow-moving in classrooms may be the fastest player on the basketball team. When specific forms of behavior are taught, such as honesty in the classroom, neatness, and cooperation, there is little tendency for similar general traits to be developed. We do not find consistency in such matters as honesty, kindness, and cleanliness, because these are in no sense biological units, but are merely ethical abstractions. At present there is no known relationship between different behaviors in the normal individual that makes it possible to study one part of a personality and then generalize about the whole.

In spite of the fallacious character of many of the so-called traits, it is evident that we cannot hope to deal scientifically with personality until we have analyzed it into what proves to be real and well defined traits, and then have devised reliable tests that truly judge the traits we have defined. As a matter of fact, it may be even more useful to begin by devising tests which give reliable results and then to inquire with all care into the matter of what they measure, with no preconceived notions based on a preliminary theoretical analysis.

TESTS OF PERSONALITY AND CHARACTER

Certain tests of behavior are now available which compare very favorably in reliability with our better intelligence tests, and a number of studies based upon these tests can be accepted as thoroughly good evidence. The study of other forms of behavior at the present time is subject to great uncertainty because of the absence of any equally reliable tests. Progress in the discovery of the normal course of development, and the treatment and prevention of undesirable characteristics, awaits the development of more adequate measures. Judgments of a semi-quantitative sort have always been made, rating some people better, others worse; but modern psychology has learned to distrust such appraisals. In order to accept ratings made in this way as significant, one must ascertain that there was an adequate number of judges, that the behavior to be observed was clearly defined, that ample opportunity was afforded to observe it, and that unambiguous devices were employed for reporting the observations. One of the most useful contributions of the "Character Education Inquiry," conducted by Hartshorne and May, was the finding that reputation agrees surprisingly well with character as a whole, except in a matter like deception.[3]

After three years of experimental work this Character Education Inquiry has released its contribution to the instruments for testing character.[2] This report contains twenty-three tests which cover such traits as moral knowledge, ethical judgment, honesty, cooperation, persistence, and self-control. Over seventy other tests have been proposed by various other workers.[2] It must not be inferred that the precision and validity of all of these tests have been established, that they are of equal value, or that their application to small samples gives conclusive evidence. The great trouble in such testing is not that of devising a test that will give consistent (reliable) results, but rather the difficulty of knowing just what it tests and how the traits it tests are related to other significant traits. Something is known about this in many cases, even though validation of this kind of test is most difficult. In regard to reliability, several of them rate .90, which is nearly as high as the better intelligence tests.

The following tests are among those that appear to have satisfactory reliabilities for the age group within which they have been developed:

I. Conduct tests

Deception (17 tests)	Reliability .24 to .84 for each, over .90 in combinations.[3]
Service (11 tests)	Reliability .64 to .91, over .90 in combinations.[3]
Persistence (9 tests)	Reliability .75 to .92, battery of four, .89.[3]
Inhibition (6 tests)	Reliability .42 to .89, battery of four, .80.[3]
Activity	Reliability .98.[5]
Physical contacts	Reliability over .90.[5]
Oral habits	Reliability .75 or, for two observers, .86.[6]

II. Self-report of attitudes, opinions, interests, symptoms, and so forth.

Allport ascendency-submission	Reliability .74 or .78.
Chassell experience record	Reliability of each item .75.[8]
Colgate tests of emotional outlets	
C-2 Introversion	Reliability .85.[7]
B-2 Emotional instability	Reliability .88.
C. E. I. Moral knowledge tests (20 tests)	Reliability .53 to .84, battery .94.[3]
Happiness	Consistency .85, repeat reliability over several weeks .60.[9]
Personal attitudes of younger boys	
Self-criticism	Reliability .92 [10]
Criticism of others	Reliability .94
Feeling of difference	Reliability .94
Sense of superiority	Reliability .94
Sense of inferiority	Reliability .76
Social insight	Reliability .87
Deviation from group idea of right	Reliability .86
Strong vocational interest test	Reliability .90
Thurstone personality scale	Reliability .95
Watson test of public opinion (fair-mindedness)	Reliability .96

We may conclude that a real start has been made, which justifies a review of the subject at this time, and there is ground for hope of more significant developments in the near future. But the conclusions drawn at the present time must be guarded and tentative, and are in most instances of more value for their suggestiveness than for their authority. It is a matter of special regret that there are no assuredly reliable techniques for recording the "personality patterns" which appear so frequently in psychoanalytical and similar theories of emotional development.

Physical Factors. We may first consider the evidence pertaining to the possible relationship between the traits of behavior which our tests disclose and physical development. The published evidence in regard to this relationship is largely based on the study of a small number of cases, and is inadequate for anything more than the most guarded suggestions. There can be little doubt that a close association exists between the mind and the body. Conscious thought must be associated in some way with physiological activity in certain parts of the central nervous system. Certain types of reflex behavior can be localized even more definitely in this way. We might well expect to find some sort of relationship between physical or physiological characteristics and the characteristic behavior of the individual. For example, some correlation would be expected between the activity of the endocrine glands and the results of any tests which effectively measure traits of behavior. The thyroid gland influences not only the rate of metabolism of the body but also the tempo of mental processes. Both the psychologist and the general practitioner recognize the emotional instability, particularly excitability and anxiety, of a person whose thyroid has become overactive, as well as the definite changes which occur in the behavior of the cretin when he begins to receive thyroid medication. We are also familiar with the disorders of behavior commonly following certain forms of encephalitis. In a certain series of cases of acute encephalitis, 20 per cent of those surviving have suffered from serious aberrations.

With these obvious relationships in mind many attempts have been made to link traits of behavior more definitely with physical characteristics. The results of most of these studies have been either definitely negative or the correlation coefficients have been too low to be convincing. On the whole, physical disorders are found much less frequently among school children who present definite problems of behavior than has formerly been supposed. Defects have often been found, but these defects are found with equal frequency among other children from similar homes. It is probable that many of the changes in behavior and temperament which are encountered in the chronically ill, convalescent, or handicapped child are the result of the special attention given to him because of the illness, rather than the result of the illness itself.

After a careful review of the studies dealing with the influence of physical factors, we must conclude that, although slight positive relationships are evident in a few conditions and suggestive in others, most traits which have been measured seem uncorrelated with physical indices and histories of illness.

Intelligence. If we may take the results of various tests at their face value, it appears that superiority in intelligence quotient is ordinarily associated with superiority in honesty,[8] cooperation,[8] inhibition,[8] leadership,[11] self-confidence, interest in reading,[11] subtleness of humor preference,[12] freedom from arrest for delinquency,[13, 14] and less conventional religious ideas in college.[15] Because of a common exaggeration of the significance of intelligence tests it is well to emphasize that adequate studies show approximately zero correlation between intelligence and emotional stability, nervousness, number and variety of play activities, popularity with schoolmates, artistic and musical talent or appreciation, and general happiness. How much of this difference should be attributed to the direct influence of the difference in intelligence and how much is due to the correlation of intelligence with home background, opportunity, cultural surroundings, and so forth, is uncertain.

Age Norms. As a result of the success attending the establishment of age norms for intellectual ability, many attempts have been made to set up similar age standards for traits of behavior. Such attempts thus far have met with little success. The approximate age of beginning certain types of social response, for example, smiling, can be determined, but most of the observations at present available have been made on too few cases to be accepted as reliable norms of behavior. Progress is, however, being made in this direction and further study along these lines should be most useful and might well bring to light the early manifestations of abnormal behavior. Studies of interests in play and in reading are available which show characteristic preferences at each age.[16] The changes, however, are very gradual, and any activity liked by ten year olds is likely to be enjoyed by some children who are six and by others who are fourteen. This wide range of normal variation renders the interests thus far studied of little value in describing the stage of development in any given case.[16]

Tests of emotional and moral behavior show few significant correlations with age except in activities dependent upon intelligence. Thus scores made upon tests of "moral knowledge" increase with age, owing to the large part played in such tests by mental ability and the power of thinking in abstract terms.[3] Similarly, ability to identify emotions from pictures and phonograph records increases with age.

Sex Differences. Whole books are devoted to speculations about the differences between men and women, and some of the probable causes and consequences of these differences. Very few of these are written by anthropologists who have studied the varying rôles played by men and women in different civilizations. Differences in interests and activities, so far as they have been accurately studied, are largely confined to our culture, and most of the differences found (for instance, much more truancy among boys) may as well be attributed to differences in training as to factors inherent in the sexes. Careful study of boys and girls in their early teens might reveal transient differences due to the earlier sexual maturation of the latter. Menstruation is known to produce transient periods of depression in some adolescent girls just as in adult women. Many differences, however, once supposed to be inherent in the nature of the sexes are apparently diminishing under our changing customs.

Race. When we realize how few definite statements can be made in regard to physical differences dependent upon race, we shall hardly expect to find much acceptable evidence regarding differences in characteristics of behavior. Racial differences are hard to establish because of the large numbers required for an adequate sample, and because of the varying contribution of the environment. There are a few facts which suggest differences along racial lines, but these are scattered and mostly unconfirmed. In the tests given by the "Character Education Inquiry," pupils from homes of certain races and nationalities (Italian, Negro, Slavic) showed deceptive behavior more often than would have been expected from their level of intelligence. In the test of cooperation these groups were likewise ranked low, but on the persistence test they excelled the native whites.

An environment like that of Hawaii is especially helpful in studying racial characteristics for, while the chief opportunities are all in control of the white (*haole*) group, other races and nationalities have more consideration than is usually given in our civilization. Our present tests for measuring traits which might distinguish the races were not available at the time Porteus and Babcock [17] made their study, but statistics on educational progress, economic advancement, delinquency, and general reputation showed that the Japanese, although not markedly different from Chinese or white Anglo-Saxon groups in intelligence, appeared to excel in the energy and ambition which made for progress. Koreans, equally or even more intelligent, were peculiarly subject to emotional disturbances.

OTHER HEREDITARY FACTORS

Most of the evidence usually cited upon the inheritance of qualities of character is ambiguous. The opportunities before the illegitimate offspring of a feeble-minded mother, granting an equal native equipment in the babies, are so inferior to those offered the children of the capable mother that the oft told story of the Kallikaks is inconclusive. Similarly, the early studies by Galton, Pearson, Davenport, and others, showing that cheerful parents have more cheerful children, that wandering parents have some children with nomadic dispositions, that well behaved children tend to have well behaved siblings, may all be interpreted in terms of training quite as readily as in terms of the germ plasm.

There is, however, some indirect evidence suggesting true hereditary factors. Studies in animals reveal differences in different strains. Wild mice do not breed tame mice, tame ducks do not breed wild ducks, although modifications in the direction of wildness or tameness are possible with any offspring. An interesting source of evidence is found in the development of simultaneous psychoses occurring in identical twins who have been separated. Some eight or ten cases are on record of similar psychoses occurring in identical twins, and in at least three pairs the disorder developed independently. In one case the twins had lived for twenty years in different countries. Scanty but suggestive evidence relates to pairs of brothers, fraternal twins, and identical twins, one of whom is in prison. Among 428 brothers of prisoners, only 35 were in prison; among 17 pairs of fraternal twins, one of whom was in prison, the other was also in prison in 2 cases; while among 13 pairs of identical twins, one of whom was in prison, the other was in prison in 10 of the cases.[18] On the other hand we have the evidence that a group of Russian immigrants in Los Angeles showed far more delinquents and criminals among their children born in this country than among those young people who spent their childhood in the old country, and Clifford R. Shaw's conclusive evidence that crime in Chicago has been for twenty-four years more closely correlated with type of neighborhood than with nationality or biological factors. It is impossible to state definitely whether there are any characteristic forms of behavior more easily developed in persons of one line of heredity than in persons of other lines, but there is considerable evidence that, with proper training, good citizenship can be achieved in persons of "bad" heredity with almost the same degree of success as in persons of supposedly normal background.[22]

INFLUENCE OF THE HOME

At present much responsibility for the development of character is placed upon the home. Other sections treat the subject of parental training. Here it is sufficient to note that many experimental data have been collected which indicate that shyness,[8] unhappiness,[9] jealousy,[10] and general misbehavior are more commonly associated with the violation of principles of parental management than can be accounted for by mere chance. It must be remembered, however, that controlled experiments in this field are exceedingly difficult.

INFLUENCE OF ASSOCIATES

The type of group with which the individual associates is undoubtedly an important determinant of character. No other factor has been found to give so good a basis for predicting the amount of honesty or deception a school pupil will show as does knowledge of the amount of deception carried on by a friend or classmate. Even sitting near children with nervous habits seems to be conducive to similar behavior.[6] There is clear evidence for a kind of homogeneity within groups, such as clubs and classes, a working code which leads to clearly differentiated types of behavior in different groups. It is probable that there is no more successful method for modifying conduct, whether for better or worse, than the introduction of the individual into a group who have standards and practices different from his own, but with whom he may carry on many activities which are mutually enjoyed. If the group has prestige to offer, the influence is still more potent.

INFLUENCE OF THE SCHOOL

The major responsibility for discussing this issue is left with other committees of the White House Conference. Scholastic success or failure is significant, for chronic failure in any important task may lead to unfortunate consequences. The history of many delinquents shows, first, a poorly adapted set of school tasks; next, boredom or resentment; third, truancy; and, finally, delinquency with some street gang. Delinquents are not so often feeble-minded or generally deficient as is commonly supposed.[14] Modern readjustments are giving new life to the curriculum and in the future we may hope for methods of education better adapted to care for individual differences between children.

Many other features of our social life and many other institutions, such as summer camps, religious organizations, clubs, neighborhood, and so on, form an important part of the surroundings in which our children grow up, and each of them may have its own peculiar influence. In the few aspects of character for which adequate tests exist, studies uniformly show that much less has been accomplished by these organizations than their supporters had hoped.[3, 15, 20, 21] Until further tests are available we must form our judgments and solve our problems concerning the value and importance of these institutions on a practical and empirical basis. As yet scientific investigation has little to offer in this direction.

SUGGESTIONS FOR FURTHER STUDY

Tests of characteristics of behavior must be improved. Those now in use are for the most part inadequate. Objectivity, reliability, and validity are essential requisites. The significance of what a test actually measures must be determined, irrespective of theory, although existing and conflicting theories may point to crucial areas in which tests are needed.

After adequate tests have been made available, age norms for the various traits should be established and the relationships between the various traits investigated.

We wish ultimately to inquire into the influence upon such traits as the tests measure, of heredity, and of the environment, including home, school, and special training.

Clear definition of terms and objectives is essential, and a recognition of the possibilities and the limitations of various methods of attack. A clear distinction between fact and theory, science and metaphysics, must be maintained at all times.

References

1. For a discussion of the definition of personality traits and types from another point of view, the section on "Human Types" in Part I (General Considerations) of the report of this Committee should be consulted.
2. *Tests*. "Character Education Inquiry." New York, Association Press, 1930. (List of personality tests produced by other publishers also available.)
3. Hartshorne, H., and May, Mark A. *Studies in the Nature of Character*. New York, The Macmillan Company, 1928–1930. Three volumes.
4. Newcomb, T. N. *Consistence of Certain Extrovert-introvert Behavior Patterns in Problem Boys*. New York, Bureau of Publications, Teachers College, Columbia University, 1929.
5. Thomas, D. S. *Some New Techniques for Studying Social Behavior*. New York, Bureau of Publications, Teachers College, Columbia University, 1929.
6. Olson, W. C. *Measurement of Nervous Habits in Normal Children*. Minneapolis, University of Minnesota Press, 1929.
7. Watson, G. *Experimentation and Measurement in Religious Education*. New York, Association Press, 1927.
8. Chassell, J. O. *The Experience Variables*. Author, University of Rochester Medical School, 1928.
9. Watson, G. "Happiness Among Adult Students of Education." *Journal of Educational Psychology*, Vol. 21, 1930, p. 79.
10. Sweet, L. *Measurement of Personal Attitudes in Younger Boys*. New York, Association Press, 1929.
11. Terman, L. M. Ed. *Genetic Studies of Genius*. Three volumes. Stanford University, California, Stanford University Press, 1925–1930.
12. Kambouropoulou, P. *Individual Differences in the Sense of Humor*. Psychological Monographs, No. 121, 1930.
13. Burt, C. *The Young Delinquent*. New York, D. Appleton and Company, 1925. 619 p.
14. Healy, W., and Bronner, A. *Delinquents and Criminals; Their Making and Unmaking*. (Judge Baker Foundation Publication No. 3). New York, The Macmillan Company, 1926. 317 p.
15. *University of Iowa Studies in Character*. Three volumes. Iowa City, Iowa, University of Iowa Press, 1927–1930.
16. Lehman, H., and Witty, P. *Psychology of Play Behavior*. New York, The Macmillan Company, 1927,

17. Porteus, S. D., and Babcock, M. E. *Temperament and Race.* Boston, Richard G. Badger (The Gorham Press), 1926.

18. Lange, J. *Crime and Destiny.* New York, Albert and Charles Boni, 1930.

19. Foster, S. "A Study of Personality Make-up and Social Setting of Fifty Jealous Children." *Mental Hygiene,* January, 1927.

20. Watson, G. *Some Achievements in Summer Camps.* New York, Association Press, 1927.

21. Dimock, H., and Hendrie, C. *Camping and Character.* New York, Association Press, 1928.

22. Healy, W., and others. *Reconstructing Behavior in Young.* (Judge Baker Foundation Publication No. 5.) New York, Alfred A. Knopf, 1929. 345 p.

THE RELATION OF MENTAL AND PHYSICAL DEVELOPMENT

THERE is a general impression among physicians and teachers, as well as among many others who have given some attention to the matter, that there is a close relationship between the mental and physical development of children. The pioneer studies of the question lent support to this opinion, but it must be said at the outset that more adequate statistical appraisement of these earlier studies, as well as the results of the more recent statistical studies of the relation of various aspects of mental and physical growth, have failed to show relations which are close enough to be of significance in dealing with the problems of individual children. Differences in the group are obvious, to be sure: the genius, the bright, the mediocre, the dull, and the feeble-minded differ as groups who are average in height and weight and in some other measures of physical growth. It is also true that studies of coefficients of correlation show a positive relation between height, weight, the diameter of the head, and so forth, and intelligence, as measured by intelligence tests; but these differences in the average and these coefficients of correlation are not of sufficient size to make it possible to tell with any certainty from the physical status of a given individual, with one possible exception, anything about his mental status.

The possible exception is in the case of the lower grades of the feeble-minded. According to the findings of Murdock and Sullivan [1] it is probable that there is more correlation between mental and physical traits in the feeble-minded; and there are indications that the degree of correlation becomes progressively greater for morons, imbeciles, and idiots. They find in the case of weight and stature, correlations about three times as large for those who have an intelligence quotient below 100, as for those with intelligence quotients above 100. The correlations for the total group are in the neighborhood of $r = .15 \pm .03$, for those above average in intelligence of .04 to .06, for those below average .13 to .14. These findings are, in general, in line with those of Doll,[2] who found correlations ranging from $r = .31$ to $r = .47$, for subnormal and feeble-minded boys and girls. But even correlations of this size offer no encouragement for deducing the mental status of even an imbecile from his height and weight and size of head, unless other criteria, such as physical stigmata and previous history, are taken into account. Similarly, although Terman [3] and others have found that intellectually gifted children are gifted for the most part in both physique and intellect, there are perhaps even more exceptions to the rule in their cases. The tall, husky feeble-minded individual is frequently seen, and the puny genius is not uncommon, although the latter is by no means as typical as is popularly conceived. If one wishes to learn about the mental status of an individual it is better to give him an intelligence test than to make any number of physical measurements.

Prescott,[4] Woodrow and Lowell,[5] and others have found the same low positive relationship between mental development and the stage of ossification of wrist bones that has been found between anthropometric measurements and mental development. Correlations between dentition and intelligence appear to be even lower, though still positive.[6, 7, 8] Statistical studies have also failed to establish any really significant correlations between mental development and pubescence. It is perhaps well to stress the fact that here, as in the previous comparisons, there are no negative relations. The age of puberty appears to be slightly correlated with the grade of intelligence, as well as with other indications of the general quality of the organism, such as superior height and weight, although it must be noted that these findings are rather more conflicting than in other studies of the relation of the mental and physical aspects. Both Crampton [9] and Leal[10] found a greater proportion of post-pubescents among those who were accelerated in school and a lesser proportion among those who were retarded than among those of like age in the normal grade. Relationships such as those just cited are too low to be carried over to individual cases for prediction. After concluding that a positive relationship existed between pubescence and grade standing Leal writes, "One need be surprised at nothing in the relationships between stage [of maturity] and grade." Gesell [11] and others [12] have shown from studies of precocious puberty that an abnormally early incidence of puberty may have no demonstrable effect on intellectual development. On the other hand, Terman has produced evidence that gifted girls, representing approximately the highest one per cent of their sex in the school population, attain puberty earlier than the average girl. Forty-eight per cent of the gifted girls menstruated before thirteen years of age, as against 25 per cent of unselected girls. Similar evidence has been produced as to the early maturity of gifted boys. Leal, in another part of her study, seems to find some evidence for earlier maturing on the average in the case of the brighter girls but not in the case of boys. The results for groups of different ages are inconsistent and her statistical methods are cumbersome. She is forced to the conclusion that "the relationship between early maturing and higher intelligence is by no means definitely shown."

These negative findings are respectfully received, but are simply not convincing to the physician, the school administrator, and the teacher, who are most frequently called on for advice in these matters. They feel that if the statistics can give no answer there must be something wrong with the statistical method, at least for their purposes. Perhaps there is something wrong. Statistical studies in general seldom contribute greatly to the understanding of the individual case. Why should one expect from studies of the status of growth in different individuals to learn much about the processes of growth going on within a single individual, or of the results of these processes? Evidently what is needed is a sufficient number of studies of the ordinary course of development of individuals who are normal in these respects, to discover whether it is possible to generalize from these experiences as to the probable course of development of other individuals.

This matter has recently been well put by Boas, who instigated one of the first studies based on repeated measurements of the same individuals. "A clear understanding of the statistics of growth cannot be obtained through a study of single measurements taken on masses of children of the same age by the so-called generalizing method, but requires the study of individual amounts of growth." [13] A further comment of Boas as to the methodology of these studies is also pertinent to the present discussion. It has been observed that in these mass studies the method of averages was first used and is still used. This method can point to the presence of a relationship but it cannot indicate the degree of the relationship. The method of correlation can indicate the extent of the relationship, but it has limitations and may need to be supplemented by other methods in the study of the growth of individuals. To quote the comment of Boas in relation to one, if not the first, of such studies: "These data were calculated, according to my suggestion, by the method of correlation by Clark Wissler. It appeared later that this method is unsatisfactory on account of the asymmetry of the growth curves and because the fundamental questions are not well expressed by the coefficient of correlation."

The solution of the problems of the relationship between mental and physical growth may then rest on devising more suitable methods, and, as will be noted presently, devising more adequate measures. The studies made by the method of repeated measurements have hitherto dealt mainly with single measures, chiefly of height, weight, and intelligence. In a few instances the increments in all three measures have been compared in the same individuals. The outstanding contribution of these studies has been the demonstration of a constancy in the individual rate of growth in the physical measurements used, and a constancy in the individual rate of growth in the mental measurements used. Whether the individual's rate of growth in height and weight is the same as his rate of intellectual growth, which is a restatement of one of the primary queries of this discussion, does not as yet appear, but a constancy in the given rate holds for the great majority of individuals. It may be noted that the question as to whether these rates are independent variables for a given individual obviously could never be answered by statistical studies comparing the status of different individuals.

So marked is this constancy in the rate of growth in height, that one commentator has remarked: "On the whole, size at any age predicts size at all ages. The short remain short and the tall remain tall throughout the whole course of growth and at maturity. The idea that there is likely to be some reversal of affairs at puberty whereby a tall child will fall off in growth and become short, while the short child is likely to spurt at that time, and grow tall, has been shown to be a superstition, founded on nothing more substantial than human longings." Such a reversal almost never happens, according to the careful research of recent years.[14] The physical aspect of this question is discussed at more length in the sections dealing with "Physical Status," page 233, and in *General Considerations*.*

A preliminary sampling of the records of the Harvard Growth Study has discovered many more reversals than would be expected from the foregoing statement. Without, therefore, subscribing altogether to the uniqueness of these reversals it is well to be cautious as to generalizations on the likelihood of reversals in the other physical measurements. Height and weight are both composite measures: composites of the differing rates of growth of the segments of the body, of the head, the trunk, and the extremities, and of the organs of the body. Such constancy does not appear so generally in the rate of dentition or of ossification of the wrist bones, but a more uniform rate might also be found in these respects from an average of rates in different parts of the body.

There are more exceptions to the constancy of the rate of intellectual development as expressed by the familiar intelligence quotient, but there is no question but that con-

*"Human Types." *Growth and Development of the Child.* Part I. New York, The Century Co., 1932.

stancy is the rule. The intelligence tests which have made this finding possible owe their success in part to the fact that they are also composite measurements or averages of different aspects or samples of intellectual activity. If one wishes to compare mental and physical growth, should not the physical measurements represent a wider sampling of the different aspects or evidences of physical development?

There is plenty of evidence that the body may grow in parts, rather than as a unit; that is, first one part grows and then another part grows at a more rapid rate. For example, in terms of age norms, a child at one time may be well advanced in his osseous development but retarded in his dental development; and later, either through an acceleration in dental development, a decrease in the rate of ossification, or both, the relative amount of development of these two traits may be reversed. Even in as closely related parts as the different carpal bones of the same wrist, first one bone and then another will be found to be increasing in size at a more rapid rate. It therefore seems possible that a study of the relationship between mental and physical growth by means of a composite of physical measurements may prove to be a more profitable method of attack than a study by individual measurements. This is the theory on which the mental testers have worked. So long as they clung to separate "faculties," such as memory, discrimination, and so forth, the tests were of little value in estimating intelligence, and it was only when more complicated tests were developed and a number of these combined that the results became of value. If the fluctuations in the rate of growth of the different parts of the body could be equalized by averaging a large number of measurements, a more reliable measurement of physical development would be obtained and, in turn, the studies of the relationship between mental and physical growth would become more reliable.

Children at birth are not at the same stage of somatic development.[15] The prematurely born, as measured from the time of conception, are younger by a few weeks or more in actual time at birth. Thus in gauging the relative mental development by the life age from birth an error is introduced into his intelligence quotient. The lag in physiological development may be rapidly taken up. It is also quite possible that it may be spread over a period of years and the child's eventual I. Q., when he has caught up, may be greater than what was anticipated from the mathematics of dividing mental age by chronological age. In the meantime he has been underrated, perhaps to his harm. Others may be overrated similarly, perhaps also to their harm. When a neurologist advises that a child proceed slowly in school, that the child should not be expected to keep the usual pace or take advantage of an extra promotion for fear of a nervous breakdown, he may have sensed that the development of the nervous system has not kept pace with life age, or perhaps with somatic development as judged by other indications. It is quite possible that the development of the nervous system cannot be gauged from a "developmental age" which is derived from a consideration of such matters as growth in height and weight and in bodily proportions, in dentition, in ossification, and in pubescence. There is evidence that the rate of growth of the nervous system is different and that it is more accelerated in the early years than that of other parts of the body. Possibly the derivation of what is vaguely spoken of as an "emotional age" would be of more value in these comparisons than these other criteria. On the other hand, it would also seem reasonable to suppose that the nervous system, which maintains such an intimate relation with the changes in the body as a whole, may itself grow at some rate which is a composite of the rates of growth of the separate segments and organs of the body. All that can be said at present is that one must hold fast to such measures as are available and test the possibility that some combination of them may aid in the better evaluation of the mental status and development of the individual.

There are a number of other lines of attack which should be investigated:

1. The ratio of the rate of mental to physical growth may prove to be constant for a given individual or for cer-

tain groups. Should this prove to be the case, a short series of repeated measurements carried out in the early years would serve as a basis for the prediction of the future physical and mental development.

2. Glandular secretions, diet, and sunshine have been demonstrated to affect physical growth, but knowledge of their effect on mental growth (excluding pathological conditions) is vague if not entirely lacking.

3. Further neurological studies may at some distant time reveal a physical basis of intelligence.

4. Growth curves, with the various measurements reduced to a basis of common age, may throw light on the subject, though the relationship between mental and physical development as shown in these curves is somewhat confused by the relation between both of these factors and chronological age. The variations from the age norm in terms of "mental months" and of "physical measurement months" may be of use in eliminating the age factor.

5. When morphological types can be determined more accurately and have been further studied, they may be of value in predicting physical development and possibly, in turn, mental development.

From the material at hand all that can be stated is that, when groups are studied, there is found to be a positive but low relationship between intelligence, as measured, and the physical measurements studied. The correlation coefficients are so low and the amount of overlapping so great that for purposes of prediction they have no value. It is hoped that a thorough study of a series of measurements, repeated annually with all of the measurements previously discussed, made throughout the school period on the same individuals, such as are now being made at Harvard University, may throw further light on the subject. A paragraph from an article describing this project, which is now in its ninth year, may indicate at least the hopes and ambitions of its sponsors: "A child somewhat backward in mental development, whose yearly increments in mental age have been small and who on repeated examination proves to be correspondingly backward in general physiological development, may frequently make up for his slow start before he reaches maturity. The prognosis in his case would be better than in the case of a child of the same early mental level but who, at the same time, is found to be physically well along in the course of development. The fact that he has come on so well in general physical development in the early years without corresponding mental growth would make his prospects less hopeful. Similarly, some of the much heralded prodigies, who have rather petered out in later years, may prove to have maintained their relative superiority for a few years, because of early maturing supplemented by a kind of hothousing." [16] Such relationships as these, should they exist, would not be revealed by mass treatment of data. They must await the study of repeated measurements carried out on the same individuals over a number of years.

References

1. Murdock, K., and Sullivan, L. R. "A Contribution to the Study of Mental and Physical Measurements in Normal Children." *American Physical Education Review,* Vol. 28, 1923, p. 328.
2. Doll, E. A. *Anthropometry as an Aid to Mental Diagnosis.* Training School, Department of Research Publication No. 8. Vineland, N. J., The Training School, 1916.
3. Terman, L. M., Editor. *Genetic Studies of Genius,* Vol. 1. Stanford University, California, Stanford University Press, 1925. 648 p.
4. Prescott, Daniel A. *The Determination of Anatomical Age in School Children and Its Relation to Mental Development. Studies in Educational Psychology and Educational Measurement.* Cambridge, Mass., Harvard University Press, 1923.
5. Woodrow, Herbert, and Lowell, Francis. "Anatomic Age and Its Relation to Intelligence." *Pedagogical Seminary,* Vol. 29, 1922, p. 1.
6. Bean, Robert B. "The Eruption of the Teeth as a Physiological Standard for Testing Development." *Pedagogical Seminary,* Vol. 21, 1914.
7. Matiegka, Jindrich. "L'Age Dentaire comme Signe du Development Total." *Revue Anthropologique,* Vol. 31, 1921, pp. 333–335; 258–260.

8. Cattell, Psyche. *Dentition as a Measure of Maturity. Studies in Educational Psychology and Educational Measurement.* Cambridge, Mass., Harvard University Press, 1928. 91 p.
9. Crampton, C. Ward. "Physiological Age, A Fundamental Principle." *American Physical Education Review,* Vols. 12 and 13, 1908, pp. 141, 214, 268, 345.
10. Leal, Mary A. *Physiological Maturity in Relation to Certain Characteristics of Boys and Girls.* Philadelphia, University of Pennsylvania, 1929.
11. Gesell, Arnold. "The Influence of Puberty Praecox on Mental Growth." *Genetic Psychological Monographs,* Vol. 1, 1926, pp. 507–539.
12. Koe-Kuhlman, L., and Stone, C. P. "Notes on the Development of Children Exhibiting the Somatic Signs of Puberty Praecox." *Journal of Abnormal Psychology,* Vol. 22, 1927, pp. 291–324.
13. Boas, Franz. "Observations on the Growth of Children." *Science,* Vol. 72 (No. 1854), 1930, pp. 44–48.
14. Hollingworth, L. S. *The Psychology of the Adolescent.* New York, Longmans, Green & Co., 1928, p. 9.
15. Scammon, Richard E., and others. "The Measurement of the Body in Childhood." *The Measurement of Man.* Minneapolis, University of Minnesota Press, 1930. 215 p. (Chapter IV.)
16. Dearborn, Walter F. "The Study of Individual Abilities." *School and Society,* Vol. 18, No. 456, 1923.

THE INFLUENCE OF PREMATURITY ON MENTAL GROWTH

DOES prematurity have any significant effect upon the character and the course of mental growth? The question is one which arises frequently in the minds of parents, and is of medical importance. But there can be no simple, general answer. Prematurity of birth takes place under such a diversified array of conditions that at the one extreme there is the certainty of permanent defect or of early death, and at the other extreme the full assurance of ultimately normal maturity. The physical aspects of the premature infant are fully considered in another section. The developmental fate of the prematurely born infant is always an individual matter, depending upon the severity of the complications produced by the prematurity, and on his primary potentialities for growth. There is always the logical danger that we shall ascribe to prematurity consequences which arise out of more fundamental or purely associated factors.

Since the developmental status of each case of prematurity requires individual, clinical appraisal, it is well to rephrase our question and inquire whether prematurity as such alters the ordinary course of mental growth. At the Yale Psycho-Clinic,[1] detailed individual studies have been made of several cases of prematurity by means of a series of developmental examinations, and cinema records, with this question in mind. The development of two children, without evidence of birth injury, was investigated over a period of two years. Both children in early infancy were seriously underweight and, estimated on the basis of their behavior alone, would have been diagnosed as mentally retarded or defective. For example, one child at the age of five months resembled in behavior a child of three months, a serious degree of retardation under ordinary circumstances. But making due allowance for the two months of prematurity, the behavior was relatively normal. The detailed study of individual cases of uncomplicated prematurity strongly suggests that the general course of development is not markedly accelerated or retarded by mere precocity of birth. The central nervous system, unless it is actually impaired, tends to mature in accordance with inherent determiners, so that the cycle of the growth of behavior is not greatly altered by the displacement of the date of birth.

Similar factors of safety and stability seem to operate when the infant is postmaturely born, for in his equipment for behavior he proves to be advanced even though birth is postponed. There is a stable substrate of maturation, strongly entrenched in the nervous system, which tends to keep the underweight, the pre-term, and the post-term infant close to their normal levels of maturity in the field of behavior. Accordingly, monozygotic twin infants, whether born prematurely or not, whether alike or much unalike in weight, tend to display similar patterns of behavior. Biologically, age must be reckoned from conception rather than from birth, and when so reckoned age proves to be a fundamental factor in determining levels of behavior.

This principle of stable maturation is of importance in any critical consideration of the effects of prematurity on mental growth. Ylppö has proposed the term *immature* to designate any infant weighing less than 2,500 grams at birth, irrespective of the length of gestation. The term suggests that the infant is not completely developed and not prepared for extra-uterine life. To what extent the "immature" infant is actually immature from the standpoint of the development of behavior remains a subject for careful investigation. Unfortunately, it leads to confusion if the terms *immature, premature,* and *underweight* are not carefully differentiated. It has by no means been demonstrated that the fetus or infant of subnormal weight is correspondingly subnormal or immature in behavior equipment. Indeed there is evidence to the contrary. The developmental problems involved are so numerous and complicated that intensive clinical research alone can clarify the issues. Statistical conclusions may mislead unless the correlation of causative factors in each individual case is open to estimate.

Aaron Capper[2] has made a noteworthy study of the physical and mental development of 437 immature (including 72 per cent premature) children. His general conclusions are depressing: "The fate of immature children is not enviable; almost one half of them die during the first year of life. Of those that remain alive, the majority are physically as well as mentally underdeveloped. Some of them show a late mental development; others show a condition of psychic infantilism, if the term may be used in its non-specific sense; while still others show permanent and severe mental diseases. When they are passed in review, one is surprised at the variety and amount of abnormality encountered, almost a regular 'pathologic museum.' In brief, the immature infant becomes the backward school child, and is a potential psychopathic or neuropathic patient and even a potential candidate for the home for imbeciles and idiots."

Capper's report was based on a study of 437 histories selected from among 23,016 records in the children's clinic of the University of Vienna between 1911 and 1926. Of these 190 died in the hospital and 23 others at home after being discharged from the hospital, making a total mortality of 213 or 48.7 per cent at the time of the investigation. Of the 224 remaining, 103 reported for examination. It is unfortunate that the conclusions of the report are, of necessity, based on such a limited percentage of the premature and immature infants born in Vienna, including, as it does, only those who had occasion to visit the children's clinic. It should be further recognized that many of these infants lacked early hospital and social supervision.

Maria Comberg[3] has made a study of the fate of 212 premature infants, on the average 53 for each of four years, and 27 pairs of twins, all weighing less than 2,500 grams at birth. Her general conclusions are at variance with those of Capper and in abstract are as follows: "Neuropathic irritability, which, like cerebral hemorrhage, appears to be a sign of special immaturity, is found frequently in children at the ages of from three to seven years who were born prematurely and who showed cerebral symptoms at an early age. Any connection between cerebral symptoms in the first weeks and later impairment of intelligence is not observed in these children, whose mentality is of the highest type in almost every particular. The age at which they learn to walk and to speak is more a lack of tone and delayed development rather than a manifest and lasting mental injury. . . . The prematurity itself remains as the chief cause for the peculiar development of the children. . . . Physical and mental injuries which remain throughout life as a result of prematurity are not observed."

The mental development of the premature was especially investigated in a study by George J. Mohr and Phyllis Bartelme.[5] The subjects were prematurely born with birth weights of 2,500 grams or less. The mean fetal age was 7.77 months. The study was carried out in the infant welfare clinic in Michael Reese Hospital, Chicago. The number of subjects is: 51 boys and 62 girls, white, eight months to seven years, with mean chronological age of two years, nine months. There are 17 sets of twins and 7 surviving members of twin births in the group; and 40 of their siblings, aged six months to twelve years five months, with mean chronological age of five years eight months. Less than one-fourth of the premature children are Russian or Polish Jews, and over one-fourth are Anglo-Saxon; 10 other nationalities comprise the remainder of the group of 113 subjects. The majority of families are of lower middle economic level.

The investigators found that: "One hundred and seven of the prematurely born children were classified as of average, above average, or below average intelligence, according to performance on the Gesell Developmental Schedules and the Kuhlmann-Binet test. . . . On the Gesell ratings, 43 per cent of the children were classified as average, 35 per cent as below average, and 22 per cent as above average."

The results of this study are in general agreement with those of Comberg and also, in a measure, with the clinical experience of J. H. Hess[4] as summarized in the following statement: "The majority of premature infants born after the thirty-second week into a proper environment, without birth injuries, undergo a normal mental development, progressing more slowly than the full-term infant during the first years. They average walking and talking about six months later and are somewhat slower in learning to coordinate, as evidenced by clumsiness and ease of falling, slight defects of speech, and so forth. All of these are, however, usually temporary manifestations and are followed by normal progress."

The amount of actual retardation which premature infants as a group show in motor and linguistic functions can only be determined by normative studies which take into account the interval of prematurity. Mohr and Bartelme[5] found that: "The prematurely born children do not differ from full-term children in time of beginning eruption of teeth, in onset of walking, in beginning of talking, and in learning control of the bladder, if correction is made for the period of prematurity. The smaller prematurely born children are consistently a little later in these developments, but again the difference is minimized if this correction is made." A most interesting finding relates to the 28 of the 113 prematurely born children who "were cyanotic, had convulsions, or otherwise gave evidence of possible intracranial hemorrhage or injury of the central nervous system at birth. Twelve of these show no noteworthy deviations on present physical examination, 5 others show some disturbance of the reflexes, and the remaining 11 present various findings. Three of these latter are mentally retarded. The general distribution of these 28 cases into the 3 groups, average, above, and below average, according to Gesell's schedules, does not differ from that of the entire group."

GENERAL CONCLUSIONS

Present data, though scanty and sometimes contradictory, indicate that prematurity of birth in itself does not markedly distort, hasten, or retard the course of mental development when the age of the infant is reckoned from conception. Intrinsic organic factors of maturation, as opposed to environment, are so powerful and stabilizing that the infant tends to follow his inherent cycle of behavior development independent of the placement of birth. Deviations and defects of development occur when the conditions of the prematurity cause pathological changes in organs or tissues. Deviations, such as imperfect postural and locomotor control, are not necessarily permanent; but frequently resolve in the first two years of life.

It is even suggested that in some instances the effects of intracranial hemorrhage may be overcome, possibly by substitutive or compensatory development. Little is known about these important phenomena, and they could be analyzed fruitfully in the premature. They can be investigated systematically only by periodic examinations of behavior, supplemented by neuropathological data.

The behavior of the premature infant is not alone a subject of scientific interest from a genetic standpoint. It is a subject of medical significance with direct and indirect bearing upon the problems of child protection. Too frequently prematurity is not recognized by physician and nurse and the child's welfare suffers in consequence. When more is known about the characteristics of behavior of the premature, there will be greater accuracy in diagnosing both the presence and the degree of prematurity. Refinements in the hygiene of the premature infant also will come through a better understanding of his limitations of behavior and his activity requirements.

Prematurity carries with it numerous hazards which may inflict temporary or permanent damage; but fortunately the infant is also protected by the inherent factors of organic maturation, which make for a normal course of mental growth.

References

1. Gesell, Arnold. *Infancy and Human Growth.* New York, The Macmillan Company, 1928, pp. 299–333.
2. Capper, Aaron. "The Fate and Development of the Immature and of the Premature Child." *American Journal of Diseases of Children,* Vol. 35, 1928, pp. 262–288; 433–491.

3. Comberg, Maria. "Über Schicksal und Entwicklung von Fruehgebarenen bis zum Spiel- und freuhen Schulalter." *Zeitschrift für Kinderheilkunde,* Vol. 43, 1927, pp. 462–482.
4. Hess, Julius H. *Premature and Congenitally Diseased Infants.* Philadelphia, Lea & Febiger, 1922. 387 p.
5. Mohr, George J., and Bartelme, Phyllis. "The Mental and Physical Development of Children Prematurely Born." Manuscript Studies from the Behavior Research Fund, Series B, No. 166. *American Journal of Diseases of Children,* Vol. 40, 1930, pp. 1000–1015.

STRUCTURAL DISTURBANCES OF THE CENTRAL NERVOUS SYSTEM

ALL informed people are aware that many mentally inferior children are born annually and that their care and education involve the community in expensive and difficult problems. These problems are so serious that efforts to solve them have been made by sociologists, psychologists, statisticians, and other nonmedical individuals. The attractive theory that feeble-mindedness, insanity, and epilepsy are "units" to be dealt with in terms of the Mendelian hypothesis has been widely exploited.

Those physicians who see large numbers of individual children are, we believe, convinced that although there are numerous mentally inadequate children who owe their disability to defects of inheritance, there are many others whose defects are due to more immediate prenatal causes. Without attempting to argue the subject in detail, it seems to many physicians that the most logical method is to consider the rôle played by the various agents which can interfere with the mental development of the fetus or of the infant who is intact at the end of pregnancy. If injury, infection, or poisons of any kind are responsible, prevention can be fostered by clear understanding.

TRAUMA

In ordinary medical practice, trauma or injury leading to impairment of function of the brain is easily recognized and no questions arise except in occasional medico-legal cases. In general an abrupt change occurs after a recognized accident. However, the most frequent injury to the brain in childhood occurs during the process of birth. There is no way of estimating the previous status, and a clear estimate of damage must often wait until reliable tests can be carried out after months or years. In addition the term *birth injury* often suggests to parents and physicians that errors of technique or judgment on the part of the obstetrician are responsible. This introduces a prejudice in their minds against admitting the existence of such damage.

The delay in diagnosis and the reluctance of all concerned to admit responsibility has stood in the way of clear thinking on this subject. Certain facts are quite obvious, however. It is clear that delivery through the pelvis is always accompanied by pressure upon the head of the fetus, often severe and prolonged, sometimes violent and of short duration. Moreover, for various reasons, interference with fetal circulation may take place. Delay may threaten the life of mother or child. Entirely aside from obstetrical interference, the brain of the child may be injured by lack of oxygen, by hemorrhage, or by actual breakdown of tissue. The obstetrician must frequently interfere and impose other force, often under pressure of emergency. Naturally the suggestion that injury has occurred should carry no suggestion that obstetrical judgment has been defective.

It is difficult to analyze the large literature on this subject and to arrive at uncontested conclusions. However, it is fair to emphasize that cerebral damage occurs with unusual frequency in three groups of deliveries. Premature babies are demonstrably fragile and naturally are not so well able to resist the stress of labor as are babies carried to the usual period of nine months. A mother's first baby is naturally exposed to severe stress on account of the rigidity of the maternal passages. For various reasons it is often necessary or expedient to deliver a baby feet first, and in this case sudden stresses are set up and certain specific dangers to the fetal brain are incurred.

The frequency with which brain injuries occur cannot be estimated with any accuracy. It is possible to find a clearly defined hemorrhage in about one-third of all babies who reach the end of pregnancy alive but die during or shortly after birth. It is at least probable that a considerable portion of the remaining two-thirds have less dramatic injury. It is certain that a considerable number of babies with cerebral injury survive. The difficulties in the way of accurate estimation are great. For one thing, the diagnosis even of severe injuries during the acute state is by no means infallible, even when serious attempts are made to establish facts. Many important cellular changes produce no change in the behavior of the newborn baby. Attempts to establish a diagnosis later are open to question.

As a working method it seems fair to make a presumptive diagnosis of injury if the following evidence can be obtained: (1) that there was no suggestion that the development was not normal at birth; (2) that for a few hours or days immediately after birth there was a period of disturbed function of the brain; (3) that the later history suggests no more obvious cause; (4) that the condition does not indicate that a change in structure has occurred after the early days of infancy.

The presumption can be strengthened if a clear history of unusually difficult labor is obtainable. In certain cases, the diagnosis is entirely obvious and certain.

Crothers believes that birth injury accounts for more mental defect than any of the acute diseases or accidents which cause cerebral damage, and that enthusiasts who emphasize the rôle of heredity should search more effectively for evidence on this point. The occurrence or the importance of the developmental defects of the central nervous system which are described in the sections dealing with that system and with heredity are not here denied, but attention is called to the practical importance of searching carefully for evidence of injury in all cases.

The exact mechanism by which cerebral damage, resulting in impairment of mental capacity, takes place is difficult to discuss with any brevity. In a general way, it can be assumed that the delicate cells of the cerebral cortex will not survive unless they receive an adequate supply of oxygen. It is probable, though not proved experimentally, that these cells in the fetus or young infant are more resistant to deprivation of oxygen than similar cells in adult life. However, it is also true that the disturbance of circulation during labor may be extreme.

Destruction by deprivation of oxygen may occur during prolonged pressure without actual hemorrhage. It may be the result of shutting off the circulation by rupture or obstruction of an artery or vein supplying a certain area, or it may be the result of pressure upon the brain by diffuse hemorrhage from an intracranial blood vessel which releases blood over the surface of the brain.

Following acute damage, repair takes place, not by replacement of damaged or destroyed nerve cells but by formation of a peculiar scar tissue. This process may continue for years and may lead to a certain amount of further disability, since the scar may interfere with the blood supply of previously intact cells or may even cause traction on the whole structure of the brain near the scar. On the whole, however, these progressive changes do not lead to any considerable increase of disability.

Real knowledge about the incidence of birth injury will depend upon the collection of adequate postmortem data. These data will not be collected with any eagerness until the present tendency to regard any suggestion of birth injury as an indictment of obstetrical method is abandoned.

ACUTE LESIONS OTHER THAN INJURY

Certain poisons, notably lead, can so damage the brain as to lead to impairment of mental development. Without question cases of this sort are more common than is generally recognized, and prevention will depend upon the alertness of physicians in recognizing the condition and upon reasonable watchfulness on the part of those responsible for the care of children. Most cases occur as a result of eating paint chewed from cribs or toys.

A far more important group of acute lesions is due to infections. It is quite obvious that infections more or less specifically attacking the nervous system, such as epidemic encephalitis and cerebrospinal meningitis, can produce changes which impair the mental state of the child. It is less generally realized that the brain can be damaged by almost any one of the infections which affect children. Fortunately, these disastrous complications are rare, but whooping cough, measles, and mumps, for example, can occasionally do tremendous damage. Syphilis, which is a justly feared infection, doing vast damage to the nervous system in adult life, is relatively unimportant in childhood as a cause of mental impairment.

Any fair appraisement of the rôle of acute infections is difficult to make. Most physicians are relatively unfamiliar with the methods of recognizing acute diseases of the nervous system aside from meningitis and poliomyelitis, and most neurologists see cases of this sort after the acute process is over. Improvement in this respect will follow the steady improvement in neurological instruction in medical schools. As with birth injuries, it is worth calling attention to this frequently overlooked possibility.

FIXED LESIONS IN GENERAL

After the acute process has subsided, the fear of further deterioration is not great. Repair, as has been stated, involves no replacement of nerve cells and a certain amount of disturbance may be caused by scar tissue. In the main, however, we are faced by a fixed anatomical situation, which demands a type of reasoning not often used by physicians. Obviously no disease exists. Obviously, also, there is disability. The usual procedure is to describe the disability, call the description a *syndrome,* and think of the *syndrome* as a disease. A more logical method is to try to discover the organic changes left by the injury or infection. Disabilities due to defects of tissue, whatever the original cause, produce disturbances of function. Certain disorders are so characteristic that graphic and reliable descriptions can be given. The *clinical picture* or *syndrome,* or whatever it may be called, receives a title. Medical men are accustomed to regard the named syndrome as a diagnosis. Some of them regard a syndrome as a disease. It should be emphasized that disability and disease are not synonymous.

Three points are of real importance; none of them is likely to involve the identification of a named syndrome. They are:

1. Identification of the anatomical defect. Various con-

ventional medical procedures, such as encephalography, dynamic studies of the cerebrospinal fluid, and so on, have been added to the resources of the examiner in recent years, but at best the defect of tissue, unless it is extreme, is chiefly useful for arriving at classification.

2. Identification of the intact physiological residue is of vastly more interest. Here cooperation between physicians, physiotherapists, and psychologists is essential. If a clear idea of the physiological assets can be gained, the next step is relatively simple.

3. Educational plans based on recognition of the anatomical deficit and the physiological assets are made.

These three steps are always taken sooner or later. It is obvious that prompt and correct appraisal prevents futile and frequently disastrous errors. It is certainly well worth while to watch the progress of any valid experiment along these lines.

The failure to make adequate studies in this way leads to quite unnecessary mistakes in forecasting the future, and to disastrous errors in education. To remedy this situation physicians must become sensitive to educational and psychological problems, and a very definite effort must be made to establish centers for educational appraisal by specially trained individuals.

THE DEGENERATIVE DISEASES

The degenerative diseases can be dismissed in a very few words. The conditions leading to progressive deterioration of the mind as a result of inherent defect are well described in textbooks. Amaurotic family idiocy and other diseases of this type take an undue amount of space in medical literature. Practically no suggestions for treatment have been made, no logical plan of prophylaxis exists, and cases are so rare that there is no public problem of consequence.

Brain tumors and other expanding lesions of the brain are of obvious importance, but the complexity of the problem makes comment here useless.

NUTRITION AS A FACTOR INFLUENCING MENTAL DEVELOPMENT

THERE are practically no data, based on carefully controlled studies, as to whether or not mental development is affected by faulty states of nutrition. The question is whether the tissues of the central nervous system are affected by malnutrition in such a way as to cause temporary or permanent damage with resultant observable changes in the individual's mental development. There are two opposing statements in the literature. One is to the effect that development of the central nervous system is either unaffected or accelerated (compensatory acceleration to ensure survival) by nutritional deficiencies. The other statement declares that nutritional disorders are the cause of, or accompanied by, mental dullness or retardation.

Spargo[1] states that "there is no lack of testimony to show that low nutrition is the prime and most fruitful cause of mental dullness" but he does not state the source of his conviction. Spearman,[2] reporting Dawson's work on malnutrition, believes that there is an increase of fatigability rather than a decrease in ability. Gesell[3] says, "It is even possible, as has been suggested by some pediatricians, that faulty nutrition may, in a compensatory way for survival reasons, increase alertness, perceptiveness, reactiveness." He considers that in the presence of rickets there may be an alteration and depression of behavior output but no arrest or curtailment of basic maturation. Psychological studies of children whose degree of rickets had been carefully diagnosed by doctors connected with the United States Children's Bureau lend support to the latter statement. Holt[4] finds that some children with coeliac disease are "mentally quite precocious" but tire easily. Still[5] thinks there is a quaint precocity which is apparent rather than real and is due to constant association with adults.

Four studies reported in the literature are suggestive. Netschajeff[6] studied 98 children from the famine regions near Moscow. The group which made the greatest gain in weight in the interval of two months between examinations also made the greatest gain in score for the mental tests, having scored below the average at the time of the first examination. Blanton[7] studied a group of children from five and one half to fourteen years of age, 40 to 50 per cent of whom were supposed to have suffered from malnutrition for a period of two to three years. He concluded that "children free from organic nervous disease and with parents of average intelligence very rarely become feeble-minded through malnutrition even of an extreme degree." The study was made by the method of group observations rather than individual psychological studies. Terman's studies of gifted children[8] show that although faulty nutrition was found less often in this group than in the control group, it was not unknown. Serious digestive troubles were reported by the parents of 15 per cent of the girls and 16.8 per cent of the boys. Anderson and Smith[9] studied the effect of quantitative (reduced diet) and qualitative (protein deficient diet) stunting in the white rat upon maze learning. The conclusion that stunted rats are superior to rats that grow normally in relearning a maze is complicated by the fact that other observers have proved, first, that maze learning is affected by motivation, and that reduced diet probably resulted in increased drive; and, second, that maze learning is superior in younger animals, and therefore animals held at a lower stage of development might on this account exceed heavier, larger rats of similar age.

A few case studies are reported, but psychological examinations were inadequate and the children were not followed long enough to make the reports of value. The following case study made by the writer is suggestive, in view of the fact that socio-economic factors would have tended to affect the child's development positively rather than negatively, isolating faulty nutrition as the retarding factor:

The subject was the fifth in a family of five. All of his siblings had school records above the average. Early difficulty in adjusting the child's feeding formula appeared to have been overcome by the time he was seven or eight weeks of age, but at eleven months the mother noticed symptoms well known to her because of an older child's similar illness: failure to gain, characteristic stools, occasional vomiting, enlarged abdomen; personality changed from placid to irritable.

Normal mental development was indicated at the age of six months. At eleven to twelve months, when the unfavorable physical symptoms were noted, retardation in the gross motor field, and to a lesser extent in language, was evident with continued normal development in other types of behavior. At sixteen months gross motor development remained at the eight or nine months level with normal development in other respects. When the pediatrician was consulted about the child's continued failure to assume the seated position, much needless anxiety was caused the mother by his questioning whether the child was as bright as his siblings. By eighteen months the chronic intestinal indigestion had been essentially conquered, and gross motor development had progressed very rapidly. By twenty-one months, development was somewhat above the average in every field. Subsequent observations up to the age of four years have reinforced this impression.

Thus, detailed observation of a case which to the casual observer might present a picture of retardation, reveals the fact that retardation existed only in the gross motor field and must possibly be accounted for in terms of reduction of available energy, rather than affected mental development.

The causes of mental retardation are so complex that it is often extremely difficult to analyze the true situation. The living conditions which surround a child may be so unfavorable, or the amount of personal attention and maternal care which he receives may be so inadequate, that he may become apathetic and refuse to eat. If the situation continues, the lack of appetite may persist to the point of serious malnutrition. At the same time, the apathy may become so deeply rooted as a habitual form of behavior that it may simulate true mental retardation. Superficially the malnutrition might seem to be responsible for the mental retardation, but in reality it is not a primary factor, and only obscures the initial cause. Because there are no exact data available on such relationships there is need here for accurate observation in the future.

An ideal study of the effect of faulty nutrition on mental development postulates:

More exact medical definitions of types of malnourished children.

Due consideration paid to hereditary, socio-economic, and emotional factors which might have affected the individual's development independently of the malnutrition.

An attempt to study individuals during and after the period of malnutrition with careful retrospective study of development preceding the malnutrition.

Comparative analysis of the effects of malnutrition upon the various fields of development (such as motor development, the development of language, and so forth). This would be of particular interest in the study of children with coeliac disease where retardation of gross motor control alone is indicated.

Differentiation of the effect of malnutrition on mental development quantitatively and qualitatively conceived.

References

1. Spargo, John. *The Bitter Cry of the Children.* New York, The Macmillan Company, 1906, p. 107.
2. Spearman, C. E. *The Abilities of Man.* New York, The Macmillan Company, 1927.
3. Gesell, Arnold. *Infancy and Human Growth.* New York, The Macmillan Company, 1928, pp. 267, 391.
4. Holt, L. E., and Howland, John. *Diseases of Infancy and Childhood.* New York, D. Appleton & Company, 1928, p. 400.
5. Still, G. F. *Common Disorders and Diseases of Childhood.* Fourth edition. London, Oxford University Press, 1924, p. 240.
6. Netschajeff, A. "Psychologische Untersuchungen an Kindern in Alten von 4 bis 8 Jahren." *Zeitschrift für angewandte Psychologie,* Vol. 29, 1927, pp. 375–392.
7. Blanton, Smiley. "Mental and Nervous Changes in the Children of the Volksschulen of Trier, Germany, caused by Malnutrition." *Mental Hygiene,* Vol. 3, 1919, pp. 343–386.
8. Terman, L. M., Editor. *Genetic Studies of Genius. Vol. I.*

Stanford University, California, Stanford University Press, 1925. 648 p.

9. Anderson, J. E., and Smith, A. H. "The Effect of Quantitative and Qualitative Stunting upon Maze Learning in the White Rat." *Journal of Comparative Psychology,* Vol. 6, 1926, pp. 337–359.

II. PHYSICAL STATUS

MEASUREMENT AND ANALYSIS OF HUMAN GROWTH

THE study of physical growth has two major aspects, first, the establishment of norms by statistical methods for successive stages of development, and secondly, analysis of growth as a biological phenomenon.

NORMS OF PHYSICAL MEASUREMENTS AND THEIR USE

Norms of bodily dimensions with measures of their variability facilitate critical comparison. Classical anthropology is the comparison of different races but the comparison may be made between different groups in society such as rural and urban communities; between successive generations, or such other groupings as the investigator may desire to study.

The literature of this aspect is extensive and frequently controversial. In classical anthropology itself Martin [18] probably gives the best single bibliography.

For differences in height and weight in groups of society the work of Paton and Lindlay [15] is a good illustration. Similar studies are found in works on sociology and education. Jackson [5, 6] gives references to the available data on major bodily dimensions for American college students. MacKinnon and Jackson [11] and Jackson [7] have brought together the data on successive generations of young adults in this country and in Europe. These studies indicate that as a group the upper social classes are larger than the lower, and that the present generation of young adults as a group is larger than the previous one. All work in this field is complicated by difficulties in accurate measurement and by differences in technical methods. Anthropologists early recognized that basic measurements must be taken under standard conditions, for differences in technique yield results which are not comparable.[12,1] Various "International Agreements" have been drawn up, but none has been consistently followed. Tildesley[22] has summarized the situation as follows:

> That if the agreement essential to far-reaching cooperative racial study is ever to be achieved, it is most likely to be obtained on the basis of Martin's *Lehrbuch*, since more schools of workers have committed themselves to this than to any other system of measurement.
>
> That Martin's *Lehrbuch*, however, possesses defects which cause the results produced by different schools of workers on this basis sometimes to be noncomparable.
>
> That a way of remedying some of these defects would be an invitation to all schools of anthropometrists who have tried out the measurements from the definitions and directions given in Martin's textbook to communicate their detailed criticisms, based on practical experience; also, to say whether any changes made in the new edition of the *Lehrbuch* (1928) meet their objections.

Besides the comparison of the magnitude of different dimensions of various groups of individuals, norms have been established from presumably healthy subjects and used as standards for measuring the individual. Assuming that the original selection consists of normal individuals, then the individual of mean size is no more "ideal" in size than the largest or smallest individual, but merely more typical of the group. The Baldwin-Wood height-weight tables based upon mean weight for age and height are the most extensively used, but are of value only in determining the deviation of an individual from the average weight for age and height.

Faber[4] has proposed a modified table based on the weights of over 60,000 school children of San Francisco in which weight for a given age and height is recorded as a zone including the middle 80 per cent of the children. The assumption behind this is that the individual farthest away from the mean is the most likely to be abnormal. Faber, however, clearly recognizes that the individuals within the zone are not necessarily well nourished, nor those outside necessarily all ill or malnourished.

Two recent studies on adults point the way in which we could evaluate the probable significance of marked deviations from the mean size.

Love [10] pointed out that, among the men drafted for military service, the probability of pulmonary tuberculosis increases rapidly in passing from the short overweight zone to the tall underweight one. There are many more chances of finding tuberculosis in a man who is very tall and thin than in one who is short and overweight. He also noted that there are more chances of finding a valvular heart disease in the tall thin young man than in the short overweight one, and that both types of disease occur much more frequently among tall underweight young men than among short underweight ones.

Dublin,[8] in an analysis of life insurance data, found that individuals who were overweight when insured died at an earlier age than underweight individuals from all diseases except tuberculosis.

What has been said of weight for a given height and age also applies to other dimensions of the body which are less affected by intercurrent phenomena. At present, however, our techniques permit the use of statistical standards of physical size with their zones of variability for definition of the physical characteristics of various racial and social groups but not for evaluation of physical well-being. In fact it is questionable whether physical measurements can ever be used as tests for physical fitness of the individual. The measurements of a physically fit group selected by other criteria may be compared with those of a physically unfit group but any particular individual must fall outside the range of variation of the physically fit group before he can be differentiated from them on the basis of measurements alone.

GROWTH AS A BIOLOGICAL PHENOMENON

The second aspect of the study of physical growth is the analysis of human growth as a biological phenomenon. This is a more complicated problem of which, at the present time, our knowledge is meagre. It is very difficult to define growth clearly and sharply or to separate it from differentiation. There are, however, two very distinct phases of growth which should be recognized. Growth itself is a physico-chemical process of which we know relatively little. It is true that the course of growth may be modified by experimental means. The environment of the growing organism may be changed. Its food-intake may be reduced or increased. The effects of various ductless glands upon it may be augmented or diminished. These modifications, however, afford but few clues as to the actual nature of the physico-chemical process itself, which is one of the great future problems of the bio-chemist and biphysicist.

Difficulties in Estimating Growth

Existing studies are limited to the other phase of growth, namely the changes resulting from this physico-chemical process in structure, composition, and size of the body. But even this phase of the study of growth is not as simple as it may appear at first sight. The first difficulty encountered is the establishment of units of growth. Progressive modification of the body is so profound that a given unit increment in weight or stature or chemical composition is an entirely different thing at one stage of development from the same unit at another stage. In the infant a gain of one pound means increase of brain substance and viscera as well as enlargement of other parts of the body. In the adolescent it is primarily due to increase of bone and muscle. In the adult it may indicate merely accumulation of fat.

This phase of growth can be analyzed to some extent by quantitative study of the various parts and organs of the body during the developmental period. The extremely diverse types of growth thus disclosed are summarized in Scammon's section of *Measurement of Man*.[8] This type of analysis has been extended to microscopic structure by Hammar and his school and an example is given in the section on the thymus. However, analyses of this type are slow and tedious and have been made on only a few organs.

Another and a different picture of growth is obtained when the body is resolved into its chemical constituents. Scammon and Ness have published a preliminary note on this subject.

We are thus introduced to a second difficulty in the estimation of growth which is not a steady process but is subject to constant fluctuation. A child may gain a pound a month. It does not make this gain by constant daily increments but by irregular spurts often followed by recessions in weight, as may be seen in any weight chart. Evidently we may frame two very different criteria for measurement of the increments in living things. One is the measure of the substance which is retained as a part of the body after being added to it in a given time—the quantity which "sticks to the ribs" so to speak. The other is a measure of all the material which is added to the body in a given time regardless of whether the body retains it.

Each of these methods of analysis adds to our knowledge of human development and to our precision in describing it, but the net result of their application is to intensify our realization of complexities of the growth sequences in man. None answers the fundamental question raised as to what unit may be properly used as a criterion of growth. The solution of this problem, like that of the real nature of the growth process, has not been found in our existing techniques for estimating increments in the human body.

Such knowledge as we have of growth in this secondary and limited sense has been made by three types of technique, the pictorial, the tabular and graphic, and the analytic. A simple representation of the course of growth by portrayal of selected specimens was the method first employed. An excellent example is given by the classical series of the stages of human embryo published by His.[9] The pictorial method will continue to be profitable for the representation of those phases of human growth where material is scanty or its measurement difficult and where developmental changes are so complex that mere numerical measurement fails to give as complete a representation of its intricate interrelationships as orthodiagraphic scale maps and roentgenograms can give. But, generally speaking, as material becomes more abundant and the techniques of its measurement are improved, pictorial representation will probably decline in importance as a method of description although it will always have its place as a method of exposition.

By far the greater part of the quantitative description of human growth has taken the form of tabulated measurements together with a number of expressions, of highly variable worth, of their central tendencies and distributions. This form of description is frequently accompanied by graphic, as distinct from simple pictorial and from analytic, portrayals so that it seems unnecessary to consider the two methods separately.

Although descriptions of this type began to appear in the eighteenth century the systematic accumulation of quantitative records of human growth did not really gather force until the early part of the nineteenth century, commencing with the publication of Quetelet [18] on body weight, stature, and external dimensions in the living, and of other investigators on the sizes and weights of organs from cadavera at various ages. Scammon [20] published an analysis of the fields in which work on growth has been done and included a list of annotated bibliographies where most of the titles used in the analysis may be found.

Collected Data on Human Growth

The earlier collections of data on human growth were made by men of medicine or biologists who had little conception of the variability of natural phenomena and no adequate method of expressing it. Most of the earlier tabulations were either published in full, including individual case histories, or else as simple averages for given ages. Expressions of variability first took the form of statements of ranges (with minimal and maximal values) and, later, of more or less abbreviated frequency tables. As early as 1836

Quetelet pointed out the analogy between the "normal" or Laplace-Gauss curve of error and many of the distribution curves of human traits. While he fully recognized the importance of this concept neither he nor his contemporaries made any extensive use of it in the study of human growth.

The great value of Quetelet's discovery lies in its influence on Francis Galton and Ludwig Stieda some forty years later. The history of Galton's contribution to the quantitative aspect of anthropology, including human growth, is so familiar and has been told so well by Pearson [17] that it needs no repetition. Galton's earlier percentile notation became the recognized technique for the expression of variability in human growth studies until it was largely replaced by the standard forms developed by the school of biometry of which he is properly regarded as the founder and Karl Pearson the leading spirit.

The graphic expression of the phenomena of human growth developed step by step with their presentation in tabular form. The first integral curves of the postnatal growth of the body in weight and stature seem to have been published by Quetelet.[18] Curves of prenatal growth did not appear until much later. The data for this developmental period are discussed in detail by Scammon and Calkins.[21]

Curves of the growth of organs were also a later development. Vierordt [23] included in his classic presentation of child physiology a graph showing the growth in weight of a number of the major viscera between birth and four years, calculated in units of their initial birth weight. But the first extensive work of this kind was that of Oppenheimer,[14] who published graphs on the growth of a number of the larger organs between birth and twenty-five years.

Graphic representations of *rates* of growth (or differential curves of growth) were foreshadowed in the charts of yearly increment which accompany many of the larger studies of the general growth of children that appeared between 1880 and 1895. Later in this period *relative* rates of growth were pictured in approximate fashion in the graphs of percentage increment. The modern developments in this field are commonly based on analytic expression which will be considered in a later section. Curiously enough, graphic representation of variability in the growth period was another relatively later development. Typical distribution curves apparently made their first appearance in the studies of the 'seventies on weight and dimensions of the newborn.

The analytic study of growth involves primarily the numerical expression of phenomena of growth by analytic or mathematical symbolism. Further, the symbolic relations thus established may be roughly classified into two groups, the rational or theoretic and the empirical expressions. They have two types of symbols in common, variables such as magnitude or time, and constants which modify these variables. In its stricter definition a rational formula is one in which the constants have real physical meaning and may be experimentally determined. The laws of gases form a good illustration. When an expression is set up it fits the data; and when these data are dissected by physical methods one element after another can be removed from the physical set up, and they will appear as a definite removal of one symbol or another from the mathematical expression. The truly rational expression must be derived by the experimental method. However, the term has been used in a much broader sense for the discussion of growth and other biological phenomena. Thus any expression of phenomena which can be reduced to the semblance of some well recognized and accepted physical law has been regarded as rationalistic. In other words, if one observes a given phenomenon of growth, and if there is already existent in physics a suitable expression which is generally accepted; if the application of this expression to the growth problem is good, the expression is often accepted as rational.

Although this definition is very loose it is very generally followed in formulating rational expressions of growth. As a matter of fact, rational expressions of growth run the whole gamut from the rather specifically rational ones down to those which can hardly be distinguished from the empirical.

There should, however, be three definite criteria of any rational expression of the growth process. First, the rational expression of growth must fit the phenomenon in question. Secondly, it must be based on some universally accepted law, some law which is recognized in nature. Thirdly, there must be a universality of acceptance, or at least a fair unanimity of acceptance, of the application of this law to the phenomenon in question. These three criteria are absolutely essential but, as a matter of fact, they are rarely met.

When an observed growth sequence and a physical law can be represented by the same mathematical expression there is a strong tendency to assume that the growth sequence represents that physical law. A good example is found in the well known work of Robertson (see Scammon[20] and Brody[2]).

If growth continued in geometric ratio it would soon occupy the universe. Hence at some point in its course the growth turns over and gradually approaches a asymptote or comes to a close by a process which is expressed by various formulae, some proportional to the amount of growth yet to be acquired and some by various rather artificial formulae. This implies the second or saturation concept. Formulae of this latter type have been developed particularly in recent years out of the old formulae for population by Pearl,[16] Reed,[19] and certain other workers. Are these formulae rational? We have chosen to call them rationalistic, and we think we are using "rationalistic" in a rather true sense, because the rationalization has taken place after the curves have been established. It is perfectly true that they do have an advantage in that they establish a beginning point, an end point, and a critical point of inflection in the course of growth, which can be observed in practically all growth phenomena. Whether we are justified in going further in the interpretation of these formulae is questionable indeed.

Which of the two methods of expression, rationalistic or empirical, is appropriate becomes a matter of expediency. If one feels that the advance of science will take place more rapidly by building an elaborate system of postulates and following out growth on the basis of these postulates, then the rationalistic method might appear to be the best course to pursue. If, on the other hand, one is skeptical of such postulates and feels that the setting up of postulates leaves one blind to phenomena, one had best work on a purely empirical basis. The latter seems more advisable until the rational basis has been better established.

Now that the analytic method is coming into its own it may be well to point out the reason for its elaboration and its use. First, the analytic method of approach to the course of growth, the expression of growth in an analytic and logistic form, has the advantage of simplicity and brevity. One can depict it in simple form as compared with tabular and graphic forms which are open to questionable interpretation. Secondly, the analytic expression has the advantage of stability. Reliability in graphic expression depends on the skill of the operator. Analytic expressions once established can never be changed, and any operator can repeat them.

The difference between the analytic and the actual can be measured accurately. This perhaps is the most important of all reasons for the adoption of an analytic form of expression. It is sometimes said that an analytic expression for growth is a departure from actual phenomena. This is true but so is any expression of growth other than actual notation of observed values. The analytic expression has the advantage that this departure can be measured. One can tell how far one has wandered from the path. No other method will enable this to be done with precision and accuracy.

The analytic expression permits interpolation of values at definite intervals, which is one of the most important desiderata in studies of growth. Moreover, being in analytic form, the expressions are flexible, and may be moved from one scale to another with ease. This is absolutely essential when dealing with values of such variable magnitude. Finally, and most important, it allows the use of the calculus in the study of growth. The study of growth is the study of a moving point, and no method of measurement which does not allow us to measure the movement of a value in its relation to the movement of some other value or to the lapse of time can prove to be a thoroughly successful method. Application of the calculus is perhaps the most important feature of recent progress in the analysis of growth.

References

1. Boyd, E. "The Experimental Error Inherent in Measuring the Growing Human Body." *American Journal of Physical Anthropology,* Vol. 13, 1929, pp. 389–432.
2. Brody, S. *Growth and Development.* Columbia, University of Missouri Agricultural Experiment Station Research Bulletins. A series of fifteen papers, 1926–1930.
3. Dublin, L. I. "The Influence of Weight on Certain Causes of Death." *Human Biology,* Vol. 2, 1930, pp. 159–184.
4. Faber, H. K. "A Weight Range Table for Children from 5 to 15 Years of Age." *American Journal of Diseases of Children,* Vol. 38, 1929, pp. 758–761.
5. Jackson, C. M. "The Physique of Male Students at the University of Minnesota." *American Journal of Anatomy,* Vol. 40, 1927, pp. 59–126.
6. —— "Physical Measurements of the Female Students at the University of Minnesota." *American Journal of Physical Anthropology,* Vol. 12, 1929, pp. 363–413.
7. —— "Changes in Stature, Weight, and Body Build of Female Students at the University of Minnesota during a Period of Eighteen Years." *Anatomical Record.* In press.
8. Harris, J. H., Jackson, C. M., Paterson, D. C., and Scammon, R. E. *The Measurement of Man.* Minneapolis, University of Minnesota Press, 1930. 215 p.
9. His, W. *Anatomie Menschenlicher Embryonen.* Leipzig, 1850, 1885.
10. Love, A. G. "Somatological Norms in Tuberculosis and Heart Disease." *Human Biology,* Vol. 1, 1929, pp. 166–197.
11. MacKinnon, D. C., and Jackson, C. M. "Changes in the Physical Measurements of Male Students at the University of Minnesota during the Last Thirty Years." *American Journal of Anatomy.* In press.
12. Mahalonobis, P. C. "On the Need for Standardization in Measurements on the Living." *Biometrika,* Vol. 22A, 1928, pp. 1–31.
13. Martin, R. *Lehrbuch der Anthropologie.* 2nd Aufl. Jena, Fischer, 1928.
14. Oppenheimer, C. "Über die Wachstumsverhältnisse des Körpers und der Organe." *Zeitschrift für Biologie,* Vol. 25, 1889, pp. 328–357.

15. Paton, D. N., and Lindlay, L. *Poverty, Nutrition and Growth.* London, Medical Research Council, Special Report Series No. 101, 1926.
16. Pearl, R. *Studies in Human Biology.* Baltimore, The Williams & Wilkins Company, 1924. 653 p.
17. Pearson, K. *The Life, Letters and Labours of Francis Galton.* Cambridge, Cambridge Press, 1924. Vol. 2, Chap. 13, p. 334ff.
18. Quetelet, A. *Sur l'Homme et le Dévelopment de ses Facultés; Un Essai de Physique Sociale.* Brussels, 1836.
19. Reed, L. J. "A Form of Saturation Curve." *Journal of the American Statistical Association,* Vol. 20, 1925, pp. 390–396.
20. Scammon, R. E. "The Literature of the Growth and Physical Development of the Fetus, Infant and Child; A Quantitative Summary." *Anatomical Record,* Vol. 35, 1927, pp. 241–267.
21. —— and Calkins, L. A. *The Development and Growth of the External Dimensions of the Human Body in the Fetal Period.* Minneapolis, University of Minnesota Press, 1929.
22. Tildesley, M. L. "Racial Anthropometry; Plan to Obtain International Uniformity of Method." *Journal of the Royal Anthropological Institute of Great Britain and Ireland,* Vol. 58, 1928, pp. 351–362.
23. Vierordt, K. "Physiologie des Kindesalters." In Gehardt's *Handbuch der Kinderkrankheiten.* Band 1, 1873.

MEASUREMENT OF SUBCUTANEOUS TISSUE AND MUSCLE

THE successful measurement of characteristics which serve to distinguish individuals requires the use of indices which, by virtue of correlations, allow the expression of differences in much larger values. We aim at distinctions in growth, development, and nutritional status. Naturally we are unable to include quantitative measures sufficiently elaborate to give a full account of the individual differences in these characters. The earliest measures used were those which were most easily accessible, but our attempts to gain more valid indices should not stop with them.

THE NEED

Height-weight ratios are measures which are very objective and very easily obtained. Individual differences in this ratio, however, yield information mainly upon type of build and throw little light upon individual differences in nutritional status. The degree to which height-weight ratios are affected by breadth and depth of skeletal frame is great enough to make verdicts of dubious value if gained from this source alone. Efforts have been made to obtained deviations in weight from the weight to be expected from a more complete skeletal inventory. A residual, or verdict, of this type measures the degree to which the weight of an individual approaches that appropriate to his skeletal dimensions. This measure, though very useful for refined statistical work, has proved unsatisfactory as an index of nutritional status because deviations in weight unaccounted for by differences in skeletal dimensions are very small compared with those differences in weight which occur in the course of a day from elimination and retention of water. The deviations in weight from the weight indicated by skeletal dimensions is not an adequate guide to the recent history or nutritional care of the individual.

Since these most easily accessible measures are not satisfactory, it is desirable to direct further research to the perfection of other measures specifically designed to achieve our objective. Amount and quality of subcutaneous tissue and of muscle offer very promising possibilities. They seem natural candidates for a battery of nutrition tests for natural physiological reasons and also because of the emphasis placed upon them by physicians in their ordinary clinical judgments. When the considered verdict given by a physician upon the physical status of an individual is analyzed to elucidate the relative reliance upon different aspects of development, it will be found that much emphasis is laid upon the physician's estimate of the condition of the subcutaneous tissue. In other words, the final rating received by a child from his physician is decided in great part by the impression derived from the condition of the child's subcutaneous tissue. Nevertheless there is a high degree of disagreement among physicians in estimates of the precise condition of the subcutaneous tissue in a child under observation. The actual estimate made on a child is usually based on sight and touch impressions rather than on objective measurements. This is very important since that estimate will to a large degree determine the final opinion upon the nutritional status of the child. We conclude that the physician desires to appraise the subcutaneous tissue as a necessary foundation for his final rating but is at present unable to do so satisfactorily because his evidence is unobjective.*

THE POSSIBILITIES

Experiments with tape and calipers have shown that really objective measures can be developed for estimating the condition of subcutaneous tissue and muscle. We also find that agreement of physicians, when such measures are utilized, is very much greater than that which results when they make their judgments without the benefit of this objec-

* *Physical Measures of Growth and Nutrition.* School Health Research Monograph No. 2. New York, American Child Health Association, 1929.

tive evidence. Entirely independent measurements of groups of children yield objectivities which compare favorably with the objectivity of such common measures as pulse rate, blood pressure or tuberculin tests. The ability to measure subcutaneous tissue by calipers and to measure the girth of muscle, flexed and relaxed, is easily developed. Experienced observers show very close agreement in measurements made entirely independently of one another. This objective evidence, when relied upon by physicians, promotes clinical agreement. It thus offers a basis for a revision of judgment and tends to create a much richer common understanding. There are, of course, many problems still to be solved in measurement of the firmness of subcutaneous tissue. Quantity, for example, must be discounted. The effect of water retention upon the amount as read by the calipers must also be recognized and, if possible, discounted. But the progress made toward objectivity of caliper readings encourages us to hope for a satisfactory solution of these problems.

The value of this type of measurement hinges in part on the possibility of generalization of the characteristic. Is a greater than average amount of subcutaneous tissue in one area associated with equally significant positive deviation, that is, comparable increase, in other areas or is the measurement merely a record of a particular local area? Does a large biceps imply a large quadriceps femoris and a large gastrocnemius? Are these measures a function of the organism or are they isolated records, each characteristic only of the area upon which it is taken? Experiments have shown a high correlation of measures of subcutaneous tissue made upon various areas on the left side by one examiner and independently on the same areas of the right side by another examiner. Further, the measures are correlated among themselves and the interrelationship is high enough to say with assurance that there is a common characteristic, in the subcutaneous tissue over the entire body, representing quality. Similar experiments on muscle have yielded strictly comparable results. Our experience teaches us that measures of the amount of subcutaneous tissue and of muscle, significant as indexes of general bodily quality, can readily be made.

If, in the comparison of two children, the measurements obtained upon subcutaneous tissue and muscle are in strict proportion to the skeletal dimensions, the measurements are of limited value for the same reason that limits the use of weight as a residual from a skeletal composite. Skeletal dimensions are, of course, important measurements of growth in themselves. We do, however, wish to measure condition of the soft tissues irrespective of the individual differences which are necessarily associated with the skeletal characteristics. The multiple correlation of five skeletal dimensions with amount of subcutaneous tissue is about 0.50; that with amount of muscle is about 0.80. With weight it is about 0.95. Hence, while one might claim weight as a characteristic of dimensions, there is greater variability in muscular development and a far greater variability in amount of subcutaneous tissue. In such measure, then, do the soft tissues offer possibilities for a richer understanding of nutritional status.

FUTURE DEVELOPMENT

Since the measurements obtained on different areas are intercorrelated it is possible to find the degree to which the measurements made on any individual are intercorrelated and conversely the degree to which a particular area is in disharmony with the others. Asymmetry in subcutaneous tissue and muscle offers large possibility for inquiry concerning predisposition to disease and failure in proper development. The tendency of certain areas in some individuals to fall lower in amount of subcutaneous tissue than would be expected from the average measure of those individuals, may indicate important characteristics challenging further investigation. It is of equal importance to measure the failure of certain muscles to keep pace in their development with the rest of the musculature, and to determine the results of such failure to reach a balanced functional development.

Measures of the soft tissues, especially when they are corrected for skeletal dimensions, offer opportunities for investigation into the effect of diet. Most of the evidence purporting to indicate effects of change in diet are hard to interpret because the criteria are so inconclusive. Changes in weight, whether corrected for height or not, are so easily influenced by other features of bodily growth, entirely apart from the changes in diet, that experiments have proved equivocal. Amount of subcutaneous tissue and condition of musculature may offer new possibilities for experimentation with diet.

MEASUREMENT OF SOCIO-ECONOMIC FACTORS INFLUENCING SCHOOL HEALTH RESULTS

ANY survey of the school population includes children of varied attainments. Even though the age be identical, the children differ in knowledge of the principles of health and hygiene, in nutritional status, and in the other objectives of a public health program. They differ also in wealth, culture, and maturity. Public health policies depend in part upon recognition of the degree to which differences in health are influenced by socio-economic differences. Such recognition enables us to make allowances for irremediable and environmental barriers to health and to adjust health programs in such a way as to correct handicaps where they are found. It also makes it possible to assess for any community the true effect of public health work by excluding those findings which are the result of uncontrollable economic and social forces.

Samplings from schools represent all manner of economic and social background and, in addition, the varied parental origins characteristic of American-born white children. Groups used for experiment or survey may also differ materially one from another in a particular health feature. The average amount of uncorrected caries in the first permanent molars, for instance, varies in 70 groups used in the School Health Study from a high extreme of 12.8 to the other extreme of 1.2.* This represents a range from badly neglected mouths to satisfactory dental care. We are faced with the problem of distinguishing the effect of influences like economic condition of the parents, cultural background,

*These amounts represent 12.8 units of caries and 1.2 units of caries in the first permanent molars per mouth as explained in *Public Health Aspects of Dental Decay in Children.* School Health Research Monograph No. 3. New York, American Child Health Association, 1930.

parental origin, intelligence of the children, and so forth, from the result of effort made by the school authorities, of accessibility of dental clinics, of health education work, and the like. Such discrimination would give the proper evaluation of school health work. Any comparison of dental decay which attempts to associate these conditions with different aspects of dental school health work cannot afford to neglect the important rôle played by socio-economic factors.

TYPES OF SOCIO-ECONOMIC INFLUENCE

Each group of children under observation may be measured by as many social yardsticks as can be devised. It is not claimed that the measures here described are the best or that they exhaust the possibilities of measurement. They do indicate various types of socio-economic influence. Those have been included which it is desirable to separate from the effects of public health activities in order to adjudge clearly the results achieved by the latter. An attempt will be made later in this section to show the degree to which influences that are irremediable and those that can be amended overlap and the degree to which each is a distinct index of the social situation.

ECONOMIC RATING BY THE SCHOOL SUPERINTENDENT

At the beginning of a study the superintendent should be consulted and informed of the plan and its purposes. This ensures cooperation and precludes the necessity of repeating an explanation of the plan at each school where the children are to be examined. The superintendent may be asked to forward a complete list of all elementary schools with number of rooms and number of children in the grades involved, and to attach to each school a mark on a scale of 1 to 5 to indicate the relative economic status of each school in that

* The measures are described as used in the School Health Study of the American Child Health Association. This study found it possible to obtain and use these measures in 70 groups. A full treatment may be found in *Influence of Social and Economic Factors on the Health of the School Child.* School Health Research Monograph No. 4. New York, American Child Health Association, 1932.

city. This rating, being adjudged by the superintendent for all the public elementary schools in the city, permits a proper rating of the schools selected for use in their relation to the other schools in the city.

The instructions given to the superintendent as a basis for his rating may be the following: "To assist in selecting schools, rate each school from 1 to 5 on its economic status. Rate those schools 1 where the average income of parents is highest. Rate those schools 5 where it is lowest—3 will mean average—4 is a little better than 5 and 2 is a little worse than 1."

APPRAISAL ON THE BASIS OF RENT

About twenty-five or fifty names may be chosen at random from the pupils of each school comprised in the study and sent to the principal of the school with the request to obtain for each either the amount of rent paid by the family or the value of the house if owned. If this meets with administrative difficulties one may write directly to real-estate agents in the vicinity of the school and obtain from them estimates of the average rental of the homes of the children going to that school. From these data an estimated monthly rental for children of each group can be computed.

The ratio of this monthly rental to the city tax levy per thousand on estimated true value of the property represents the economic condition of a group in the city of which that group is a part.* Since health expenditures are correlated with other costs of living, this ratio is an attempt to measure the degree to which a group may afford health expenditures as a portion of its budget.

CULTURAL STATUS DUE TO PARENTAL ORIGIN

Even when groups studied include only white American-born children, birthplaces of parents show a broad geographic representation. It is possible that children of the

* The ratio of tax paid to tax levy per thousand would give a direct measure of the economic status of a group. But adequate measures of tax paid by the parents of the children are not obtainable.

same economic status but of different parental origin might have very different home conditions in ways vital to health. For this reason the socio-economic data should include birthplaces of both father and mother.

One aspect of cultural influence of great importance is the degree of Americanization. One must take note of the clinging to religious and native customs which are not adapted to American life and which may even be subversive of health. There are computations available giving the average Army Alpha score of the white draft classified by birthplace.* These average scores made by groups with defined birthplaces may be used as an index of cultural status.

The assumption implied in the foregoing may be checked by another index of the degree of absorption into American life of each foreign-born constituent. An English-born parent is as likely to be married to an American-born parent as to another English-born parent. An Italian-born parent, on the contrary, is far more likely to be married to another Italian-

TABLE 1

A COMPARISON OF TWO METHODS FOR WEIGHING PARENTAGE AS A GUIDE TO CULTURAL STATUS

Birthplace	Average army alpha score [a]	Absorption ratio [b]
England	14.87	.51
Scotland	14.34	.59
Holland	14.32	.73
Germany	13.88	.56
Denmark	13.69	.36
Canada	13.66	.69
Sweden	13.30	.28
Norway	12.98	.46
Ireland	12.32	.57
Austria–Hungary	12.27	.11
Russia	11.34	.15
Italy	11.01	.08
Czechoslovakia	11.00	.08
Poland	10.74	.08
Lithuania	10.74	.08

[a] *National Academy of Sciences, Memoirs*, Vol. 15, Part 3, Chapter 6, 1921.
[b] Number of children having one American parent and other as designated divided by total number of children having one or both parents foreign-born as designated.

* *National Academy of Sciences, Memoirs.* Vol. 15, Part 3, Chapter 6, 1921.

born parent. In one of our samples only 47 out of 600 children of Italian-born parentage had an American-born mother or father. We may compute an "absorption ratio" which is the proportion of the total number of children with one American-born and one foreign-born parent to the total number of children with one or two foreign-born parents. Table 1 gives the absorption ratios and the Army Alpha scores of all national origins having sufficient representation in our materials to allow such computations.

The correlation of the two columns in Table 1 is .84. A correlation of this size between the two independent estimates of the influence of American culture upon the various kinds of foreign stock is justification for either measure.

CLEANLINESS

The health opportunity of the child varies according to the degree of care and cleanliness which characterizes the home management. A socio-economic picture is incomplete without some measurement of this influence. The cleanliness test measures old (ingrained) dirt and new (surface) dirt separately. By forcing this distinction reliable measures of persistent lack of attention are reached.*

AGE, GRADE, AND SEX

Records should be kept of the age, grade, and sex of all individuals involved in the study. This allows the computation of maturity indices to be used as controls. We wish to avoid attributing superiority of groups to health procedures when they are really due to maturity factors influenced by accidents of selection. Age by itself is important and age in relation to grade even more so.

INTELLIGENCE

Each child may be tested by some general intelligence scale. For the purposes of most health experiments it is not

* This test is described in Appendix A, *Influence of Social and Economic Factors on the Health of the School Child.* School Health Research Monograph No. 4. New York, American Child Health Association, 1932.

necessary to distinguish between genetic and economic causes of superiority in tests which gauge the facility in learning. Individual differences in this trait under conditions imposed by a paper and pencil test are, of course, partly due to inherited ability and partly to social and educational advantages. As all of these qualities need to be controlled, an intelligence test is an appropriate item in a battery of socio-economic measures.

RELIABILITY OF MEASURES USED AS SOCIO-ECONOMIC CONTROLS

In order to ascribe to a group of children only those deviations from the usual range which are truly appropriate to them it is necessary to determine the degree to which individual differences between groups are due to chance or to causes not involved in our procedure.* If a group is truly lacking in cleanliness it will show this distinction from other groups for any random half of the children. So, too, a group which receives a good score in any one of these measures must be shown to be good when the measure is based upon any half of the children. If, under this rigid testing, lack of cleanliness is found it is certainly a function of the community or the school, and therefore a quality with which a social study should deal. The measure of reliability is the correlation between two sets of scores computed on random halves of the data. These halves must be chosen in such a way as to have equal representation of the two sexes. This latter precaution is important mainly in measures like cleanliness where scores by boys are far different from scores by girls and so a variation in percentage of boys would make a difference in the scores.

Not only are girls generally cleaner than boys, but the distribution of the scores within the several groups may vary. This may be shown by a difference in the correlation obtained between random halves and the correlation obtained between scores for boys and scores for girls, and indicates the

* This reliability must be distinguished from one judging the precision of the measure. The latter is the correlation between random halves of the test materials. This is the correlation between random halves of the groups.

existence of a sex difference toward cleanliness in community and school. In some places efforts toward cleanliness are more successful with one sex than they are with the other. In 70 groups used in the School Health Study the correlation between boys and girls was .75 whereas the correlation of any random half against another random half with equal sex representation was .94. This study found no other important sex differences in the measures here described.

It is possible to compute reliability coefficients for five of the seven socio-economic measures. By definition the superintendent's rating of economic status for random halves of the group is not available. Grade of the groups, as usually determined, has no error of measurement and so needs no reliability computation. The reliabilities of the other measures computed in the School Health Study were:

Rent appraisal	.94
Cultural status due to parental origin	.95
Cleanliness	.94
Age	.91
Intelligence	.93

These results insure the chosen measures against chance error. We may be certain that distinctions between groups resulting from such an appraisal are truly distinctions resting in the communal structure underlying the groups.

INTERRELATION OF SOCIO-ECONOMIC MEASURES

As stated previously, the measures above recorded are in no sense mutually exclusive of one another. They supplement each other because of a difference in emphasis. One way of showing the amount of interrelation of these measures of the social situation is to give the multiple correlations of each one with all the others. The high multiple correlations indicate greatest overlapping of other factors and the low multiple correlations indicate the greatest degree of unique contribution. They are arranged from high to low.

Socio-economic measures

	Correlation coefficients
Age	.77
Economic rating	.72
Grade	.70
Rent appraisal	.67
Intelligence	.64
Cleanliness	.60
Cultural status	.47

From these correlations we conclude that cultural status is most unique and that age, economic rating, and grade are the elements which most overlap the others. Each of them, however, has a very definite place in the battery since reliability coefficients are all over .90 and therefore each measures something specific not in any way incorporated in any combination of the others. If such a multiple correlation and the reliability of some measure were about the same, then it would show that the measure was of no practical value since it agrees statistically with a combination of the others as well as it agrees with itself. Much is to be hoped from the inclusion of cultural status and perhaps also of cleanliness, because the low relation of each of these to the other six indicates that such influence as they may have on health does not duplicate to any large extent the influence of other socio-economic measures. Any battery of tests is therefore greatly improved by their inclusion.

ROENTGENOGRAPHIC APPRAISEMENT OF DEVELOPMENTAL GROWTH IN THE SKELETON

PRINCIPLES AND TECHNIQUE OF STUDY

FROM the account of growth and development of the skeleton it is apparent that roentgenographic study may be expected to yield a measure of physical development in so far as this is reflected in the bones. In earlier childhood at least it will also provide a running commentary upon the misadventures met with in health or circumstances in so far as these have been severe enough to leave an imprint upon the skeleton.

Essentially the records on the bones depend upon two main features, namely, growth of the area undergoing ossification and deposition of calcium in the growing area. The two features do not necessarily keep pace with each other nor indeed are they inevitably present together. The intricacies of calcium metabolism find no explanation here although they are plainly involved in the morphological patterns which form and dissolve under our observation when an adequate study is made by roentgenographic investigations repeated upon the child at appropriate intervals of time.

Once roentgenograms of the several growing skeletal areas are available, the age indicators may be checked against a time table empirically constructed from the records of a large number of children, and the signals of disease or other misadventure be read likewise in the light of experience.

To make the roentgenograms of suitable areas is an easy task. To read these with accuracy and assurance is less simple but can be accomplished with increasing satisfaction if the observer will be patient and will recognize that an instrument requiring experience does not yield perfect results in the hands of a beginner.

The roentgenograms required for a full study of developmental progress toward maturity need not involve the entire body. Unless particular cranial and facial features are desired the skull can be omitted. Vertebral column and ribs give no significant information in this special study. Indeed, shoulder, hip, and lateral of hand may also be omitted if it is desired to reduce roentgenograms to a minimum, though these often give valuable information. To facilitate an adequate study, however, there should be anteroposterior and lateral roentgenograms of hand, elbow, knee, and foot, together with anteroposterior roentgenograms of shoulder and hip. These will include all significant secondary ossification centers and diaphyso-epiphysial junctions.

The method of making the roentgenograms is of prime importance, for it is essential that the etched outline of bone in the roentgenographic shadow be not distorted, so that a reasonably accurate estimate can be made of the progress of bony penetration in the epiphysial cartilage and the state of the diaphyso-epiphysial plane.

Uniformity of roentgenographic picture will not be invariably secured because the precise shapes of the several bones and the freedom of movement in the joints necessarily included display individual modifications. Nevertheless care in following the instructions will, in most instances, result in favorable conditions of study.

For the anteroposterior hand picture, the hand should be laid palm downward on the film envelope with the fingers adducted and the thumb close to the index finger. For the lateral, the ulnar border of the hand rests on the envelope and the palm is inclined toward the envelope with fingers extended and thumb adjacent to the index so that the shadows of metacarpals and phalanges will be separate and not obscure each other by overlapping. As in the pictures of elbow, foot, and knee, both anteroposterior and lateral pictures can be made on a single 8 x 10 film by covering the redundant part of the film envelope with a sheet of lead. In roentgenographing the hand the longer dimension of the film is in the long axis of the hand, thus securing a picture of the lower end of the radius and ulna as well as the hand proper.

In making pictures of the elbow the limb is placed transversely on the film so as to secure enough film for the lateral view. In the anteroposterior picture the elbow is extended and its dorsal aspect laid next the envelope. The forearm is supinated. Some elbows, even of children, cannot be fully extended and a compromise must be made. The elbow can, in all instances, however, be laid squarely on the envelope. It is important not to tilt it either to radial or ulnar side. In the lateral view the elbow should be flexed to about sixty degrees in order to draw the olecranon out of the humeral shadow. The forearm in this view is kept half-way between pronation and supination.

Pictures of the knee are also made with the limb placed transverse to the long axis of the film. In the anteroposterior view the patella lies directly on the film envelope. Special care must be taken to center the film just above the tibial tubercle to ensure the inclusion of all parts of the diaphyso-epiphysial planes of both femur and tibia. Again, tilting of the knee to lateral or medial side should be avoided but this can be guarded against by keeping the dorsum of the plantar-flexed foot in contact with the table. In the lateral the knee is slightly flexed and its lateral aspect is in contact with the film.

To cover the foot the long axis of the film is used. The dorsi-ventral view is secured by laying the sole of the plantar-flexed foot next the film and extending the knee as far as possible in order to restrict tibial and fibular interfering shadows as much as possible. It is quite impossible to obtain a picture of the calcaneus in this view. The lateral picture requires a dorsi-flexed foot placed so that its lateral or fibular side lies immediately on the film envelope. So far as possible the foot is everted at the mid-tarsal joint in order to secure a relatively uninterrupted view of the several metatarsal heads and phalanges. It should be remembered that, in many children, there is no ossification center for the epiphyses of the second phalanges, especially those of the fifth and fourth toes.

For the single roentgenograms of hip and shoulder it is best to use a casette in place of the regular film envelope. This shortens the exposure and reduces secondary fog. A Bucky diaphragm is also advisable if time will permit.

For the hip the child lies prone with the hip and knee extended, the foot dorsi-flexed and the toes pointing slightly laterally in order to ensure that both greater and lesser trochanters are clearly shown. The casette should be adjusted so that the iliac crest is completely included and lies near the top of the film. The symphysis and ischial tuberosity should also be evident on the roentgenogram. These features can be obtained by placing the long diameter of the film in the long axis of the limb and allowing just enough film to overlap the iliac crest and great trochanter to cover these features.

For the shoulder picture the placing of the child is particularly important, for if any detail of the placing be omitted the roentgenogram will not show clearly the diaphyso-epiphysial plane and the outline of greater tuberosity as distinct from the head. The child lies prone with the shoulder near the outer margin of the film, which has its long diameter transversely placed to include the entire length of the clavicle. The face is turned away from the shoulder which is being roentgenographed, the elbow is extended, and the forearm supinated. These positions are secured by laying the hand palm downward on the table, thumb outward and elbow extended.

From a little manipulation of film envelopes and lead plates the investigator will readily learn the quickest and most satisfactory way of handling the films. All the roentgenograms mentioned can easily be made in five minutes by adopting a standard sequence. The left side only of the child is examined, since practical uniformity of progress is evident on the two sides except in markedly pathological cases in which asymmetry of development, not merely of growth, has occurred.

The child lies first on his back on the roentgenographic table. This permits him to see every manoeuver and steadies him if he is nervous. The roentgenograms are made in the following order: anteroposterior of hand, lateral of hand, anteroposterior of elbow, lateral of elbow, dorsi-ventral of foot. Then the child lies on his left side to permit first lateral of foot and then lateral of knee to be made. At this point the child is turned on his stomach and lies prone so that anteroposterior of knee, anteroposterior of hip, and anteroposterior of shoulder may be rapidly made, in this order. If it be desired to get a roentgenogram of the head it is suitably included at the end of the series. The right side of the head is laid on the casette with the knuckles under the chin to secure approximate parallelism of the median skull plane with the film. Heads roentgenographed by this rather rough method yield much less information than by the carefully prearranged and controlled method of Broadbent, which is described in another section. For exact and detailed studies Broadbent's procedure is indispensable. As it is carried out also in our combined investigation the roughly arranged roentgenograms are used only for estimation of tooth development and eruption and for certain gross features of cranial growth.

In addition to the data which these roentgenograms give on skeletal maturation, much information can be gathered from them on thickness of subcutaneous tissue and even on muscle bulk. These latter problems, however, are dealt with elsewhere: our present concern is the interpretation of skeletal features.

Appraisement in Preschool and High School Periods

In the report upon skeletal growth and development are chapters discussing the value of the date of and early progress in ossification of the epiphysis and likewise the importance of dates of epiphysial unions as indicators of skeletal maturation. The principles of morphological modification of the diaphyso-epiphysial plane have been thoroughly discussed and the reader who desires information on assessment of skeletal age and progress during childhood under the age of five years and over twelve must be referred to that account. A relatively short experience will enable him to utilize the provisional tables of dates of ossification and of union which are given there. Certain cardinal observations, however, may profitably be repeated here because, without them, the investigator may easily be misguided in assessment.

In the first place, so sensitive is calcium deposition in epiphyses and in bones of the wrist and ankle that it suffers actual inhibition during periods of life which may give no outward indication of disturbance. It is true that an attack of measles, a severe gastro-intestinal upset, recurring low fever or colds, or disorganization or irregularity in habits of life may produce this defect in the progress of ossification. But often enough no definite contributing cause can be identified. Children whose time table of ossification centers is being actively interrupted are liable to colds and infections, but those in whom the ordered sequence is again established may still lack for a long time the centers inhibited while interruption was active though they suffer no consequent disability in any way. If, then, one uses the appearance of centers as an age indicator *it is the latest appearing center which gives the real measure of maturation,* not the average, which is extremely fluctuating. The missing centers, or those but little ossified for the years, testify to disasters which have overtaken the child and indicate the earliest possible date of onset.

The second important observation is the absence, as yet, in our account, of any reliable age indicators between three and five years in the girl and between four and five years in the boy. This lack will be filled in time but there is no relevant information at the moment.

The third observation is the direction of attention to successive stages in preparation of the diaphyso-epiphysial plane for actual union. These stages are listed as: III, the formation of a definite delimiting surface of bone, seen on the roentgenogram as a white line; IV, billowing of the surfaces, and amplification of stage III; V, parallelism of surfaces of shaft and epiphysis, which is the final form of interlocking emphasized by previous authors; VI, narrowing of the diaphyso-epiphysial gap, the indication that commencement of union is near. How long it will be after the appearance of stage VI before union actually commences depends somewhat upon the site, but nine months is an approximate average. Care must be taken lest overlapping of shadows be mistaken for union. Except in the very thick bones, humerus, femur, and tibia, a double white line is present, the remains of the lines first observable in stage III, where the pattern has not yet been broken down by the process of union. In these large bones, however, the differentiation between stage VI and stage VII is extremely difficult and some later modifications may be made upon our provisional table. Necessary as it is for one's training to check roentgenographic observations made on the cadaver against the actual dissected bones, one must recall that a dead person, whether adult or child, if he had died from some cause other than accident or acute disease like lobar pneumonia, is a defective person. Such a body will be retarded in the union of its epiphyses and is not a safe guide to the dates of union in the healthy living individual.

The fourth and last observation which must be made at this stage is the reminder that, as the child grows older, he becomes far less susceptible than in early life to the effect of those influences that disrupt skeletal maturation. Whereas, in early life, there is not only delay in appearance of ossification centers but also disorganization of sequence, no interruption in order is ever present in the pattern of union. The order pattern is invariably the same though the date of union may be greatly delayed.

Appraisement in the Grade School Period

The assessment of status by roentgenograms is relatively simple before four and over twelve years. It is in the school period that appraisement is most difficult because, during these years, progress is not indicated by an easily ascertained finding such as the appearance of an ossific center or the union of an epiphysis. It depends upon a reading of progress of ossification registered by bony penetration of the cartilage. But we have already pointed out that the actual beginning of ossification is subject to interruptions and delays. This does not necessarily mean that there is interruption comparable in degree in the growth of the preosseous material. It does mean, however, that, especially in the earlier years and in some children, there will be shown irregularities in progress toward maturity of different areas. The greatest difficulty will be encountered between seven and nine years, more especially in the hand, foot, and elbow than in the knee. During these years the grade school spurt in developmental growth takes place and this complicates a pattern already somewhat confused by the remains of irregular commencement of ossification. Hence more experience and judgment are necessary for correct interpretation than at other ages before or after.

It is impossible to give a fully detailed account of the features of bony penetration in the space of this report, but the following general analysis will guide the reader to the main diagnostic features. He will doubtless add many features from his own growing experience.

Since the sex linkages are not simple relationships based on sex, but are really a measure of relative immunity in the female to the effect of misadventures from which the boy characteristically suffers, we shall record here the outstanding features of the boy's progress only. A general survey of sex differences is contained in the section on skeletal growth and development in *Anatomical and Physiological Considerations,* Part II of *Growth and Development of the Child.* The time relationships noted in the following pages are those of the mediocre average. Children of good endowment at birth and good nurture, who have been reasonably free from severe disease and economic privation, will usually be nine months ahead of this schedule and may even be two years or more advanced. The advancement above the mediocre average is a measure of the credit balance, one might say, at the child's disposal for coping with health disasters. In every affliction it will be drawn upon and after convalescence restoration will be attempted.

Principles of Bony Differentiation in the Knee (Boys)

At the knee we depend almost entirely upon bony differentiation of the epiphyses of femur and tibia for our standards. The patella commences to ossify erratically like the carpals. While it should show a center at two and a half years it may still be unossified on the fifth birthday in boys so one may rule it out as an age indicator until much later. The upper epiphysis of the fibula likewise is of relatively little service until it is almost completely ossified, an event which does not occur until after the twelfth birthday.

5.0–5.5 Years. Ossification is still limited to the deeper part of both femoral and tibial epiphyses. In the femur the ossification scarcely advances beyond the dorsal line of the shaft. The lateral epicondyle shows more ossification than the medial.

The outline of the tibial ossification is much rounded with but a suggestion of the ultimate appearance of two condylar surfaces, the medial of which shows some condensation into a white line. The backward extension, as in the femur, scarcely reaches the level of the dorsal line of the shaft.

5.5–6.0 Years. Femoral epiphysial ossification projects beyond and tibial ossification reaches the dorsal shaft projection line. The medial femoral epicondyle is now ossifying more rapidly than the lateral. The tibial epiphysis shows medial and lateral extensions, the former even showing a condylar face. A faint haze springs up along adjacent shaft surfaces of both bones.

6.0–6.5 Years. The lateral femoral epicondyle casts a shadow almost as far as the lateral angle of the shaft, but the medial epicondylar ossification lags behind and has a ragged appearance. A lateral condylar surface begins to appear on the tibia. The shaft surfaces maintain their slight haziness.

6.5–7.0 Years. The bony medial femoral epicondyle is still ragged but now almost reaches the line through the adductor tubercle. The limiting angles of ossification nearest the shaft on both epiphyses are somewhat squared. The shaft haze remains.

7.0–7.5 Years. The shaft hazes have become quite widespread from the surface. In both epiphyses ossification has extended behind the beveled contours of the shaft. In the femur the intercondyloid notch is still shallow and in the tibia the lateral condyloid surface is a little more clearly indicated.

7.5–8.0 Years. No significant change.

8.0–8.5 Years. The lateral tibial tuberosity extends like a long tongue almost as far as the shaft line. The medial epicondyle of the femur and the intercondyloid notch are both better marked. The shaft hazes begin to diminish.

9.0–9.5 Years. Shaft hazes have given place to a white line of delineation and a similar line, maturing during the last few periods, is now complete on the adjacent epiphyseal surface. Both diaphyso-epiphysial gaps are broad and trumpet-shaped at both extremities.

9.0–9.5 Years. Little change. The adjacent surfaces of shaft and epiphysis parallel each other more closely.

9.5–10.0 Years. The margins of the femoral epiphysis lose their rounded outline and assume adult rugged contours. The intercondyloid notch is also more significantly adult. Squaring of the periphery of both tibial condyles proceeds apace.

10.0–10.5 Years. The trochlear extension of the femoral epiphysis shows a faint upwardly directed beak.

10.5–11.0 Years. The trumpet-shaped extremities of the epiphysial gaps are lost by development of peripheral rims on the shaft side of the bony epiphyses.

11.0–11.5 Years. The diaphyso-epiphysial gaps show increasing parallelism. The adult contour of the articular surface of the patella is now visible.

11.5–12.0 Years. The tibial spines have not yet acquired sharp outlines. The epiphysial peripheral margins are almost completely adult in contour and the condylar outlines almost sharp, though the bony epiphyses do not as yet fit like caps overlapping the shafts.

12.0–12.5 Years. There is no marked change.

12.5–13.0 Years. The epiphysial peripheries almost cover the shafts.

13.0–13.5 Years. The tibial tubercle is a downwardly directed tongue of bone. The tibial spines are sharply outlined. The epiphyses of both bones surround the shaft peripheries as with a claw.

Beyond thirteen and a half the knee epiphyses are of service only at intervals.

14.5–15.0 Years. Stage VI on tibia with narrowing of the epiphysial gap.

15.0–15.5 Years. Stage VI is apparent in the femur and in the fibula.

16.0–16.5 Years. The epiphysial gap in the tibia is so reduced that the roentgenogram is apt to give misleading and fallacious evidence of commencing union, but the area has not really yet reached stage VII, where union begins.

Only the most careful examination of the roentgenogram of seventeen to seventeen and a half years will indicate to the experienced observer that union is incomplete in the femur, tibia, or fibula. The naked bone may show no surface indication of union though it would be an untenable position to hold that nowhere in the depths of the gap is there any fusion, at least in the tibia.

Between seventeen and a half and eighteen and a half years both stage VIII, of recent, and stage IX, of perfected union are passed through in all three bones.

Principles of Differentiation in the Hand (Boys)

In the knee the massive epiphyses of femur and tibia carry so much of the information applicable to a study of time linkage in differentiation that one is apt to overlook, on that account, the significant information to be obtained from the shafts. In the hand, however, the shafts and epiphyses of the long bones and the bony maturation of the carpals all play their part. Phalanges and ulna are of little value for this investigation. The radius, on the contrary, is of paramount importance. Metacarpals follow close behind the radius. And the carpals also give us very definite information once their apparent vulnerability to retarding influences is recognized and discounted.

Shortly before the sixth birthday the bases of metacarpals II and III foreshadow their adult outline. The saddle-shaped contour of the second is definitely attained although the clear white line which marks its ultimate differentiation does not appear until almost eighteen months later. The bony invasion of the radial epiphysis is not far advanced at this stage, though an oblique line marking the border between palmar and distal surfaces is evident.

6.0–6.5 Years. Epiphyses of metacarpals II and III, sometimes of IV, but never of V are so far penetrated by bone that on the roentgenogram they appear as D-shaped shadows with the flat outline next the shaft.

6.5–7.0 Years. Head of metacarpal V is now D-shaped and so also is IV if not previously so shaped.

7.0–7.5 Years. White line of compacta demarcating the saddle-shaped base of metacarpal II makes its appearance.

7.5–8.0 Years. Radial epiphysis shows ossification of the styloid process. The adjacent surface of shaft represents a thin white billowed outline.

8.0–8.5 Years. There is a white line of facet on the os capitatum for articulation with metacarpal II.

8.5–9.0 Years. Ossification in the radial epiphysis extends medially as the "ulnar tongue."

9.0–9.5 Years. The bony heads of metacarpals II, III, and IV possess a clearly defined squared outline like those of the adult.

9.5–10.00 Years. Ossification of the radial epiphysis fills up the angle next the shaft.

10.00–10.5 Years. No significant change.

10.5–11.0 Years. The radial outline appears on metacarpal heads II, III, IV, and V.

11.0–11.5 Years. Adult outline in the two multiangulars.

11.5–12.0 Years. The ulnar tongue of the radial epiphysis shows indications of the recurvation characteristic of a year later. The bony epiphysis for the first phalanx of the index finger protrudes beyond the line of the shaft on the lateral or radial aspect.

The hand has now reached a stage at which it gives but little direct indication of the progress of age.

12.0–12.5 Years. No significant change.

12.5–13.5 Years. The recurved ulnar tongue forms a small beak. Later phases of preparation for union of the epiphyses in the phalanges and metacarpals begin to make their appearance.

After thirteen and a half years, as in the knee, we change our method of analysis and look for stages VI to IX.

14.0–14.5 Years. Epiphysial gaps in the phalanges and metacarpals commence to diminish.

15.0–15.5 Years. All phalanges have reached stage IX (perfected union). The metacarpals are in stage VII (commencing union) if not already in stage VIII. The gaps in the radius and ulna now begin to shrink.

16.0–16.5 Years. The metacarpals have followed the phalanges into perfected union (stage IX) and the roentgenographic shadows of the radius and ulna are overlapping so that both diaphyso-epiphysial planes seem broken up, though comparison with the naked bones shows that this is not really so.

18.0–18.5 Years. The epiphyses of the radius and ulna have reached the condition of recent union (stage VIII).

Principles of Differentiation at the Elbow (Boys)

In the elbow the diaphyso-epiphysial line of the capitulum alone appears to be helpful. The head of the radius is little more than a scale. The olecranon and medial epicondyle have little specific character. Trochlear ossification is very various in type, since the amount of humerus developed in the epiphysis is quite erratic. Sometimes there is a sizable epiphysis; in other individuals it is but a scale smaller than that for the radial head. Interpretations of the capitulum are greatly strengthened, however, by differentiation of the adjacent shaft. Hence, in the elbow, our observations, unlike those of the hand and knee, are just as closely related to the shaft as to the epiphysis.

5.0–5.5 Years. There is incomplete ossification resulting in apparent incomplete formation of the ends of all three shafts. The coronary beak of ulnar shadow is not at all well marked. The olecranon process shows but the faintest indication of billowing. It is indeed a mere ripple confined to the shaft surface of which the postero-superior area is not yet completely ossified. On the humerus the capitular ossification has an irregular margin, faintly billowed, facing the shaft surface. There is only slight angularity evident between the shaft surfaces which support the medial epicondyle and the trochlea respectively. There is no ripple as yet on the surface of the radial shaft.

5.5–6.0 Years. The coronoid beak is now clearly visible.

6.0–6.5 Years. The bony olecranon is more massive and squarer in outline on the lateral roentgenogram. The ossific nodule in the humeral capitulum begins to show a saddle-shaped outline.

6.5–7.0 Years. No apparent characteristics.

7.0–7.5 Years. The ossification center in the capitular epiphysis throws out a bony tongue toward the trochlea.

7.5–8.0 Years. There is bony delineation between the medial epicondyle and trochlea, although the outline is not yet as sharp as it will eventually be, and extension of rippling from the capitular shaft surface on to that for the trochlea.

8.0–8.5 Years. Trochlear ossification is extended and the beak of the shaft between the trochlea and medial epicondyle is further delineated.

8.5–9.0 Years. The outline of the humeral shaft supporting the medial epicondyle becomes distinctly concave.

9.0–9.5 Years. No special features.

9.5–10.0 Years. The distal humeral shaft shows distinct growth so that the capitulum seems mounted on a pedestal which is developing particularly on its lateral aspect. The supporting surface for the medial epicondyle begins to show rippling.

10.0–10.5 Years. Very little progress.

10.5–11.0 Years. A proximally directed beak develops at the lateral extremity of the capitular ossification. This claw precedes the beveling of the outer angle of the humerus. Ossification should begin in the trochlea and olecranon.

11.0–11.5 Years. There is an increasing angulation at the distal lateral area of the humeral shaft, of the capitular epiphysis in the same region, and of the proximal, though not yet the distal, extremity of the ossific nodule for the medial epicondyle. As an age indicator the elbow is already becoming less useful.

11.5–12.0 Years. The capitular ossification projects backward like the tail of a comma and there is an increasing parallelism in the adjacent surfaces of the shaft and epiphysis. If the olecranon center has hitherto failed to appear it is present now.

12.0–13.0 Years. The several beaks and angulations already mentioned continue their differentiation.

13.0–13.5 Years. The subcapitular plane begins to narrow and, in this respect, leaps ahead of all the others at the elbow. Thereafter we are concerned with the pattern of epiphysial closure rather than with progress of ossific differentiation.

14.0–14.5 Years. There may be commencing union (stage VII) of the distal epiphysis of the humerus, the trochlear and capitular ossifications having fused together. The union is perfected during the following six months, a period marked also by shrinkage in the gap between the radius and its head but not in that between the humeral shaft and the medial epicondyle. Not only is the olecranon gap reduced but union has commenced.

15.0–15.5 Years. Union has commenced in the diaphyso-epiphysial junction of the radial head, and the gap beneath the medial epicondyle is reduced. The olecranon is in the stage of recent union (VIII) and in the distal humeral epiphysis fusion is perfected.

16.0–16.5 Years. Fusion is complete in all the epiphyses of the elbow and the area passes out of the series of age indicators.

Principles of Differentiation in the Foot (Boys)

The foot, like the hand, gives the assessor trouble at first because of the differences in vulnerability of its various areas. Some parts may then indicate a greater age than others. If we seek chronological age we must pin our faith to the most advanced area; if we desire information on differential progress we must assess separately each part.

5.0–5.5 Years. It is usual in boys to find billowing of the hinder subepiphysial surface of the calcaneus together with definition and squaring of the posterior articular surface for the talus. There is also some expansion of the head of the talus.

5.5–6.0 Years. There is definition of the articular facet for the tibia, an extension of the bony center forward in the lower tibial epiphysis, and some sharpening of the lower tibial shaft outline behind. The hazy outline of the subepiphysial distal extremity of the metatarsal shafts, so obvious later, has scarcely started.

6.0–6.5 Years. The haze is now well defined and there is a square outline of the lower tibial bony epiphysial mass.

6.5–7.0 Years. The distal extremities of the metatarsal shafts are cup-shaped.

7.0–7.5 Years. The peroneal groove on the under surface of the cuboid makes its appearance and white lines of definition replace the grey posterior outlines of both the navicular and the cuboid.

7.5–8.0 Years. The olive and pre-olivary groove are found on the calcaneus and a whiter outline marks its posterior subepiphysial outline. A woolly sleeve terminates the tibial shaft below.

8.0–8.5 Years. There is squaring of the metatarsal heads (epiphysial centers). Slight woolliness is apparent on the outline of the dorsal calcaneus and there is some ossification of its overlying epiphysis. In the dorsoventral roentgenogram the navicular tubercle is defined. It, however, remains more or less quiescent till after the tenth birthday when backward extension occurs.

8.5–9.0 Years. The calcaneal beak, at the junction of the upper and anterior surfaces, projects forward and the pre-olivary groove deepens.

Beyond a further extension of ossification in the calcaneal epiphysis soon after the ninth birthday there seems to be no significant progress until between nine and a half and ten years, when the diaphyso-epiphysial gap of the lower tibia begins to narrow and white outlines define the anterior sigmoid calcaneal surface and the base of the first metatarsal.

10.0–10.5 Years. The posterior tubercle of the talus begins to ossify separately or as a projection of the bone and a backward extension develops in the navicular tubercle.

10.5–11.0 Years. The calcaneal epiphysis shows greatly increased ossification and the first beaking appears in the base of the fifth metatarsal.

Then, until eleven and a half, we find no further noteworthy developments.

11.5–12.0 Years. There is parallelism and squaring of the tarsals, talus, navicular, and medial cuneiform. The gap between the talus and the ossified lower tibial epiphysis is reduced.

From twelve to thirteen years one can point to nothing of significance as specially characteristic.

13.0–13.5 Years. The final beaking occurs in the dorsal navicular margins and the lateral outline of the fifth metatarsal. The diaphyso-epiphysial gap of the lower tibia is very greatly reduced.

14.0–14.5 Years. The foot enters the series of uniting epiphyses.

Principles of Differentiation at the Shoulder (Boys)

The shoulder is more difficult to assess than any of the foregoing areas. In the first place there is nothing to go upon during the preschool and grade school stages except the upper extremity of the humerus and the general size of the bones. Secondly, even the humerus fails if the roentgenogram is not made exactly according to directions.

5.0–5.5 Years. There is, in boys, imperfect union of the centers for the head and greater tuberosity. The lateral slope of the shaft surface begins to show a woolliness; the medial slope is flat. Finally there is a relatively slight bony penetration of the lower lateral angle of the greater tuberosity.

5.5–6.0 Years. There is further bony penetration into the greater tuberosity with a slight lateral convexity of its growing bony margin and a filling out of the lower lateral angle. The characters of the shaft slopes are much changed from the previous period.

6.0–6.5 Years. The woolliness of the lateral shaft slope is reduced and the squaring of the upper and outer part of the greater tuberosity increases.

6.5–7.0 Years. The medial shaft slope loses its flatness and is rounded and the lower lateral angle of the bony greater tuberosity becomes sharper.

7.0–7.5 Years. There is growth in breadth of the upper humeral shaft with a laterally directed beak tilted slightly upward. The woolliness of the lateral shaft slope begins to diminish. There is recession of the greater tuberosity from the lateral shaft line and the bony epiphysis does not cover the shaft medially.

7.5–8.0 Years. The bony epiphysis extends medially to cover the shaft. The lateral outline of the greater tuberosity reaches the line of the shaft or extends beyond it. There is the commencement of a notch between the head and greater tuberosity and the latter is squared both above and below.

8.0–9.0 Years. The lateral extension of the upper shaft has largely lost its woolliness and remains as a beak. There is general expansion of the greater tuberosity.

9.0–10.0 Years. The lateral extension of the upper humeral shaft has become more massive and loses all trace of beak. The greater tuberosity also commences to square in its lower angle after the recent extension. All woolliness of the lateral slope is lost.

10.0–11.0 Years. The diaphyso-epiphysial gap is narrowed and the notch between the head and greater tuberosity is now fairly marked.

11.0–12.0 Years. The woolliness of the lateral shaft slope is renewed, the medial epiphysial outline is extended as a tongue, and the bony greater tuberosity extends beyond the shaft line.

12.0–13.0 Years. The woolliness of the lateral shaft slope is reduced and the bony epiphysis overlaps the shaft medially.

On the whole the shoulder is rather unsatisfactory during the grade-school period. Its features, however, serve to confirm the impressions obtained from other areas.

Roentgenograms of the Hip

Records of hips have not yet undergone the intensive study which has been given to other parts of the skeleton. We can make little comment upon the os innominatum and none upon the femur.

A special technique would have to be followed to ascertain exactly the stage of development at the junction of pubis and ischium along the subpubic arch. We have, on the other hand, definite information regarding union of the three centers at the acetabulum and the date of appearance of an ossific center in the epiphysis of the iliac crest.

The regular date for union of the three acetabular elements is about fourteen years and three months in the boy but eighteen months earlier (that is, twelve years and nine months) in the girl. The bigger and more advanced boys may show this phenomenon at about thirteen years and nine months but there is no similar precocity for the correspondingly bigger and more advanced girls.

Ossification appears near the front of the iliac crest in boys at about fourteen years and nine months though it is found a year earlier in many of our finer male types. In the girls it almost always appears during the six months immediately preceding the thirteenth birthday.

Modifications Characteristic of Girls

There is no need to make another long record of the progress in differentiation of the bony centers in girls. The several phases gone through by both sexes are precisely similar but the dates when the successive phases are reached differ in certain parts of the development schedule.

So far no regular pattern has been clearly defined. There is, however, undoubted evidence of a female spurt in development at about the sixth birthday and another at about the tenth. The female precocity is not, however, maintained.

It is gained only to be lost again. Between the eighth and ninth birthdays and again between the thirteenth and sixteenth birthdays it rapidly dwindles so that at the close of each period the female cannot be held to have any precocity whatever. As elsewhere stated, the so-called sex distinctions are not truly sex-linked but are a measure of the greater vulnerability of the male calcium metabolism over the female. The notes appended upon female divergences from the male patterns just described take into consideration the average dates of skeletal progress in the two sexes in a random sample of grade-school children. There is, however, no clear distinction between the most advanced males and the most advanced females. As a group, the boys lag temporarily behind the girls at two periods.

Knees. The average female knee of five years to five and a half closely resembles the male of six months later. This female precocity of six months is maintained until six and a half years. During the half year before the seventh birthday, however, the female enters on a period of great variability. During the six months after the seventh birthday the female knee increases its velocity of differentiation so that it is more nearly eighteen than twelve months ahead of the male, and just previous to the eighth birthday it is two full years ahead of the male. Between eight and eight and a half years differentiation of the female knee slows down in speed and the two years' precocity dwindles to eighteen months. Between nine and nine and a half years this is further reduced to one year. In the following six months the preadolescent spurt begins in the female and once again the female knee becomes two years advanced over the male. This is maintained until the eleventh birthday after which the male knee begins to catch up again. Just after the female's eleventh birthday the male is eighteen months behind. In the next six months the difference is but a year. Between twelve and twelve and a half the female precocity has sunk to six months and before the thirteenth birthday the two sexes are indistinguishable in age relationship.

Hands. The sex differences in differentiation of hands are far more complex than in knees simply because of the greater number of more or less independent areas involved. Between five and six years there are no sex differences. In the six months after the sixth birthday the female advancement over the male is less than six months, and up to ten years and a half the advancement is never more than six to nine months. Then the female takes a spurt. Between ten and ten and a half years the females vary greatly in their development, but just after the eleventh birthday they are almost two years ahead of the males. This amount of advancement is continued until twelve and a half years when the male slowly begins to catch up. From this time till thirteen and a half he appears to be not more than twelve months behind.

Elbow. Between the fifth and sixth birthdays the female elbow is somewhat more advanced in differentiation than the male. The advancement is erratic but it is not more than six months on the average, and during the six months after the sixth birthday there is no sex difference. Thereafter until the eighth birthday the female just keeps pace with the male. But between eight and eight and a half years the female elbow suddenly reaches the stage attained by the male just before his tenth birthday. Having shown this spurt the female pauses so that at between nine and a half and ten years the female is only six months advanced beyond the male. Just after the tenth birthday there is another female spurt which suddenly brings the female elbow to the phase attained by the male two years later. This precocity is continued for a year, but between eleven and eleven and a half years the female advancement sinks to eighteen months and there it remains until union of the epiphyses begins in the female at about twelve years and nine months, one year and a half ahead of the male.

Feet. The female foot of five to five and a half years has the same characteristics as that of the male of the same age except that there is as yet no billowing of the subepiphysial calcaneal surface. Six months later the female has attained the features of the male of between six and seven years and indeed has already developed the peroneal groove on the cuboid. By six to six and a half years the female foot is equivalent to the male foot a year later. From six and a half to seven years it retains the same pattern and is therefore only six months advanced in general, but the woolly sleeve of the tibia is distinct. Between seven and seven and a half the one year precocity of the female is scarcely attained. Progress in the female is now gathering momentum so that the characteristics of seven years six months to eight years are those distributed between nine years and eleven years in the male. No further progress occurs in the female foot until the six months after the ninth birthday, when a new acceleration takes place, bringing the picture into superficial resemblance with the male foot of twelve years six months to thirteen years. However the posterior tibial tubercle is no further advanced than in the male of about eleven years and on critical analysis we cannot allow the female more than two years' precocity. Thereafter the female shows little or no advancement until six months previous to the thirteenth birthday when the epiphyses for the calcaneous and terminal phalanges unite. In this the female still shows about eighteen months' precocity over the male.

Shoulders. The relation of the roentgenogram of the female shoulder to that of the male during the grade-school period is very simple. From five years to seven and a half, progress in the two sexes is indistinguishable. From seven and a half to nine years the female development lags slightly behind the male. Then the preadolescent spurt occurs so that in the six months beyond the ninth birthday it is slightly in advance of the male, but between nine and a half and ten years it is a full year ahead. After this the male begins to catch up and the female is only six months in advance between ten and ten and a half years, and from this date to thirteen years the sexes again run parallel in their growth progress.

Hips. The sex distinction in union of the primary elements and ossification of the epiphyses of the iliac crest has been presented in the description of the male hip.

THE VITAL CAPACITY OF THE LUNGS AS RELATED TO PHYSICAL STATUS

RELIABLE appraisement of physical status demands that the items on which dependence is placed shall be valid measures of relative physical fitness; that the measurements be as objective as possible; that the results obtained shall be capable of repetition in identical circumstances; that the nature of the measurement be such that fluctuations from the standard are of proven significance; and that the standard or norm shall be applicable to the *individual,* not just an average from a physically heterogeneous group. By the criteria just set forth, measurement of the vital capacity of the lungs has, at present, a doubtful place among our reliable indicators of physical status. Nevertheless some observations should be made upon its possible significance in the future. The validity of the crude measurement has indeed been very definitely discredited. Consequently, the use of vital capacity as a measurement of physical status is still a problem for investigation.

Attempts have been made to use vital capacity for the following purposes: [6]

1. To measure the relative physical endurance. The fact that outdoor workers and athletes have a larger average vital capacity than do sedentary workers and nonathletes has been thought to be of significance.

2. To indicate the presence of potential or actual disease; for this purpose a subnormal standard has been proposed, all cases falling below that standard being classed as medically suspicious.[1, 6, 10] The use of vital capacity as an indication of relative recuperation from certain diseases has also been suggested.[5]

3. To measure relative physical adequacy. This differs from the first use in that it attempts to measure, not active ability or potentiality for physical performance, but exuber-

ance or excess of potential health. It is the opposite of using vital capacity as a predictor of actual or potential disease.[10]

To utilize this measurement for any of the purposes stated above, several critical objections must be overcome.

1. The measurement must be accurate.

(a) *The Instrument.* Only the wet type of spirometer is sufficiently accurate for scientific purposes. This instrument may give readings that vary as much as 15 per cent in volume recorded unless the temperature of the water contained therein is controlled. The dry type of spirometer is of dubious accuracy under any conditions.

(b) *The Subject.* Like most other physiological criteria of fitness, measurement of vital capacity is a problem of understanding and cooperation by the subject as well as one of lung capacity and chest flexibility. Mental subnormals and very young children frequently give obviously inaccurate records because of lack of understanding and effort. Most records of individuals below eight years of age are worthless as an appraisement of physical status. Whether or not any individual's record should be considered for this purpose should be determined by the examiner who is aware of the conditions existing at the time. In view of this nature of the determination, it is perhaps worth stating that standardized techniques are undesirable.

Another uncontrollable complication is the high record made by the practiced performer. There are large numbers of individuals, especially males over fifteen years of age, who have practiced with the spirometer or with a tape measure, trying for a maximal chest size and expansion. These persons develop a trick of muscle control that throws confusion into vital capacity readings. The development of muscle control and the learning of small details of technique, such as placing the hands either upon a table or upon the hips to bring into action the extraordinary muscles of respiration while taking an inspiration and the trick of gulping down air into the lungs, are examples. There is no method of compensating for these tricks, but the competent observer can note these unusual factors and exclude the data.

2. The standard, or normal, vital capacity should be

one that is fair to the individual. Once again, there is no simple solution. Three types of standards are widely used at present. The first is stature alone, which, in general, gives a higher correlation with vital capacity than does any other *one* physical trait. Sitting height, although it gives the next highest correlation, need not be considered if only one or two variables are to be used.

Another commonly used standard is weight. Theoretically this should be a valid standard, but as it is found that vital capacity is correlated more closely with surface area than with bulk, weight is, in practice, inacceptable. The correlation with weight has been found to be less than that with height.

DuBois and others have suggested using surface area of the body, as computed by the DuBois formula,[3] as a standard. Use of this standard for determining normal vital capacity, however, depends upon premises difficult to substantiate. As no really satisfactory method of computation, reliable for the individual, has yet been designed, it is natural to find that surface area gives slightly lower correlations with vital capacity than does the multiple regression value based on height and weight combined, especially when this is restricted to a relatively small age range.

The problem of adapting a standard to the individual can readily be seen, in that if two individuals are of the same height, one may be much larger of trunk than the other. It would not be expected that the two should have the same vital capacity. How best to allow for such differences of build, however, is not entirely clear.

Numerous unsatisfactory attempts have been made to reduce the error of predicted standards by the use of multiple regression equations. These efforts were bound to fail, since no amount of skill in handling statistics will repair errors in the basic data.

Studies on men of the British Royal Air Force[2] show that the addition of circumference of the chest raises the correlation very slightly from what one finds with height and weight alone. The addition of sitting height, however, raises it significantly.

Preliminary studies on ten and thirteen year old children of both sexes[4] give somewhat conflicting results. The combination of height and weight significantly raises the correlation obtained with height alone. The addition of shoulder breadth significantly improves the correlation. Size of the chest is of negligible value for predicting vital capacity if weight is included in the equation.

At the present time age, height, weight, and shoulder breadth should certainly enter into the prediction. From the study on the British Royal Air Force,[2] while this is outside of the children's age range, comparable multiple correlations render it probable that sitting height is a significant variable, due to its correlation with the length of the thorax. In future studies other measurements than the ones now ordinarily taken in biometric studies may possibly yield higher predictive values. Recent findings on motor performance, height, and weight show that with other variables held constant, these three have a relatively high correlation with physiological age or state of pubescence.[4]

In this connection it may be well to point out that there is a relationship between relative size of vital capacity and build. It is found that the more slender, not too heavily muscled individuals have a relatively higher vital capacity for height and weight than do the shorter, stockier, and more heavily muscled individuals.

With our existing techniques, determinations of vital capacity are unreliable as measures of physical status in normal children under the age of eight. The value of records obtained from mentally subnormal children must, of course, be evaluated by the examiner. In cooperative studies, such as are to be found in a student health service or in employment certification, vital capacity may be used as a part of the regular program. For this purpose only the wet spirometer should be used. It should be clearly understood that the present actual vital capacity is of less significance than relatively wide fluctuations from the average for the individual of that size. A vital capacity of 15 per cent or more below the average calls for a thorough medical examination, and a vital capacity of 10 per cent below the normal is evidence of probable physical unfitness. There is additional evidence that general physical fitness is positively correlated with relative vital capacity.

Diminution of vital capacity is frequently an early sign of lung disease. The measurement may also be applied with profit to other difficulties in health, such as cardiac disease and asthma. In cardiac disease it can serve as a rough guide to the recovery of compensation, in order to predict when the patient may safely be discharged from hospital or certified able to return to work. But there are better criteria for these predictions and it is not often that vital capacity is relied upon for this determination.

In asthma the measurement of vital capacity does, indeed, even by existing methods, fill a useful rôle. If, after the administration of adrenalin, the vital capacity immediately rises, the condition is proved to be largely one of bronchiolar spasm. Peribronchial thickening with consequent constriction is ruled out as a dominating factor.

In using vital capacity in this way, it is most useful when noted as a diminution from the previously noted vital capacity. An individual may originally have had a supernormal vital capacity. A significant diminution from this may still leave the individual with a vital capacity that is within the normal range. In growing children the normal increase to be expected from growth should be taken into consideration.

In conclusion, in the light of our present knowledge it would seem that vital capacity should be measured as a routine under conditions that will ensure accuracy of measurement, and that norms for the individual should be determined as accurately as possible from a number of significant variables. All children whose vital capacity is as much as 10 per cent below this standard should be carefully examined by a physician and put upon a regimen calculated to bring the individual up to normal. These records should be available in terms of percentages of the norm of the time, and should thus be made available to family physicians and others who desire to compare present status with past performance.

References

1. Campbell, J. M. H. "Weight, Vital Capacity, Pulse Rate Before and After Exercise, and Physical Fitness in Health." *Guy's Hospital Report,* Vol. 75, 1925, pp. 263–285.
2. Cripps, L. D., Greenwood, Major, and Newbold, E. "A Biometric Study of the Inter-relation of Vital Capacity, Stature, Stem-length, and Weight in a Sample of Healthy Male Adults." *Biometrika,* Vol. 14, 1923, p. 316.
3. DuBois, D., and DuBois, E. F. "Clinical Calorimetry." Tenth Paper. "A Formula to Estimate the Approximate Surface Area if Height and Weight be Known." *Archives of Internal Medicine,* Vol, 17, 1916, p. 863.
4. Studies of the Iowa Child Welfare Research Station. Unpublished.
5. McCloy, C. H. "On Using the Spirometer as an Instrument of Precision." *American Physical Education Review,* Vol. 32, 1927, p. 323.
6. Myers, J. A. *Vital Capacity of the Lungs.* Baltimore, The Williams & Wilkins Company, 1925. 140 p.
7. Roberts, F. L., and Crabtree, J. A. "Vital Capacity of the Negro Child." *Journal of the American Medical Association,* Vol. 88, 1927, p. 1950.
8. Shephard, W. P., and Myers, J. A. "Normal Vital Capacity." *Archives of Internal Medicine,* Vol. 35, 1925, p. 337.
9. Smillie, W. G., and Augustine, D. L. "Vital Capacity of Negro Race." *Journal of the American Medical Association,* Vol. 87, 1926, p. 2055.
10. Turner, Abby H. "The Vital Capacity of College Women." *American Physical Education Review,* Vol. 32, 1927, p. 593.

THE APPRAISEMENT OF PHYSICAL STATUS

THE PHYSICIAN'S RESPONSIBILITY

ASSESSMENT of the physical status of children is becoming a more and more general practice, and its increase indicates an advance in our conception of collective public and professional responsibility. Curative medicine has always profited from its appeal to human sentiment, whereas preventive medicine depends upon reason for its furtherance. Whether considered from the point of view of the individual child or from that of the group, preventive medicine requires planned and concerted action. We do not deal with ill health as it arises, but with the cultivation and maintenance of good health. Fundamentally, preventive medicine is educative. It seeks cultivation of positive health habits and the maintenance of a sound constitution. In the face of temporary defeat by disease it attempts to restore and enhance resistance against further disaster. Its standard is perfection rather than the mediocre average. Difficult as the problem of curative medicine certainly is, the task of preventive medicine is far more formidable. But granted that its standard is perfection, that its doctrine is educative, and that its prosecution calls for planned concerted action, its active progress depends upon the enlargement of medical skill and understanding in disciplines which hitherto have fringed, or found themselves beyond the range of, medical training.

The physician's relation to most of the conditions of life with which preventive medicine must cope has in the past been largely advisory at best. The physician of the future must exercise his right of pronouncement, of warning, and of guidance in social and economic fields. His training must be amplified to make his leadership in these problems wise and constructive, and lying at the base of this professional equipment is his skill in physical assessment.

Physical assessment, being a record of progress, is a periodic or serial inquiry into the well-being of the child. It should be commenced as soon after the child's birth as possible, and, if properly carried on, requires re-examination at definite intervals determined by the age and rapidity of developmental growth. During these impressionable years of childhood the value of systematic periodic re-examination throughout life should be emphasized as an important aid to the maintenance of health. The examination must be as comprehensive as possible in order that assessment may be dependable. The various agencies now organized for care of the sick child and the partial examinations conducted by the school medical service in no way replace this important systematic, serial, comprehensive assessment of the individual child.

It is the personal physician who carries the responsibility for this preventive measure. It is our object to emphasize the significance of the work and to point out the methods by which, in the Committee's opinion, physical assessment can be carried out most effectively. We recognize that partial assessments for special purposes have a certain value and will inevitably be made, and we shall lead up to the really efficient total appraisement by reviewing the circumstances in which partial examination may be condoned and the purposes which it subserves. But throughout this presentation we desire specially to focus attention upon the complete, systematic, serial assessment of the individual healthy child. Nothing can equal this measure as a safeguard for the health of the nation in the future.

MEASUREMENTS OF WHOLE POPULATIONS

We of this generation are familiar with the use of crude measures for the estimation of physical status. Unhappily we are too well acquainted with war and pestilence and famine. For such emergencies, where we think of whole populations rather than of individuals, the crudest measures of physical status give results quite as serviceable as the more refined measurements, for the first objectives are the prevention of wasted effort and the avoidance of misleading conclusions. This phraseology has been used in order to include the word *prevention.* But it is essential to emphasize the fact that our very phraseology, customary though it be, obscures our intention. Prevention is no negation: it is positive as a clarion call. "Prevent us, O Lord, in all our doings," says the Anglican Prayer Book. We do not mean merely prevention of waste effort and avoidance of misleading conclusions, but rather assurance of effective effort and accuracy of conclusions. In so urgent an emergency, assessment of physical status reduces itself to a determination of numerical indices.

With the passing of urgency the continuing need calls for further data. Assuming that we are feeding a population, we must check the success of our efforts. To ascertain this we institute measures of nutrition. Again the crudest methods suffice. The height-weight ratio, statistically determined at intervals of time, will give an adequate answer to the question. But it permits no discrimination. Distribution of food may be correct; other conditions may be at fault.

The term *physical status* seems to imply a determination made once and for all. As with the term *preventive medicine,* we are again unfortunate in our phrase. We do not really mean status: we mean progress. If, in the face of calamity, we are to restore and enhance resistance against further disaster, we must ensure that those committed to our care maintain an active progress in health. Life will not tolerate stasis; the only alternative to progress is retrogression.

In schools and institutions innumerable over the entire country, records have been made in recent years of the height and weight of children. For the most part these lie unutilized, and the observers, who, it can be confidently assumed, have carried on the record with all possible skill and patience, have had too little encouragement and support. Criticism has been corrective rather than sympathetic. We have tended to apply the standards necessary for individual assessment to criticism of this mass material. A little more understanding and an inquiry into the conditions under which the observations have been made, will render these data distinctly useful. Granted that we deal here with group determinations, these records of physical status now in existence can give information, at least, as to stature and weight by age, corrected if need be for shoes and clothes, by geographic areas. But, with adequate attention, much more may be obtained from such records, for they can usually be amplified by information regarding average economic status, density of population, and even national origins. Statistical reduction is itself a relatively rough method of analysis. The very need for large numbers postulated by statisticians is, in its simplest terms, a confession of this fact.

In commending the efforts which have been so widely and so faithfully directed to the simple determinations of height and weight, we would stress the necessity of utilizing the data for the purpose to which alone they are adapted, namely, the estimation of physical status by local areas. And, in doing this, we would call the attention of those responsible for this type of study to collateral observations, the appending of which would enhance the value of the data obtained. Briefly, this appendix should include the following information: type of population, urban or rural; average economic and social status of the families; density of population from which the sample is drawn; rapidity of change of population within the district; year of assessment and general economic condition within the district; composition of the group by national origins; conditions of determination, including the social calling of the observer, the type of instruments used, the units of measurement adopted, the character of clothing, with an average determination of weight of clothing and height of shoe heels where necessary. We do not believe that observations of the foregoing type are adapted to the determination of the nutritional status in the individual child, and we assume that only the most guarded statements would be issued by the observers on the basis of such determinations.

Assessment of a population can be used to determine not merely the average growth and development of the children, but the prevalence of disease or other physical handicap. Measurement by methods of precision will determine the advisability of employing unusual medical or public health services. By the same technique a valuation can be made of the remedial measures applied. The *pelidisi* and *sacratama* scheme of von Pirquet is a notable example of an index extensively used during the World War for judging the needs of a population on the basis of an assessment of the growth and development of its children.

An index of change in the number and character of a population, as in periods of immigration, or in its physical well-being, as in periods of unemployment, has always real usefulness, even though far removed from any specific problems concerning the individual child. But before the technique of population assessment can be established, the objectives must be clearly defined and these will vary according to the problems involved. In some circumstances comparison of one population with another is sufficient; in others the specific problem requires a redetermination of the physical status of a single population after a lapse of time. Or, again, the relative needs of different groups within a population may be the objective.

Comparison of one population with another, or of different groups within a population, is significant when the problem is a relatively simple one like average dimensions or parasitic infestation. But in practice it will be complicated by geographical and social factors which must receive adequate consideration and which have been fully enumerated.

Assessments intended to determine the decline of disease or of other handicap in a community must involve the repetition of several measurements carefully planned ahead. If physical growth is an item in the assessment, due consideration must be given to the changes naturally to be expected with the lapse of time. In determining the frequency of two or more measurable features, for example, physical growth and economic conditions, or intelligence quotient and parasitic infestation, statistical methods may be advantageously employed. The results will give an estimate of actual association: they are not necessarily a measure of causal relationship.

In making any assessment of population status, adequate consideration must be given to fundamental characteristics of the people. The family lines represented demonstrate themselves in details of build, in skeletal growth patterns, and in distribution of subcutaneous fat. These hereditary tendencies cannot be ignored in evaluating the state of nutrition. These characteristics, the type of measurements to be used, their objectivity and validity, together with the use of proper and adequate samples of the population, are fully emphasized in other sections.

Our standards of comparison need amplification, extension, and verification. Further research is also required in the choice and the detailed application of technical methods and the methodology of interpretation. We need further knowledge of the present trends of our various population groups and of the significance of factors which may interfere with a reliable assessment. Even more important is a careful planning and thorough consideration of the project in order to guard against wasted effort and misleading conclusions. Not only must the technique of measurement be carefully considered, but the objectives must be clearly defined according to the needs of the situation.

THE GROUP EXAMINATION

Most local authorities nowadays attempt a more ambitious scheme of examination than that just set forth. Our manifold and rapidly expanding health services play a most significant rôle in public education and protection, and in the determination of individual fitness. These are the proper functions of such examinations and it is only when the measures adopted for these purposes are assumed to give a complete individual assessment that they justly fall under adverse criticism. Recommendations based on such data, uncorrected by the other findings of a more intensive examination, are frequently unwise and occasionally positively harmful, and it is enough for us to draw attention to this provision. Even specialized measurements carried out consecutively upon groups of children should not, except in very restricted manner, be used as criteria for making final diagnoses; nor should recommendation of ultimate procedure be made on the basis of these restricted examinations. In other words, the type of health examination to which we have just referred cannot replace the supervision of a competent personal physician whose duty lies in making a complete and leisurely appraisement of all of the factors entering into the individual problem.

In discussing the details of such partial examinations we must obviously take into consideration the object for which the study is instituted. Since the measures adopted will necessarily vary with the end to be attained, and this end must be entirely dependent upon the local needs, we cannot draw up even a selected list of the technical procedures. Our function here lies in insistence upon appropriate objectivity of appraisement, upon precision of measurement, upon validity of method, and upon reasonableness of standards.

Objectivity should mean agreement of observers upon distinctions which are important in diagnosis. For example, the objectivity in a test of hearing need not necessarily imply an agreement of observers upon all degrees of acuity, but it must mean agreement upon a definite predetermined minimal standard.

Precision of measurement need not require the utilization of a unit so small as a millimeter, but, having determined beforehand the unit to be adopted, this must be rigidly enforced, and circumstances rendering this enforcement impossible or even difficult must be effectively circumvented.

Validity of a test must be established in order that its verdicts may be truly indicative of the objective sought. If we appeal to a Wassermann or a tuberculin test, every technical and clinical precaution must be adopted to ensure that the verdict will really carry the authority which we wish to attach to it.

Since a measure has meaning only in so far as it is referred to an average, it is necessary to be sure that the *sampling of the group* from which the average is derived is entirely adequate. If determinations of weight for a group of children with given age, height, and hip and chest dimensions are made from one hundred cases which have an unrepresentative proportion of any combination of characteristics, then, of course, the average weight is not truly representative. If an average is to be used as a point of reference, we must have mathematical assurance that the sampling was such that the average is truly representative of all cases that are of the type under consideration.

LIMITED APPLICABILITY OF GROUP EXAMINATIONS

Judgment of a child's particular needs can be formed only after consideration of the child's hereditary endowment and of the nature of his environment. Many rather unobjective determinations must necessarily be included. We are therefore limited in the extent to which routine methods of physical examination, carried out hastily on large groups of children, may be relied upon in forming judgments on the individuals themselves. This, in turn, determines for us the items with which such examinations may properly concern themselves. Since final judgment of a child's total structural and functional adequacy cannot be reached without relating single findings to all other findings in the child, it is obvious that hasty or specialized measurements carried out on groups of children should not, except in very restricted fields, be used as the basis for final diagnoses, nor should recommendations be based upon these single individual elements.

These remarks do not reflect upon the wisdom and usefulness of our rapidly expanding health services in schools and elsewhere, except in so far as they are attempting to expand beyond their proper sphere of activity. The school health examination, as part of the health service offered to children of school age, renders a number of most important services, but of necessity they are limited in their application. Not only parents and teachers but examining physicians and nurses have at times failed to realize the extent and limitations.

The first function of a school health service is educational in character. Schools have a tremendous opportunity not only to teach children the rudiments of health and the factors which are important in maintaining health, but they have a great influence in transmitting such knowledge to the parents, and thus in improving the care and supervision which the parents themselves afford their children. In this capacity the school health service should be exemplary rather than paternalistic.

The second function of a school health service is to protect one child from acquiring disease from another. Under this heading are commonly included such protective inoculations as vaccination, toxin-antitoxin, Schick testing, and the like. Although the school lends itself admirably to the carrying out of these procedures in an economical and efficient manner, and may for this reason assist the community in providing protection for those who have been neglected, it is primarily the responsibility of the parent, of the personal physician, or of the community to see that every child is offered this protection. It must not be forgotten that these procedures should be carried out in the first year of life, and never be left until the school years. Properly to defend one child from exposure to communicable disease in another, certain elements of a physical examination must be applied to all children. In conducting this limited examination, an opportunity is afforded, however, to detect conditions which are of importance to the individual child, irrespective of his school career, and out of this opportunity has developed the fourth school health activity, which will be discussed.

The third function of a school health service is to give assurance that each child is fit for the routine to be imposed upon him. School attendance is compulsory, and this very fact lays the responsibility upon members of boards of education to make reasonably certain that activities are not required which endanger health. The school régime is planned for the average child, but constant vigilance is necessary to avoid injury to the occasional child. As examples of this, one may cite children with damaged hearts who, if not restricted to appropriate activities, may be engaged in gymnastics or athletic activities which are harmful to them. Children suffering from chronic fatigue need revision of their programs beyond the mere restrictions of physical activities. This is frequently the great contribution of so-called *open air schools.*

The final function of a school health service is an outgrowth of the others. It is the one that has most commonly led to unwarranted activities. We refer to the finding of defects and the attempts made to have these defects corrected. It is only natural and proper that, if physical examinations are to be conducted for other purposes and signs suggestive of defects are discovered, these signs should be reported to the child's guardian or personal physician. It would seem proper that the school should, by correspondence and through nurses' visits, make every effort to persuade parents to consult their personal physicians and adopt definitely indicated procedures. They may even offer incentives by providing certain services in the schools which lend themselves to efficient and economical application there. In the study and control of tuberculosis, for example, the community may utilize to great advantage the school and its organization, and should receive from the school health service active cooperation in such undertakings. Most of the items in a physical examination, however, taken singly, serve only as indicators, and cannnot be accepted as criteria upon which diagnoses are to be made or recommendations for procedure developed. For example, on inspection a child may show a pair of tonsils that indicate to the school physician the presence of disease. This finding should most certainly be reported to the parents as deserving their attention and that of their personal physician, but rarely does such an inspection justify the positive recommendation of early tonsillectomy. Again, the routine measurements of height and weight in a given child, compared with the usual tables of expectancy, may indicate a deviation considerably below the average for children of the same age and sex. The examining physician on inspection may agree that there are other general signs which suggest that this height and weight finding is of significance. These facts should surely be reported to the parents and further investigation as to cause and significance be urged, but such findings rarely warrant the reporting of malnutrition. They may have nothing to do with the amount or quality of food taken, and may lead to unwise changes in diet. The great majority of unusual findings detected in school examinations should be reported as indications of possible defect requiring further study, and not with appended diagnoses or therapeutic recommendations.

While these considerations apply to all appraisements applied to children in groups and not conducted along extremely individualistic lines, whether in school, preschool, or infant health conferences, in physicians' offices or on examination for certification for employment, they do not detract from the usefulness of these services nor gainsay the tremendous contribution they have made to the health of American children. Nor do they preclude the probability that further development of mechanical measures and extended use of the services of specialists and technicians dealing with specific problems will greatly improve the efficiency, accuracy, and significance of our health appraisals. These methods may be greatly extended after their objectivity has been well established, but in their application we must never lose sight of the individuality and complexity of the child as a growing organism.

THE NECESSITY OF PERIODIC OR SERIAL EXAMINATIONS

The appraisement of physical status is a program of health education and assessment appropriate to the individual. It cannot be confined to a single determination, but, for effective national betterment, should be instituted as soon after conception as practicable and continued at appropriate intervals throughout life. Opinions may well differ, pending fuller information, regarding the exact details of this program and even regarding the precise age at which each detail should be carried out. Later on in this essay we shall attempt a general survey of the approach to such a program for the future, although the attitude will be exemplary rather than paternalistic. The functions of physicians are the establishment and maintenance of health, the protection against injury and disease, and the rehabilitation to the maximal degree attainable of constitutional soundness.

These responsibilities demand that we preach with all earnestness the necessity of serial examinations. And the establishment of this doctrine, in turn, requires the direction of attention to aspects of community life into which we have as yet entered reluctantly or with diffidence. We may not ignore economic conditions, the problem of the adequate wage, the distribution and regulation of employment, or those purely domestic details of family organization which spell well-birth and well-being in the children. And, setting our own house in order, we must insist upon a greater measure of consideration, in medical education, of the themes of growth and repair. In the lists of psychology, sociology, and economics the pennant of medicine must be found in the future, and our successors must be given that training necessary to equip them for wise disposition of their influence.

In a proper assessment of health it is most desirable to have a continued record of illness.

In some communities it is customary for the commissioner of health to send a form letter to the parents of all children as the births are registered. In this letter the commissioner points out fundamental features in a health program for the child and makes specific recommendations for further cooperation with the family physician. This direct relationship with parents affords an excellent opportunity to emphasize the value of the continuous record of illness so that when the child enters school he may bring with him a statement of his preschool history. The difficulty of obtaining this cooperation is by no means underestimated here. Indeed unless the facts are regularly entered in some type of health-book for future reference, the statement is apt to be quite inadequate. In order to start the procedure, perhaps the most effective method would be to introduce it as part of the health education of the schools. If each child were provided with a health-book in which could be entered the record of illness during school life, the parents could probably be induced to make entries of most of the preschool disorders before their nature and date are forgotten. Health books for the younger children could be issued from the schools or from the commissioner's office.

But the schools should not bear the sole responsibility for serial examinations. Employers of labor, parents, and guardians must be encouraged in every way to develop their sense of responsibility not alone for the immediate health of those committed to their care, but for the establishment of this cardinal tenet of positive national health, the serial examination. Lastly, physicians themselves, enlarging their understanding, owe a debt to the community. They must decide what weight should be laid on each detail of our complex modern culture in its relation to the other factors involved in a particular child problem. They must decide what, in the interests of the family, is due to the parents and what to the child. If undue insistence upon a regimen for the infant depletes the health of the parents, it is the physician's duty to modify this regimen. If the parents' method of protection of the child against possible disease involves a physical and spiritual isolation which may result in an inadequately trained mind, it is the physician's responsibility to urge suitable correction. If compulsory school attendance, conflicting with the economic necessity to earn a wage, endangers the mental or physical health of the adolescent, the physician has a clear mandate to make such representations as seem to him necessary to both parents and school authorities.

Recent years have seen a great reduction in infant mortality. There has not been that improvement in general child health which we might reasonably have expected. This is part of the cost of success in infant welfare: it is not a subject for pessimism. There is still much eradicable organic disease, but the great majority of childhood disorders are slight and remediable defects, the persistence of which in uncorrected form is directly due to neglect of personal hygiene. The periodic examination, which is an indispensable aid to inducing health habits, compels cooperation by all guardians of the life, liberty, and happiness of the children.

THE APPRAISEMENT OF THE INDIVIDUAL CHILD

When we come to the appraisement of physical status of the individual child, we shoulder our full duty. Hitherto we have been guardians only, with but limited responsibility. In this aspect of our work we must act as guides. We have the right to demand entire cooperation of those who come to us for advice, and in return our judgment must be balanced by the most comprehensive and thorough evaluation possible of the child set before us. As this judgment is to be practical it carries with it the necessity to frame recommendations for future care and discipline. Our goal in assessment is a determination of the actual possibilities or capacity of the child, an estimate of the degree in which these possibilities are being realized, and an outline of training designed to fulfil them more completely. In the partial examination, attention may be focused upon temporary or minor defects. In the assessment of the individual these defects are noted and provision is made for their correction, but they are now viewed as actual or potential handicaps to progress in development and training in habits and control.

The practical problem of a well child is far more difficult than that of one in whom some radical or remediable defect can be demonstrated, for the continued interest and cooperation of the parents can be gained only if a positive program is set before them. They desire more than to be told that the child is well, that he is of adequate development or dimensions, or that he has a certain defect and what steps can be taken toward its correction. They will be satisfied with nothing less than guidance in the further nurture and training of the child, whether it be to overcome a handicap or to provide adequate opportunity for the more complete fulfilment of his talents.

It is necessary, at this point, to appeal to the medical schools for more efficient training of students in the importance and technique of routine health examinations. Few schools, as yet, require their students, as part of their pediatric training, to attend well-child clinics or provide instruction in mental or physical health examination. As a result, it is only by his personal alertness and his own practical experience that the physician becomes really expert in quantitative assessment of deviations from the normal limits of children as a group, and in the far more difficult problem of appraising optimal development and health for each individual child, the solution of which problem is not to be sought in reference to tables of standards alone. There is a large field of investigation open to the clinician who will study the child from the points of view of both physical development and functional behavior. Health in its physical, mental, and social aspects is due to receive far greater emphasis in our medical schools than it has in the past.

THE DETAILED EXAMINATION

In this survey we can lay down only the general principles involved in what we regard as an adequate appraisement of physical status.

The Clinical Examination. The assessment may well begin with a thorough clinical examination of the child, calculated to determine the healthy activity of his various systems and members. This comprises the usual routine of the pediatric service and is familiar to every well trained physician. It is in the further extension of our observations that mere student experience often becomes inadequate, although the steps by which we progress into less explored regions of medical thought and practice are not difficult.

A complete physical examination should be the nucleus of every appraisal. It is not the purpose of this report to outline what constitutes a complete physical examination. It is, rather, its purpose to accent the features of the examination which require more thoughtful attention than they usually receive, and to offer examples of the kind of useful evidence which may be elicited by various procedures. Such an examination must include a consideration of general bodily growth and of the adequacy of nutrition, a search for congenital or acquired defects, latent or active infection, allergic manifestations, endocrine disturbances, or other disease process whether generalized or local. The relative importance of these objectives in the physical examination varies somewhat with the age of the child. For example, we look particularly for congenital defect in the newborn and for acquired defect or infection in the older child. But all of these elements must receive due consideration at all ages.

In general, the examination should consider, first, the present status and, second, the progress made since the last examination. The progress made over a period of time is often of far greater significance than the status at the moment. In only a limited number of the items may reliance be placed upon single findings at individual examinations, whereas many more take on real significance when compared with previous findings. Herein lies the importance of regularly repeated examinations.

Objectivity of measurement should be constantly sought, but not to the exclusion of other indicators which have proved of real assistance to the physician. In certain instances, decisions of importance are dependent upon the interpretation of data from the history and of evidence from the physical examination which does not meet the ordinary requirements of objectivity. For example, inspection of a child's tonsils reveals certain data as to size, blood supply, superficial inflammation, or draining crypts, but this information may be inadequate to determine their effect upon health. In a large number of cases decision as to the desirability of removing the tonsils must be reached by inference from a variety of evidence which, although not exact or positive, may indicate useful procedure. Inferences thus reached should be acted upon if the chance of doing harm is minimal and the chance of benefiting the child is good.

In undertaking the physical examination of children, particularly in the early years, the physician must be prepared to sacrifice time to secure the cooperation of his subject, and must be willing to dispense with orderly routine in order to grasp opportunities for securing information as they present themselves. The manner of approach to the patient deserves careful attention. Such apparently minor maneuvers as the application of a cold instrument, the passing of an instrument close to the eyes, or sudden movements which startle or terrify, sometimes prevent the examiner from obtaining desired information thereafter.

Observation greatly facilitates the estimate of the child's general well-being. It is of prime importance in this connection for the observer to know how a normal healthy child looks and acts. He should observe the expression, attitude, and other general manifestations of well-being, and the appearance of the eyes, skin, mucous membranes, and the subcutaneous tissue. The distribution and quality of hair is worthy of note, because they are not only indicators of age, but also at times of disease or glandular dysfunction.[1] The observer should note also the condition of the teeth and formation of the jaws, the contour of the chest, abdomen, and extremities, and the condition of the genitals.

The muscular development and body mechanics are also readily appraised by observation. The child should stand with chin raised, back straight, chest elevated, and abdomen not protruding. Errors in posture are often brought into striking relief by dropping a plumb line from behind the ear of the child. When the child walks, runs, or moves about in the examination room he should use his body easily. The feet, soon after the child begins to walk, should show development of the anteroposterior arch, and absence of such calluses on the toes as indicate short stockings or badly fitting shoes. By observing the child during the process of examination it is possible to get some idea as to whether he has been properly trained. If he is unduly apprehensive or rebellious and if his mother is constantly yielding to every whim, independence has not been cultivated, and there are probably other faulty habits as well. If he appears tired and irritable, it may mean that he is sick, but it may just as well indicate that he is overstimulated or has had insufficient rest.

Glands. Certain of the glands of internal secretion and the lymph nodes should be examined. The thyroid should be palpated routinely. In the male infant the testes should be located and it should be determined whether they are descended or not. The size of lymph nodes and the spleen should be ascertained, because their condition may suggest the presence of local or general chronic infection. The condition of the lymph nodes is of particular assistance in judging the presence of infection.

Nose and Throat. Much information may be obtained regarding the condition of a child's upper respiratory tract by observing the type of breathing, the discharge from the nose or the evidences of discharge through excoriation of the nares, and even from the odor of the breath. Indirect evidence may also be obtained from consideration of the cervical glands. Even the condition of the conjunctivae and the drums of the middle ears is suggestive of the condition of the nose and throat. Inspection of the throat gives evidence as to the size and the superficial appearance of the tonsils, the presence of postnasal discharge, and the condition of the mucous membranes and lymphatic tissues of the nasopharynx. The cycle of perfectly normal physiological enlargement of the tonsils should be borne in mind, and their mere size, except when this causes mechanical obstruction, should not be the criterion for removal. By the same token, tonsils which are almost invisible can be inferred to be the seat of disease from a history of frequent attacks of throat or ear trouble or by the enlargement of the cervical glands.

Lungs. The clinician should be the first to admit his inability to detect other than gross morbid processes in children's lungs, and should, on the slightest suggestion of pathological condition in either the history or physical findings, seek the added help contributed by the roentgenogram. We are often unable to recognize without this assistance the early stages of enlargement of hilus glands, calcified mediastinal nodes, or the other early manifestations of the childhood type of tuberculosis. On the other hand, our knowledge of the significance of certain shadows in the roentgenogram is not yet complete, and the interpretation of roentgenograms of the lungs must often be made in the light of clinical findings such as temperature and weight curves. The usual methods of examination of the chest, however, should be a part of the routine, because, if carefully done, many of the lesser manifestations of infection may thus be recognized or suspected and gross changes should be found.

Heart. Physical examination of the heart reveals factors of importance in regard to its size, location, rate, and rhythm, and the quality and intensity of its various sounds. Murmurs occurring in the newborn are very likely to be transitory, and it is most difficult at any age to differentiate sharply between those of pathological significance and those of functional character. Murmurs must be interpreted in the light of other findings and of the history, and after noting on repeated examinations whether they are persistent or transitory. It should also be remembered that in the presence of rheumatic disease the absence of murmurs does not exclude the possibility of heart lesion.

Abdominal Viscera. Examination of the abdomen frequently contributes information of importance. The delay caused by having the child lie down and relax, and the necessary extra exposure of the body, often lead to the omission of this procedure. In the newborn the condition of the umbilicus should always be observed, inasmuch as it is the point at which infections, as well as abnormal congenital conditions, may first be noted. Palpation of the wall of the abdomen gives evidence as to tone, changes in subcutaneous deposits of fat, and turgor, findings of significance even in the well child. In addition, the familiar signs of acute illness, such as tenderness and spasm, should be mentioned. On deeper palpation one may detect enlargement or abnormal position of the liver, kidneys, spleen or mesenteric lymph nodes, as well as pathological masses within or behind the peritoneum.

Teeth. In inspecting the teeth one should determine the stage of development, as far as the pattern of eruption and the shape and size of the jaws are concerned. One should also look for defects and indications of local infection in the teeth themselves or in the gums. A roentgenogram will assist materially when there is doubt in regard to the presence or extent of local infection. One should examine the teeth for information regarding past dietary or disease experiences and from the standpoint of their relation to general health, as well as from the standpoint of their own protection.

Special Senses. Although the physician engaged in the general appraisement of the child is not in a position to apply all of the measures used by specialists to determine the adequacy of the special senses, he must consider the problem of their functional adequacy and its relation to other phases of growth and development.

Sight. The physician, trained and experienced in the care of children, may conduct the cruder tests for visual acuity and note the movements of the eyes and the ability of the child to focus upon objects. To determine whether the infant can see is often difficult, and sometimes requires search for proof on more than one examination. The physician may also note irregularities in pupillary reactions, opacities in the lens or conjunctiva, and disease conditions or defects of the lids and lacrimal apparatus. Every child should have a careful examination of his visual mechanism before his schooling begins, and as often thereafter as special findings indicate. This special examination should be provided at an earlier date if the family history indicates the possibility of hereditary defect or if the physician's cruder methods bring to light evidence of abnormality. These special examinations require the services of a well qualified and experienced ophthalmologist. Nearsighted children should have an examination each year until growth is completed.

Hearing. The presence or absence of the sense of hearing in the young infant can usually be detected in a crude way, but it is difficult to appraise the adequacy of this sense until the child is old enough to cooperate. The early recognition of defects is of great importance, because of the interference with the general development which results from impaired hearing. The cruder methods of testing, by the whispered voice at given distances, may be applied to the child ready to enter school, but above the third grade the phono-audiometer is a useful "screening process" in detection of impaired hearing. By means of this instrument a large number of children can be examined simultaneously.

Laboratory Tests. There are certain laboratory tests which are so regularly required that they should be considered part of every complete appraisal. Among these should be mentioned urinalysis and a study of the blood cells. Other procedures require only single or infrequent application. The Schick test is one of these, and should be applied six months after the prophylactic inoculations for diphtheria, and the latter should be given at about six months of age. The tuberculin test gives valuable information in the presence of obscure symptoms or in the presence of possible exposure to tuberculosis and for the confirmation of clinical diagnosis. The physician trained and experienced in the care of children should be prepared to apply this test when the information derived from it would add to the facts which he may bring to bear in handling the case. A positive reaction to the tuberculin test need not necessarily be taken as indicative of active disease and must be interpreted only in the light of other data, the age of the subject being of prime importance. That blood for a Wassermann test can and should be taken from every infant whose mother or father has given a positive test or suggestive history, or who himself shows evidence suggestive of syphilis, should be stressed, since such procedure is often erroneously considered to be too difficult, or even imposible, in young infants.

The scar resulting from a successful vaccination against smallpox should be sought. If it is not apparent, inquiry as to previous vaccination should be made, and in case this procedure has not yet been carried out, prompt attention to it is indicated.

History of Exposure to Infection, and Past Diseases. It is well to emphasize the importance of determining the presence of tuberculosis in either parent or any member of the household, as a part of the appraisal of the infant or young child. In view of the fact that the younger the child, the more serious the consequences of infection, it is essential that the physician should recognize his heavy responsibility in deciding whether or not this contact should continue.

Exposure to certain chronic or recurrent respiratory infections, such as sinus disease or tonsillitis may account for recurrent infections in the child, and the occurrence of these cannot be intelligently dealt with until the source of infection is recognized. A history of recent exposure to acute communicable disease is also helpful in establishing early diagnosis upon the occurrence of these diseases, and in some instances in providing preventive measures or early treatment. What we may properly expect of a given child at any time is influenced by his disease history, and this history should be elicited in considerable detail as to time, sequence, and nature of the illness involved. Such information will aid in developing a proper understanding of the findings on examination, in making early diagnosis, and in constructing recommendations for routine and care.

The General Personality; Postures and Gaits. Thus gradually we have begun to explore the child as a single organism. Though localization of function is characteristic both of body and of brain, the body functions in terms of its training, the mind in terms of its experience. In exploration of the personality we commence with posture, and again we meet a misadventure in phraseology. We speak of posture when we mean to study poise, while by our faulty technique we frequently elicit pose. Poise, whether in rest or in action, is a most important indicator of health, but if by self-consciousness poise is galvanized into pose, our record is misleading or even positively useless. The position of the newborn in repose, his gestures during activity, grimaces, sucking movements, movements of arms and legs, the ease with which he is awakened, the type and maintenance of his cry all indicate his general condition and special requirements. In successive stages of infancy the fixation of his eyes, his manner of holding his head, his efforts to sit up, and, later, his creeping and early attempts at walking each carry its own suggestion. Then appear, in order, the balance of his body in the erect posture, including particularly the movements of his toes and adjustment of his feet, and the character of his running, which undergoes a marked change at approximately three years and again at about his ninth year. From all of these much is to be learned.

Attitudes, Overt and Covert. By any easy transition from posture and gait we encounter attitude, the overt form of which is physical and the covert, psychic. At this stage of the examination we are confronted by a host of indicators, even a survey of which could not be attempted in this review, but among which the experienced physician will pick out signals of habit formation and training. The articulation of speech, general alertness and activity of body and mind, the responses to parents, to physician, and to other environmental stimuli, all tell their tale to the discriminating observer. Acquired defects of body and behavior betray themselves.

With the many interests and opportunities opening up before the child as his experience of life grows larger, there is a greater tendency to excessive activity and to the development of strain and fatigue, which, just as much as evident physical defects, calls for correction. It is rare for the physician himself to make an adequate psychological and emotional appraisal of the child, but these aspects must not be belittled. Indeed, their importance becomes more evident with the growing objectivity of method, and wherever possible we recommend their inclusion in this assessment.

Nutritional and Developmental Status. Holding his judgment in abeyance while noting the signals surveyed in preceding paragraphs, the physician will inquire further into the general nutritional and developmental status of the child. The height and weight, the power and firmness of muscle and character of subcutaneous tissue, the appearance of skin in scalp, face, limbs, and torso fall under review. Height and weight should preferably be considered separately, remembering that a relatively low weight may equally be an indication of undernourishment or of recent rapid growth. The muscular power, provided it be not falsified by self-consciousness, may be aberrant solely because of deviations of height and, especially, of weight from the average. Tests for firmness of muscle and character of skin and of subcutaneous tissue are considered in other chapters.

Nutrition. On physical examination one seeks evidence as to the fitness of the various tissues, realizing that it may be materially influenced by the amount and quality of food taken and by the function of the nutritional processes. But one should keep in mind the possibility that their lack of fitness may be due to constitution, to disease, or to other errors in routine besides diet. There is a variety of kinds of evidence which may relate to the nutritional processes. The weight and the ratio of weight to height, in relation to previous weight and height, are the most commonly used and generally satisfactory single measures, but the physician must take into account the influence of body build and other factors. The hemoglobin content of the blood; softness, deformity, or tenderness of the bones; the conditions of the muscles and subcutaneous fat; changes in the mucous membranes of the eye, the blood vessels, and peripheral nerves may all be indicators of deficiency in diet.

Musculature and Body Mechanics. The musculature, joints, and ligaments are indices of the development, general health, and well-being of the child, and probably to some extent of the function of the nutritional processes. These should be noted individually and also in relation to posture. The general muscular development of an infant should probably receive more attention than it customarily does. Unfortunately we have no adequate measure of muscle quality, quantity, or tone; but as the ability to support the head, sit, stand, and walk all involve an adequate degree of development of certain groups of muscles, much may be learned by noting the infant's facility in these activities. In the older child posture reflects the condition of the muscles and ligaments and the presence of fatigue or other dysfunction.

The physician must be sure that he is measuring poise and not pose, as the latter is irrelevant unless habitual. Perhaps the readiest method of eliciting poise is not to strip him of his clothes, but merely to remove his shoes and stockings and ask him to climb and descend a short stair. Lining up children in school and in other groups for examination of posture or shadow graphs also accentuates the element of pose, and this must be either discounted or corrected by further individual observation under other circumstances. Pose may accentuate a mildly exaggerated curve into one of marked abnormality, or, if the child knows what is desired, may temporarily correct a naturally poor posture into a satisfactory one. In considering the child's vertebral column it is well to remember that the only curve present at birth is that of the thoracic vertebrae. The cervical curve appears when he learns to hold up his head, the lumbar curve when he stands erect. Faulty posture may be a consequence of general weakness. It may also result from a one-sided defect in length of leg or construction of foot. The general similarity of feet and hands must not obscure the essential fact that hands are free grasping organs at the extremities of anchored arms, whereas feet are members clinging to a fixed surface upon which legs and torso are balanced, the muscles of the toes being the fine adjustors in this mechanism.

Subcutaneous Tissues and Skin. We still lack adequate objective measures of skin and subcutaneous tissue, but their quality may be judged by feeling them. They are an important index of utilization of water and other nutritive substances, of certain glandular functions, of the amount of exposure to sun, and of certain phases of vasomotor control and circulation. The relative amount of subcutaneous fat, as judged at clinical appraisal, varies with the age of the child and with the type of body build, but its evaluation is a great aid to the clinician in judging the success of the nutritional processes. It is important to determine by repeated examinations what is the optimal amount of subcutaneous fat for each individual child.

Build. Lastly, before leaving the specific measurements, the physician will investigate the build of the child. The proportion of limbs to torso, of chest conformation with subsidiary features of shoulders and shoulder blades, and relative development of cranium, face, and jaws, together with eruption and occlusion of teeth, illustrate tendencies and point to prognoses of great significance.

The physician should first attempt to appraise the gross and proportional adequacy of the child's skeletal development by observation and palpation, and then supplement this information with certain measurements. In this phase of the examination, however, he should be particularly conscious of his objective: he is using these measures as an aid in drawing certain conclusions of practical importance to the health of the particular child. It is important that the physician remember the variations which occur in these measurements, and relate each to its normal distribution curve rather than to its average. The interpretation to be put upon measurements has been discussed elsewhere, and it has been shown that their chief value lies in the determination of the amount of change between consecutive examinations rather than in their specific readings.

The size and shape of the head, with palpation of the fontanelles and sutures in the young infant; the development of the face and jaws; the relative proportion of head and chest, and head, trunk, and extremities; the curvatures and mobility of the spine, the contours and the size of the extremities of the epiphyses all contribute valuable evidence to supplement the usual measurements. In examining the skeleton one should seek to recognize pathological changes in the bones, as well as the adequacy of bony growth. Because of the normal variation in shape and contour of bones and because pathological conditions often bring about changes in the shape of bones which are but exaggerations of the normal, it is often difficult, if not impossible, to draw a line between the normal and the slightly abnormal. The roentgenogram of the bones is of very great value in determining both the stage of bony development and the pathological conditions which involve bones.

The Roentgenogram. A very useful adjunct at this stage of the examination is the roentgenogram of limbs and chest. We readily admit that indiscriminate roentgenography should be discouraged and that interpretation is still far from perfect. But in recent years the technique of roentgenographic work has been much simplified, the cost of satisfactory equipment greatly reduced, and physicians are becoming better trained in the interpretation of the more common roentgenographic findings. We may therefore look forward to the inclusion of the roentgenogram and to roentgenoscopic examination as a frequent procedure in physical appraisal. Without an appeal to this method it is difficult to determine the earliest stages of pulmonary tuberculosis. The roentgenogram moreover often gives a clear indication of present or past disorders, like syphilis, rickets, scurvy, the more obscure nutritional derangements, and dietetic disturbances. Even the character of the ossification centers, the penetration of epiphyses by bony growth and the general features of epiphysial union are indicators of relative health and development.

The Heritage. Having gathered by these means a mass of detailed information regarding the child's physical condition, and setting aside the purely temporary or irrelevant features, the physician is then in a position to investigate the conditions of the child's life, seen from the child's point of view, which, despite a decision that he may be comparatively sound in health, suggest endorsement or adjustment of the child's attitude. The child's heritage shows clearly in his physical form and behavior. We use the word heritage advisedly, for it is not our present purpose to make an academic distinction between heredity and environment. We comprise, under the term heritage, both the endowment of the child at his birth and the modifications of that endowment by his environmental circumstances thereafter, the direct and indirect gifts of his parents.

Diet and Regimen. In the inquiry concerning environmental conditions of the child, questions concerning diet and regimen form a suitable introduction both because of their immediate significance and for their reassuring effect upon the cooperative attitude of the parent from whom the information is sought.

A knowledge of the diet and nutritional experiences of the infant must be fairly detailed because minor irregularities or changes, and the conditions which made the changes seem advisable, are all fraught with profound significance. Indeed, to a physician of skill and appropriate training, evidence of these past conditions and dietary changes may be apparent in the roentgenogram. At all ages, however, it should be determined by questioning whether all the nutritional requirements have been provided in adequate amount or whether gross indiscretions are customary in type, quality, or amount of food or in frequency of eating. A detailed history of digestive disturbances and of the factors leading up to them must always be sought where there is evidence that nutrition has been inadequate. Equally important to the health of the child and closely allied with diet is a consideration of his routine of living. Careful planning of the diet is of little avail unless the child's eating habits have been so disciplined that he will take the food offered.

The amount of sleep and rest, of exercise and play, of exposure to sun and time in the open air, the extent of nervous stimulation, and such other features of the routine as suggest themselves to the physician must be investigated.

We realize that there are marked individual variations in the requirements for sleep and rest and in tolerance for exercise, and a proper judgment can be attained only after careful consideration of the way in which the child has responded to his previous experiences. But it is the physician's duty to explain the conditions appropriate for the child so that they will be understood by the parents and effectively applied.

Socio-economic Factors. The adequacy of adjustment may be determined by observation of the child during the history-taking and physical examination. Again we realize that even an unhappy or unhealthy environment affects some children more than others. But the physician is wise to inquire closely into the social and economic conditions of the household. He may start with questions upon the number and ages of the children, upon the amount of time and strength of the mother available for the care of the child. He will learn of the housing facilities and sleeping conditions; of the intimacy of exposure to, the prophylaxis against, and the actual contraction of disease; of the character of the district, the family income, and those racial and familial customs which are so potent for the welfare of childhood.

The Endowment. Finally, the physician enters the most difficult field of investigation, which may lead him to request opportunity to examine the parents themselves, a duty which he may not shirk, both because of its direct value in the specific child problem and its educative value to the parents. He will inquire concerning the mother's health and regimen during pregnancy, the possibility of maternal toxemia, chronic or acute disease, especially the deficiency diseases. He will attempt to determine the degree of fetal maturity at birth and the infant's adequacy for extra-uterine existence. He will obtain from the family history information regarding inheritable tendencies, racial or familial diseases and defects, including those immunological and allergic tendencies which are inherited but do not manifest themselves until later infancy or childhood. And at the same time he will observe the general fitness of the parents to nurture the child, noting their mental equipment, robustness, vigor, frailty, placidity, excitability, and even the physical evidences of family lines, such as height and weight. Whether or not all of these characters are inherited, the general attitude and capacity of the parents have so marked an effect upon the child that they may damage or destroy even a favorable endowment and at best constitute so severe a handicap to adequate growth and development that they must be very seriously viewed by the physician and an earnest endeavor must be made to mitigate their effects.

In conclusion, the physician will recognize that etiological factors may vary with economic status. The mere obtaining of food correct in type and amount is the outstanding problem in the lowest economic group; the prevention of infection in the middle group, and the regulation of habits of living in that stratum highest in the economic scale. The fact must not be overlooked that adoption of good habits is more dependent upon intelligence and education than upon economic status.

THE TRAIL OF PAST DISEASE

We have sketched as lightly as may be the general principles upon which the examination for individual appraisement of physical status is based, but this account may not be terminated without a reference to the sequelae of past disease. There are still far too many children mutilated for life from tuberculosis of bowels, bones, lymph nodes or lungs, from measles, from rheumatic fever. And to these may be added the permanent scars of scarlet fever, of pyelitis, and of poliomyelitis. Each physician will add others to the list. The actual ravages of disease are stayed, but leave a distorted physical frame and, all too frequently, a marred behavior pattern. The physician will point out the parent's responsibility in such cases, that the child may be assisted to rise above his handicap.

It is to be remembered that the scars of disease are honorable scars and by no means always spell infirmity. Most people gain immunity from infectious disease without actually suffering the disease. An attack of the infection, provided the child recovers, is of undoubted benefit in raising his immunity.

Resistance is not the same thing as immunity. The former implies bodily vigor; the latter, a biochemical property of the tissues. The strongest looking interns are those who usually contract hospital infections, and the thin wiry child may have a better health record than his active robust fellow. Nor must it be imagined that the so-called hardening processes which develop robustness necessarily increase the immunity to disease. Cold baths and exercise may do no more than produce fatigue, but in some cases are actually harmful. The physician conserves the best interests of the child by prescribing rest periods rather than athletics for children who are undernourished or who have returned to school after an attack of some infectious disease.

The value of the serial examination is nowhere more clearly demonstrated than in the trail of past disease. Given a fighting chance, the amazing vitality of the child will overcome many an apparently insuperable handicap, for the attribute of compensation, which characterizes all of his bodily functions, comes powerfully to his aid. Nevertheless it is incumbent upon the physician, at all times, but especially in the periods following disease, to maintain a proper and effective balance between food and rest and exercise, between activity of mind, of emotions, and of body. More than ever he must be the guide as well as the guardian.

THE SCHEDULE OF PROGRESS

In our discussion of appraisement we have assumed that the physician is examining the child for the first time. But we have hinted that if he is able to present to the parents a program of health training, he will stimulate their appreciation of the advantage to be gained from a periodic check upon progress. This must be ever foremost in his mind. Really satisfactory judgments can never be made from a single examination. The régime suggested by him calls for repeated assessment, first, for the benefit of the child in question, and, second, for the welfare of children in general. Parents will readily appreciate timely prophylaxis and the ultimate economy of periodic examinations if the advantages of these are laid before them. We, on our part, need further information as to the optimal period in the child's life at which certain measures should be undertaken. We are fairly certain about the best time to advise inoculation against smallpox, diphtheria, and typhoid, or such surgical procedures as operations for cleft palate or hernia. But there are others, notable among them orthodontic and orthopedic devices, concerning which further experience and investigation are required.

The objectives in individual appraisement are the same in all stages of development and the principles underlying our recommendations apply to all the years during which growth is taking place. Certain features, however, require special attention at particular periods, owing to the changing mental and physical status of the child. Emphasis upon items will differ according to the developmental phase, and even the techniques of examination will differ in detail. The various laboratory procedures involved in the examination also will vary in relative importance.

The Neonatal Period. During the early weeks after birth the infant goes through more profound anatomical and physiological changes than he will ever go through again in so short a time, and the neonatal period is generally admitted to be fraught with more numerous and serious risks than any other phase of the life cycle. The fact that recent years have witnessed less reduction in its mortality than we had hoped, in spite of the advances in knowledge and health practices, compels our insistence upon appraisal at least at the end of the second or third week in addition to that made at birth. Early diagnosis and immediate application of proper treatment are of more importance at this phase of life than at any other. Certain conditions, such as birth injuries, may not make their appearance until some weeks after delivery. On the other hand, some disquieting findings at birth, such as heart murmurs, may disappear or so alter as to change the first impressions of the physician.

Early Childhood. The transition from infancy to childhood is marked by increased muscular activity, by decrease in rate of growth, and by loss of that chubbiness which is so characteristic of infancy. The milk teeth make their appearance. Labial sounds are formed. Measurements of growth in body and limbs become more significant than those of the head. The infant walks, uses spoken language, and is transformed into a child. With these changes there go many adjustments which are a subject of concern to both parents and physician. It is important to appreciate the relationship between these phases and the occurrence of marked deviations from normal range of date for the changes involved. In appraisals of this period one must inquire especially into the accomplishments of the child and try to explain apparent retardations.

The Preschool Period. After the child runs about tendencies toward poor posture and improper arch formation in the feet, toward eye strain and defects of the ocular muscle, toward imperfection in formation and alignment of teeth, and toward defects in growth of the jaws begin to manifest themselves. Escaping from the constant supervision of his mother, the child runs new risks of disease, especially of the exanthematous type. Corrective procedures for deformities and defects and various prophylactic measures should be undertaken to fit the child for his school life.

School Entrance. Until periodic examinations during the preschool years become general, attention to prophylaxis against infectious disease and correction of defects must remain an important part of appraisal at the time of entrance upon school activities. If appraisals have been made during the early years, the records covering the child's history and examinations will be useful to the school physician, as it is desirable to have a very thorough history obtained at the time of school entrance. Careful records should be established which will serve as a basis for later examinations. The ideal examination on entrance to school calls for the same facilities as at other periods, and should be conducted by a physician possessing thorough knowledge of children and the preventive point of view, with the child undressed and with facilities for thorough examination, including access to supplementary means of diagnosis (clinical, laboratory, roentgenographic, and so forth).

The fundamental purposes of this appraisal, as of others, are: (1) Educative; to teach the child the wisdom of having periodic examinations by his personal physician. (2) To ascertain if the child's condition is satisfactory for the school routine or if that routine should be modified. (3) To provide an examination for those who may not have had this service, and to advise the parents if conditions are found which indicate the need of further attention by the personal physician.

During the school years appraisals should be repeated at frequent enough intervals to be certain that recognized defects are eliminated as far as possible and that newly acquired defects are discovered.

Puberty. About the time of puberty special hazards arise, owing to the altered character of growth, the readjustment of bodily functions, and to psychic, emotional, and social readaptation. Thyroid dysfunction, increased susceptibility to fatigue, tuberculosis, the lighting up of old infection, and aggravation of cardiac disease are common accompaniments of this period, and enhance the difficulties consequent upon the variation in date and type of manifestation of the gonadal change, which itself is all too subject to disorder. It is especially important, because of the high degree of suggestibility incident to this phase of growth, to carry out the examination with all tact and reserve.

Competitive Athletics. The examination of fitness for competitive athletics must be carried out by a physician and not by lay examiners only. Potential susceptibility to overstrain is quite as significant as the existence of actual disease. The condition of the nutritional processes and the state of the muscles and subcutaneous tissues are of great importance. The condition of the entire respiratory apparatus, of the heart, the neuromuscular mechanism, the endocrine system, and of the skeleton should be minutely scrutinized, and hernia, actual or potential, looked for. Although there is a wide variety of so-called functional tests of the cardiovascular system, and one or more of them should doubtless be employed to make a preliminary estimate of the individual's response to and capacity for strain, it is more important to make the final determination of his fitness for games involving high degrees of strain by careful observation of his response while he is engaged in the games themselves. The examination includes registration of the degree of fatigue exhibited after a measured effort, the rapidity of recovery from this fatigue, the ability to maintain the rate of expected increase of weight during training, and the maintenance of fitness over the entire season. It is not enough to give a preliminary permissory certificate of probable fitness. The fitness to continue must be determined by repeated examinations while the games continue.

Certification for Employment. The age at which a child may enter into gainful occupations varies widely in different states. Further, certificates of fitness required for employment have commonly been granted on the basis of exceedingly perfunctory physical examination and without any adequate consideration of factors other than physical which obviously enter into a satisfactory and complete appraisement. Again, many of these laws do not apply to children engaged in street trades, despite the plain fact that risks to health may be as great in these as in other occupations.

While striving for redress in these important matters, the physician will carry out this examination with all the devotion which he would apply to a school appraisement. Freedom from disease and physical capacity for the occupation in question will be insisted upon, but in addition we recommend to the physician a careful assessment of mental and emotional fitness, in order that the child may be adequately protected.

The general situation can be greatly improved by the adoption of certain self-evident precautions. First, during the later school years fitness of the child for particular tasks or functions should be recorded in order that a vocation may be advised which is adapted to his particular abilities. Secondly, the adoption must be urged of special standards by states which have low legal age requirements as well as inadequate regulations. This might well result in improvement of conditions of child labor even where the legal age limit cannot at present be raised. Thirdly, adequate time and facilities must be insisted upon in order that the examination may be, in reality, a serious assessment of the child's fitness to enter upon his required duties. There must also be adequate time and facilities for repeated examination, to detect any deleterious effects of the occupation itself.

THE PHILOSOPHY OF MEASUREMENT

In all of our determinations we seek to estimate the degree in which optimal functional potentiality is approached. This by no means implies maximal capacity. Perfection is a rallying standard but adequacy is the goal for attainment. Balance is fostered by the ability of each organ system and member of the body to function satisfactorily within a limited range of conditions. It is customary to speak of this attribute, by which handicaps to function are overcome and spurts of maximal activity are rendered possible without ill effect, as compensation. Nature has a comforting habit of overlooking failures to attain perfection, provided the pragmatic standard of adequacy is attained. One can imagine her stalking among her creatures with the ever present question on her lips, "Will it work?" Our standard of a normal child is not measured in terms of bodily dimensions or intellectual range but of soundness of body and mind. Hereafter, therefore, when we speak of a normal child we do not mean a child of certain dimensions or particular ability, but a child sound in body and mind, harmoniously developed physically, mentally, and emotionally, and consistent in developmental progress with his years.

Years, being units of time, are equal subdivisions, but they do not imply regular increments of growth or advances in development. It has indeed been suggested that they be replaced in our terminology by such phrases as *developmental levels* and *growth stages*. This is cumbersome, and provided we acknowledge the fact that growth and development occur in spurts, with marked fluctuations in velocity so that successive years represent very unequal increments and advances, there is no need to change our expression of time relationships.

Growth means increase in dimensions; development means advance toward maturity. The terms, however, become confused in practice and are so often interchanged as to require the context to point their exact significance. The expression *developmental growth* is sometimes useful where both phases are under review, but the context may render even this unnecessary.

The Application of Statistics. Developmental growth is fundamentally a problem for case study. The interplay of factors which influence its course is so complex that we are apt to evade the effort to analyze them. We mass them together and call them chance, and then appeal to the statistician for an analysis by the indirect mathematical approach, tacitly signifying thereby that our own clinical appreciation has no applicable standards of judgment or that our attention has flagged. When the physician speaks of chance he often means luck. There can be no measurement of luck, but the laws of chance are definite and understood. They must assume, however, an approximate equality of influence in all factors entering the problem. As physicians, we know that equality of influence never occurs in our biological problems, that the laws of chance never get a fair opportunity. The deviation of our actual findings from statistical prediction is a measure of that handicap under which statistical methods must operate.

To render approximately equal the influences of the several factors, the statistician demands large samples. These, as a rule, we cannot give him. He has met us more than half way. Asking numbers of 1,000 in even a fairly homogeneous sample, he has given us determinations of distribution within the sample and of probable error if we can give him no more than 100 or even 50. Generously he has descended, with warnings, to 15. But, in the end, he must depend on us for our estimate of homogeneity.

There is no evading this responsibility. Given the accuracy of the quantitative determinations, the real significance of the quality to which the quantitative differences are ascribed must be established. If the evidence is not what it purports to be, even in kind, its quantitative aspect is certainly valueless. Thus when the weight of a child of given height and age is measured, the accuracy (meaning the control of technique) of the weight determination is far less important than the significance attached to the weight itself. We must decide whether the relationship of weight, height, and age means, for us, hereditary body build, rate of growth, or adequacy of nurture. And, whichever we mean, our standard must itself be established.

The Mediocre Mean. It is possible to conceive of perfection, but less easy to measure it. Granted it can be measured, there will be few children who attain it. The great majority of our cases will group themselves about an average which fails of perfection by an amount varying with the sample. In our minds we are trailing perfection, but from our actual determinations it is the mediocre mean which emerges. We speak, therefore, of the fluctuating average, and the statistician, patiently enough, has given us a measure of dispersion and probable error applicable to our imperfect data. When we say that the well nurtured child is above the average, it is this mediocre mean, derived from the vast group of physically imperfect children, which we have in mind. No more can be extracted from the mass of our observations, even by statistical skill, than was in these observations to begin with. Stringency of selection by the physician is a fundamental need, but the greater the stringency the more biased is the factorial influence and the less amenable are the observations to analysis upon the laws of chance.

We come back, therefore, to the consideration of perfection. There is no evidence that life can be indefinitely lengthened, dimensions indefinitely increased, or capacity indefinitely enlarged. If the child is to be sound, there is an upper limit to all quantitative determinations. We seek these limits for our standards. Certain attempts have been made to discriminate the upper limits, but no conclusive evidence has yet appeared that they have been discovered in the temporal relationship of either growth or development. Pending this discovery, the evaluation of the mass of children by the mediocre mean must remain our standard. From a biometric point of view *central tendency* and *norm* mean the same thing. The terms refer to this mediocre mean which fluctuates with every sample. It is merely a provisional point of reference which defines biological relativity, not an ideal of excellence for the individual. As we rarely find total absense of the quality to be measured, zero has no biological significance. It is, we should say, far more important to compare the height of a ten year old child with the average height for that age than to refer it to the physical zero.

Biometrical computations of expectation are averages also. When one asks what the blood pressure of an individual "should be," one is asking what is the average of others like him. What we expect an individual to be in regard to any given measurement is the amount usually found under the conditions which describe the individual as far as we know him. This is as true of the intuitive judgments made clinically as it is of judgments made on the basis of quantitative determinations.

The weakness of the tabular material representing norms and expectancy values is the limited scope of our present material. The logic of comparing a measured aspect of an individual to a series of similar measures for other individuals like him in certain other ways is unassailable. But at present, norms based upon selected groups of individuals representing *desirable* combinations of heritage, history of disease, and home influences are not available. Further biometrical work to furnish these norms will do much to promote useful application of measurement.

Family Lines. In our observations on the growing child we are constantly warned not to mix examples of different racial or national origins. It is held, for example, that developmental progress or rate of maturation is greater in Sicilian than it is in Scandinavian children. It is also held that the adult limits of growth in dimensions differ markedly in two such samples. One hears constantly that Negro children must not be subjected to the same standards as children of white stock, and that white children in the tropics must be judged by standards other than those applicable to children in temperate climates. We must beware here of confusing dimensions of growth with levels of development. That there is a relation between them is undeniable. The problem for elucidation is the degree of relationship. That there are hereditary tendencies toward large or small adult dimensions we all admit, and that large or small family lines are characteristic of different geographic localities is self-evident. But there are many exceptions. Moreover investigations have shown that, in this country, the differences of children in rate of growth and ultimate attainment of dimensions are influenced very largely by differences in culture and economic opportunity. Both heredity and environment contribute to the character of physical growth.

Developmental progress is in a different category. Adults of all races and nationalities have attained the same stage of maturation. We are concerned here with relative rate of progress only, and we understand very little of the factors which control this rate. There is evidence which indicates that developmental progress is controlled by internal readjustments of functional activity, which we may provisionally call *booster stations*. The most obvious one is that gonadal booster station which usually becomes active about the twelfth birthday but may be delayed in its operation for several years. Our segregation of children by national origins is a crude recognition of this problem. Much more work is essential before our minds can become clear upon this issue.

Sex Differences. The foregoing remarks apply with special directness to the sex influences on growth and development. We have, as yet, no adequate conception of the causation of these obvious differences. It has been shown without doubt that, upon the average, the girl develops and grows faster than the boy, at first by days, then by weeks, and ultimately by years. But the standard utilized is, of necessity, the mediocre mean. It has not been shown that the upper limits of developmental growth differ markedly in the two sexes except in so far as the growth reaches adult dimensions. Indeed the upper limits of individual variation indicate, on the contrary, that developmental progress, if not held back by internal or external interference, follows a similar time relationship in both sexes.

Age Standards. Measurements of physical status must of course take chronological age into account. Measurements differ in their relationship to the lapse of time. Since children neither grow nor develop in all traits at the same rate at the same chronological age, it often tends to obscure rather than clarify the problem if we translate traits into years, and compare individuals upon the basis of the average status of the trait in terms of years. Time is the increment of years; age is the progress of development. The one is a feature of the universe; the other expresses the interaction of influences at work within the organism. Nevertheless years make a useful measure of developmental growth as soon as the investigator learns to use them as indicators of developmental level in the mediocre mean of the sample rather than as units in the unvaried march of time. The true interpretation of the statement that a child of ten chronological years is twelve years old in breadth of hips is that the intercristal diameter already shows the local influence of the awakening gonadal factor, which in the mediocre average of a random sample makes its presence manifest at twelve years.

If years are used as convenient indicators of developmental level, one must repudiate the untenable assumptions: first, that the correlation of both measures with years is the same, and, second, that any one year's development in each trait is equal in amount and importance to every other year's development.

The Influence of Health Habits. It has been pointed out that differences in race, nativity, geographical location, socio-economic status, and sex make the grouping of data without discrimination exceedingly misleading. It is this difficulty which makes all the data obtained in Honolulu so confusing. Through all these phenomena there shines the influence of health habits. Thus, measurements on the child population of Porto Rico show a much larger frequency of discrepancies than can be accounted for by change of environment. We do not, however, need to travel so far for illustrations. The comparison of relative growth and development in nursery schools on the one hand and day nurseries on the other points the same lesson. It is rendered clearer by a roentgenographic study of the limb bones of the groups in question. On these films are portrayed the evidence of past disease, domestic inadequacy, and economic privation. Growth suffers earlier, and as a rule more profoundly, than development. The undernourished child, the stunted child, and, lastly, the maldeveloped child are the danger signals which mark the extent to which humanity has been marred by improper health habits following in the train of socio-economic disaster. Parental inadequacy, despondency, and despair are ever the most formidable of our adversaries in well-birth and well-being of children.

Allowance for the Effect of Variables. Measures of physical status are interrelated. For given age and sex, height and weight are correlated, and so are many other pairs of measures. Many simple variables are involved in complex conceptions. Examples such as strength, development, and nutritional status occur readily to the mind. Children who do well in a test of strength are often merely heavy for their age, and those who do badly are usually below average weight. These weights, in turn, are highly correlated with physical build. Hence, measures of strength, to be valuable as appraisals of relative physical attainment, must be so used as to be expressions of superiority or inferiority. When weight and build are controlled or, as we would say, adequately allowed for, they must pronounce certain individuals deficient in strength with due consideration for other factors. We shall not pursue this subject further but pass to the final feature of our theme.

Emphasis of Items. Tests of physical status usually include more than one item. A test of strength necessarily measures the force of several groups of muscles. The roentgenogram gives information on the developmental stage of various bones. The amount of subcutaneous tissue is usually measured in more than one area. Choice of items and emphasis to be placed upon the information yielded by each are important features in the construction of a judgment of physical status, and the physician must use his own ingenuity in deciding the details of his examination in every case upon which he is called to report. Whenever a quality can be measured by several possible techniques, it is desirable to know the degree to which a common factor enters all, and also the relative significance of each for a final assessment. We nearly always interpret our measures as if they were characteristics of the individual rather than of the particular area. But the presence of a hernia, a club foot, a stammer, or underweight is not necessarily an indication that the child is built of poor materials throughout. It is most important to choose those indicators which, for a particular child, will be most representative of the total picture, and to weight the component items in order that the quality which we are attempting to estimate may be, as truly as possible, representative of the child's real status.

Cerebral Pattern. Before taking leave of the fundamentals we must glance at the subject of cerebral development, crude and inadequate as our present knowledge undoubtedly is. Psychologists, by patient study, begin to reduce chaos to order and, little by little, are giving us measures of developmental levels. They admit the wide variation in relation of these levels to age and they rightly insist that age be kept out of the picture until their norms are attained. The anatomical study of cerebral developmental pattern has not yet progressed as it must do if we are to keep pace with mental investigation. Nor have we devised methods whereby clinical appreciation may be obtained of the developmental stage. We know that brain weight and volume are about a quarter adult size at birth, that at two years they have reached three-quarters of the adult figure, and that growth is very slow and limited after six years. We are just beginning to realize the general features in the developmental pattern from birth onward, that there are wide variations in this progress in relation to age, and that the unfolding pattern stabilizes itself into permanent form at various stages in different individuals. We know that there are successive levels of mental development and that mental development progresses much more slowly after six years. These bald facts give great encouragement to the collaboration of the physician and the psychologist in their common inquiry into the development of the mind and the factors which favor or which cripple that development.

THE CHOICE OF MEASURES

Relation to Clinical Judgments. Some measures of physical status are ready to hand in every situation. Stature and weight determinations are always possible, like many other indicators which fall within the ordinary clinical estimate.

Some measures, however, involve appliances which are not in general use. Others require expert technique or interpretation and therefore have a limited applicability. It is most important to know the exact relation to experienced clinical judgment of each particular measure employed. We may thus estimate the value of the diagnosis irrespective of the particular observer who makes the assessment, and we can also determine the degree to which the measurement is required for an accurate judgment.

Studies of the relative accuracy of judgments with and without certain instruments would eliminate some procedures and indicate better methods of approach.

Nutrition Standards. The variety of methods advocated in the assessment of nutritional standards indicates our need of more generally useful and accurate indicators. Determinations of build, of bulk, of subcutaneous tissue, of skeletal development, of muscle turgor, and other less direct approaches have been made and should be further evaluated.

Anthropometry. Four proposals for the measurement of physical status by external anthropometric measurement deserve special consideration because of their relation to nutritional status: (1) Deviations in weight from the weight to be expected on the mediocre mean, for height and age. (2) Deviations in weight from the weight to be expected for age and a more complete composite of bodily dimensions. (3) Deviations in the amount of muscle and subcutaneous tissue from that to be expected from a composite of bodily dimensions. (4) Disharmonies, or lack of proper proportion, between skeletal, muscular, and subcutaneous tissue developmental growth.

1. Deviations in weight on a basis of height and age are often a better measure of build than of nutrition. Children, underweight for height, may be narrow of hip, inadequate

in chest dimensions, or aberrant in relation of torso to limbs.

The height-weight ratio has serious defects if used, unqualified by other measures, as an experimental criterion. As previously indicated, deviation in the ratio can occur during developmental progress both from the rapid growth of boisterous health and the undernutrition of disease. Any experiment in which it is assumed that groups of less than 100 are subject to the same average increments in weight in relation to increase of bodily dimensions is fraught with error. Moreover, differences in weight due to dimensional increase are often large compared with those directly attributable to changes in nourishment.

2. The warning issued in the preceding paragraph is equally applicable in the bodily measures. It is assumed that the bodily measures adopted will necessarily be determined by subcutaneous bony points, for it is obvious that confusion must not be introduced by measurements which depend upon the soft tissues which are actually being evaluated in the investigation. The point can be illustrated by the difference in shoulder breadth according to whether it is measured from tip of acromion to tip of acromion or over the maximal distance between the outer aspects of the shoulders (deltoid muscles and subcutaneous tissue).

The weight of a child should be fitted into his own weight curve, not that of other children. Change of weight and rate of gain in the individual himself are the really significant measures of his progress.

3. The substantial differences which can be detected by appropriate means in muscle volume (e.g., biceps) and thickness of subcutaneous tissue have a very low correlation with increase in skeletal dimensions. Estimates on these tissues are therefore excellent measures of the recent records of nourishment, sleep, and expenditure of energy.

Gross measures of girth are quite acceptable in this determination of muscle volume, provided they be carefully planned in precise bodily location. Estimates of subcutaneous tissue by calipers with a constant spring tension depend upon resistance to pressure. It is apparent, therefore, that the water content of an edematous tissue will give a false impression of favorable tissue firmness. Clinical judgment must therefore be invoked in every such determination pending the invention of a more reliable method.

4. Measures of disharmony aim at prognosis even more directly than the foregoing. Unequal skeletal growth, irregular muscular development or erratic distribution of subcutaneous fat, together with disharmonies between these several systems, are certainly significant, and we need further investigation to determine the best methods of measuring these disharmonies.

Indices of Development. Everyone is familiar with the ordinary indications of oncoming puberty. But so far these are almost the only measures of developmental level. We have indicated earlier in this study the types of such measures which are now available or to be hoped for in studying mental and behavior development. To complete the list it is but necessary to add that in separate sections will be found a suggested means of determining skeletal development and using it as a measure of the effect produced by certain disorders of the entire constitution induced by internal disease or by poor health habits.

Again we would emphasize the fact that cerebral development attains relatively early completion by passing through a phase of maximal velocity in infancy and early childhood, which ages therefore are fraught with greatest risk to adequate mental growth.

ANTHROPOMETRIC TECHNIQUE

As a matter of general precaution the following statements, most of them already emphasized in the body of this section, are repeated here for convenience.

Th dimensions selected for measurement are determined by the purpose to be met by securing the data. We wish to learn if children are developing in satisfactory fashion, if there are any idiosyncrasies of development that require correction. For example, we wish to answer such questions as these: "Is the child undernourished?" "Is his chest developing properly?" "Is he developing postural defects?" "Are his limb muscles increasing in proper fashion or is there sign of atrophy?" "Are there evidences of dysfunction in the thyroid, anterior pituitary, or gonadal glands?"

Owing to family idiosyncrasies it is not always possible to conclude that departures from the average indicate conditions requiring remedial measures, but extreme departures are to be regarded as signals of possible danger. At least it is desirable to have the details of a child's physical development recorded in the gymnasium, as his mental development is recorded in the schoolroom. The statistical correlation between physical and mental development is about 0.5. Low as this is, it indicates that we may well seek further positive evidence of the interrelation of developmental growth of mind and body during the entire period of childhood.

With this general principle in mind, what are the essential principles in anthropometry? Without going into details it is necessary, first of all, to stress a fact recognized by all experts, namely, that to measure the human body with significant accuracy is exceedingly difficult. The body is a live, pulsating, mobile thing; and the question which arises on each dimension is how and at what *phase* it is to be measured. Within reasonable compass it is impossible to give an adequate explanation of the pitfalls encountered in making any selected measurement. The anthropometrist should have a satisfactory training by a person of extensive experience.

No set of measurements is satisfactory if it is not in some degree self-checking. Careful and accurate observations must be confirmed by alternative methods of measurement as checks to show the limits of significance which can be attributed to any results obtained.

Each child should be measured at least annually, if possible in the week of his birthday. It is desirable, during the second decade, when changes are most rapid, to measure twice a year. On account of the school vacation it will not always be feasible to have the second measurement come six months after the birthday measurement. Five or four, with the complement of seven or eight, months may then be the interval. Also, if the birthday falls during the holidays, measure six months after the birthday, as the date next best to the birthday.

Examiners. To reduce self-consciousness and mitigate pose and attitude, girls should be measured by women and boys by men, though the distinction is unimportant in children below six or seven years. If the general setting be that of a medical clinic, it is unnecessary to differentiate the sex of the examiner.

Instruments. It is preferable to use instruments of metal. They can be obtained from Germany and Switzerland. They are also manufactured in this country. Application should be made to the following persons for prices and other details: 1. Hermann, Rickenbach, and Sohn. Scheuchzerstrasse 71, Zurich, 6, Switzerland. 2. Alig and Gaumgaertel, Schuetzenstrasse 4, Berlin, S. W. 68, Germany. 3. The Stores Department, Western Reserve University, Cleveland, Ohio, U. S. A. Descriptions of instruments and instructions on technique can be obtained from the International Agreements (reprinted by Hrdlicka, 1920) and from such standard texts as those of Martin,[7] Hrdlicka,[5] and Davenport.[2] Special recommendations have been made by Scammon and Calkins,[8] Schultz,[10] Schreiber,[9] Thompson,[13] and Todd.[14]

Clothing. If possible, clothing should be removed, and the bladder (and if possible, bowels) emptied before measurement. If the clothing must be retained, shoes can usually be removed. In any case, the circumstances should be noted and an attempt at estimate of clothing weight recorded at the time.

Number of Observations. For exact study 1,000 or more are desired by statisticians. For adequate annual standard deviations, 300 persons for each year of age is an advisable number, but in view of the inevitable reduction of numbers with successive measurements this implies an original selection of 600. Very small numbers may be interpreted statistically,* and if the experiments are planned in duplicate or triplicate, greater satisfaction is obtained, as pointed out by Wilson.[15]

* See *Student Biometrika,* 1908, Vol. 6, pp. 1–25.

Reliability (objectivity). It is essential that we try to increase the objectivity of measurements as pointed out in the recent paper by Mahalanobis.[6]

Essential Items. Certain notes should always be recorded, for they are pertinent to the interpretation of all observations. These are the following:

1. Date or season of year, and time of day. Both factors may be of special significance especially in weight determinations.

2. Homogeneity of material. The basis should be clearly stated, that is, sex, age, race, socio-economic status. Observations on the two sexes should be considered separately as a rule. In some types of work they can be consolidated, but only after mature consideration.

Age must be recorded in years and months. An exact statement of range within each time unit must be included.

Race may be disentangled by a statement of the birthplace of both parents, though specific investigations on race require birthplace of grandparents also.

Socio-economic status may be inferred from parents' occupations, family income, or district.

Medical observations, such as history of disease, and such brief characterization as degree of fatness or thinness, goiter or other evident endocrine disturbance, or any abnormality in bodily proportions, should be noted.

Selection of Anthropological Measurements. Weight, stature (or in infants recumbent length), sitting height (for its discrimination of torso and true leg lengths), bi-acromial, bi-iliac (intercristal), transverse and anteroposterior diameters of chest, head length, breadth, auricular height especially in young children, and girths of chest and upper arm are the measures of more general application. Detailed features of face, nose, ear, lips, hair, and hand are of particular significance in appropriate studies. Determinations of subcutaneous tissue and estimates of skeletal development are of much more restricted application, in view of their newness and intrinsic difficulty of application.

SUMMARY

In order to clarify the reader's mind regarding the several recommendations and particular points of special emphasis embodied in this discussion, a brief summary of the more salient features follows.

1. Appraisement of physical status is a fundamental feature of preventive medicine.

2. Crude methods of appraisement are effective only when the sample is very large and discrimination forms no part of the assessment.

3. The group examination is applicable only to the specific restricted requirements of a local situation. Objectivity, precision of measurement, and validity of tests are as important in this as in the more detailed individual appraisements.

4. The periodic examination is a very necessary part of national betterment. Appraisement of physical status is really a program of health education and assessment. It has intimate relation to economic conditions, the problem of the adequate wage, the distribution and regulation of employment, and those purely domestic details of family organization, such as maternity regulation or spacing of pregnancy, which spell well-birth and well-being in the children. The whole responsibility should not be laid upon school health inspections. It compels cooperation of all those responsible for the welfare of children.

5. In appraisement of the individual child we meet our responsibility as guides rather than as guardians. We must set forth a positive health program to enlist the sympathetic cooperation of parents and child.

We need more effective training of our medical students in the well-child clinic.

6. In the section upon the detailed examination we have set forth our aims and recommendations for the guidance of those who endeavor to make positive child health habits a widespread duty of the nation at large.

7. The sequelae of past disease lay the child under a

physical and psychic handicap which must be recognized and overcome.

8. While the objectives in individual appraisement are the same at all stages of development and the principles underlying our recommendations apply to all the years during which growth is taking place, certain features require special attention at particular periods, owing to the changing mental and physical status of the child. These we have detailed at some length, emphasizing the physician's responsibility to the family and to the nation at large.

We lay particular stress upon the duties of the physician, as we see them, when the child is being prepared for his life's occupation. And we emphasize the urgent need of legislative improvement to better the conditions of child labor throughout the country.

9. We have made a careful presentation of the principles underlying the measurement of physical status, taking optimal functional potentiality as our ultimate goal, and accepting compensatory adequacy as an immediate objective only until our methods shall have become refined enough to permit an appraisement in terms of the optimum.

10. Finally, we have appended a brief dissertation upon the choice of measures, realizing that each problem which faces the physician indicates the manner of its solution, but setting forth, from our own experience, the information which has been tried and proved of value.

References

1. Danforth, C. H. "Studies on Hair with Special Reference to Hypertrichosis." *Archives of Dermatology and Syphilology*, Vol. 11, 1925, pp. 494, 637, 804; Vol. 12, 1925, pp. 76, 195, 380, 528.
2. Davenport, C. B. *Anthropometry and Anthroposcopy.* Cold Spring Harbor, New York, Eugenics Record Office, 1927.
3. Gray, H., and Walker, A. M. "Length and Weight." *American Journal of Physical Anthropology*, Vol. 4, 1921, p. 231.
4. —— "Stem-Stature Index." *Archives of Internal Medicine*, Vol. 31, 1923, p. 491.

5. Hrdlicka, Ales. *Anthropometry.* Philadelphia, Wistar Institute, 1921. 164 p.
6. Mahalanobis, P. C. "On the Need for Standardization in Measurements on the Living." *Biometrika,* Vol. 20A, 1928, p. 1.
7. Martin, R. *Lehrbuch der Anthropologie.* 2 Aufl. Jena, Fischer, 1928.
8. Scammon. R. E., and Calkins, L. A. *Development and Growth of the External Dimensions of the Human Body in the Fetal Period.* Minneapolis, University of Minnesota Press, 1929, 367 p.
9. Schrieber, Otto. "Anthropologische Messungen an Neugeborenen." *Zeitschrift für Konstitutionslehre,* Vol. 13, 1928, p. 675.
10. Schultz, A. H. "Fetal Growth of Man and other Primates," *Quarterly Review of Biology,* Vol. 1, 1926, p. 465.
—— "The Technique of Measuring the Outer Body of Human Fœtuses and of Primates in General." *Contributions to Embryology,* Vol. 20, 1929, p. 213.
11. Student. "The Probable Error of a Mean." *Biometrika,* Vol. 6, 1908, p. 1.
12. Sullivan, L. R. *Essentials of Anthropometry.* New York, American Museum of Natural History, 1923.
13. Thompson, H. "A Measuring-board for Infants." *American Journal of Physical Anthropology,* Vol. 13, 1929, p. 281.
14. Todd, T. W., and Kuenzel, W. "The Thickness of the Scalp." *Journal of Anatomy,* Vol. 58, 1924, p. 231.
15. Wilson, E. B. "What is Statistics?" *Science,* Vol. 65, 1927, p. 581.

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