WHITE HOUSE CONFERENCE
ON CHILD HEALTH AND
PROTECTION

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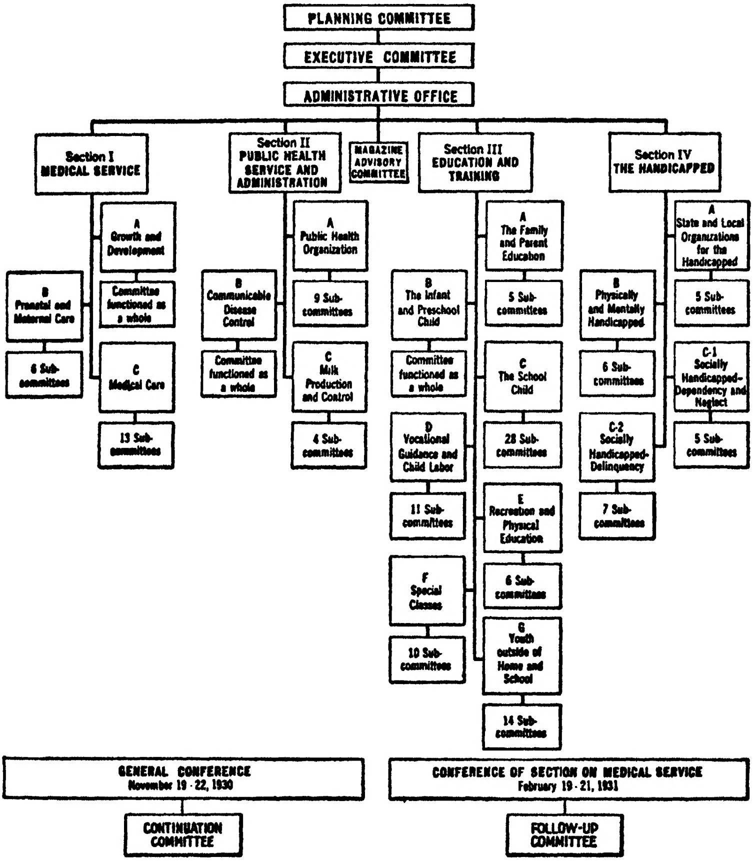

Section I—MEDICAL SERVICE

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 I
GENERAL CONSIDERATIONS

GROWTH AND DEVELOPMENT OF THE CHILD

REPORT OF THE COMMITTEE ON GROWTH AND DEVELOPMENT

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

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PART II. ANATOMY AND PHYSIOLOGY
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GROWTH AND DEVELOPMENT OF THE CHILD

PART I

GENERAL CONSIDERATIONS

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WHITE HOUSE CONFERENCE ON
CHILD HEALTH AND PROTECTION

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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
MEDICAL SERVICE

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PART I

GENERAL CONSIDERATIONS

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GENERAL CONSIDERATIONS

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 socioeconomic 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

HEREDITY AND ITS INTERACTION WITH ENVIRONMENT

DIFFERENCES BETWEEN CHILDREN

IN considering the growth and development of the child the first fact to be faced which requires an explanation is that children are very unlike. This unlikeness is, first, associated with sex. Typically, the boy and girl are physically and temperamentally dissimilar. There is, second, a difference associated with age. A child at birth is different from a child in the postpubertal stage. There is, third, a difference in physical traits that we associate with race. The Negro child has not the same physical characteristics as the white child. Even among white boys at the age of thirteen years there is a great diversity in body build, in pigmentation, in intelligence, in temperament, in instincts and interests, and in other qualities. They have become unlike in the course of their growth and development.

How is this fact of variability in the developmental processes to be explained? There are two main factors underlying the variability: the genetical or hereditary factor and the environmental factor. Useful as this separation of internal and external factors in development may be for academic purposes, it is impossible to separate them in practice. The internal factors cannot operate at all excepting in the presence of suitable conditions of life, and the conditions of life are entirely ineffective in modifying development excepting as they have the developing organism to act upon. The end result in the development of the child is due to interaction of internal and external factors. Only in specific instances can we inquire as to their relative importance. No one can for a moment deny that differences in the bringing up of a child may have an influence upon his development. Equally futile is it to explain the effect of environment without understanding the constitutional or genetical peculiarities of the developing child. For example, musical training has little effect upon persons who cannot make fine pitch discrimination.

At the moment we may focus attention upon the genetical factor because it is the one whose action is least generally understood and has been the least studied in the past. Everyone is familiar with the differences of grown children. These differences are sometimes ascribed by the pure environmentalist to differences in early experiences. Particularly in the realm of human behavior we are invited to interpret differences on the ground of unlike conditioned reflexes resulting from unlike early experiences of the child. However, it has to be recognized that children are already different at birth. Accordingly, some environmentalists would assume that differences in prenatal influences are responsible. The logical position to be assumed by such pure environmentalists would seem to be that all fertilized eggs are alike and that if they fail to develop into similar human beings it is because they have experienced different conditions during the course of their development.

The student of genetics, however, finds quite the reverse. He finds, first, that the germ cells of even the same parents are very dissimilar from each other so that fertilized eggs are as unlike in their genetical potentiality as the average of grown children of different European nationalities. The geneticist, indeed, finds that the internal factors do, in the course of generations, undergo profound changes, called mutations, so that a certain proportion of children in any generation are from the start variants from the type. These mutations are often so extreme as to cause the death of the embryo. There is reason for believing that among humans the children who are born constitute only a fraction of those whose development has started. Unrecognized embryonic death at an early stage may be inferred from its frequency in the lower animals, where studies can be made upon the contents of the pregnant uterus and where it is found that intrauterine death is the fate of half or more of the embryos that start development. Also statistics gathered in regard to human embryos indicate a similar mortality in them. This intrauterine mortality seems to be nature's method of eliminating non-viable mutations. A few mutations continue development to birth, and die in early infancy. A few others may pass on to mature childhood. A consideration of deaths at all ages makes it quite clear that during the course of development nature is lopping off those less fitted to survive. Thus we reach the conclusion that the fertilized eggs differ more from one another than do children or adults. The process of elimination of the more or less extreme variants is nature's method of maintaining the type.

THE NORMAL CHILD

We have now to consider what is the type or, in other words, what is the *normal* child. It is sometimes defined as the *average* child; but what is the average child? Now it is foolish to inquire what is the average height of a child. We must distinguish, obviously, between a child of one year of age and a child of fifteen. We must distinguish between boys and girls, for they have different rates of growth. We must distinguish between a child of a European stock or of Central African stock. In other words, in order to secure an average to determine the normal child we must, first of all, measure a group which is homogeneous as to sex, race, and stage of development. In *Appraisement of the Child,** this whole question of the determination of the normal is considered in some detail, and the importance of comparing the individual to others like himself in age, race, sex, and even in socio-economic background is emphasized. A variety of norms must be established for different groups, and in establishing them it is more important to obtain a *homogeneous* group than a very *large* group.

Anticipating briefly the conclusions arrived at in *Appraisement of the Child,* we may say that when we have measured a reasonably homogeneous group in respect to some particular trait we find that all are not equal to one another. The individuals fall into a number of classes, and

* "Physical Status." *Growth and Development of the Child,* Part IV. A Publication of the White House Conference. New York, The Century Co., 1932.

the number of individuals in each class follows, in general, these laws:

The commonest condition is a central one in the entire series. This is called the mode.

As the size classes depart more and more from the mode they have a progressively smaller frequency.

The frequencies of classes at the same distance above and below the mode tend to be equal.

Extreme variants do not occur.

Our immediate concern is the fact that a certain range of variation above and below the mode or average must be recognized as normal. Only when we know the variability of the group can we begin to form an estimate as to the normality of a given individual. And even then the decision as to what point on the distribution curve represents the borderline between the normal and the abnormal must be either arbitrary or empirical. A sound principle would seem to be to try to establish empirically the point with respect to each trait under consideration at which some definite handicap or dysfunction begins to be associated with the extreme variation. The conclusion is that *normal* is not *average* but includes a considerable range of variation above and below the average.

TYPES

The normal curve of distribution is by no means the only one which human variations follow. A distribution curve may show two or even more peaks or modes. When this is the case it may be taken as evidence that we are dealing with two or more types, more or less clearly distinct from each other. This is, indeed, the best criterion of types. If there is no evidence of plurimodality in the distribution curve then the reality of distinct types in the population is doubtful. The question of human types is taken up later in this volume. Its present importance lies in the fact that clearly distinct types indicate differences in the internal or genetic constitution. They represent different tendencies in development which give rise to differences in respect to the trait in question even though the individuals may grow up under identical environmental conditions, and a given individual may be well within the normal range for his own type even though he would be considered pathological for another type. Racial differences may usually be considered as type differences or groups of type differences. The hereditary character of racial differences is universally recognized, and also the necessity for judging the individual in terms of his own race.

DIRECTION AND CONTROL OF DEVELOPMENT BY INTERNAL AND EXTERNAL FACTORS

What is it that directs the course of development of the embryo so that in it the family type becomes realized again?

One group of directing factors are internal, and depend on the original egg and sperm. More specifically these factors, representing the various hereditary tendencies, are spoken of as *genes*. Modern experimental research on both plants and animals has given us good reason to believe (Morgan[1])* that these genes are associated in a very definite way with certain structures known as *chromosomes* which can be seen microscopically in the nucleus of all cells. It is presumably chemical differences in different parts of these chromosomes which are responsible for the hereditary make-up of the individual. These chemical packets play a very significant rôle in directing the differential growth upon which orderly development depends.

Another group of directing factors is to be found in the surroundings of the developing egg. If the embyro fails to make proper connections with the uterine wall so that it is improperly nourished it may fail of normal development. If the maternal blood is abnormal, in consequence of disease or otherwise, then the course of the development of the embryo may be disturbed. Sometimes the blood stream of the illnourished mother may furnish an insufficient food so that the potentialities of the young are stunted in their unfolding. The last few years have indeed revealed an unexpected degree of general control in mammals by the

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

mother over the course of development of the young. In *Anatomy and Physiology* * it is pointed out that hormones may pass through the placenta from mother to fetus, and that this is undoubtedly one factor influencing early development. Exact knowledge on this point is still very inadequate, however. Recently Ratner and Gruehl[2] have shown that sometimes female guinea pigs sensitized to horse dander may give birth to young that are already, before birth, sensitized to the same dust, so that they may die of shock when an extract of it is injected intravenously.

We may now trace in bold outline the processes of development of the child, directed as it is by internal factors, but modifiable at every stage by the external world. As the fertilized egg begins its development the cells increase in number. When these cells have increased to a few score the embryo becomes attached to the uterine wall. Days of rapid development are spent in the embryonic process of becoming attached and establishing vital relations to the maternal tissue. When this process is finished the embryo proper begins its development. Its axis elongates; the nutritive tract is laid down. On the surface the central nervous system is blocked out, together with the peripheral sense organs, especially the eye. The nervous system thus laid down sinks below the surface and is covered by the skin. Between skin and nutritive tract certain cells are cut off which form the beginning of the muscles; others migrate into the interspaces to form the blood and circulatory system, and others form tubes that carry to the exterior the waste products of metabolic activity.

The body continues to elongate. The head end enlarges while the tail end is growing rapidly in the axis of the embryo. At four points limbs begin to bud out, and toward these muscular masses and nervous filaments find their way. The future child is blocked out.

At or about this stage, many failures of development occur, largely due to defective genes or combinations of genes which are regulating these developmental operations.

* "Glands of Internal Secretion." *Growth and Development of the Child,* Part II. A Publication of the White House Conference. New York, The Century Co., 1932.

In humans we have long recognized that whereas about 9 per cent of human ovulations are double ovulations less than 2 per cent of human births are twin births. Even allowing for the cases where one of the twins dies before birth, it seems probable that at least half and perhaps two-thirds of the eggs that are brought in contact with sperm either fail to be fertilized or after fertilization fail to develop to a stage where their death is recognized as a miscarriage or stillbirth.

Such studies as have been made support the view that these early deaths are due, first of all, to so-called *lethal factors* in the egg and sperm. It has long been known that, in mice, there are certain combinations of eggs and sperm that will not develop. The first to be discovered was that of yellow mice, which are not found as adults in the homozygous (or duplex) condition. Since this discovery numerous other cases of lethal factors or combinations have been found in mammals, insects and plants. In other cases the offspring may be born or hatched but will show more or less striking deformities. That the same explanation is to be applied to human deformities is reasonable, though the difficulties in demonstrating this conclusion in so slow breeding and sparse an animal are enormous.

Some of the conditions due to such lethal factors are cited by Mohr [8] as follows:

> *Ichthyosis congenita,* due to a recessive factor, is a condition in which the entire skin is transformed into leather-like scales. Most cases are born as abortions or stillbirths, and the others die within three days after birth.
>
> Amaurotic family idiocy (Tay-Sachs disease) is associated with blindness and with degeneration of all nervous elements of the brain and spinal cord. Death usually occurs within three years after birth.
>
> *Xeroderma pigmentosum* is characterized by heavy pigmentation in sunlight with formation of carcinomas. Death usually occurs before twelve years.

Almost any organ of the body may be adversely affected in its development by a *sublethal* factor. Thus we find in the muscular system, spinal progressive atrophy; in the bony system, achondroplasia and osteogenesis imperfecta; in the vascular system, hemophilia; and so on. It is probable that many of the grosser development defects described in works on teratology are due to gross germinal defects.

It is evident that the combination of genes furnished by egg and sperm must be favorable to ensure normal development. So also freedom from toxins due to disease or other abnormal conditions of the mother is essential (since the embryo receives through the maternal blood plasma the nutritive particles which have to be worked over and assimilated into its own body), but it is, of course, absurd to ascribe the specific form of the developing embryo to peculiarities of the maternal blood. It would be equally absurd to assert that the genes can do their work without any assistance from the maternal blood plasma, from the constant body temperature, or from the aquatic medium in which the embryo floats. The internal and external factors cooperate at every stage.

Range of Action of Internal Factors

We have considered the universal action of the internal factors in directing the development of the child. These factors are present in each cell of the body and by their cooperation play an important rôle in bringing about individual differences. The degree of individual differences thus affected is very diverse. One factor may extend over only a single cell. Thus in the larkspur a single cell has been found to be affected by a genetic mutation. In other instances a group of four or sixteen cells or more may be involved, or groups of several thousand cells. In man the internal control of bodily features may be specifically localized. Thus the appearance of a particular pit in the skin or a mole at a particular part of the body has been observed in two or more members of a family. On the tips of the fingers are the complicated papillary patterns. These patterns are very similar in identical twins and show a high degree of relationship in members of the same family. Thus the control of details of bodily form and function are extended to the minutest parts of the body.

On the other hand the internal influence may be widespread over the body. Thus the difference between a Negro and a white man extends not only to the pigmentation of the skin but to the form of the features, the proportions of the face and head and appendages, to the reaction of skin to injury, to the form and resistance to disease of the pharynx, and to a less well known degree to mutations of the skeleton and of the viscera. Some of these differences may be, as Sir Arthur Keith [4] maintains, due to differences in the endocrine glands; but these differences in the endocrine glands are themselves determined largely by the internal genetic factors, as has been demonstrated by the experiments of Benedict and Riddle [5] on pigeons. The internal factors, acting directly or more vicariously through the endocrine glands, impress themselves upon the whole body.

Mechanism of Inheritance

The familiar fact of family resemblance has been recognized since man became a sentient being; it is probably well appreciated by all gregarious mammals and birds that, all unconsciously perhaps, expect their offspring to react as they themselves react. The duckling, hatched by the hen, is a real trial to its foster mother because of its failure to show the familiar traits of the hen.

The question now arises, What is the mechanism by which this repetition of traits in successive generations is secured? It is to the answer of this question that the modern science of genetics has made such large contributions.

We have already shown that the hereditary factors must reside in a single cell. It is a single microscopic cell derived from the male parent that determines the male heritage, and it is the minute egg cell from the mother that determines the female heritage. Studies of the germ cells showing the best powers of analysis, combined with studies of inheritance in rapidly reproducing animals and plants, have shown that the genetic factors called genes reside in small particles (chromosomes), which are concentrated in the nucleus of the cell.

About the way in which the genes exercise their control we know very little. We know that the genes are not alike and that each plays a more or less specific rôle. Some of them give rise to oxidyzing agents; others to reducing agents;

some promote the formation of fats; others of amino acids. Others produce, perhaps as end products, materials which, when acted upon by light, produce pigments. Others are responsible for interaction of cells by which cells are brought together or separated from each other in the development of the body. A specific illustration of the way in which the genes act as chemical determiners is seen when an egg from an albino mouse combines with a sperm from a black coated mouse. As the embryo grows, melanic pigment becomes formed by the activity of the cells of the skin in which the maternal genes, which lack the capacity of forming pigment, are associated with the paternal genes that bring in the other element necessary for the formation of pigment.

In small organisms, consisting of only a few cells, the form, coloration, and activity are determined directly by the character of the genes themselves in their reaction with the environment in which the organism is developing. In the higher animals, however, in which the body consists of numerous organs composed of scores of tissues and millions of cells, the genes apparently do much of their work by building up certain cell groups in the various organs that produce special promoters of metabolism in various parts of the body. These organs are called the endocrine glands. They act largely in quantitative fashion to provide the more rapid growth of particular parts of the developing organism or a more or less active functioning of that part. Thus the hormones from the testis can, within a few hours, stimulate an increase in size of the epithelium lining the prostate gland so that the nucleus now becomes extraordinarily active and in each cell vacuoles of the specific secretion are being formed. On the other hand, if the supply of the testicular hormone be cut off the cells quickly become inactive again. Similarly the inactivity of the thyroid in the early stages of postnatal development cuts off an important growth stimulating substance and the child remains a cretin—dwarfish and infantile.

The intermediation of the endocrine glands has recently been strikingly brought out by the work of MacDowell and Smith [6] on dwarf mice. An hereditary strain of these dwarfs has been for some time known. Dwarfness depends on a single gene. A genetically dwarf mouse, mated to a normal, would have only normal offspring, but two such normal offspring will have dwarf offspring in turn. The dwarf mouse is ordinarily sterile but Smith has succeeded, by engrafting the anterior lobe of the pituitary gland, in making these dwarfs grow to practically normal size and become fertile. Examination of the glands shows that in the untreated mouse the anterior pituitary gland, the thyroid, the suprarenal gland, and the gonads are all more or less rudimentary. After treatment with anterior pituitary gland, the thyroid, suprarenal, and testes develop normally. However, the anterior pituitary remains rudimentary and this fact leads to the inference that it is the defective gene that is responsible, first of all, for the imperfect development of the anterior pituitary lobe and that all of the rest of the defective development follows in consequence.

An important consequence of the transfer by the genes of some of their function to the endocrine glands is that the very activity of the endocrine glands is sensitive to the needs of the organism and to the modification of those needs imposed by changes in the environment. While the activity of the genes is rather rigorously fixed, that of the endocrine glands is more or less responsive to external requirements.

If any gene is absent the child develops, if at all, differently and perhaps abnormally. It is of first importance therefore, that each and all of the thousands of genes shall be transmitted to the next generation in precise fashion.

The necessity of securing that each and all of the genes shall get into the germ cells, and so to the child, is met by the chromosomes. At the time of cell division, the genes are arranged in linear series and in definite sequence along the chromosome. In this linear arrangement each gene is already double, for it is one of the fundamental properties of the gene that when it reaches a certain size it divides into two particles which retain all of the qualities of the parent particle. Soon in the line of double particles of the chromosome (which is really already a double chromosome) a split occurs and each whole chain falls apart into two chains each having the same genes as the other. These chains are, as stated, the chromosomes. Chart I illustrates the appearance of the human chromosomes during cell division, as seen under a high power microscope. The number of these chromosomes is ordinarily constant for a given species. In man there are 48 of these chromosomes. They may be regarded as 24 pairs, one member of each pair having been received from each parent. In ordinary cell division each chromosome splits so that each new cell receives a chromosomal constitution exactly like the original cell.

At an early stage in the development of the individual certain cells are set apart to form the organs of reproduction. These cells are at first like all other cells in the body in

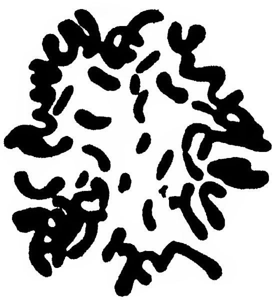

CHART I. DRAWING OF CHROMOSOMES IN MAN. (From T. S. Painter, *Journal of Experimental Zoology*, Vol. 37, 1923, pp. 291–321.)

that they contain a full complement of chromosomes, half paternal and half maternal in origin. They divide as do other cells, and at each division each chromosome splits lengthwise. But there comes a time when a new process appears in the germ cells. The chromosomes come together in pairs, each maternal chromosome coming into close association with a paternal chromosome of the same kind. Then follow two cell divisions in rapid succession. At one of these divisions the double chromosomes separate so that each resulting cell comes to contain some maternal and some paternal chromosomes; that is, one or the other member of each pair. Only rarely do all of the paternal chromosomes go into one cell and all of the maternal into the other; there is simply a haphazard assortment. In each germ cell there are only half as many chromosomes as in the typical body cell. The full number is restored when egg and sperm meet in fertilization.

Chart II may help to clarify the relation between the genetic constitution of parents and offspring. The two upper rows (P) of dots and circles represent two (corresponding) chromosomes in the body cells of the father. The dots and circles represent the position of the genes in linear arrangement on the chromosome; M represents the same pair of chromosomes in the cells of the mother. The genetic constitution is represented as being in part similar and in part

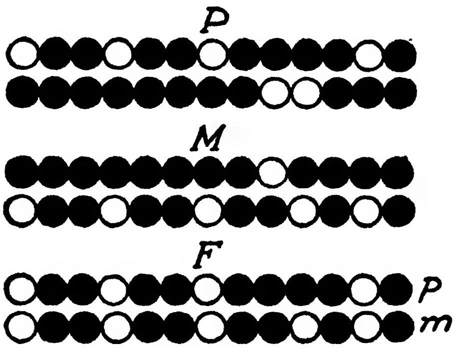

CHART II. DIAGRAM OF CHROMOSOMES WITH THEIR CONSTITUENT GENES, SHOWING THE METHOD OF INHERITANCE FROM PATERNAL (*P*) AND MATERNAL (*M*) SIDES BY CHILDREN (*F*). (Modified from H. S. Jennings' *Biological Basis of Human Nature*, New York, Norton and Co. 1930.)

different from that of the father. During the formation of the sperm the pair of paternal chromosomes has separated, and the upper row has gone into the next generation (F). In like manner only one of the maternal chromosomes, the lower one in the diagram, has been the one to enter into the egg which was fertilized. Thus the chromosomes of the offspring are half maternal and half paternal in origin. In the paired chromosomes of the typical body cell corresponding points are occupied by corresponding genes. These corresponding genes may differ to some degree, or one may even be absent while the other is present. This condition of unlikeness in the paired gene is called *heterozygosity*. It is this condition of unlikeness in the paired genes of the parents and their haphazard assortment in the course of formation of egg and sperm that makes possible the differences among children of the same parents.

If in the union into pairs of the chromosomes of two germ cells one carries a gene, α, that the other lacks, or has in a modified condition, then the individual that arises from the fertilized egg will in forming his germ cells produce some that have and some that lack the gene in question. If both parents are heterozygous for this gene then each produces in equal numbers germ cells with and without the gene. If the germ cells come together in the next (third) generation they will form the following combination:

Egg with gene α + sperm with gene α;
Egg with gene α + sperm without gene α;
Egg without gene α + sperm with gene α;
Egg without gene α + sperm without gene α.

Therefore 25 per cent of the fertilized eggs will have the α genes paired; 25 per cent will be without the gene, and 50 per cent will be heterozygous again. When we are dealing with a case of mere presence or absence of a given gene, as in the above example, only two kinds of individuals will result as far as their external appearance is concerned. The single gene will affect the development of the individual in the same manner and to the same extent as the double gene α. Now in this case 25 per cent will be without the gene and 75 per cent will have the gene either in simple or duplex condition. This is the 1 to 3 ratio so often found in the simple cases of Mendelian heredity.

In many cases the gene in question is not absent in either parent but is present in one of them in modified form. As a rule in such cases one form or the other of the gene will prove to be dominant over the other and will express itself in the characteristics of the individual. He will resemble one parent in this particular respect even though he carries also the modified recessive gene from the other parent, and will hand it on to half of his offspring.

This simple form of heredity is illustrated in the case of human eye color. If one parent is of pure brown eyed stock, then all of his germ cells carry the gene for brown eye. Assuming that he marries a blue eyed woman (all of whose germ cells lack the gene for brown eye color), their children will all be heterozygous for brown eye color; though they will have brown eyes, because brown eye color is dominant over blue eye color.

These children are, however, heterozygous and each produces germ cells in equal number with and without the gene which gives a brown iris. If two such heterozygous persons marry they will have brown and blue eyed children in the proportion of 3 brown to one blue. The phenomenon of the recurrence of the characteristics of the grandparents is called segretation. Its significance is clear, from a consideration of its cytological basis.

TABLE 1

DISTRIBUTION OF ONE GENE (A) AND ITS ABSENCE (a)

Each parent is assumed to have the chromosome constitution Aa, that is, they are both brown eyed but are heterozygous.

Sperm..................		A	a
Eggs...........	A	AA	Aa
	a	aA	aa

Types of Eye

Brown eye (3)..................	AA
	Aa
	aA
Blue eye (1)..................	aa

The foregoing represents the simplest form of Mendelian inheritance; the form where a given trait depends on only one gene. But sometimes one trait depends on two or more genes. A simple case of this kind seems to be the skin pigmentation of the Negro, which apparently depends on two genes. Table 1 represents the kinds of fertilized eggs resulting (as in eye color) from one gene. Table 2 represents the kinds and relative number of zygotes resulting from two genes, A and B, which we may take to represent the two factors for Negro skin pigmentation.

TABLE 2

DISTRIBUTION OF TWO INDEPENDENT GENES (A, B) AND THEIR ABSENCE (a, b)

Each parent is assumed to be a mulatto, of the chromosomal constitution AaBb, giving four kinds of egg or sperm cells as indicated.

Sperm............	AB	Ab	aB	ab
Eggs.......AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

Types of Skin Color

Full Negro, black	(1)...........................	AABB
¾ black, "sambo"	(4)...........................	AABb AaBB AABb AaBB
½ black, mulatto	(6)...........................	AaBb AAbb AaBb AaBb aaBB AaBb
¼ black, "quadroon"	(4)...........................	Aabb aaBb Aabb aaBb
White	(1)...........................	aabb

The complications in Mendelian inheritance go far beyond this. Since in more difficult cases the assistance of a trained geneticist will be required, no attempt will be made to explain the more complex situations, but throughout the various perplexities the same principles that we have just outlined still remain fundamental.

In types of disease or congenital defect the clinical entities are not always genetical entities. A given defect may have in various families a different genetical basis. Thus myopia is sometimes genetically sex-linked; at other times not. These types are quite distinct genetically.

Also one and the same genetically simple clinical entity may show special symptoms in different families. There are special modifying factors, constituting particular biotypes. Thus in Huntington's chorea the disease affects in one family primarily the hands; in another, the head; in some it is accompanied by mental symptoms; not so in others.

SEX AND SEX EXPRESSION

From the lowest plants and animals to the highest there runs the duplicity in organisms which we call sex. The union of male with female elements cannot be regarded as essential in initiating development since development is proceeding in all youthful, growing tissues of trees and other organisms without this fusion occurring at frequent periods. Indeed, animals that reproduce from the egg may do so without the intervention of the sperm, for many species have, as it were, acquired the special trait of reproducing from the egg alone by parthenogenesis, just as in each succeeding spring the buds of the tree start into rapid development. The absence of sexual reproduction in organisms must be regarded, however, as a secondary and temporary arrangement; and, even in parthogenetically reproducing species, the male is usually to be found, although perhaps in a more or less rudimentary condition.

While the biochemical significance of the sexual differences in protoplasm are not clear, there is much evidence that this difference is associated with differences in the chromosomal complex in the nuclei of the cells of the two sexes. The so-called *X-chromosome* is that which is believed to be particularly involved in sex determination. In mammals the female has two functional X-chromosomes, while the male has only one. In birds and certain insects the female has only one while the male has two. In both cases, however, the difference in chromosomal constitution determines the differences in the protoplasm of the two sexes. In the case of man, as with other mammals, the female carries two X-chromosomes, so that all of the eggs which she produces are alike. The male carries only one, so that two kinds of sperm are produced in equal numbers, one with the X-chromosome and one without. When a sperm of the first kind fertilizes an egg the embryo receives two X-chromosomes, one from each parent, and a female results. When a sperm of the second kind unites with an egg the embryo receives only the single X-chromosome from the mother, and a male results. It will thus be apparent that the sex of the individual is determined from the moment of fertilization of the egg by the sperm.

This difference in the chromosomes is sufficient to produce differences also in the bodies of the two types of individual that arise. These differences are, of course, primarily protoplasmic and so far largely unknown. Secondarily these differences consist in dissimilarities of the germ glands so that in one sex there are produced eggs and, in the other, sperm. These differences in the germ glands seem, first of all, to be determined by the chromosomes. After these glands have become established and functional they take over the work of determining the sex expression of the individual. The hormones produced by the male and by the female sex glands are very different from each other. The difference is best known through its effects. Thus, in females, the female sex hormone plays an important part in ovulation, the implantation of the placenta, and the menstrual cycle. The male hormone plays an important part in stimulating the activity of the glands along the efferent duct. In both cases the respective glands exercise an influence which affects every part of the developing body. There is some reason for believing that the gonad interacts with the anterior lobe of the hypophysis and, perhaps, the suprarenal cortex and thyroid in determining the rate of growth.* This action usually occurs earlier in the female mammal than in the male mammal, as we see most strikingly in the case of primates. We shall see that the maximal spurt of growth is about a year and a half earlier in the girl than in the boy. The female is precocious in development.

The differences in the hormones produced by the ovary and testis are responsible for universal differences in the organism of the girl and boy respectively, in differences not only of size but of frame, even of proportions of parts, in average vigor of muscular reaction, and even in various mental and temperamental traits. Before the hormones of the sex

* "Glands of Internal Secretion." *Growth and Development of the Child,* Part II, *Anatomy and Physiology.*

glands have become active the boy and the girl are more like each other than during the period of adolescence and adult life; again, in advanced age, when the sex hormones are less active, the man and the woman approach each other in sex expression.

The activity of the hormones in development and their influence upon secondary sex characters may be altered by disease, by loss of functions of the secreting glands, by operations on the body. In cases where the specific hormones are insufficient the characters of the opposite sex may be, in part, assumed, as is seen in the acquisition of masculine characters by women, in the acquisition of female plumage by castrated cocks. In the case of birds in which only one ovary (the left) is ordinarily functional, the removal of that ovary may cause the development of the rudimentary gland on the opposite side into a testis with complete reorganization of the efferent duct. This fact throws an important light upon the conditions seen in certain children in whom the secondary sex characters are of an ambiguous nature and are intermediate in development between the conditions typical of each sex. The development of the child, as a boy or a girl, cannot be understood without recognition of the part played by the sex hormone in influencing the physical development and the psychology of the child.

Sex-linked Traits

As pointed out above, sexes differ in their chromosomes and so in their complement of genes. In the sex chromosomes there lie not only the factors that are responsible for sex but also other genes that influence the so-called *sex-linked* characters. Of such sex-linked characters numerous examples are known in various organisms. In man one of the most clear cut cases is that of color discrimination, the basis of which seems to lie in the cones of the retina. A failure in color discrimination, especially at the red-green part of the spectrum, is found in about 4 per cent of boys but in hardly one in a thousand girls. The evidence is clear that color discrimination depends upon a gene in the sex chromosome; color blindness, upon the absence or modification of such gene. The genetical history of color blindness, its method of recurrence in the family, demonstrates its dependence on the sex chromosome. Thus a male carrying a defect in the gene for color discrimination in the X-chromosome will, himself, be color-blind. His sons do not receive their (single) X-chromosomes from him, but exclusively from the mother. Consequently the sons of the color-blind man have color discrimination, and color blindness does not recur in their progeny unless marriage takes place with another defective strain. With the daughters of the color-blind men the situation is quite different. They receive not only the X-chromosome from the mother but they receive the defective X-chromosome from the father. However, the defective gene in the X-chromosome is prevented from expression by the corresponding normal "allelomorph" from the mother so that the daughters of a color-blind man can discriminate color normally. But when in these daughters the mature eggs are formed, half of them contain the defective chromosome and half contain the chromosome without defect. Such defective X-chromosomes may go to form the X-chromosome of their sons and such sons as receive them will be color-blind. Consequently half of the sons of the daughters of color-blind men will be color-blind. If a color-blind man should marry a woman carrying a defective X-chromosome, then half of his sons will be color-blind because they will receive the defective X-chromosome from their mothers. The father has nothing to do with inheritance of sex-linked traits by the son.

Besides color-blindness a number of other sex-linked traits are known, of which hemophilia is the most striking. This is a very serious condition and is the cause of neonatal and later deaths and probably also of intrauterine deaths. It is important that a hemophilic child should be early recognized as such in order that precautions may be taken to prevent its bleeding to death from wounds. Still another important sex-linked trait is atrophy of the optic nerve which leads to a loss of distinct vision, usually at the onset of adolescence. There are a few other sex-linked traits which have been imperfectly studied. Certain types of shortsightedness, or myopia, are sex-linked and certain defects of the neuromuscular system have been found to have a similar sex-linked relation.

Non-sex-linked Traits

Since only one chromosome out of the twenty-four pairs of man is concerned with sex-linked traits, it is not surprising that the majority of well marked hereditary traits have a non-sex-linked basis. The number of such hereditary traits that are known is considerable, but vastly longer is the list of inheritable conditions whose hereditary properties have not yet been analyzed, if indeed they are capable of analysis. This failure to analyze human traits in a Mendelian fashion is partly due to the circumstance that no other species is so unsatisfactory as the human species for the study of genetical traits, on account of small families of children, slowness of reproduction, the inability to control matings, and probably on account of the very complexity of the human constitution and of the human germ plasm.

The growth of the body as a whole, particularly when measured in terms of weight, as is usually done, affords examples of hereditary traits, and also even more strikingly of the interplay between internal and external factors influencing development. Here also, as evidenced by the space given in this report to its consideration, practical considerations of evaluating and controlling the external factors of the quality and quantity of food, assume a position of the greatest importance. As will be emphasized in the discussion to which we refer, we must, in any effort to appraise the nutritional state of a child or to decide upon the adequacy of a given nutritional regimen, always consider the hereditary constitution of the child in question. The child is an individual, with his own hereditary endowment. This can be inferred in part from a consideration of his ancestors, but it can never be inferred in this way with certainty and finality. We can only arrive at certain presumptions. Now although the genetic factors governing growth are more or less alike in all children, in that they determine certain periods of rapid growth, notably the adolescent spurt, as compared with other periods of slower growth, still there are differences between individuals as to the time at which this spurt occurs, and also in the ultimate goal which is eventually to be reached. Both in the matter of the normal weight of an adult and in the matter of the normal time for the occurrence of the adolescence spurt in growth we must look for a considerable range of variability. Each individual has, therefore, his own normal which we may think of as determined by his own hereditary constitution, and the more closely we can estimate this normal the more intelligently can we deal with this individual. We must carefully avoid the fallacy of trying to run all children into the same identical mold.

The interplay of heredity and environmental factors is strikingly illustrated by considerations taken up later in the discussion of the matter of what is optimal nutrition in *Nutrition.** MacDowell, working with mice, has by judicially reducing the number of young to the litter, found that the rate of growth of the individual mouse may be vastly accelerated during the period of suckling by making more milk available for it, and Mendel has obtained similar acceleration in older mice by increased rations. The question which arises as to what is really the normal and the optimal, in terms of the ultimate growth and in terms of general well-being, is an important one, which is discussed later. For the present it is of interest as a clear illustration of the cooperation of internal and external factors in shaping the growth and development of the individual.

Children differ from each other in the rate of development and in proportional development so that they naturally differ in size and in bodily proportions and body build. That this has a genetical basis is clear on account of the fact that races of mankind differ in stature and proportions. Thus the Negroes, especially of the Nilotic region and of the west coast of Africa, are characterized by relatively long legs, while the Chinese are characterized by short stature and proportionately short legs.

* "Optimal Growth and Nutrition." *Growth and Development of the Child,* Part III. A Publication of the White House Conference. New York, The Century Co., 1932.

Similarly, as investigators in the field of human constitution have pointed out, we have differences in body-build in persons, ranging from slender to stout. These extremes tend to run in families. By inbreeding, one of them may become the characteristic of all of the children of one family.

The *appendages* arise from minute outbuddings of the trunk which constantly increase in size and particularly in length. Simultaneously an axial skeleton is laid down, first in cartilage. This is in definite segments corresponding to the upper arm, lower arm, carpus and hand in the case of the upper appendages. Simultaneously the muscles begin to develop; the blood vessels and nerves grow into and develop within the appendages. So complicated a structure comes, not unnaturally, to show many irregularities in development, most of which have an hereditary basis. One of the most striking of these defects is seen in the hand or foot where the segments of the digits (phalanges) may be imperfectly divided, or in which the number of digits may be abnormal, as seen in the cases of polydactyly and syndactyly, brachyphalangy and others. So far as known these abnormalities are not induced or greatly modified by environment. Even the theory of mutilation by adhesions with embryonic membranes is not well founded.

The degree of development and vigor of the *muscles,* as is well known, depends to a large extent upon the exercise of these muscles and their proper innervation. But cases are known in which the muscles, once normally formed, fail of proper development in the child, so that they tend rather to diminish in function. Muscular dystrophy is a tragic condition which runs very definitely in families, as a recessive trait.

Different races of Europeans, like those of mankind in general, are characterized by differences in *head* form. The Northern European and the Mediterranean races are characterized by a relatively long head, while those of the central parts of Europe, especially in the Alpine region, are characterized by relatively short heads. The Negroes contrast with Chinese in the same fashion. Head form is a racial character and, as such, is under genetic control. These considerations are developed at greater length in the section "Human Types" (p. 80).

The *features of the face* are those which most strikingly differentiate the human species from the other primates. They vary greatly in the different races of mankind. They serve to enable us to distinguish our friends from each other. Their distinctive characters are laid down at a very early age in the development of the child.

The fact that the facial features are under the control of genetical factors is sufficiently demonstrated by the great resemblance of identical twins—a resemblance so close that such twins are often confused even by those who know them intimately. How often a peculiarity in the form of the nose, mouth or chin will recur in striking fashion in the different members of a family! And this resemblance cannot be ascribed to unconscious (or conscious) imitation.

Teeth. Perhaps there is no part of the body that undergoes in a small region such profound changes as the margins of the jaws, where in the course of the late intrauterine and the early extrauterine developmental periods forty-four organs of complicated structure and sculpturing are developed. The teeth are, apart from bilateral symmetry, all different from each other. They are affected by conditions of health during the period of their development. They are subject to attack by microorganisms which tend to destroy them. Despite their complicated developmental history the teeth tend in one and the same family to show similarities of constitution in respect to number, size, quality of dentine, perfection and resistance of the enamel. Although the resistance of the teeth to caries can be shown in many cases to be dependent upon nutritional factors, yet lack of resistance due to these or other factors varies greatly in different families, according to the constitutional nature of the teeth. Also the arrangement of the teeth, the degree of crowding which they show, depends upon the size of the teeth and the form of the jaws, determining the special further development of the teeth. These factors have often a genetical basis, and an unfortunate combination of large teeth with small jaws may lead to a crowding that is destructive of beauty of the face as well as care of the teeth. The demonstration of the influence of nutritional factors on jaw and teeth development does not negative the importance of the genetical factors.

The alimentary and respiratory tracts. The genetical factors governing the development of the viscera are far less well known than those influencing the development of the external organs. This is just because the morphology that leads to these organs is so difficult to observe. On the functional side we are familiar with family resemblances in these viscera. Thus the tendencies toward gastric ulcer and toward intestinal stasis are familiar to the students of family traits. Similarly the resistance of the lungs to infection by the ubiquitous germs of tuberculosis leads to the general observation that pulmonary tuberculosis will often run a similar course in different members of a family while in other families none of the individuals show any tendency to this common disease.

The *blood* shows several interesting examples of hereditary characteristics. One of these has already been mentioned as a sex-linked characteristic, namely hemophilia. In this condition the coagulation time of the blood is greatly prolonged, so that an individual may readily bleed to death from a relatively trivial wound. One of the necessary factors for the normal coagulation of the blood is deficient. Individuals may be divided into four quite definite groups depending on the presence or absence from the blood of certain substances which cause the blood cells to clump together or agglutinate when the bloods of two different individuals are mixed. Without going into details, which are presented in the section "Human Types," we may simply point out that these chemical differences between different bloods follow very definitely the Mendelian laws of inheritance, and represent two different mutations which have occurred independently of one another. They are distributed with varying frequency among different races. These blood groupings are of practical importance when the question of blood transfusion arises.

Among the abnormalities of the *blood vessels* is the condition known as hemorrhagic telangectasis. This is characterized by frequent bleeding at the nose during early life and is followed in later age by the formation of reddish, star-like markings in the skin, due to the fact that the blood penetrates through the lining of small blood vessels. This disease, which is not serious although often striking, runs in particular families and is inherited as a simple dominant.

The *eye,* whose beginnings are laid down in very early development and which passes through a complicated developmental history, is subject to a large number of defects that have an hereditary basis. A list of such defects was prepared by Lucien Howe.[8] It is unnecessary to describe in detail the two or three score of hereditary defects listed there. There are defects in the eyelids, defects in the tear passages, defects in the eyeball, defects in the anterior membranes of the eye, the cornea, conjunctiva and iris, in the lens, in the membranes in the rear of the eye, particularly the choroid coat and the retina. Finally, the optic nerve itself undergoes in some families atrophy and even the muscles of the eye have their defects. With so complicated a history it is rather a wonder that the eye is so often a nearly perfect organ in young people.

Next to the eye, the *ear* is characterized by a complicated developmental history and adult structure. Some defect in hearing is widespread, due to imperfections in the organ. Sometimes there is a progressive hardness of hearing due to change in the structure of the bony capsule in which the inner ear is embedded. This condition, discussed in more detail in *Anatomy and Physiology,** has a clear, although complicated, hereditary basis. It is to be hoped that some day the nature of those defects, upon which the modifications of the bony capsule depends, may be understood and, if possible, the processes that cause them may be retarded in early childhood. Deafness is due to so many causes that one can give no general rule of its inheritance. In the same family, however, it is frequently due to the same cause. Consequently the marriage of deaf cousins is exceed-

* "Deafness in Childhood." *Growth and Development of the Child,* Part II.

ingly dangerous to the offspring, a large proportion, if not all, of whom then show the family deafness.

Variations in *the sense of smell,* in extreme cases leading to its entire absence, as well as variations in the allied chemical sense of taste, are known to have, in some cases, an hereditary basis.

The *nervous system* is subject to quite a number of developmental and functional defects which have an hereditary basis. Some of these, such as amaurotic familial idiocy and Huntington's chorea, have already been alluded to in illustration of other points. No attempt will here be made to give a complete list of such conditions. The list would be extensive, since a lesion of fundamentally the same sort, such as the degenerations of multiple sclerosis, may cause symptoms differing widely in character when it affects different portions of the nervous system. Since our recognition and classification of diseases depends largely on their symptomatology, the result is a great array of disorders of the nervous system, many of which may be more or less closely related to one another in their genetical basis.

Much the same kind of consideration applies to the interesting and important questions of inheritance of mental faculties and mental ability, or conversely of feeble-mindedness. The evidence on this question, as well as the methods by which mental ability may be measured and different individuals compared one with another, is taken up at length in *Appraisement of the Child.** There also is to be found a discussion of the relative significance of heredity and environment in bringing about a given end result in terms of mental development, and the interaction of these two factors and the tremendous difficulty of distinguishing clearly between them in any particular case is again emphasized. It will be evident from a perusal of that section that there is unquestionably a very important hereditary factor making for mental competence as measured by our mental tests and also as evidenced by successful adjustment to the world at large, and conversely a lack of this same ability which gives

* "Mental Status." *Growth and Development of the Child,* Part IV.

a definite tendency for feeble-mindedness to run in given families. There seems to be some evidence that rather specific functions of the nervous system which express themselves as particular abilities, such as musical ability, finger dexterity, mechanical ability, mathematical ability, and the like may depend to a considerable extent on hereditary factors. In this connection it should be borne in mind, however, that whatever the endowment or lack of endowment in a particular direction a person may receive in the form of hereditary tendencies, his final ability and performance can be improved by training. Training here represents an environmental factor, which, as usual, plays its part in the development of the individual.

That *longevity* is in part inherited is quite plain from the studies that Alexander Graham Bell made in the Hyde genealogy. When both parents died at under sixty years, the average age at death of the children was thirty-three years; when both parents were over eighty years old at death, the average age of the children at death was fifty-three years, or twenty years above the mean length of life of the general population of this family.

The matter of *general or specific resistance to disease* has been rendered more precise by the studies of Wright and Lewis [7] on guinea pigs. They demonstrated that certain pedigreed strains were much more resistant to tuberculosis than others. The evidence for difference in humans is clear though less definite than in the case of guinea pigs. The germs of tuberculosis are so ubiquitous that nearly every one becomes infected early. In some families two or more children die of tuberculosis even when the conditions that heighten resistance are good. In other families all the children pass through adolescence successfully without showing serious symptoms of this disease.

In general there are genetical factors that produce immunity even independent of any acquired immunity. Herszfeld and Broklam have demonstrated that normal diphtheria antitoxin occurs in some families where there is no evidence of exposure to diphtheria. In agricultural plants and domestic animals the existence of genetical strains resistant to specific diseases has been repeatedly demonstrated. The precise method of inheritance has been worked out in some cases.

Closely related to the phenomenon of resistance to disease by artificial immunization is that of hypersensitiveness of the organism which has been dosed with certain protein substances to further dosage with those substances. The reactions of the hypersensitized individuals belong to the class of allergic diseases, of which examples are ivy poisoning, hay fever, bronchial asthma, angioneurotic edema, urticaria, and eczema. Now it has long been known that certain families are characterized by high incidence of these diseases; other families, by low incidence. Thus edema of the glottis has been considered as inherited as a simple Mendelian dominant. Susceptibility to hay fever appears to be a recessive, either simple or complex. The method of inheritance has not been satisfactorily worked out in any case. Difficulties are introduced by the fact that the reaction is brought about only by a specific irritant, and if the irritant is not experienced the individual may be unaware of his susceptibility.

The matter is further complicated by the circumstance that, as Ratner has shown in guinea pigs, hypersensitiveness acquired by the mother may reappear in the offspring through the "passage of antibodies from the mother via the placental route." This is, of course, not heredity; it belongs to the category of intrauterine infection, like prenatal syphilitic infection. Hypersensitiveness thus acquired is lost after a time and it is very uncertain whether in so slowly developing an animal as man the hypersensitiveness acquired *in utero* would persist to the age when the best known allergic diseases are commonly observed.

CONCLUSIONS

In closing this discussion the opportunity may be seized of recapitulating some of the general principles which seem to flow from it.

Heredity and environment are not, as some seem to think, two more or less independently operating factors in child development. They are so intimately tied together that one cannot be properly thought of independently of the other. An illustration may make this clearer.

Life depends on a constant interchange between the organism and its environment. Were the organism for the briefest interval cut off from its environment it would die; and of all of the environment that the world affords, only a very small section has anything to do with the organism, so restricted is the environment of which the organism can make use, or by which it can be affected. Thus, in a world offering great ranges in the density of oxygen that may surround the organism, the organism goes on comparatively unmodified, taking what it must have and rejecting what it does not need. In a world supplying all sorts of inorganic and organic material that might be utilized, each different organism goes its way developing normally if only it can obtain the specific things that it needs and paying no attention to the other materials which are not specifically required by it. Similarly, although a multitude of stimuli are showered upon the organism, the sense organs are specifically adapted to respond to certain stimuli and not to others. Only these affect the organism. The response of the organism depends in part upon the specific selection of stimuli which its sense organs make, and also upon the particular nature of its own nervous mechanisms which receive the sensations. Training implies a modification of the response of the organism, and training obviously cannot be successful unless it is suited to the specific nature of the individual to be trained.

This general criticism must be laid at the door of many pure environmentalists. They seem to assume that there is *the child* about which generally applicable rules of handling may be laid down. Now *the child* is, after all, an abstraction; a convenient one, it must be admitted, and one used here. But it is a dangerous abstraction, if taken literally and carried out to its logical consequences. So we conclude where we began that children differ in their constitution; in their genetical make-up; in their capacity for development in particular directions. Children are genetically unlike just as different breeds of dogs are genetically unlike.

There is nothing novel in all this. Every parent who has brought up three or four children knows it; philosophically minded psychologists, like E. L. Thorndike, have emphasized it; every director of physical training is constantly reminded of it. It is the almost unconsciously accepted fundamental principle upon which society is founded. Yet we forget. We get so enthusiastic over our successes with one method, that we forget that it was due largely to our fortunate selection of those to whom the method was applied. We overlook the failures in the application of the method. Enthusiastic optimism is one of the most appealing and infectious qualities in mankind. But not less important to progress is insistence upon the grim facts of the complicated world in which we live.

This, then, is the conclusion of the whole matter. Secure for each child the best environment for *that* child. This requires a study of each child; of his constitution or heredity; the measurement of his capacities; an alert attitude toward his reactions to special environments. Study each child as a lock, unique in its mechanism; and then devise the special key that will fit that lock; so will the door of opportunity be thrown open, as widely as constitution permits, for each child to develop under individual training his individual innate capacities.

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THE WELL BORN CHILD

THROUGHOUT the long past the physician has been called upon to cure disease and relieve suffering, and that service he will continue to render. But often the physician was called upon only when it was too late; and at present our conception of the physician's duty and opportunity includes the prevention of disease as well as its cure. Physicians are now doing much to forestall disease and suffering, whether physical or mental. The real significance of the White House Conference on Child Health and Protection is that a new era is dawning in which the physician, particularly he who deals with the young, must recognize his responsibility for the general health and well being of the rising generation. And caring for the health means more than merely curing, or even preventing, diseases.

Every physician knows of children for whom healthy growth and normal development are out of the question. Each child is born with a definite genetic inheritance from his parents and this is sometimes hopelessly bad. He is born into a social and economic environment which all too often is sadly unfavorable. Society has not hesitated to modify the handicaps of the social environment by providing free education in the schools, medical, dental, and nutrition services, and by more aggressive measures such as adoption, orphanages, and, finally, special institutions for the care of those more seriously handicapped either physically or mentally. But society has done nothing to insure that the constitutional inheritance of the child will be an asset and not a handicap. It has done as much as this for its domestic animals and plants, but not for its own children. Almost nothing has been done to prevent future generations arising from parents whose children must in all probability be doomed to misfortune and misery, a liability to society as well as to themselves. This is not a matter of class prejudice, for men and women know well that parenthood is beautiful only under conditions which make possible a heritage of physical and mental health and a favorable environment.

Has the child a right to be well born? Has society any need that the child should have that right? Has the physician, when he undertakes to promote the health of the rising generation, the right to have under his care only children for whom healthy growth and satisfactory development are possible? Is the time coming when society must answer "yes"? We believe so. The Children's Charter already foreshadows this answer when it says:

> For every child full preparation for his birth . . .
>
> For every child such teaching and training as will prepare him for successful parenthood . . . for parents, supplementary training to fit them to deal wisely with the problems of parenthood . . .
>
> For every child the right to grow up in a family with an adequate standard of living . . .

What is it to be well born? We cannot yet make a complete answer. Human traits are numerous, human heredity is complex, and our social organization greatly multiplies the intricacies of the problem. Much careful investigation is still needed upon the details of human heredity, upon conditions making for fertility and sterility, and upon the issues which involve not only the child but the home into which the child is born. The general principles of heredity and the influence of the environment have been established and are presented in other sections of this report, but much work still remains to be done to clarify the details of their operation, particularly in regard to the human race. We must face this pressing human problem with true devotion to the interests of the children, yet unborn, whose lives and usefulness, whose very souls, depend upon our pledged faithfulness. The physical and spiritual worlds are but two aspects of the same thing. Our efforts must be directed to see the problem whole, not split up into separate parts, and to frame our investigations with all human values uppermost in thought. We must seek the truth, the whole truth and nothing but the truth.

Although we shall not know until much further research has been accomplished and adequately digested what is a practicable social definition of the condition of being well born or what means society should take to apply its definition in practice, every physician already knows of specific types of cases in which it is obvious that children should not be born. The physician's criteria are better than those applied by the general populace because his are based on better information and on a more detached point of view, but there are laws in many states which limit the freedom and effectiveness with which a physician may give advice in these cases.

Upon the serious problems involved in sterilization of the unfit, control of conception, prenatal handicaps, and birth injuries we urge the necessity of intensive study and unfettered education, in order that our children may be born with a heritage of mental and physical health and into favorable home environments and thus become effective directors of our Nation's destiny.

IDENTICAL AND FRATERNAL TWINS

THE purpose of the study, on which this section is based, was a definite classification of twins into the two classes, identical and fraternal, to study the differences and correlations between the two kinds of pairs and gain, if possible, some evidence concerning the factors producing these differences. The separation into the two classes was made by H. H. Newman. Fifty pairs of each class of twins are included in the study, making in all 200 individuals. They were given a comprehensive series of physical measurements and a number of mental and educational tests. The conclusions are based on the averages of these measurements, on the differences between members of twin pairs, and on correlations between the measurements of pairs.

TABLE 1

MEAN HEIGHT OF TWIN BOYS OF VARIOUS AGES IN COMPARISON WITH BALDWIN'S MEANS. FROM MEASUREMENTS OF BOYS IN THE HORACE MANN SCHOOL

Age	Identical twins	Fraternal twins	Both	Horace Mann boys
9	135.4 (10)	132.6 (10)	134.0	130.7
10	142.8 (4)	129.8 (2)	138.5	135.5
11	143.5 (8)	143.1 (4)	143.4	140.3
12	151.6 (6)	..... (0)	151.6	144.8
13	146.0 (6)	152.6 (6)	149.3	151.0
14	158.2 (4)	156.0 (4)	157.1	157.0
15	147.6 (2)	156.9 (4)	153.8	163.1
16	169.2 (10)	172.6 (10)	170.9	169.2
17	163.9 (6)	177.0 (4)	169.1	172.9
18	176.0 (2)	176.1 (4)	176.1	.....

Numbers in parentheses indicate number of cases

A comparison between the physical and mental measurements of these twins and existing norms reveals little or no significant difference between twins and other children or between the two types of twins, so far as the limited number of cases enables us to judge. In Table 1 are presented the

Note: The original study on which this section is based was made by F. N. Freeman in collaboration with Karl J. Holzinger.

means of boys of various ages in height in comparison with Baldwin's norms. The twins, who do not represent a selected sampling, compare favorably with the Horace Mann boys and the identical twins are as tall as the fraternal twins. The same is true of girls in height and of boys and girls in weight (Tables 2, 3, and 4).

TABLE 2

MEAN HEIGHT OF TWIN GIRLS OF VARIOUS AGES IN COMPARISON WITH BALDWIN'S MEANS. FROM MEASUREMENTS OF GIRLS IN THE HORACE MANN SCHOOL

Age	Identical twins	Fraternal twins	Both	Horace Mann girls
8	133.3 (2)	126.0 (8)	127.5	124.2
9	138.4 (2)	132.7 (4)	134.6	129.1
10	141.8 (10)	..... (0)	141.8	135.5
11	144.5 (2)	144.4 (6)	144.4	140.6
12	145.6 (4)	141.1 (2)	144.1	145.6
13	145.4 (2)	153.0 (14)	152.0	151.7
14	146.9 (2)	159.5 (6)	156.3	156.0
15	160.9 (6)	159.1 (10)	159.8	159.7
16	162.5 (10)	164.1 (4)	162.9	161.6
17	..... (0)	165.3 (2)	165.3	161.8
18	164.1 (2)	..... (0)	164.1	.....

Numbers in parentheses indicate number of cases

TABLE 3

MEAN WEIGHT OF TWIN BOYS OF VARIOUS AGES IN COMPARISON WITH BALDWIN'S MEANS. FROM MEASUREMENTS OF BOYS IN THE HORACE MANN SCHOOL

Age	Identical twins	Fraternal twins	Both	Horace Mann boys
9	71.2 (10)	66.9 (10)	69.0	60.5
10	72.0 (4)	63.6 (2)	69.2	65.8
11	78.8 (8)	80.0 (4)	79.2	71.7
12	100.0 (6)	..... (0)	100.0	78.1
13	95.1 (6)	86.7 (6)	90.9	88.2
14	103.6 (4)	98.4 (4)	101.0	97.9
15	82.4 (2)	99.3 (4)	93.6	109.8
16	134.7 (10)	135.6 (10)	135.1	121.0
17	115.7 (6)	142.3 (4)	126.4	130.0
18	145.5 (2)	145.8 (4)	145.7	.....

Numbers in parentheses indicate number of cases

In intelligence and educational accomplishment also the twins appear to be equal to the average. The mean I Q on the Stanford Binet test of the 100 identical twins is 101.0 and that of the 100 fraternal twins 96.1. On the Otis

TABLE 4

MEAN WEIGHT OF TWIN GIRLS OF VARIOUS AGES IN COMPARISON WITH BALDWIN'S MEANS. FROM MEASUREMENTS OF GIRLS IN THE HORACE MANN SCHOOL

Age	Identical twins		Fraternal twins		Both	Horace Mann girls
8	75.0	(2)	56.9	(8)	60.5	53.7
9	70.2	(2)	57.9	(4)	62.0	61.2
10	76.4	(10)	.....	(0)	76.4	69.1
11	84.5	(2)	82.8	(6)	83.2	75.7
12	83.2	(4)	76.7	(2)	81.0	83.6
13	81.2	(2)	104.0	(14)	101.1	96.1
14	97.9	(2)	102.9	(6)	101.7	105.8
15	108.5	(6)	114.7	(10)	112.4	117.5
16	121.9	(10)	119.7	(4)	121.2	121.9
17	.....	(0)	126.7	(2)	126.7	122.5
18	141.8	(2)	.....	(0)	141.8	.....

Numbers in parentheses indicate number of cases

TABLE 5

MEAN DIFFERENCES BETWEEN THE TWO MEMBERS OF A PAIR IN VARIOUS TRAITS

Trait	Identical twins	Fraternal twins	Siblings
Height, standing.........	1.7 cm.	4.4 cm.	4.5 cm.
Weight..................	4.1 lb.	10.0 lb.	10.4 lb.
Head length.............	2.6 mm.	5.9 mm.	....
Head width..............	2.2 mm.	3.9 mm.	....
Cephalic index...........	.015	.027	....
Number of finger ridges...	3.8	22.4	....
Tapping.................	19.4	29.0	....
Binet I Q...............	5.9	9.9	9.8
Otis I Q................	4.5	9.2	....
Educational age..........	6.5	11.6	....

TABLE 6

CORRELATION BETWEEN THE MEASUREMENTS OF MEMBERS OF IDENTICAL AND FRATERNAL TWIN PAIRS IN CERTAIN PHYSICAL AND MENTAL TRAITS

Trait	Identical twins	Fraternal twins
Height, standing..................	.93 ± .01	.65 ± .05
Weight...........................	.92 ± .01	.63 ± .06
Head length......................	.91 ± .02	.58 ± .06
Head width.......................	.89 ± .02	.55 ± .07
Cephalic index....................	.90 ± .02	.58 ± .06
Number of finger ridges............	.95 ± .01	.46 ± .07
Tapping..........................	.69 ± .05	.38 ± .08
Binet I Q........................	.86 ± .02	.60 ± .06
Otis I Q.........................	.92 ± .01	.62 ± .06
Educational age...................	.89 ± .02	.70 ± .05

Self-administering test the mean I Q's are 103.4 and 99.2 respectively. The mean accomplishment quotients, using the Stanford Achievement test, are 105.4 for the identical twins and 103.2 for the fraternal twins. The identical twins are slightly superior to the fraternal twins. The results of the tests do not warrant the suspicion that either type of twin is inferior to other children.

The comparative likeness between members of identical and of fraternal pairs of twins has been calculated by finding and tabulating the differences between the members of pairs and also by finding the correlation between them. A group of significant differences is presented in Table 5. For three traits, height, weight, and Binet I Q, differences between siblings have also been calculated. In these three traits the differences between siblings are remarkably similar to those between fraternal twins, which is consistent with the view that the biological relationship between fraternal twins and siblings is the same.

In all cases the mean difference between members of identical pairs is much less than that between fraternal pairs. The difference in likeness of the two types of twins is greatest in number of finger ridges, which can hardly be conceived of as affected by environment. The degree of difference is of about the same order in the other traits, physical and mental, except rate of tapping, in which the two types of twins show less contrast.

A typical list of correlation coefficients is shown in Table 6. The correlations in the case of identical twins are all high, except in rate of tapping. The highest is in number of finger ridges, while Binet I Q is lower than any other except tapping. In the case of fraternal twins the correlation in number of finger ridges is low, namely .46. This seems to indicate that fraternal twins are by nature much less alike than are identical twins. All the other correlations in the case of fraternal twins are higher than that for finger ridges, particularly, height, weight, I Q, and educational age, suggesting that resemblance in these traits has been increased by similarity of environment.

An attempt has been made to estimate the relative influence of nature and nurture by a formula devised by Karl J. Holzinger.[1] The ratios for seven traits are given in Table 7.

TABLE 7

RATIO OF THE INFLUENCE OF NATURE TO THAT OF NURTURE IN DETERMINING DIFFERENCES IN VARIOUS TRAITS IN TWINS ACCORDING TO HOLZINGER'S FORMULA

Trait	Ratio
Height, standing	4.0
Weight	3.6
Head length	3.7
Number of finger ridges	17.0
Binet I Q	2.0
Educational age	1.7
Rate of tapping	1.0

If the indication of this calculation is correct, nature is seventeen times as influential as nurture in determining number of finger ridges, about four times as influential in determining height, weight and head length, about twice as influential in determining I Q and educational age, and about as effective in determining rate of tapping. While these ratios are not set forth as exact or final it does seem reasonably certain that the relative influence of nature and nurture is widely different in determining various traits.

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PREMATURITY

MATURE, IMMATURE AND PREMATURE INFANTS

IN obstetrics a mature infant is one born at term, that is, at the end of from 270 to 290 days, irrespective of the degree of the development of the baby.

Immature infants, classified from the clinical standpoint according to Ylppö,[1] include any infant whose weight at birth is below 2,500 gm. In his interpretation he implies that the infant is not completely developed and, therefore, is not prepared for normal, independent extrauterine life. A classification from the standpoint of weight alone, however, does not satisfy the needs of the clinician who must draw conclusions as to future expectancy for normal physical and mental development.

Premature infants are those born before full term, and represent the major number of the infants classified as immature. The growing importance of the subject is indicated by the increase in the number of infants recorded as premature during recent years. Of 2,806 deaths of infants occurring in Chicago during one year, 739 deaths in the first month of life were due to prematurity. Of 860 who died during the first twenty-four hours, 399 deaths were due to premature birth, while of 1,700 who died during the first week of life, 588 deaths were due to premature birth.

In the United States the care of premature infants has not received the general attention of the medical profession which it merits. Hospital facilities for the care of such infants are lacking; first, because special obstetric hospitals in most instances decline outside cases, and, second, because comparatively few general hospitals are properly organized to undertake the special care required.

In a study of premature and congenitally debilitated infants, at least two factors in the life history of the fetus must be considered:

The term of intrauterine life; the younger the fetus when it leaves the uterus, the greater the difficulties to be overcome in carrying out the body functions necessary to life and, therefore, the lower its vitality. Biologically age must be reckoned from the time of conception rather than from birth.

The state of its functional development at birth, as evidenced by the presence or absence of inherited disease; full consideration must be given in the case of each individual infant to the causes in the parents, and the infant as well, which might lead to premature delivery or poor physical development.

CLINICAL CLASSIFICATION

Immature infants may be grouped as follows:

Premature infants with no pathological changes: those normal for their fetal age.

Premature infants with pathological changes due to (1) constitutional disease or chronic infections in the parents; (2) maternal factors influencing the fetal nutrition, such as overwork, undernourishment, and acute illnesses during pregnancy; (3) local conditions in the mother, such as contracted pelvis, premature separation of the placenta, difficult presentations, or uterine fibroids, which have resulted in improper nutrition and asphyxia due to various causes; (4) multiple pregnancies; (5) constitutional defects and congenital malformations in the fetus; (6) infants born to parents late in life.

Full-term but immature infants with pathological changes due to the causes enumerated.

MORPHOLOGICAL AND FUNCTIONAL CONSIDERATIONS

Thermolability, the inability to regulate and maintain a normal body temperature, is due to diverse factors. Among these, incomplete development of the heat regulating center and intracranial injuries are the most important. The relatively large body surface, the extensive vascularization of the skin and the thinness of its epidermal layers, and the meager subcutaneous deposits of fat all predispose to excessive loss of heat through irradiation. Physiological loss of weight, due to dehydration, is another factor. The question of body temperature will be considered more fully later.

Feature Stigmata. The appearance and characteristics of the healthy premature child vary with the fetal age at the time of birth. Both the premature and the immature full-term infant may exhibit the following features in varying degrees:

> The body is usually small and puny, although it may be of considerable size with very imperfect development of the internal organs.
>
> The weight is low, varying in the viable infant from amounts approximating 700 gm. to 2,500 gm. The latter figure may be exceeded in infants nearing maturity and by some of the full-term weaklings.
>
> The skin is soft and usually of a vivid red color due to marked vascularization. The epidermis is thin and the blood vessels easily seen. The skin frequently hangs in folds. The adipose tissue is scant, the features are angular, and the face looks old.
>
> The lanugo is plentiful, especially upon the extensor surfaces of the extremities.
>
> The skull is round or ovoid, instead of dolichocephalic. The fontanelles are large and the sutures, prominent.
>
> The nose exhibits many small comedones.
>
> The ears are soft and small and snug to the skull.
>
> Other characteristics are a short neck, a long broad trunk with deeply seated navel, and short legs. These can usually be observed by the second to the fourth month of life and they gradually disappear during the second year.
>
> The cry is feeble, monotonous, and whining.
>
> The infant lies in deep sleep and must be awakened for its feedings.
>
> Efforts at sucking are weak or absent.
>
> All movements are slow and sluggish.
>
> The temperature has a very decided tendency to remain below normal and to fluctuate.
>
> The urine is usually scanty.

The bowels are sluggish.
Early and intense jaundice is common.

These are the principal findings on superficial examination. Any of them may vary in different individuals of the same age, depending upon the cause of prematurity and upon the condition of health of both mother and child. With increasing age, the characteristics become less marked until the picture eventually merges into that of the full-term infant. In the presence of proper feeding the small, thin face with its mass of wrinkles soon becomes rounded out by the deposit of layers of fat, the skin becomes smoother, and the face, more nearly like that of a normal nursling. The sucking cushions remain, for a more or less indefinite period, more prominent than those of the normal infant. Enlargement of the tongue and sometimes an exophthalmos may be noted until toward the end of the first year. The nose may also remain small and stumpy until the end of the first year. The

TABLE 1

COMPARISON OF THE FETAL WEIGHT AND LENGTH WITH THE AGE. FIGURES (HIS' [2])

Fetal age	Weight	Length
16 to 20 weeks	250 to 280 gm.	17 to 26 cm.
20 to 24 weeks	645 to 1,000 gm.	28 to 34 cm.
24 to 28 weeks	1,000 to 1,200 gm.	35 to 38 cm.
28 to 32 weeks	1,220 to 1,600 gm.	39 to 43 cm.
32 to 36 weeks	1,600 to 2,500 gm.	46 to 48 cm.
36 to 40 weeks	2,500 to 3,100 gm.	48 to 50 cm.

OBERWARTH'S [3] AVERAGES

Fetal age	Weight	Length
26 weeks	330 to 1,041 gm.	28.0 to 37.0 cm.
28 weeks	995 to 1,408 gm.	36.3 to 37.5 cm.
30 weeks	797 to 1,700 gm.	33.1 to 41.3 cm.
32 weeks	1,868 to 1,964 gm.	42.0 to 42.7 cm.
34 weeks	1,286 to 2,213 gm.	39.0 to 47.0 cm.
36 weeks	2,424 to 2,700 gm.	46.1 to 48.0 cm.

AHLFELD'S AND HECKER'S [4] AVERAGES

Fetal age	Weight	Length
27 weeks	1,140 gm.	36.3 cm.
29 weeks	1,575 gm.	39.6 cm.
31 weeks	1,975 gm.	42.7 cm.
33 weeks	2,100 gm.	43.9 cm.
35 weeks	2,750 gm.	47.3 cm.
37 weeks	2,875 gm.	48.3 cm.

doll type of face is usually present until after the fourth to sixth month of life.

Body Weight and Other Measurements. Infants born at full term weigh on the average from 3,000 to 3,500 gm. The dividing line between the premature and full-term infant has been generally placed at 2,500 gm. The weight depends upon the cause of the premature birth and upon the age of the child. Those born of mothers afflicted with nephritis, tuberculosis or other wasting diseases, and those showing active syphilis are usually considerably smaller than infants of healthy parents. Diseases and abnormal location of the placenta also restrict the growth of the fetus. The infant in instances of placenta previa is often undersized, even when born at term. Multiparity may predispose to undersize.

Other Measurements of the Fetus. Von Winckel [5] regards the circumference of the head as of importance for the diagnosis of the age of the fetus and gives the following figures:

4th month.....	10 to 14 cm.	8th month....	25 to 30 cm.
5th month.....	13 to 18 cm.	9th month....	29 to 33 cm.
6th month.....	19 to 24 cm.	10th month....	32 to 37 cm.
7th month.....	23 to 28 cm.		

TABLE 2

COMPARATIVE BODY MEASUREMENTS (REICHE [6])

Group 1	12 Children		Weight 800–1,200 gm.
	Minimum	*Maximum*	*Average*
Length of the body...	34 cm.	41.0 cm.	37.4 cm.
Circumference of chest	21 cm.	24.5 cm.	22.5 cm.
Circumference of head	24 cm.	29.5 cm.	26.8 cm.
Group 2	26 Children		Weight 1,200–1,500 gm.
			Average
Length of the body...	27.0 cm.	45.0 cm.	41.6 cm.
Circumference of chest	22.5 cm.	27.5 cm.	24.8 cm.
Circumference of head	26.0 cm.	31.0 cm.	28.4 cm.
Group 3	28 Children		Weight 1,500–2,000 gm.
			Average
Length of the body...	41 cm.	48.5 cm.	44.2 cm.
Circumference of chest	25 cm.	32.5 cm.	27.2 cm.
Circumference of head	27 cm.	32.0 cm.	30.3 cm.
Group 4	22 Children		Weight 2,000–2,500 gm.
			Average
Length of the body...	41.5 cm.	49.0 cm.	46.5 cm.
Circumference of chest	26.0 cm.	30.0 cm.	28.4 cm.
Circumference of head	29.0 cm.	33.5 cm.	32.2 cm.

These figures show a gradual and steady increase in weight in measurements of the chest and head up to the time of maturity, when they should average 3,200 gm. in weight and 50.5 cm. in length, with a chest circumference of 32.9 to 33.8 cm. and a head circumference of 34.5 cm.

Ylppö[1] studied the relation of the circumference of the chest to that of the head in premature and full-term infants. He found that at birth the circumference of the head is greater than that of the chest, and the greater the prematurity, the more marked is the relative disproportion between the circumference of the head and chest. These facts are borne out in Table 3.

TABLE 3

RELATION OF CIRCUMFERENCE OF HEAD AND CHEST (YLPPÖ)

Weight of infant, grams	Number	Circumference of head	Circumference of chest	Chest circumference, *per cent* of head circumference
Under 1,000	16	25.0	20.8	83.2
1,001 to 1,500	78	31.8	24.5	77.0
1,501 to 2,000	75	30.0	26.3	87.7
2,001 to 2,500	74	32.3	29.5	91.3
New born				
3,000 to 3,500	100	33.5	31.0	92.5

INTERNAL ORGANS

Brain Weight. Ylppö[1] presents figures on brain weight, which are given in Table 4.

TABLE 4

BRAIN WEIGHT—BOYS

Age	No. of cases	Average weight in grams		Ratio of brain to body weight
		Body	*Entire brain*	
Fetus of eight months...	3	2,440	248	1 to 10
Newborn...............	3	2,785	389	1 to 7.2

Thyroid. This is very small but has a very rich blood supply. By the eighth month or earlier colloid is usually found in the center of the follicles.

Thymus. In premature infants weighing 1,000 to 2,000 gm. it is between 1.0 and 3.0 gm., while in full-term infants it may be as much as 20.0 gm.

Heart. The heart on the average is from 0.5 to 0.75 per cent of the body weight of premature infants. In those weighing from 900 to 1,200 gm. Ylppö found that the weight ranged from 4.5 to 7.0 gm. In full-term infants and premature infants with a longer intrauterine growth, the relation between the weight of the heart and that of the body was found by Lomer to remain about the same, thus:

Infant weighing 4,000 gm. heart 27.6 gm. = 0.7 per cent body weight
Infant weighing 2,000 to 3,000 gm. heart 20.7 gm.
Infant weighing 1,000 to 2,000 gm. heart 11.4 gm.

Liver. This is the largest of the internal organs of the premature body. The smaller the premature infant, the greater is the relative size of the liver.

TABLE 5

WEIGHT OF THE LIVER IN PREMATURES (YLPPÖ)

Weight of infant, grams	No. of cases	Average weight of liver, grams	Liver weight, percentage of body weight
Under 1,000	11	43.73	4.8
1,001 to 1,500	12	53.17	4.3
1,501 to 2,000	4	56.75	3.3
2,001 to 2,500	3	102.33	4.5

With the increase in weight of the body the weight of the liver slowly increases. The figures in Table 5 for the group weighing from 1,501 to 2,000 gm. are based on four observations only. The weight of the liver in premature infants depends on the richness of its blood supply.

TABLE 6

WEIGHT OF SPLEEN (YLPPÖ)

Weight of infant, grams	Number of cases	Average weight of spleen, grams	Spleen weight percentage of body weight
Under 1,000	14	1.5	0.17
1,001 to 1,500	12	2.8	0.21
1,501 to 2,000	4	4.4	0.22
2,001 to 2,500	8	7.2	0.28

Spleen. The spleen, like the liver, is very rich in blood. As with the liver, the spleen increases in size with increase in the body weight.

Kidneys. The ratio of the weight of both kidneys to that of the body is greater in premature than in full-term and older infants. Gundobin [7] showed that in full-term infants the percentage was 0.38. The embryonic features of the kidneys are very marked, but the fetal markings disappear fairly rapidly.

TABLE 7

WEIGHT OF KIDNEYS (YLPPÖ)

Weight of child, grams	No. of cases	Average weight of kidneys, grams	Kidney weight, percentage of body weight
Under 1,000	15	5.2	0.59
1,000 to 1,500	17	8.9	0.76

BODY TEMPERATURE

During intrauterine life the child receives gratis the material necessary for its maintenance, for the development and regeneration of its cells. The maternal blood stream brings to the placenta the oxygen and other substances needful for its nutrition, and no effort on the part of the fetus but the cardiac contractions is required to pass these foods into the antenatal circulation. After birth a much greater amount of energy is necessary because of the more extensive changes taking place within the tissues and because of muscular activity. Increased metabolism is also necessary for the accomplishment of the digestive and respiratory functions and to enable the infant to fight against external physical agents, principally cold.

Cause and Nature of Hypothermia. Heat regulation is one of the least developed functions of premature infants, their body temperature showing marked fluctuation, with a tendency to hypothermia. This is due to several factors:

Faulty heat regulation due to lack of development on the part of the nervous system. It is possible to imagine that in a premature infant, in whom the development of the brain is still going on and the differentiation of white and gray matter has not been completed, that the nervous system is not sufficiently matured to function normally.

Loss of heat through radiation. The extent of the heat loss from the body of an animal by conduction, radiation, and evaporation from the skin and the surface of the lungs, is determined by the extent of the surface and by the thickness of the subcutaneous fatty layer. In a premature infant the body surface is relatively greater than in a full weight newborn. Wrinkled skin and the absence of fat deposits in the skin are responsible for still greater loss of heat. The thinness of the epidermal layers and extensive vascularization are important factors.

Insufficient oxygen supply. Metabolism may be limited if a poorly developed respiratory center causes partial asphyxia.

The circulation. The circulation, as affected by its nervous mechanism and weak cardiac action, is another important factor.

Insufficient heat production, due to lack of food or improper metabolism. This cause of hypothermia is of minor importance in the premature infant who is fed a sufficient quantity of breast milk and who is able to assimilate it. As the sucking centers are too poorly developed to enable the infant to obtain sufficient nourishment, most of these infants cannot be trusted to their own resources in obtaining their food.

A careful consideration of all of the factors tending to hypothermia makes it evident that we cannot depend on an equalization of the heat loss from the body surface by internal production of heat, and therefore, in order to maintain a uniform temperature, it becomes necessary to assist the infant by giving him an artificial environment of good air sufficiently heated and moistened to maintain a normal body temperature.

Blackfan and Yaglou [8] have investigated the conditions of temperature and humidity which seem best suited to the needs of premature infants. The infants are kept in a nursery which is so heated and ventilated that temperature, humidity, and rate of air movement are constantly controlled.

The success of any particular combination of temperature and humidity was judged by observations of body temperature, gain in weight, incidence of diarrhea, motility, and the general behavior of the infants. A relative humidity of 65 per cent was adopted in practice as most satisfactory, and with this humidity the temperature requirements ranged from 75° to 88° F. The particular temperature range is determined to a considerable extent by the humidity employed. The cooling power of the air, which depends on both of these factors, seems to be the significant point.

Tablot, Dalrymple and Bates[9] made detailed studies on the heat regulation in premature infants, as compared with full-term infants. Four infants were chosen. Two of them were premature, of a fetal age of about seven and one-half months. The other two infants were normal and were used as controls. In one series of observations, the temperature of the room was increased from the customary level of 80° to 90° F. In another series, the temperature was decreased from 90° to 64° F. The relative humidity was maintained at 30 per cent in both series. All other conditions, such as clothing, feeding, manner of exposure, and so forth, were kept unaltered. The reactions of the infants to the changes in the environmental temperature were studied by observing the changes in the rectal and skin temperature. The comparative reactions of normal and premature infants to cooler and warmer surroundings are summarized in Table 8.

TABLE 8

EFFECT OF COOLING THE ROOM 9° C. EXPOSURE, TWO AND ONE-HALF HOURS

		Skin Temperature	
	Rectal	Trunk	Extremities
Normal infant	−0.0 C	−1.3 C	−3.8 C
Premature infant	−0.2 C	−3.6 C	−6.3 C
Effect of Warming the Room 5.5° C			
Normal infant	+0.0 C	+2.5 C	+2.4 C
Premature infant	+0.5 C	+4.6 C	+5.2 C

The reactions to both heat and cold were much more pronounced in the premature than in the normal infant. This seems to indicate that the heat-regulating mechanism of the premature infant was not functioning as efficiently as that of the infants who had reached term.

Another interesting observation is that normal infants perspired readily in conditions of high temperature, in contrast to the delayed perspiration of premature infants. The normal infants began to perspire when the difference in temperature between the skin of the trunk and the rectum was from 1.3° to 2° C. The premature infants did not commence to perspire until this difference was about 0.6° C. Apparently, this is evidence of undeveloped activity of the sweat glands.

GROWTH OF THE PREMATURE

Initial Weight Losses. Loss in body weight during the first days of life occurs so constantly in full-term infants that moderate losses must be considered physiological. This is also true of premature infants, but they lose relatively more and regain their birth weight more slowly, often requiring a month. The nearer the prematures are to full term, the lower is the relative loss of weight as expressed in percentages. The loss in weight in premature infants should not average more than 7 to 8 per cent of the birth weight.

The average loss in weight in premature and in other infants of relatively low birth weight during the first days of life is shown in Table 9 adapted from Reiche.[6]

TABLE 9

AVERAGE LOSS IN WEIGHT OF PREMATURE AND LOW BIRTH WEIGHT INFANTS

Weight	Length	Average decrease
800–1,200 gm.	32.0–40 cm.	71 gm.
1,200–1,500 gm.	37.0–44 cm.	97 gm.
1,500–2,000 gm.	40.0–48 cm.	137 gm.
2,000–3,500 gm.	41.5–50 cm.	177 gm.

These figures apply, of course, to the healthy prematures only, and not to those debilitated by disease or by unfavorable environment or food.

CHARACTERISTICS OF VARIOUS ORGANS

Respiratory Tract. The premature inspires at birth, but its muscular power is weak and its efforts are insufficient to raise the thoracic wall and thus dilate the pulmonic cavity. As a result, though the large bronchi are filled with air, many of the small bronchioles are not dilated. A large portion of the lung continues, therefore, to remain in a fetal stage and several weeks may be required for its complete expansion. The deficient oxygenation of the blood is accompanied by attacks of cyanosis, during which respiration ceases entirely. The apneic interval may last as long as for one to two minutes and then breathing is resumed. Clinically, the weakened respirations are manifested by the monotonous, feeble, whining cry and grunting expirations of the infant, the comparative immobility of the thorax, and the superficial and often irregular character of the respirations, which become abdominal in type. The frequency of respiration in the sleeping premature is frequently as high as forty to fifty a minute.

Digestive Tract. The muscles of the buccal region, of the tongue, and of the soft palate are weak. The stomach of the premature infant before its first feeding, as seen at autopsy, is in an almost vertical position and tubular in its form. In the premature infant which has been fed, the fundus is fairly well developed, and causes the stomach to assume a more oblique position. This is corroborated by roentgen-ray examination. The cardiac end of the stomach is found well to the left, and usually at about the level of the tenth dorsal vertebra. The cardiac sphincter is usually poorly developed. This accounts in part for the ease with which the premature infant regurgitates its food. The pylorus lies somewhat higher than that of the full-term newborn, in whom it is found about midway between the ensiform cartilage and the umbilicus. Before feeding it is almost always found to the left of the median line. The pyloric musculature is usually quite well developed, even in the newborn premature.

Gastric Capacity. Although many authors have measured the capacity of the full-term infant's stomach, both at autopsy and in the living, their figures vary considerably. In a postmortem study of 34 stomachs under pressure of a column of 15 cc. of water, J. H. Hess estimated the average sizes of fetal stomachs as follows:

24 weeks......	5 cc.	32 weeks......	18 cc.
26 weeks......	8 cc.	36 weeks......	25 cc.
28 weeks......	10 cc.	40 weeks......	45 cc.

Mosenthal[10] after a careful study of full-term infants measured during life and post mortem, states that the physiological capacity of the stomach exceeds the anatomical gastric capacity during life, because of the rapid passage through the pylorus of the individual feedings during the act of nursing. This fact has been corroborated by the roentgen ray in several cases. Therefore, the gastric capacity, as measured post mortem by filling the stomach with water under pressure of 15 cm. of water with the pyloric end of the stomach ligated, must also fall short of giving the functional capacity.

The stomach of the premature infant on a diet of breast milk is usually found empty at the end of one and one-half to two hours. The stomach of the artificially fed infant requires a considerably longer period of time to empty, depending upon the nature of the food administered, even in the case of feeding with predigested milk.

Nervous System. The cerebrospinal nervous system is less well developed than the sympathetic system. This is most markedly evidenced by the lack of muscular activity shown by the infant. Many premature infants lie in a state of stupor or somnolence, from which they must be aroused to be fed. Others can be aroused by external stimulation, but such stimulation elicits only a weak cry and slight movements of the body. These movements are slower than those of the full-term infant, and the child tends to relapse into a deep sleep as soon as the stimulus is removed. The weak respiratory function and the feeble sucking movements are also dependent to some extent upon the incomplete development of the nervous centers.

The nasal and pharyngeal reflexes are particularly weak in children born before term. Abdominal reflexes are almost never present in the premature; in fact, they are rarely seen in any newborn infant.

Among many neurologists the opinion is prevalent that prematurity predisposes to idiocy, imbecility, and epilepsy. However, it appears that in such instances the premature birth is not responsible but rather there seems to be a common cause leading to retarded development and premature expulsion of the fetus. This point is considered more fully in *Appraisement of the Child.**

Cardiovascular System. The pulse rate of the premature newborn ranges from 90 to 200 a minute, with an average of about 120. This variability is due to lack of development of the cardioinhibitory centers.

The vascular walls are weaker in the premature than in the infant at term, and because of this premature infants are subject to hemorrhage following relatively slight trauma. This is particularly true of the intracranial vessels, and thus hemorrhages in this region are relatively more frequent in the premature. The intracranial hemorrhages are usually followed by early death, and in many instances such deaths are undoubtedly interpreted as respiratory deaths, because of the influence of pressure on the respiratory center.

Lymphatic System. This system is well developed, and does not differ materially from that of the full-term newborn, unless possibly its circulation is slowed as a result of the slowing of the general circulation.

Thymus and Thyroid Glands. These organs present the highest degree of development of any of the glandular structures. In fetal life they contribute to the formation of blood and during the first few weeks of life have a phagocytic action.

Genito-urinary System. Albuminuria is a symptom shown by almost all infants just after birth, full-term as well as premature. This seldom persists for longer than the first few days, and the quantities of albumin present are small; 0.25 gm. of albumin per 100 cc. of urine is a maximum which is frequently reached in the full-term infant. Albumin

* "The Influence of Prematurity on Mental Growth." *Growth and Development of the Child,* Part IV.

in the urine of the newborn would seem to be somewhat of a physiological condition; certainly it bears no relation of a causal nature to the infections or other toxic factors of the later periods of life. Von Reuss [11] believes that the condition can be explained most easily on the basis of circulatory stagnation, which occurs in a more or less pronounced degree after every delivery.

Skeletal Development. The stage of ossification of the skeleton of the fetus, as observed in roentgenograms, is of

TABLE 10

TIME OF APPEARANCE OF CENTERS OF OSSIFICATION

HEAD	Week
Mandible	7th
Occipital bone (squamous portion)	8th
(lateral and basilar portion)	9th to 10th
Superior maxilla	8th
Temporal bone (petrous, mastoid and zygoma)	9th
Sphenoid (inner lamella of pterygoid process)	9th
(great wings)	10th
(lesser wings)	13th
(anterior body)	13th to 14th
Nasal bone	10th
Frontal bone	9th to 10th
Bony labyrinth	17th to 20th
Milk teeth (rudiments)	17th to 28th
Hyoid bone (greater cornua)	29th to 32nd
BODY	Week
Clavicle (diaphysis)	7th
Scapula	8th to 9th
Ribs	Week
Rib, 5th, 6th, 7th	8th to 9th
2d, 3d, 4th, 8th, 10th, 11th, 9th	9th
1st	10th
12th (very irregular)	10th
Sternum	Week
Sternum	21st to 24th
Upper extremity	Week
Humerus (diaphysis)	8th
Radius (diaphysis)	8th
Ulna (diaphysis)	8th
Phalanges, terminal	9th
basal, 3d and 2d	9th
basal, 4th and 1st	10th
basal, 5th	11th to 12th
middle 3d, 4th, 2d	12th
5th	13th to 16th
Metacarpals, 2d and 3d	9th
4th, 5th, 1st	10th to 12th

TIME OF APPEARANCE OF CENTERS OF OSSIFICATION—*Continued*

BODY—*continued*

Vertebrae	Week
Arches, all cervical and upper 1 or 2 dorsal	9th
all dorsal and 1 or 2 lumbar	10th
lower lumbar	11th
upper sacral	12th
4th sacral	19th to 25th
Bodies from 2d dorsal to last lumbar	10th
from lower cervical to upper sacral	11th
from upper cervical to lower sacral	12th
5th sacral	13th to 28th
1st coccygeal	37th to 40th
structural arrangement	13th to 16th
odontoid process of axis	17th to 20th
Costal processes, 6th and 7th cervical	21st to 33rd
5th cervical	33rd to 36th
4th, 3d and 2d cervical	37th to 40th
Transverse processes, cervical and dorsal	21st to 24th
lumbar	25th to 28th

Pelvic girdles	Week
Ileum	9th
Ishium (descending ramus)	16th to 17th
Os pubis (horizontal ramus)	21st to 28th

Lower extremity	Week
Femur (diaphysis)	8th to 9th
(distal epiphysis)	35th to 40th
Tibia (diaphysis)	8th to 9th
(proximal epiphysis)	40th
Fibula	9th
Os calcis	21st to 29th
Astragalus	24th to 32nd
Cuboid	40th
Metatarsal, 2d and 3d	9th
4th, 5th and 1st	10th to 12th
Phalanges, terminal 1st	9th
terminal 2d, 3d, 4th	10th to 12th
terminal 5th	13th to 14th
basal 1st, 2d, 3d, 4th, 5th	13th to 14th
middle 2d	20th to 25th
middle 3rd	21st to 26th
middle 4th	29th to 32nd
middle 5th	33d to 36th

considerable practical importance in determining the age of the fetus. In addition, observation by the roentgenographic method is more reliable than determination of age based on length and other measurements, since osseous development is more regular and offers many more factors for consideration. Pathological conditions may often be readily recognized. Studies thus far have shown that more accurate determination is possible in the early months than in the later months, because many more new centers appear in the first months, and the time of appearance is more constant. The study of the roentgenograms for diagnostic purposes discloses that the cephalad segments, including the upper axial skeleton and upper extremities, are far more constant as to time of development of their osseous centers than the caudad segments and those of the lower extremities. This should be borne in mind in making comparative studies.

Different Values of the Different Portions of the Body

In the very early period (second month) the stage of ossification of clavicle and mandible is of chief importance. Next in importance are the centers of the upper extremity, and especially of the hand (metacarpals and phalanges) which are very regular, not only in time of their appearance, but also in their sequence.

The progress of ossification of the head is also of considerable diagnostic importance, but the centers in many bones of the head are very difficult to demonstrate. Those, however, that can be well demonstrated are of much value in the determination of age. This is especially true of the occipital bone, superior maxilla, tympanic ring, nasal bone, and hyoid bone.

The axial skeleton (the vertebral column) is less reliable than the above named portions of the skeleton, and its lower portion, especially, is of little value in diagnosis of age. It is not the absolute number of arches or of bodies ossified which determines the age of the fetus, but rather the region involved and the extent of the development in that region of the vertebral column (cervical, dorsal, lumbar, sacral).

While the ossification of the long bones of the legs is pretty regular, since it occurs at an early period, ossification in the foot is very irregular and the stage of ossification of the foot is of little value in the determination of the age of the fetus.

From the above it may be seen that, as a general rule, the earlier a center appears, the more regular it is, and since the process of ossification starts in the cephalic region and spreads caudally, the more caudad a skeletal segment is situated, the more it is subject to variation and irregularity.

OUTSTANDING CLINICAL PATHOLOGY

In the premature ward at Sarah Morris Hospital for Children, of the Michael Reese Hospital, Chicago, a careful record was made, at one time, of the clinical pathological findings in 399 of the infants. Each of the pathological entities was listed according to the number of infants in whom it was reported. Many of the infants had several of the conditions recorded.

Cyanosis was the most frequent pathological finding noted. It was present in 138 infants, of whom 85 died. The cyanosis varied in degree from the extreme purple of infants with marked atelectasis to a slight degree of blueness noted occasionally during or after feeding.

In a special study [12] of the appearance and course of cyanosis in 102 infants, marked cyanosis was observed in 53 (51 per cent) of these cases; 46 of the infants died. All but 2 of the infants who died exhibited cyanosis at some time during the course of the illness. In the infants who survived, cyanosis occurred as a single attack or as an occasional attack associated with some demonstrable cause, such as hypothermia, hyperthermia, vomiting during feeding, or the presence of abdominal distention, diarrhea, and infection. Temporary attacks of a minor degree are not uncommon in premature infants who survive.

Apathy of marked degree was present in all the infants who died, especially in those who had intracranial hemorrhage. It was also marked in small and debilitated infants.

Fever. Sixty-five per cent of those infants having infections showed little, if any, rise in body temperature. The infections were chiefly those of the upper respiratory tract and otitis media, pyelitis, and pneumonia. A rise in temperature does not necessarily occur as a symptom of infection, as in some of the most severe cases the temperature was normal or subnormal. Subnormal temperatures often indicate a poor prognosis, especially in the smaller infants.

Jaundice of severe type is a frequent symptom in the premature. There are two types of severe jaundice: that which occurs during the first two weeks of life; and that which becomes increasingly evident during or after the seond week. In the former, among fatal cases, intracranial hemorrhage complicated by infection was frequently present. In the second group, infection appeared to be the predominating factor.

Vomiting, severe and persistent, may be present in cases of intracranial hemorrhage, more especially in those of the infratentorial type, and in systemic infections. Abdominal distention, gastric irritability, and pylorospasm may all result in repeated attacks of vomiting. Toxemia of pregnancy is a common cause of vomiting in the fetus. About 75 per cent of all prematures regurgitate some feeding during the first three days.

Diarrhea is a frequent occurrence in the premature infant and always calls for careful judgment in feeding regulations, in order to avoid dehydration and inanition.

Twitchings (indefinite symptoms) occurred at times in infants suffering from various conditions. Numerically they were not more frequent in the cases in which hemorrhage occurred than in the others. This was probably explained by the early death of patients with severe cases of intracranial hemorrhage.

Generalized convulsions in very young infants are most often due to intracranial hemorrhage and infection. Anoxemia and gastrointestinal upset rank next in importance. In the older premature, tetany should always be thought of as a possible cause, since this condition may develop at a much earlier age in the premature than in the full-term infant.

Congenital syphilis was diagnosed in only 4.3 per cent of 853 cases, notwithstanding the fact that with a few exceptions a Wassermann test was made in one or both parents. A positive diagnosis of syphilis was established in 36 cases, of whom 15 died. Eleven showed no outstanding clinical signs. While the percentage of proven syphilis was very low, the mortality among infants with syphilis was exceptionally high.

Cerebral hemorrhage was diagnosed in 108 infants, either clinically or at autopsy or both. Twelve of these infants recovered. It is interesting that among the large group of infants visiting the clinic for station graduates, only 4 showed evidence of intracranial hemorrhage. Out of 203 infants who came to autopsy, 80 had intracranial hemorrhage. The location of the hemorrhages was as follows: supratentorial, 24; infratentorial, 43; intraventricular, 9; diffuse hemorrhage, 22. The discrepancy in figures is due to the fact that in some cases hemorrhage occurred in more than one region.

Saenger [13] found macroscopic intracranial hemorrhages in 73 of 100 cadavers of newborn infants. The tentorium was intact in only 3 of the 46 with much hemorrhage, and in 15 of the 27 with slight hemorrhage. Framm [14] gives intracranial hemorrhage as the most frequent cause of death. It was present in 24 per cent of his cases. Yagi [15] found 34.3 per cent in his cases.

Meningitis was diagnosed in 6 infants, all of whom died.

True hydrocephalus was diagnosed in 5 infants, of whom 2 died before leaving the station.

Megacephalus was a frequent clinical finding, the condition gradually disappearing with the infant's development. The concept of megacephalus of the immature infant is credited to Ylppö, who explained it by saying that the brain continues to grow independently of the rest of the body and reaches its normal size, but because of slow growth and development of the body the head seems disproportionately large. In other words, the head is normal but the body is subnormal in size. It is possible, however, that the megacephaly of later months is a summation of the effects of immaturity and of rickets.

Enlarged thymus. In 104 autopsies in which special attention was paid to the thymus gland, only 5 cases were reported as showing marked hypertrophy.

CEREBROSPINAL FLUID OF PREMATURE INFANTS

In the study of the spinal fluid in cases of intracranial hemorrhage of the newborn, premature infants offer, perhaps, the best material as subjects of investigation, not only because intracranial hemorrhage occurs so frequently in these infants but also because permission for postmortem examination is more easily obtained than in any other class of hospital patients.

The presence of red blood cells in microscopic numbers in the cerebrospinal fluid of premature infants during the early days of life is so common that it may be considered as a psychological phenomenon. On lumbar puncture, it is not always possible to distinguish between fluids which are bloody as the result of congestion and fluids which contain blood as the result of intracranial hemorrhage.[16]

In a series of 35 cases of cerebral hemorrhage or acute meningeal congestion, proved by necropsy, the cerebrospinal fluid obtained by lumbar puncture was grossly bloody or hazy in 28 cases, or 80 per cent. In a series of 42 cases in which evidence of meningeal hemorrhage was not found at necropsy, the spinal fluid was grossly bloody or hazy in 13, or 31 per cent, of the cases. This percentage is sufficiently high to indicate the danger of making a diagnosis of cerebral hemorrhage solely on the basis of bloody spinal fluid withdrawn by lumbar puncture. Meningeal congestion alone may be the underlying cause.

It was also shown that clear spinal fluid may be obtained in certain cases of subpial hemorrhage. Crenated red blood cells in cerebrospinal fluid were regarded as cells which were in the fluid prior to the time of the lumbar puncture at which they were obtained. Cerebral hemorrhage probably contributes to the degree of icterus neonatorum, and unrecognized cerebral hemorrhage is perhaps the cause of some cases of so-called physiological icterus neonatorum.

RICKETS, ANEMIA, TETANY AND SCURVY

Not only is *rickets* a common disorder of premature infants, but it appears much earlier in them than in full-term infants.

Closely associated with rickets in prematures, is an *anemia* which develops quite regularly during the first three months of life. Unless very early preventive measures are instituted, there is a distinct impoverishment of the hemoglobin in the blood, which reaches its maximum in about the third or fourth month. In some instances there is a hypoplastic condition of the hematopoietic system. Diet and lack of sunshine play a large rôle.

Typical attacks of *tetany,* with all of the characteristic manifestations, are but rarely observed in premature infants. Hyperirritability and convulsions are the most common manifestations, and are frequently seen as early as the second to the fourth month. In the majority of cases the disappearance of the symptoms occurs simultaneously with the disappearance of craniotabes and improvement of the anemia.

Acute florid cases of *scurvy,* presenting all of the classical findings, are only occasionally seen. Far more common are the subacute or latent manifestations, characterized by an insidious onset and evidenced by lack of gain in weight, anorexia, irritability, and progressive anemia. These latent cases are often overlooked. General improvement following the introduction of antiscorbutic dietetic measures confirms the diagnosis.

Thus it becomes more and more apparent that anemia, rickets, tetany and scurvy in premature infants have largely a common background.

PROGNOSIS AS TO LIFE

In estimating the outlook for an infant born before the natural termination of the normal period of pregnancy, one must consider the prenatal and the postnatal factors before arriving at a conclusion. Of prenatal influences, the most important are the fetal age, the physiological development and an absence of constitutional anomalies, transmitted parental conditions, and malformations. Of postnatal conditions, the occurrence of any of the various diseases of the newborn affects the prognosis. In addition to these, the age at which the infant is received for treatment and the character of the treatment it receives go far in determining the probable outcome. The prognosis becomes better as time passes, in proportion to the care the child receives with respect to its hygiene and feeding. The secret of success in rearing the premature lies in avoiding refrigeration and infection and in selecting the food properly as regards quality, quantity and method of administration.

Of 1,041 infants admitted to a station, 690 lived and were transferred to their homes. This represents 66.2 per cent. If we exclude the patients who died in the first twenty-four hours, 79.2 per cent survived. The high mortality of the first twenty-four hours is in large part due to birth trauma and immaturity, but is influenced greatly by outside factors such as previous care and transportation. At the present time, of these 690 graduated infants, approximately 375 are in attendance at a clinic for graduates; 82 others have been transferred to the care of private physicians; and 21 are out of town patients; there are records of the deaths of 76 after discharge from the hospital or on readmission.

PHYSICAL DEVELOPMENT

The relation of mortality to the different age periods up to the time of puberty and the effect of premature birth on the mental and physical development of the child must be considered in ascertaining the course of development of children born prematurely.

We may look for our best results during the first months of life in the premature born without physical defects, of healthy parents, and who has been able to take an ample amount of breast milk. Similarly, in such an infant we may expect a good response to artificial feeding when it becomes necessary to discontinue the breast. This group will also show a resistance to infection which compares favorably with that of a full-term infant.

The presence of early rickets and spasmophilia, together with the secondary anemia which so commonly accompanies these conditions, will leave their inhibiting impress upon growth and development during early childhood. As stated above, prophylaxis against their appearance is imperative in well directed care of premature infants.

In most premature children a gradual equalization begins at the second or third year so that by the fourth to sixth years the curves of growth run parallel to those of full-term children. Early defects gradually disappear, and in by far the larger percentage of those who survive, the differences between the premature and the full-term child have disappeared by the time of puberty.

Data relative to the time of eruption of teeth, development of static functions, and development of bladder control have been assembled for groups of prematurely born and full-term siblings.

TABLE 11

MEAN AGE IN MONTHS AT ONSET OF DENTITION, WALKING, SPEECH, AND BLADDER CONTROL OF PREMATURELY BORN CHILDREN, THEIR SIBLINGS, AND NORMAL CHILDREN

Age at onset	Total premature		Premature below 2,000 gm.		With birth wt. 2,000 gm. and above		Total siblings	
	No.	*Mean age*	*No.*	*Mean age*	*No.*	*Mean age*	*No.*	*Mean age*
Dentition	111	8.757	60	9.361	51	7.980	31	7.516
Walking (unsupported)	100	16.240	54	16.704	46	15.696	31	14.355
Speech (words)	106	14.897	57	15.035	49	14.694	30	15.233
Bladder control	65	22.292	37	23.243	28	21.036	27	20.630

The data would indicate that prematurely born children are not delayed in eruption of teeth. They walk at a chronological age a little older than their siblings. Since the prematurely born average a gestation period of 7.7 lunar months, this difference closely corresponds with the degree of retardation in walking when compared with siblings. They are not delayed, then, if correction is made for the period of prematurity. Similar considerations pertain to age of onset of talking. With great regularity figures relative to onset of talking indicate a more precocious age than might be expected from other statistics available. They are fairly consistent, however, with age of talking as reported for the siblings, but nevertheless indicate slight precocity of onset of talking for the prematurely born. The most valid data were obtained on 56 children between the ages of six months and thirty months, who were tested on Gesell items. Of these children, every one with a chronological age of fifteen months or over talked at least to the extent of using one word; 7 under fifteen months of age did not talk; 2 under fifteen months of age said one word, and 6 under fifteen months of age said more than one word. In addition to this group, one child forty-eight months of age, with an intelligence quotient of .66 and evidence of glandular dystrophy, did not talk.

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 of bladder control, 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.

MENTAL DEVELOPMENT OF PREMATURE INFANTS

The mental development of children born prematurely has received limited study. Psychological reports are meager, and offer widely conflicting statements.

TABLE 12

DATA ON VITALITY (MARCH 1, 1930)

Birth weight in gm.	Total admissions	Surviving first 24 hours, number	Surviving first 96 hours, number	Graduated		Graduated infants surviving first day, *per cent*
				Number	*Per cent*	
Less than 1,000	44	19	15	5	11	26.3
From 1,000 to 1,500	173	110	107	65	37	59.1
From 1,500 to 2,000	314	276	272	214	70	81
From 2,000 to 2,500	227	210	210	186	80	88
From 2,500 to 3,000	50	49	49	46	92	92
Over 3,000	7	7	7	4	57	57
Unknown	48	46	46	29	60	63
Totals............	863	717	706	549		

A study [17] of the older graduates from the clinic for prematurely born children conducted by the Sarah Morris Hospital for Children was undertaken in order to evaluate the mental development of a considerable group of these infants. The station had been in operation for eight years, and therefore a number of these children were old enough to afford a comprehensive study. It was the object of this investigation to draw a true cross section of the mental age of the infants, and every effort was made to prevent discrimination in favor of the better types. In a group over four years of age, every available child was brought into the investigation. These findings are presented in *Appraisement of the Child.**

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HUMAN TYPES

PERSONALITY, TRAITS, AND TYPES

INDIVIDUALITY is the essence of personality. No two persons are exactly alike. On the other hand the possession of similar characteristics or traits makes it possible to classify persons into types. This involves an analysis of the traits which characterize a person. These traits may be conveniently divided into two groups, physical and psychological, although the two groups are closely united. The physical traits may be considered as composing the constitution of the individual; the psychological traits as denoting his character; and the combination of constitution and character as forming his personality. A complete study of the personality of a human being requires analysis of his constitution from the standpoint of external form, structural organization, physiological activity, development and heredity, and of his physical adjustment to his surroundings past and present. It requires an analysis of his character from the standpoint of his mental activities and of his social history and behavior.

The number of traits that may be selected to describe an individual, morphological, physiological, psychological, or social, is limitless. Heredity and environment both play a part in the development of all traits but for some we consider genetic factors as dominant, for others, the influence of the conditions surrounding the individual. Some traits or trait complexes we ascribe to racial inheritance. The presence of such traits characterizes racial types. Some traits are characteristic of sex. Some are characteristic of various stages of the life cycle. Some make it possible to classify individuals of a given race, sex, and age into contrasting constitutional groups or types. When individuals are thus classified into groups great caution should be exercised in ascribing to the individuals of a given group traits not immediately utilized as a basis of classification. Negroes and whites, males and females, children and adults, the slender and the stocky are contrasting groups easy to distinguish from one another on the basis of contrasting physical traits. Traits other than these contrasting traits are to be ascribed specifically to none of these groups until careful study has shown a close connection between the second set of traits and the first. For this reason in the classification of persons from the standpoint of significant traits or trait complexes it is well so far as possible to avoid the term *type*. As a rule this term in this connection merely adds vagueness to the classification. Thus, for instance, to call a person *muscular* indicates an individual with a well developed voluntary muscular system. This implies a relatively robust skeletal system, since strong muscles require strong bones for leverage. It implies reasonably good respiratory, digestive and circulatory systems, at least during the time when the musculature was developed. But if we say a person belongs to the *muscular type* the picture becomes beclouded. Each author using the term is likely to throw a different set of vague traits into the type part of the designation.

The traits or trait complexes used for the purpose of classification should be clearly defined and, when possible, given quantitative as well as qualitative expression. Few human traits used for distinguishing individuals from one another are of the *presence or absence* nature. Most significant traits or trait complexes from the standpoint of personality are of the *more or less nature*. A person is tall or short, light or heavy, slender or stocky, light complexioned or dark complexioned, a child or an adult. The differences between the extremes are clearly definable. Giants are not to be mistaken for dwarfs; the aged for infants, even though in the latter case we may speak of second childhood. But if individuals are arranged in series according to stature, bulk, or age, there are no sharp lines of division and arbitrary ones have to be drawn if we are to classify with precision.

The problem of classification of persons into types is further complicated by the phenomena of growth. The individual to be classified is not a fixed object but one undergoing the series of complicated changes which constitute the life cycle. Fundamentally the constitution depends upon genetic factors and a given type of constitution depends upon similar combinations of these factors in the members of the group. But the surroundings profoundly affect growth. The intrauterine environment varies somewhat. There are differences in the place of attachment of the ovum within the uterus. There are differences in the chemistry of the mother's blood. There may be exposure to infection. During postnatal life the differences in environment affecting the individual become far more varied. The part played by the environment in the development of the individual becomes more and more marked, and it becomes more and more difficult to separate the genetic from conditions produced by the environment. Bluish weak teeth may be due to lack of calcium in the food rather than to inheritance; poor development, to lack of iodine or vitamins rather than to genes; poor posture, to bad habits rather than to defects inherent in skeleton and musculature. The classification of individuals of a given stage of development into constitutional types can be wisely done only when preceding growth and future probable development are taken into consideration.

RACIAL TRAITS AND TYPES

Modern man constitutes a single species divisible into various racial groups. Traits used for classifying mankind into such groups may be designated *racial.* Deniker's classification of human varieties, adopted by Martin in his *Lehrbuch der Anthropologie* as the most satisfactory at present, bases the primary subdivisions on hair form and color; the secondary subdivisions on skin color; the tertiary subdivisions mainly upon relative stature. Other traits made use of in defining racial groups are shape of nose, cephalic index, eye color, face shape, hairiness of skin, and prominence of cheek bones, but none of these traits are used consistently for group classification. Among other characteristic racial traits are protrusion of the mucous membrane portion of the lips (in general marked in Negroes); a fold of skin at the medial side of the upper eyelid found in many Mongoloid groups, but also in Hottentots, and various differences in skeletal proportions including the narrow pelves and relatively long lower extremities distinguishing most Negroid groups. In general the traits selected for human racial classifications are superficial traits. It has been suggested (E. Fischer [22]) that such traits are in large part domestic traits due to mutation and selection similar to the processes playing a part in the development of our domestic animals. Man has selected those mutations which he has fancied for breeding. The modern eugenic movement is an attempt to make selection for the propagation of mankind more deliberate.

Associated with the relatively superficial traits utilized for human racial classification, there are more fundamental, morphological, physiological and psychological differences characteristic of the different racial groups. The difficulty of defining these with precision is made evident by the retention of the more superficial traits for racial classification. Schultz [42] has shown that marked morphological differences between whites and Negroes occur early in fetal life. Lipiec [29] finds in newborn Poles, Swiss and Jews differences similar to those described by Schultz. We are at present, however, far from much exact knowledge concerning racial differences in anatomy and physiology. Nevertheless, in spite of the slight knowledge which we have of fundamental constitutional differences due to race, it is well to begin classification of individuals on the basis of race in so far as exact knowledge concerning racial origins may be obtained.

CONSTITUTIONAL ASPECTS OF SUPERFICIAL TRAITS

In discussing constitution and race we have referred to the relatively superficial traits which have proved of greatest convenience in classifying mankind according to race. We may now briefly review some of these traits from the point of view of the light they may throw on constitution, irrespective of race.

Complexion, Color of Skin, Hair and Eyes. While hair form plays a considerable part in defining racial characteristics, little or nothing is known as to the relation of hair form to general constitutional conditions. Nor are there obvious relations between hair distribution and constitution or build. The pigmentation of the skin, hair, and iris, which we may group together as the complexion, appears to have some constitutional significance, although there is lack of much exact knowledge concerning this. While the color of the skin, hair, and eyes vary more or less together there is no perfect correlation. Data as to the relation of the complexion to disease are contradictory.[28]

Of other characteristics of the skin and its appendages, the subcutaneous fat has considerable significance from the standpoint of the general constitution and from that of build. It is normally better developed in infancy and early childhood, especially on the face, than when puberty is approached. It is better developed in girls than in boys, in women than in men, and in women has a characteristic distribution about the pelvic region. There is a characteristic difference in the distribution of the subcutaneous fat of the face in whites and Mongolians. For further discussion of the subcutaneous fat see *Appraisement of the Child.**

The head and face are largely utilized for personal identification. Much study has been devoted to the form and proportions of the head as a whole, and of its various parts. Long heads are usually associated with slender build, broad heads with stocky build, but there are exceptions, as racially illustrated by the stocky, long headed Eskimos.

In the study of face form, three segments are recognized, cranium, upper face, and lower face. The lower face is especially well developed in the European races. It appears to be more or less independent in development, and lack of harmony is frequently seen between upper and lower jaws. In Europeans the nose is usually long, projecting and narrow in tall slender individuals; shorter, flatter and broader in stocky individuals. The lower jaw is usually small and narrow in slender individuals, larger and broader in the stocky. Details concerning the development of the teeth, jaws and face may be found in *Anatomy and Physiology.*†

The external nose, a human characteristic, changes con-

* "Physical Status." *Growth and Development of the Child,* Part IV.

† "Development of the Face and the Dentition." *Growth and Development of the Child,* Part II.

siderably in shape from infancy to maturity as pointed out in *Anatomy and Physiology.** The majority of noses in early childhood are broad with concave backs and elevated anterior nares, while in the adults of the white race these forms are relatively rare. The greatest change takes place in the first nine years of life, but some progressive changes in nasal form take place between twenty and fifty years of age. In general the white races have narrow, the yellow races, intermediate, and the Negro races, broad noses. Concerning constitutional differences associated with variability in nasal form within a given race little is known.

The external ears vary considerably in size and shape. In vertical length the Negro race has in general relatively short ears, and the Mongoloid race long ears compared with the white race. The infant ear is relatively short compared with that of the adult. Bean [8] has laid considerable stress on differences in ear form associated with various types of build, but his work along these lines has thus far received little support from other investigators.

BLOOD TYPES

Recent studies on blood grouping are of interest from the standpoint of racial constitution. So far as at present known the specific ability of the blood serum of certain individuals to agglutinate the blood corpuscles of certain other individuals is not correlated with any other constitutional phenomenon. On the basis of this phenomenon people may be divided into four groups, O, A, B, and AB. These blood groups are phenotypic manifestations of definite Mendelian factors. Europeans in general show a high frequency of A and a low frequency of B. A second center for a high frequency of A and a moderate frequency of B is found in Japan, Korea and South China. The Indo-Manchurian people show a high frequency of B and a low frequency of A. American Indians appear originally to belong to the O group. The factor for B appears to have arisen by mutation in India, that for A by mutation possibly both in Europe and in the neighborhood

* "Growth and Development of the Skeleton." *Growth and Development of the Child,* Part II.

of Japan. From these two centers the factors, A and B, appear to have spread widely showing the great intermixture of human races. No conscious selection could have been at work in distributing this trait. Lawrence H. Snyder's recent book on *Blood Grouping* gives an excellent summary of what is known on this subject. Reference to the establishment of blood groups in infancy is made in *Anatomy and Physiology.**

SEX TRAITS

Girls are, on the average, slightly smaller than boys at birth, and they continue on the average smaller than boys until puberty is approached when, as Bowditch first pointed out, they grow faster than boys for a time, and exceed them for a brief period both in stature (usually from the eleventh to the fourteenth year), and weight (usually from the thirteenth to sixteenth year). During adolescence boys grow faster than girls, and growth extends over a longer period. In all races the average stature and weight of man exceeds that of woman. Processes such as dentition and ossification on the average appear earlier in girls than in boys, and the signs of puberty likewise appear earlier. The secondary sexual characteristics, relatively slight during childhood, become more marked as puberty is approached and well defined during adolescence. These include the development of pubic and axillary hair, the development of the breasts in women, and of a beard in man, further changes in the shape of the pelvis, and an increase of subcutaneous fat in women in the pelvic region. Girls and women have a relatively greater amount of subcutaneous fat than boys and men and a relatively greater amount of fat compared to musculature. Their skeleton is likewise relatively lighter. Although there is still much to be learned regarding differences between the sexes other than those recognized as primary and secondary sexual characteristics, the differences between the two sexes are so profound as to necessitate in most instances a separation according to sex before proceeding to further classification according to type.

* The Hematopoietic System." *Growth and Development of the Child, Part II.*

DEVELOPMENTAL TRAITS AND TYPES

Stockard[44] has pointed out that all structural form in animals results from processes of unequal growth: "The problem of human types is a problem of growth, and all individuals that may be grouped together under one type are individuals with closely similar growth histories." From this point of view he recognizes the two fundamental types of build as the linear, faster growing, high metabolizing, thin but not necessarily tall group, and the lateral, more slowly maturing and metabolizing stocky type. While no sharp lines of division can be drawn between the slender, the stocky and those of medium build, constitutional differences in the two contrasting types have been recognized from the time of Hippocrates, and in one guise or another they form the basis of most attempts to correlate mental traits on the one hand, and liability to disease on the other hand, with physique.

The development of the mind in association with the development of the body is a topic of great interest to all who deal with children, and especially to teachers. The recent advance in methods of measuring intelligence has made it possible to correlate study of mental and physical development more effectively than hitherto, but at the same time has revealed the need of improved methods of obtaining and making use of data, not only on the development of the mind, but also on the development of the body. Studies along these lines may ultimately furnish a basis for classification of children more far-reaching than any now available, but more data than we now have must first be accumulated before this can be accomplished. Noteworthy progress is now being made at the Iowa Child Welfare Research Station at Iowa City; The Psycho-Educational Clinic at Harvard University; the Psycho-Clinic, Yale University; the Institute of Child Welfare of the University of Minnesota; the Bureau of Educational Experiments, The Child Development Institute of Teachers College, Columbia University, and the American Child Health Association, New York City; the Department of Psychology, Leland Stanford University, California and other organizations devoted to scientific study of children.

A summary of our present knowledge of the relations between physical and mental growth is given in *Appraisement of the Child.**

Keith [26] and others have attributed racial differences to differences in the relative activity of the endocrine glands, and Stockard [44, 45] and others have attributed differences in build to similar factors. Present knowledge appears to be far too meager to offer a sound basis for classification of normal individuals into types along these lines. Some pathological conditions of growth, such as cretinism and eunuchoidism, some forms of gigantism and dwarfism, and some forms of adiposity are clearly associated with endocrine defects. Excessively fat children and adults form a more or less well defined group, but the members of this group range from those clearly pathological to those between whom and normal individuals no clear line can be drawn. A summary of the known action of the various endocrine glands is given in *Anatomy and Physiology.*†

MENTAL TRAITS AND TYPES

Kretschmer [27] defines character as the complex of traits which distinguish the mental aspects of an individual. From this standpoint, we are confronted with the general vagueness of psychological and psychiatric terms. We can do little more at present than call attention to the need for clear definitions of psychic traits.

Karl Menninger's [31] division of psychological processes into perception, intellection, emotion and volition (motivation), each of which may exhibit deficient or excessive activity or distortion, appears to be a step in the right direction.

As in the study of physical build it is convenient to consider contrasting types such as the slender and stocky, although there are many intermediate varieties, so also it is convenient in the study of character to consider contrasting types such as introverts and extraverts, though the mind like the body is highly variable. Kretschmer, Stockard, and others

* *Growth and Development of the Child,* Part IV.

† "Glands of Internal Secretion." *Growth and Development of the Child,* Part II.

who have attempted to associate mental and physical types appear on the whole to associate the introvert type of mind with slenderness, the extrovert with stockiness of build. While such attempts over simplify the complex, they are of stimulating interest if not taken too literally. Concerning fundamental temperamental relations of mind to body in normal children practically nothing is known.

CONSTITUTIONAL TRAITS AND TYPES

The primary interest in constitutional types is individual variability in fitness to meet similar situations and the desire to classify individuals from the point of view of physical response to environment. The physical response to environment is closely bound up with psychic response. The two can never be completely separated but purely objective study of the reactions of the body, as such, is an aid to the understanding of the behavior of the person as a whole. Physiology deals largely with analysis of general biological processes. The study of constitutional behavior is an attempt at insight into the synthetic behavior of individual human beings. It had its origin with clinicians interested in disease. The subject of constitutional fitness also has proved of interest to educators and to those engaged in trying to fit persons to occupations.

During the whole period of development from the fertilization of the ovum to the attainment of maturity the organism has a double function, to prepare for the future and to meet present demands. After maturity is reached the body is called upon to maintain its equilibrium for future demands as well as to meet the immediate situation. As old age is approached this equilibrium can no longer be maintained. What we are concerned with here is the ability of the body as a whole to meet immediate situations during infancy, childhood and adolescence. There are practically no data on the action of the body as a whole from the point of view of different physiological types of constitution during this period. For the adult male considerable attention has been given to Sigaud's constitutional types, respiratory, muscular, digestive and cerebral (Chaillou and MacAuliffe[18]). Carl

Coerper,[19] has pictured similar types for fourteen year old boys and girls. The idea in these types is to express the predominant element in the constitution. Individuals possessing the types of build pictured may doubtless be found if sought among the immense variety of persons presented by mankind, but the classification as a whole appears fanciful rather than of practical value.

Individuals may be classified according to the functional activity, sensitivity or strength of various organs or organ systems. Clinical diagnosis in large part depends upon such a classification. Variability in functional activity is due both to immediate environmental conditions and to factors deep seated in the constitution of the individual. It is difficult to distinguish with precision these constitutional factors. For this reason classification into types on the basis of functional differences, while at times of clinical value, has as yet proved of relatively little importance from the standpoint of the classification of normal individuals into physical types. J. Bauer[7] and G. Mittasch[33] give good summaries of the literature on the constitutional predisposition to disease. Carl Coerper[19] and Edgar Atzler[1] give good summaries of the literature on the human constitution from the standpoint of work and play.

Two terms especially frequently used by clinicians and others relative to types of constitution are *asthenic* and *pyknic*. The asthenic is a weak individual, typically slender. The pyknic is a robust individual, typically stocky and inclined to put on fat. The two terms are not good contrasting terms. Asthenic means lack of strength and should be applied, if used at all, to individuals lacking in strength and vigor. Such individuals are quite as apt to be over average weight for stature and age as under, at least after the early years of childhood. If the term is to be retained, methods of measuring strength and vigor should be devised and *sthenic, asthenic,* and *hypersthenic* should be applied to individuals on the basis of their response to these tests. *Pyknic* means stocky, and, if used, should be applied to those over average weight for stature. Such individuals may be essentially muscular or essentially fat.

During the World War, it was found that many individuals suffering from heart disease, constitutional weakness, neurasthenia, and other defects frequently made more active and better soldiers than the average person classed as normal (Brugsch[15]). The influence of the will and of education on the development of personality was then brought to light as never before. As a strong mind can in large part compensate for a weak body, so a body crippled or weakened in one direction may frequently compensate by vigorous development in other directions. There is no subject in the field of study of the constitution more important than that of readjustment to compensate for injury. This subject can, however, be merely alluded to here.

Davenport[20] has studied the association of various diseases with slenderness and stockiness of build and points out certain differences in incidence of various diseases. As for the reverse relationships he states that, "the one clear conclusion from this study is that no single disease and no special single collection of diseases is exclusively responsible for exceptionally slender or exceptionally fleshy build. The variations in build are due primarily rather to various idiosyncrasies of development and metabolism which have largely an hereditary basis, upon which may be superimposed modifications by various types of diseases."

There are undoubted differences in the susceptibility of persons to infection and in the susceptibility of the same person at different periods. The relative immunity may be in part genetic, but it is undoubtedly in part acquired.

The work of Davenport already referred to indicates apparent differences in susceptibility to disease in the slender as contrasted with the stocky. That such differences must be accepted with caution is indicated by the experience of Wenckebach (cited by F. Schiff[41]). Wenckebach found in Holland the slender Friesians quite susceptible to tuberculosis. This fitted in well with the current theory of the habitus phthisicus prone to the disease. But when he moved to Alsace where stocky build is common and slender build rare, he found tuberculosis of the lungs more widespread and severe.

In a study of build in relation to infection, age, sex and race should be considered. There is some evidence that the relatively stocky are more resistant to disease up to maturity, the relatively slender after that period is reached.

Young children are apt to show less resistance to infectious diseases than older children. For diseases such as cholera, typhoid fever, pneumonia, diphtheria, scarlet fever, meningitis, and poliomyelitis the per cent of lethality drops from early childhood to the prepubertal period and then increases with age (see tables of F. Schiff[41]).

With respect to sex, girls in general are somewhat more susceptible to the acute exanthemata, dermatrophic infections; boys to neurotropic infections such as poliomyelitis and meningitis.[41] From the standpoint of lethality, boys exceed girls in all diseases except typhoid, meningitis, whooping cough, pneumonia, influenza, and sepsis. (Note that the morbidity and lethality tables differ.[41])

Racial differences in resistance to infection depend to a considerable extent upon exogenous factors, and it is difficult to judge to what extent these differences are to be ascribed to such factors. Negroes are said to be more resistant than whites to malaria. The colored as opposed to the white races are said to be relatively immune to scarlet fever and support to this idea is given by the Dick test.[41] As yet, however, we have little definite knowledge as to racial differences in resistance to disease.

CLASSIFICATION INTO TYPES ON THE BASIS OF QUANTITATIVE DIFFERENCES OF BUILD

The most important and most used measurements of size are stature and body weight. Both stature and weight need to be correlated with development because they vary with the phenomena which characterize the various phases of the life cycle. Since chronological age is much more easily recorded than stage of maturation, average statures and average weights for given chronological ages as a rule furnish the basis of height-weight tables used by those interested in the growth of children or in life insurance. It is to be remembered, however, that development measured by ossification, dentition, puberty, the beginning involution of old age and similar phenomena characteristic of different phases of the life cycle, varies greatly relative to chronological age, so that individuals classed according to chronological age may developmentally belong in different groups, especially if near the period of transition from infancy to childhood, childhood to youth, youth to maturity and similar periods.

Stature

Growth in stature is very rapid in infancy, slows down during childhood, is accelerated preceding, during and immediately following puberty, and then slows down more and more until full stature is reached. According to Martin,[80] full stature is reached on the average by Europeans in the twenty-fifth year in men, by the eighteenth to twentieth in women, but the men grow as a rule but a few millimeters after nineteen years of age, and women after seventeen.

From the standpoint of stature we classify individuals as tall, medium and short with special names for the extremes, giants and dwarfs. In the adult this classification is relatively simple, although opinions differ as to where to draw the line between the different groups.

The United States has been largely populated by people from north western Europe and Great Britain, belonging to exceptionally tall racial groups. The average stature of the principal races represented in the United States ranges for men from 158 cm. (62 in.) to 173 cm. (68 in.), and for women from 147 cm. (58 in.) to 160 cm. (63 in.). In Table 1 the data for a few of these races are reproduced from Martin.

The mean stature of the adult population in various parts of the United States differs partly according to the proportions of various racial components, partly also probably according to differences in average living conditions.

The stature finally reached by the individual depends in part upon genetic inheritance, in part upon environmental conditions. There is ample evidence that growth in stature may be accelerated by an environment favorable to such

TABLE 1

MEAN STATURES OF SOME OF THE CHIEF RACIAL GROUPS REPRESENTED IN THE UNITED STATES, AFTER MARTIN, 1928 [30]

	Men, cm.	Women, cm.		Men, cm.	Women, cm.
Japanese	159.3	147.2	Danes	169.1	159.2
Ruthenians	159.5		Germans	169.2	158.0
Polish Jews	161.0	150.6	Swedes	170.9	
Italians	164.0		Finns	171.0	160.0
French	164.1	157.0	Norwegians	172.0	162.4
S. Russia Jews	165.1	153.6	Sioux-Indians	172.6	159.5
Serbs	167.4		English (middle class)	172.8	159.9
Dutch	167.5		Scotch	173.0	

growth, retarded by an adverse environment. In a given individual growth in stature may be temporarily retarded by disease or other adverse conditions and then recovered through subsequent acceleration. For a discussion of seasonal variation in rate of growth see the section of this volume on the influence of atmospheric conditions p. 234.

Individuals relatively short for a given age during childhood on the average grow more following puberty than do those relatively tall for their age. Thus Beyer [11] found that from age sixteen to age twenty-two short cadets grew, on the average, 4.2 in., medium 3.3 in., and tall, only 2.0 in., the relative stature being based in each case upon the conditions at age sixteen.

The problem of relative stature during childhood is thus complicated by individual acceleration and retardation of growth. Since, as a rule, tall individuals attain final stature at least at as early an age, if not earlier, than short individuals, the genetically tall must grow on the average faster than the genetically short. But at a given period the genetically short individual may be temporarily accelerated in growth, the genetically tall individual, temporarily retarded. The fundamental factors involved in the two cases are quite different. In studying stature during growth and development it is therefore important, so far as possible, to observe an individual at successive periods of growth. Up to the present our knowledge of growth has been based too much upon average measurements and observations upon children of a given age and not enough upon a study of the complete life cycle of individuals.

The stature of the individual relative to his group is indicated by the percentile method more satisfactorily than by any other method yet devised. Individuals of a given sex and age are classified with respect to a trait, such as stature, in which they differ in magnitude, according to percentile grades. Thus, the one percentile grade is the stature exceeded by 99 per cent of individuals but not exceeded by one per cent. The 50 percentile grade is the median below and above which there are equal numbers of individuals. An ideal percentile grade table or chart for the United States as a whole would be based upon a large number of individuals for each half year or less of age from birth to full maturity and at lesser intervals until old age. The number of individuals utilized for each age period should be sufficiently large and the individuals sufficiently heterogeneous to make the group a fair cross section of the general population of the given age group. The data compiled by Robert E. Woodbury for the Children's Bureau of the United States Department of Labor[49] meet these specifications very well for the height and weight of white children from one month of age to six years. They are based on records of 167,024 children selected for accuracy from the records of over 2,000,000 children measured in various parts of the country. These data have been utilized in preparing the percentile tables and charts given below. The age groups based on these data represent all individuals falling within a month of the age given. Thus, the five years group represents all individuals fifty-nine or more, but less than sixty-one months of age. White children only are included. The number of children in the various groups is as follows:

	NUMBER	
Age	Boys	Girls
3 months	3,580	3,466
6 months	3,721	3,517
1 year	3,413	3,063
2 years	2,638	2,484
3 years	2,541	2,392
4 years	2,407	2,462
5 years	1,652	1,679
6 years	519	505

The Woodbury records are unsatisfactory for the lengths of children at birth. The most extensive series of such measurements available for American percentile tables are those of Montague and Hollingworth,[86] but these measurements were made on New York babies from social classes not representing a fair cross section of the population but distinctly shorter. Rood Taylor[46] has given careful measurements of 250 full-term infants born in Minneapolis about equally distributed as to sex. Benedict and Talbot[10] have given careful data on 105 newborn Boston infants, also about equally divided between the sexes. In lieu of more extensive data, those of Taylor, of Benedict and of Talbot have been combined to furnish the percentile grades for the newborn in Tables 2 and 3 and Charts I and II.

There are a large number of studies published on school children six to eighteen years of age in various parts of the country. The most extensive compilation of these data thus far made is that of Boas.[12] The records embrace 41,151 boys and 43,298 girls from various parts of the United States and Canada. The ages at which these records were recorded were ages last birthday. The records were made during the last quarter of the nineteenth century. Since they were taken there appears to have been a general acceleration in the growth of children in this country amounting to at least half a year for the school period. In Chart I the growth curve for Toronto school boys, based on data reported by Boas in 1896–97, but measured a few years earlier, is compared with the growth curve for Toronto school boys based on data published by the Toronto department of public health in 1924 but also measured a few years earlier. These curves appear to show a slight but distinctly greater stature in 1924 than in 1896. Data published by Porter[89] and Gray[23] show a greater increase in average stature of Boston school boys compared with that of the boys studied by Bowditch[14] in 1877.

Whether or not an actual general acceleration of growth in stature has taken place in this country, the percentile grades for five and one-half years and six and one-half years based on the Boas data coincide almost perfectly with the five-year and six-year percentile grades based on the data of the Woodbury tables.[49] In compiling the percentiles given in Tables 2 and 3 and Charts I and II, we have therefore assumed a uniform acceleration in growth of one-half year over that actually recorded in the data on which these percentile grades are based.

For young male adults the data at mobilization and demobilization of United States troops for the World War, as compiled by Davenport and Love,[21] furnish the most satisfactory cross section of the general population. They include Negroes but this inclusion probably does not noticeably affect the stature. The average stature at mobilization was 67.49 in., 171.4 cm. The average stature at demobilization was 67.72 in., 172 cm. (Table 4).

For adult young women, data are lacking which give a fair cross section of the general population. The abundant data on college women are of a selected group rather than of a cross section of the general population. There appears to be little evidence that women grow significantly beyond the seventeenth year. We have selected the data given by Porter[38] on St. Louis high school girls for the percentile grades for young women of seventeen and eighteen years of age and the data given by Boas[12] for compiling the percentile grades for girls of sixteen years of age and below. As in the case of the young men, it is possible that the figures selected in the percentile tables and charts to represent full stature are a few millimeters less than they should be to represent a cross section of full adult stature.

The percentile tables and charts presented here are thus essentially patch-works and yet it is believed that until more complete data are available they should prove of use not only in the study of individual growth but also as a means of evaluating the various tables of norms prepared for use in schools and for other purposes.

Tables 2 and 3 show the stature percentile grades for males and females for the age groups indicated, prepared as described. The stature at each percentile grade is given both in centimeters and in inches, the former above, the latter below. The tables also show the percentage of adult stature reached in each percentile grade at each age.

TABLE 2. PERCENTAGE OF ADULT STATURE FOR PERCENTILES

Age, years	Short								Medium			
	1		5		10		20		30		40	
	Stature	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*
21–30	154.6	100	159.9	100	162.6	100	165.7	100	167.9	100	169.8	100
	60.9		63.0		64.0		65.2		66.1		66.8	
18	153.4	99.2	158.2	98.9	161.9	99.6	164.7	99.4	166.9	99.4	168.8	99.4
	60.4		62.3		63.7		64.9		65.7		66.5	
17	150.3	97.2	157.1	98.2	159.5	98.1	163.0	98.4	165.2	98.4	166.9	98.3
	59.2		61.9		62.8		64.2		65.0		65.7	
16	143.3	92.7	150.7	94.2	154.3	94.9	158.4	95.6	161.1	95.4	163.4	96.2
	56.4		59.3		60.8		62.4		63.4		64.3	
15	138.7	89.7	143.2	89.6	146.9	90.4	150.8	91.0	153.6	91.5	156.2	92.0
	54.6		56.4		57.8		59.4		60.5		61.5	
14	132.5	85.7	138.5	86.6	141.3	86.9	145.0	87.5	147.4	87.7	149.6	88.1
	52.2		54.5		55.6		57.1		58.0		58.9	
13	128.1	82.9	133.8	83.7	136.4	83.9	139.5	84.2	141.7	84.4	143.6	84.6
	50.4		52.7		53.7		54.9		55.8		56.5	
12	125.5	81.2	129.9	81.2	132.1	81.2	135.0	81.5	136.9	81.5	138.8	81.7
	49.4		51.1		52.0		53.2		53.9		54.7	
11	121.6	78.7	126.4	79.0	128.2	78.8	130.8	79.0	132.9	79.2	134.6	79.3
	47.9		49.8		50.5		51.5		52.3		53.0	
10	117.9	76.3	122.0	76.3	124.0	76.3	126.6	76.4	128.5	76.5	130.1	76.6
	46.4		48.0		48.8		49.9		50.6		51.2	
9	113.5	73.4	117.9	73.7	119.8	73.7	122.1	73.7	123.9	73.8	125.4	73.9
	44.7		46.4		47.2		48.1		48.8		49.4	
8	108.6	70.0	113.0	70.7	115.1	70.8	117.5	70.9	119.2	71.0	120.6	71.0
	42.8		44.5		45.3		46.2		46.9		47.5	
7	105.0	67.9	108.2	67.7	110.2	67.8	112.4	67.9	114.0	67.8	115.5	68.0
	41.3		42.6		43.4		44.3		44.9		45.5	
6	97.1	62.8	103.0	64.4	105.0	64.6	107.1	64.6	108.7	64.7	110.1	64.9
	38.2		40.6		41.4		42.2		42.8		43.4	
5	92.7	59.9	97.2	60.7	99.0	60.9	101.5	61.2	103.1	61.4	104.4	61.5
	36.5		38.3		39.0		39.9		40.6		41.1	
4	87.6	56.7	91.3	57.1	93.7	57.6	95.9	57.9	97.4	58.0	98.6	58.1
	34.5		36.0		36.9		37.8		38.3		38.8	
3	82.7	53.5	85.8	53.6	87.7	53.9	89.3	53.9	90.7	54.3	92.3	54.3
	32.6		33.8		34.5		35.2		35.7		36.3	
2	75.1	48.6	78.2	48.9	80.0	49.2	81.5	49.2	82.8	49.3	83.8	49.4
	29.6		30.8		31.5		32.1		32.6		33.0	
1	65.2	42.2	68.1	42.6	69.7	42.9	70.9	42.8	72.1	42.9	73.0	43.0
	25.7		26.8		27.4		27.9		28.4		28.8	
½	58.4	37.8	62.0	38.8	62.6	38.5	64.0	38.6	65.2	38.8	66.0	38.9
	23.0		24.0		24.6		25.2		25.7		26.0	
¼	52.3	33.8	55.2	34.5	56.7	34.9	58.2	35.1	59.5	35.4	60.4	35.6
	20.6		21.7		22.3		22.9		23.4		23.8	
Birth	45.9	29.7	47.5	29.7	48.3	29.7	49.7	30.0	50.2	30.0	50.8	29.9
	18.1		18.7		19.0		19.6		19.8		20.0	

NOTE: The stature at each percentile grade is given both in

Percentile Distributions at Given Ages, Males.

PERCENTILES

Medium						Tall							
50		60		70		80		90		95		99	
Stature	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*	*Stature*	*Per cent*
171.5	100	173.2	100	175.0	100	177.2	100	180.2	100	182.8	100	187.7	100
67.5		68.2		68.9		69.8		71.0		72.0		73.9	
170.6	99.5	172.2	99.4	173.9	99.4	176.2	99.4	179.6	99.7	181.5	99.3	182.8	97.4
67.2		67.8		68.5		69.4		70.7		71.5		72.0	
168.9	98.5	170.8	98.6	172.9	98.8	175.0	98.8	178.1	98.8	180.3	98.6	184.2	98.1
66.5		67.3		68.1		68.9		70.1		71.0		72.5	
165.3	96.4	167.3	96.6	169.2	96.7	171.2	96.6	173.9	96.5	176.5	96.6	180.5	96.7
65.1		65.9		66.6		67.4		68.5		69.5		71.1	
158.7	92.5	161.0	93.0	163.6	93.5	166.5	94.0	170.0	94.3	172.6	94.4	178.0	94.8
62.5		63.4		64.4		65.5		66.9		68.0		70.1	
151.7	88.5	154.1	89.0	156.4	89.4	159.5	90.0	163.6	90.8	165.9	90.7	173.4	92.4
59.7		60.7		61.6		62.8		64.4		65.3		68.3	
145.5	84.8	147.5	85.2	149.7	85.5	152.4	86.0	156.1	86.6	158.8	86.9	166.0	88.4
57.3		58.1		58.9		60.0		61.5		62.5		65.4	
140.4	81.9	142.1	82.0	144.0	82.3	146.3	82.6	149.6	83.0	152.6	83.5	157.7	84.0
55.3		56.0		56.7		57.6		58.9		60.1		62.1	
136.1	79.4	137.7	79.5	139.4	79.7	141.4	79.8	144.2	80.0	146.8	80.3	151.8	81.0
53.6		54.2		54.9		55.7		56.8		57.8		59.8	
131.7	76.8	133.3	77.0	134.9	77.1	136.8	77.2	139.5	77.4	141.8	77.6	146.2	77.7
51.9		52.5		53.1		53.9		54.9		55.8		57.6	
126.8	73.9	128.3	74.1	129.8	74.2	131.6	74.3	134.2	74.5	136.4	74.6	140.8	74.9
49.9		50.5		51.1		51.8		52.8		53.7		55.4	
122.0	71.1	123.3	71.2	124.8	71.3	126.7	71.5	129.1	71.6	131.4	71.9	135.8	72.3
48.0		48.6		49.1		49.9		50.8		51.7		53.5	
116.8	68.1	118.2	68.2	119.6	68.3	121.3	68.4	123.8	68.7	125.8	68.8	129.6	69.0
46.0		46.5		47.1		47.8		48.7		49.5		51.0	
111.3	64.9	112.5	65.0	113.9	65.0	115.3	65.1	118.4	65.6	120.1	65.7	123.1	65.6
43.8		44.3		44.8		45.4		46.6		47.3		48.5	
105.7	61.6	106.9	61.7	108.2	61.8	109.8	61.9	112.7	62.5	114.1	62.4	116.9	62.3
41.6		42.1		42.6		43.2		44.4		44.9		46.1	
99.6	58.1	100.8	58.2	102.0	58.4	103.4	58.4	105.2	58.4	107.1	58.5	110.9	59.1
39.2		39.7		40.2		40.7		41.4		42.2		43.6	
92.9	54.2	93.9	54.2	95.0	54.3	96.4	54.4	98.3	54.5	100.2	54.8	104.6	55.7
36.6		37.0		37.4		37.9		38.7		39.4		41.2	
84.8	49.4	85.8	49.5	86.7	49.6	88.1	49.7	89.9	49.9	91.8	50.2	94.8	50.5
33.4		33.8		34.1		34.7		35.4		36.1		37.3	
73.8	43.1	74.7	43.1	75.7	43.3	76.8	43.5	78.6	43.6	79.9	43.7	84.0	44.7
29.1		29.4		29.8		30.3		30.9		31.5		33.1	
66.8	39.0	67.7	39.1	68.6	39.2	69.6	39.2	71.4	39.6	73.2	40.0	80.4	42.8
26.3		26.7		27.0		27.4		28.1		28.8		31.7	
61.2	35.7	62.0	35.8	62.9	35.9	64.0	36.1	65.4	36.3	66.8	36.5	69.6	37.1
24.1		24.4		24.8		25.2		25.7		26.3		27.4	
51.3	29.9	51.8	29.9	52.2	29.9	52.8	29.8	53.8	29.9	54.3	29.7	55.6	29.6
20.2		20.4		20.6		20.8		21.1		21.4		21.9	

centimeters and in inches, the former above, the latter below.

TABLE 3. PERCENTAGE OF ADULT STATURE FOR PERCENTILES

Age, years	Short								Medium			
	1		5		10		20		30		40	
	Stat-ure	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*
18	147.0	100	151.1	100	153.5	100	155.7	100	157.1	100	158.5	100
	57.9		59.5		60.4		61.3		61.9		62.4	
17	146.2	99.5	150.4	99.5	152.5	99.3	154.7	99.4	156.6	99.7	157.8	99.6
	57.6		59.2		60.0		60.9		61.7		62.1	
16	144.5	98.3	148.4	98.2	150.6	98.1	153.1	98.3	154.9	98.6	156.5	98.7
	56.9		58.4		59.3		60.3		61.0		61.6	
15	141.3	96.1	146.5	97.0	149.1	97.1	151.5	97.3	153.4	97.6	155.1	97.9
	55.6		57.7		58.7		59.6		60.4		61.1	
14	135.3	92.0	141.7	93.8	144.9	94.4	148.2	95.2	150.4	95.7	152.1	96.0
	53.3		55.8		57.1		58.3		59.2		59.9	
13	130.5	88.8	136.4	90.3	138.9	90.5	142.3	91.4	144.0	91.7	146.8	92.6
	51.4		53.7		54.7		56.0		56.7		57.8	
12	124.5	84.7	130.4	86.4	134.1	87.4	136.3	87.5	138.6	88.2	140.6	88.7
	49.0		51.3		52.8		53.7		54.6		55.4	
11	121.2	82.4	125.6	83.2	128.0	83.4	130.9	84.1	132.9	84.6	134.6	84.9
	47.7		49.4		50.4		51.5		52.3		53.0	
10	117.0	79.6	121.2	80.3	123.4	80.4	126.0	80.9	128.0	81.5	129.6	81.8
	46.1		47.7		48.6		49.6		50.4		51.0	
9	112.5	76.5	116.9	77.4	119.1	77.6	121.4	78.0	123.2	78.4	124.7	78.7
	44.3		46.0		46.9		47.8		48.5		49.1	
8	108.3	73.7	111.9	74.1	114.0	74.3	116.5	74.8	118.3	75.4	119.8	75.6
	42.6		44.1		44.9		45.9		46.6		47.2	
7	104.1	70.8	107.4	71.1	109.4	71.3	111.6	71.7	113.3	72.1	114.8	72.4
	41.0		42.3		43.1		43.9		44.6		45.2	
6	98.0	65.3	101.4	67.1	103.6	67.5	106.4	68.3	108.0	68.7	109.2	68.9
	38.6		39.9		40.8		41.9		42.5		43.0	
5	91.4	62.2	96.0	63.5	98.3	64.1	100.8	64.8	102.4	65.1	103.6	65.4
	36.0		37.8		38.7		39.7		40.3		40.8	
4	87.7	59.7	90.7	60.0	92.7	60.4	94.5	60.7	96.0	61.1	97.3	61.7
	34.5		35.7		36.5		37.2		37.8		38.3	
3	80.5	54.8	84.6	56.0	86.1	56.1	88.1	56.6	89.4	56.9	90.7	57.5
	31.7		33.3		33.9		34.7		35.2		35.7	
2	73.2	49.8	77.0	50.9	78.5	51.1	80.3	51.5	81.3	51.7	82.3	52.2
	28.8		30.3		30.9		31.6		32.0		32.4	
1	62.7	42.7	66.6	44.0	67.8	44.2	69.3	44.5	70.6	44.9	71.4	45.2
	24.7		26.2		26.7		27.3		27.8		28.1	
½	56.9	38.7	59.8	39.7	60.9	39.7	62.5	40.1	63.4	40.2	64.2	40.5
	22.4		23.6		24.0		24.6		24.9		25.3	
¼	51.4	35.0	54.2	35.8	55.4	36.1	57.2	36.7	58.4	37.1	59.0	37.2
	20.2		21.3		21.8		22.5		23.0		23.2	
Birth	45.4	30.9	46.5	30.8	47.2	30.8	48.3	31.0	49.1	31.2	49.7	31.4
	17.9		18.3		18.6		19.0		19.3		19.6	

NOTE: The stature at each percentile grade is given both in
1 and 99 percentiles inter

Percentile Distributions at Given Ages, Females.

PERCENTILES

Medium						Tall							
50		60		70		80		90		95		99	
Stat-ure	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*	*Stat-ure*	*Per cent*
159.5	100	160.6	100	162.3	100	164.3	100	166.5	100	169.6	100	173.2	100
62.8		63.2		63.9		64.7		65.6		66.8		68.2	
159.4	99.9	160.5	99.9	162.0	99.8	163.8	99.7	166.2	99.8	168.5	99.4	172.2	99.4
62.7		63.2		63.8		64.5		65.4		66.3		67.8	
158.1	99.1	159.6	99.4	161.0	99.1	162.8	99.2	165.2	99.2	167.6	98.8	171.8	99.2
62.2		62.8		63.4		64.1		65.0		66.0		67.6	
156.4	98.1	157.9	98.3	159.6	98.3	161.5	98.3	164.1	98.6	166.4	98.1	170.7	98.6
61.6		62.2		62.8		63.6		64.6		65.5		67.2	
153.7	96.4	155.3	96.7	156.8	96.6	158.8	96.7	161.7	97.1	164.1	96.8	168.8	97.5
60.5		61.1		61.7		62.5		63.7		64.6		66.5	
148.9	93.4	150.8	93.9	152.6	94.0	154.9	94.3	157.9	94.8	160.3	94.5	164.6	95.0
58.6		59.4		60.1		61.0		62.2		63.1		64.8	
142.4	89.3	144.2	89.8	146.3	90.1	148.9	90.6	152.5	91.6	155.3	91.6	160.0	92.4
56.1		56.8		57.6		58.6		60.0		61.1		63.0	
136.3	85.5	138.2	86.1	140.1	86.3	142.3	86.6	145.4	87.3	148.4	87.5	153.0	88.3
53.7		54.4		55.2		56.0		57.3		58.4		60.2	
131.2	82.3	132.7	82.6	134.4	82.8	136.4	83.0	139.2	83.6	141.7	83.6	146.4	84.5
51.7		52.2		52.9		53.7		54.8		55.6		57.6	
126.1	79.1	127.6	79.5	129.0	79.5	130.8	79.6	133.4	80.1	135.8	80.1	140.0	80.8
49.7		50.2		50.8		51.5		52.5		53.5		55.1	
121.2	76.0	122.6	76.3	124.2	76.5	126.2	76.8	128.4	77.1	130.4	76.9	134.6	77.7
47.7		48.3		48.9		49.7		50.6		51.3		53.0	
116.2	72.9	117.5	73.2	119.0	73.3	120.7	73.5	122.8	73.8	124.9	73.6	128.6	74.2
45.7		46.3		46.9		47.5		48.4		49.2		50.6	
110.5	69.3	111.8	69.6	113.0	69.6	114.6	69.7	116.8	70.1	118.9	70.1	121.5	70.2
43.5		44.0		44.5		45.1		46.0		46.8		47.8	
104.7	65.6	105.9	66.0	107.2	66.0	109.0	66.3	111.0	66.6	112.8	66.5	116.4	67.2
41.2		41.7		42.2		42.9		43.7		44.4		45.8	
98.6	61.8	99.8	62.2	101.1	62.3	102.4	62.3	104.4	62.7	106.2	62.6	110.1	63.6
38.8		39.3		39.8		40.3		41.1		41.8		43.4	
91.7	57.6	92.7	57.7	94.0	57.9	95.2	57.8	97.3	58.5	99.1	58.4	102.4	59.1
36.1		36.5		37.0		37.5		38.3		39.0		40.3	
83.3	52.2	84.3	52.5	85.3	52.6	86.6	52.7	88.4	53.0	90.2	53.1	94.8	54.7
32.8		33.2		33.6		34.1		34.8		35.5		37.3	
72.2	45.2	73.2	45.6	74.2	45.7	75.2	45.8	77.0	46.2	78.7	46.4	84.2	48.6
28.4		28.8		29.2		29.6		30.3		31.0		33.1	
65.2	41.0	65.9	41.1	66.8	41.2	68.0	41.4	69.6	41.8	72.3	42.7	79.1	45.7
25.7		26.0		26.3		26.8		27.4		28.5		31.2	
59.9	37.6	60.7	37.8	61.5	37.9	62.5	38.0	64.0	38.4	66.9	38.2	68.7	39.7
23.6		23.9		24.2		24.6		25.2		25.5		27.0	
50.1	31.4	50.5	31.5	51.2	31.6	52.0	31.7	52.9	31.7	53.5	31.6	54.8	31.6
19.7		19.9		20.2		20.5		20.8		21.1		21.6	

centimeters and in inches, the former above, the latter below.

polated for ages 18 and 17

The data given in Tables 2 and 3 are illustrated in Charts I and II. These charts show clearly the early rapid

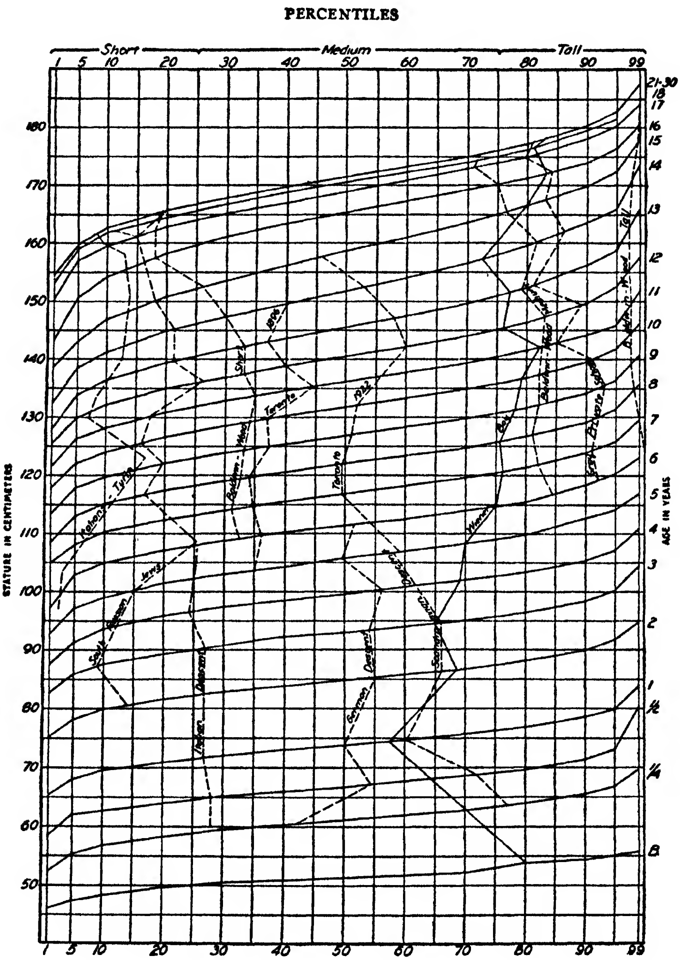

CHART I. UNITED STATES STATURE PERCENTILE CHART—BOYS

growth in the taller percentile grades and the more persistent postpuberal growth in the shorter percentile grades.

Individual Stature Curves. The first question of interest in connection with these tables and charts is the extent to

PERCENTILES

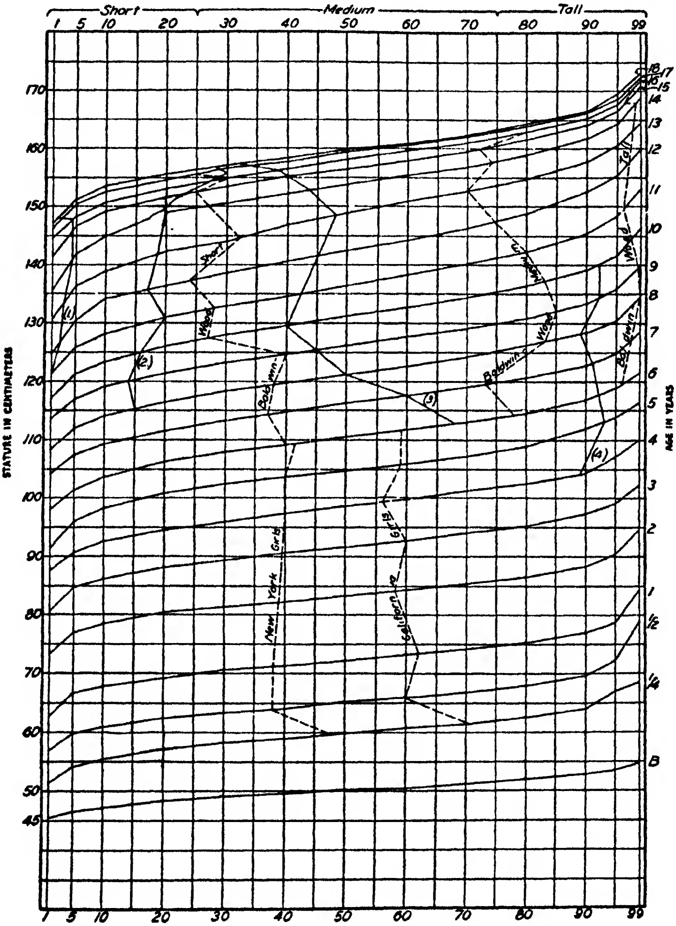

CHART II. UNITED STATES STATURE PERCENTILE CHART—GIRLS

which individuals deviate from a given percentile grade during growth. Records of individual development for the whole

TABLE 4

MEAN STATURE OF MEN OF NINE EUROPEAN RACES AT DEMOBILIZATION. AFTER DAVENPORT AND LOVE, 1921[21]

	cm.		cm.
Italians	165.18	Negroes	171.99
Hebrews	166.91	Germans	172.04
French	168.59	English	172.08
Poles	169.41	Scotch	172.54
Irish	171.36		

period of growth are scanty. Records are available for Wiener's four sons (Karlsruhe, 1890. Cited by Burk[16]). The percentile chart growth of the third son has been traced on Chart I. The curve of growth of this son is fairly uniform in the 80 percentile grade. It shows, however, a slight retardation down to the 60 percentile grade during the first year and subsequent steady acceleration to the tenth year, followed by a slight retardation from eleven to fourteen years of age and a subsequent acceleration. None of the other three sons show so uniform a development from the standpoint of percentile grades. The growth of the first son is especially irregular. At birth this son was in the 90 percentile grade. By the end of the first year he had dropped to the 26 percentile grade. Following this a fairly rapid growth brought him to the 70 percentile grade by the sixth year at which he remained approximately until his tenth year when a rapid acceleration set in which carried him over the 90 percentile grade at fourteen years of age, but this period of exceptionally rapid growth was followed by a marked retardation and the stature finally attained was merely of the 60 percentile grade.

Scammon[40] has cited data for several other individual growth curves from infancy to maturity. These, like the curves referred to, show from the standpoint of the percentile grades some irregularities, but on the whole a tendency to retain a given position throughout the growth cycle.

For more limited periods, a considerable number of individual records of growth in stature are available. The most extensive study of individual growth records is that of Porter.[39] From his data it appears that the chances are three in ten that from one year to the next a given boy will remain in the same percentile grade during the period under discussion; the chances are even that no boy will vary more than 2.3 grades and three to one that no boy will vary as much as 5.1 grades. For longer periods the chances are three to one that no boy will vary as much as 14 grades between six and thirteen years of age.

These conclusions of Porter appear to be fairly well supported by data on individual growth curves furnished by other investigators. On Chart II four growth curves of girls are reproduced from Baldwin[8] data. These are here numbered (1), (2), (3), and (4). The curves of (1), a short individual, and of (4), a tall individual, are fairly uniform. The curve of (2), a short individual, shows a steady acceleration. The curve of (3), an individual of medium stature, shows on the whole a marked retardation. The large majority of individuals appear, however, to maintain approximately similar percentile grades from year to year. The exceptions to the rule make it impossible to predict from the percentile grade of an individual at a given age just what stature he will ultimately reach. The longer the individual maintains a given percentile grade the greater the chances are of predicting his future stature. With all its imperfections the percentile grade method is our best available means of predicting future growth. At the same time it offers the best method of judging whether or not environmental conditions are acting favorably on growth in stature. Persistent retardation, persistent approach to a lower percentile grade, is likely to indicate untoward conditions. Persistent acceleration, approach to higher and higher percentile grades may, on the other hand, indicate a not wholly desirable condition of the glands of internal secretion or of other factors influencing growth.

Boas,[13] who has recently been making a new study of the growth curves of individual school boys has again emphasized the increase of variability of individual growth processes, including rate of growth, with increase of age. Variability in rate of growth and variability in adult stature is the greater the later the period of most rapid adolescent growth. The earlier the most rapid adolescent growth occurs, the more intense is the total amount of increment during the period around the maximal rate. The intensity of growth during the period of adolescence is the less the later adolescence begins. He concludes that while available data show a very clear influence of social status upon the rapidity of the life cycle, heredity control is not so clear.

In civilized countries, at least, the average stature of those of the upper and middle classes is greater than that of the lower classes. University students may be selected to represent the former, workmen the latter. Martin[30] cites figures shown in Table 5 on the comparative stature of these two classes in various countries.

TABLE 5

COMPARATIVE STATURE OF TWO CLASSES IN VARIOUS COUNTRIES

Country	Author	MEAN STATURE Students	MEAN STATURE Workmen
Spain	Oloriz	163.9	159.8
Italy	Levi	166.9	164.4
France	Longuet	168.7	164.4
England	Roberts	172.4	169.8
Germany	Martin	172.7	165.0
Germany (women)	Roth	161.2	156.5

This class difference is shown not only in adult stature but also at each year of age during childhood and adolescence. For a discussion of the socio-economic factors which influence growth see the section on that subject in this volume, p. 273.

Group Stature Curves. Percentile tables and charts are of value not only in the study of growth of individuals but also in the comparative study of the growth of groups. For a given group, where large numbers of individuals are involved, the average stature and the median, or 50 percentile grade, as a rule nearly coincide. In comparing the average stature of a given group with the data of the standard percentile tables and charts, we may thus assume that this average indicates approximately the median of that group and that the difference in percentile grades between 50 and the percentile grade shown in the table or chart for a stature of the magnitude given indicates the relative difference in statures of the two groups.

The average statures of the male South Russian Jews studied by Weissenberg[48] are given for each year of age from two to twenty-five. This group has a percentile grade on the United States percentile chart (Chart I) of approximately 20. The growth curve of the group shows retardation to the 10 percentile grade at age three and a similar retardation at age eighteen. The growth curve for male Italians based on the data of Pagliani[37] for school children of Turin is shown at the left in Chart I. It follows fairly closely the 10 percentile line but with retardation during the fifth and sixth years and acceleration during the thirteenth and sixteenth years. Data on children born in this country of Italian mothers have been given by Woodbury[49] and the growth curve for Italian boys has been plotted in Chart I. This curve runs close to the 25 percentile grade line and where it overlaps the Pagliani curve it shows marked acceleration compared with that curve. The growth curves for boys born of German and of Scandinavian mothers have likewise been plotted on Chart I from the Woodbury data. The German curve runs close to the 50 percentile grade line. The curve for those of Scandinavian descent runs in the main between the 60 and 65 percentile grade lines, although it is somewhat irregular. On Chart II growth curves have been plotted for the New York and for the California girls for which data are given by Woodbury, the shortest and the tallest of regional groups for which data are given. The New York curve runs close to the 40 percentile grade line, the California curve close to the 60 percentile grade line.

Another use of percentile grade tables and charts, based so far as possible on a cross section of the general population, is to place in relative positions tables of norms used as standards. The standards for stature most in use in this country at present for school children are those prepared by B. T. Baldwin and T. D. Wood and published by the American Child Health Association. These standards have been plotted on Charts I and II. The medium stature curve for boys runs near the 80 percentile grade line until age fourteen and then drops nearly to the 70 percentile line at age seventeen. It thus really represents a tall rather than a medium position relative to the general population. It is not greatly exceeded by the standard prepared by Gray [28] to apply to boys of the private schools patronized by the well-to-do. The *tall* standard applies to a stature attained by only one to 3 per cent of the population. The *short* standard up to age thirteen applies to low medium rather than short up to age fourteen and then drops to a distinctly short percentile grade at ages sixteen and over. It appears best to reserve the range of the probable deviation from the mean, from percentile grades 25 to 75, for medium stature and to call those falling outside of this range respectively short and tall.

For the girls, the Baldwin-Wood *medium* stature standard hovers above the 75 percentile grade on the border line between the medium and short as thus defined. The *tall* standard represents a stature attained by less than five per cent of the general population. The *short* standard runs at about the 40 percentile grade to age nine and then drops to the 25–30 percentile grade for the older girls. The Baldwin-Wood tables for stature do not fit well with the Woodbury data with which they are coupled and which have been utilized in preparing the percentile grades for the preschool children.

Weight

We classify persons according to weight as heavy, medium, and light. As in the case of stature, the most practical division between these three groups appears to be one in which the medium range embraces the middle 50 per cent of the individuals selected to furnish the standard; the heavy, the upper quartile; the light, the lower quartile. Weight is closely correlated with stature, and where practical it is best first to classify individuals according to stature and then to classify individuals of a given stature as medium, heavy, or light, relative to that stature.

Weight relative to stature may be considered from two points of view, that of physical build and that of physical condition.

From the standpoint of build, weight represents the bulk of the body relative to stature, and light and heavy are terms essentially synonymous with slender and stocky. Differences in weight are due primarily to differences in skeletal proportions, muscular development, and other inherent physical traits determined by heredity and the whole life history of the individual.

Weight relative to stature is also of interest from the point of view of the present physical condition of the individual. Starvation and disease may produce loss in weight, and overeating and certain diseases may give rise to excessive weight. Weight relative to stature and age in children has received chief popular interest from the standpoint of nutrition. This aspect of the subject and the popular fallacies connected with it is considered in *Appraisement of the Child.**

We are primarily interested in constitutional types. While no sharp lines can be drawn between the light or the heavy and those of medium build, we have in this general classification the most obvious classification of physical types within groups of individuals of the same age, sex and race. There is considerable evidence that both psychological and physiological factors are involved in these fundamental types, but into this aspect of the subject we cannot enter at this time.

The value of height-weight tables in the classification of those of slender, stocky and medium build is to give, so far as these factors will allow, mathematical precision to the grouping. Weight relative to stature varies with age, and for this reason the age factor must be considered in the use of height-weight tables. We shall not here attempt to enter into an extended description of the data on height-weight-and-age.

The best data at present available are those of Woodbury[49] on preschool children. These show that during the first year weight relative to stature varies with age. For a

* "Physical Status." *Growth and Development of the Child,* Part IV.

given stature the average weight of the older infant is greater than that of the younger infant. For a given stature and month of age the probable deviation from the average runs at about 7 to 8 per cent. Those who vary more than this from the average may be considered heavy or light relative to stature and age. This is also true of the newborn.

During childhood, from the latter part of the first year until puberty is approached the average body weight for a given stature varies comparatively little with age. For the preschool period use may therefore be made of the tables given by Woodbury of the average weights for a given stature for each sex irrespective of age. These data show for a given stature a probable deviation in weight from the average decreasing for boys from 9.8 per cent at 23 in. to 7.3 per cent at 27 in. and 5 per cent at 45 in., and for girls a decrease from 9.4 per cent at 23 in. to 7.3 per cent at 27 in. to 5.4 per cent at 45 in. For children from one to six years of age the medium range of weight may be taken to be within 6 per cent above or below the average weight for a given age and stature.*

For older children there are abundant data on average weight for a given age, but these data suffer in the main from including the variable factor of clothing. The data on weight for a given age and stature are less abundant and on the whole are unsatisfactory for the purpose of standards based on a cross section of the population. Such data as are available indicate a gradual increase in the probable deviation from the mean weight for a given age and stature. For boys the increase appears to be from about 5 per cent at six years of age to 7 per cent in the young adult. For girls the increase appears to be from about 5 to 6 per cent at six years of age to about 9 per cent in the young adult. These figures relate, however, to those of medium stature for a given age. The extremely tall or short show a greater variability in weight.

* The actual distribution of weight for stature is skew. The average is greater than the median weight and the weight intermediate between that of the 25 and that of the 75 percentile grades falls between the mean and the median weight. For practical purposes the probable deviation from the mean offers, however, a satisfactory medium range.

Body Build and Relative Proportions

We have seen that while mere size, as estimated from measurements such as stature and weight, has value in study of the human constitution when considered relative to age, sex, and race, the value of such measurements is increased if considered also from the point of view of body build. Since build deals essentially with the relative proportions of various parts of the body to one another, it is convenient to select one measurement as a standard with which other measurements may be proportionately compared. Stature is the measurement most frequently used for this purpose, and on the whole is the most suitable. Any other linear measurement may be proportionately compared with stature by dividing this measurement by stature and multiplying by 100. Surface measurements may be similarly compared with stature squared, volumetric with stature cubed.

Relative Bulk. The popular method of expressing bulk of body relative to stature is to use weight to represent volume. Since the specific gravity of the body as a whole is not far from that of water, weight in grams very nearly represents volume in cubic centimeters. When pounds are used to express volume, a pound may be considered roughly to represent a 3 in. cube or 27 cubic in. For individuals of a given stature, the average cross section of the body varies directly as the weight, and relative weight is a good index of the bulk of the body relative to stature. A fat, small boned person of a given weight has, however, a greater bulk than a muscular, heavy built person of the same stature and weight, since his specific gravity is less. In any case a given linear measurement in a transverse plane, such as a width or depth or circumference, varies on the average, not directly as the weight, but as the square root of the weight. The amount any given linear measurement varies depends upon the shape of the body as a whole and the shape of the cross section involved in the measurement.

So long as we are dealing with individuals of the same stature, the matter is comparatively simple, but if we desire to use weight relative to stature as a measure of relative bulk in individuals of different stature, the situation becomes much more complicated. Weight representing volume has not the same relation to stature in persons of the same proportions but varying in stature. A volumetric measurement cannot be proportionately compared with a linear measurement. To overcome this difficulty we may compare the volume as represented by weight with a volume the size of the cube of the stature. This is the underlying principle of Rohrer's * index of relative bulk, $\frac{\text{body weight}}{\text{cube of stature.}}$

For ordinary purposes it is more convenient to make use of height-weight tables and to compare the weight of a given individual with the average weight for individuals for the same stature and stage of development.

The chief changes in the proportions of the body during growth may be summed up as follows:

First half year after birth, *infancy,* rapid growth but relatively slight changes in bodily proportions.

From this period to puberty, *childhood,* growth of limbs rapid, head slow, trunk intermediate.

Puberty to maturity, *adolescence,* growth of trunk and limbs at first about equal in the male, followed by a relatively more rapid growth of trunk. Growth in girth of trunk continues longer than growth in length. In girls the trunk is elongated in the lumbar region and the pelvis is enlarged while the lower extremities cease to grow proportionately with the trunk. Growth in stature ceases earlier than in boys and increase in width of trunk, except in the pelvic region, is less marked during the latter part of adolescence.

Period of relatively stable proportions, *maturity.* Some increase in thickness of muscles during the early part of this period and of fat in the latter part.

Period of decline, *old age.* Loss of fat and musculature, decrease in stature and in relative length of spine. These changes may be illustrated by the changes which take place in volume in the various parts of the body.

* For a further discussion of this subject see Bardeen.[4]

For an infant 21 in. long and weighing 8.5 lbs.; a child of five, with a stature of 42 in. and a weight of 39.3 lbs.; and a youth of fifteen, with a stature of 63 in. and a weight of 104.5 lbs., Bardeen[4] estimated the following relative volumes. The neck is divided between head and trunk:

	Infant	Child	Youth
Head	0.280	0.164	0.082
Trunk	0.495	0.523	0.523
Lower extremities	0.135	0.226	0.292
Upper extremities	0.090	0.087	0.103
	1.000	1.000	1.000

These data may be compared with similar data for a mature man 67.5 in. tall, weighing 148 lbs.; a mature woman 63 in. tall, weighing 127.5 lbs.; and an old man 67 in. tall, weighing 155 lbs.:

	Mature man	Mature woman	Old man
Head	0.071	0.068	0.070
Trunk	0.542	0.527	0.573
Upper extremities	0.285	0.320	0.265
Lower extremities	0.102	0.085	0.092
	1.000	1.000	1.000

These changes in volumetric proportions during the life cycle are accompanied by changes in linear proportions which are discussed by Bardeen. The linear measurements most frequently used in the study of the proportions of the body are chest girth and sitting-height.

Relative chest girth at rest, on the average, decreases from about 67 per cent in the young infant to about 48 per cent at puberty and then increases to about 50 per cent in women and to over 50 per cent in men, becoming greater as a rule in short than in tall individuals. The tall show an average chest girth of less than 50 per cent of the stature. The technical difficulties connected with measuring chest girth make it an unsatisfactory measurement for the purpose of classification of build. Into a discussion of these difficulties we shall not attempt to enter here. Available statistics indicate a probable variation in chest girth for a given stature and age of about 4 per cent of the stature, or 2 per cent of the mean girth for that stature. In *Anatomy and Physiol-*

ogy * a probable variation of about 7 to 8 per cent in vital capacity for stature is indicated.

Sitting-height, or stem length, offers the most convenient method of estimating limb length relative to stature, since stature less stem length, while not measuring stem length, is a good index of limb length. The long stemmed are short limbed, the long limbed are short stemmed. Sitting-height relative to stature on the average in white American children decreases from about 67 per cent of the stature in the young infant to 56 per cent in a child 42 in. in stature, and to 51.5 per cent in a boy 63 in. in stature. It is, as a rule, smallest about the period of puberty. In girls, in whom puberty is reached earlier than in boys, the sitting-height does not on the average decrease below 52 per cent of the stature. During adolescence in both sexes the relative sitting-height again increases. In young men 68 in. tall the mean sitting-height is about 52.5 per cent. In young women 63 in. tall, it is 53.2 per cent. But young women 68 in. tall have a mean relative sitting-height of 51.8 per cent. The increase in relative sitting-height during adolescence is more marked in the short than in the tall. Available data show that for a given stature and age the probable deviation in relative sitting-height is about one per cent of the stature. Thus if the average relative sitting-height is 50 per cent of the stature, those with a relative sitting-height of over 51 per cent would be long stemmed or short legged, those of a relative sitting-height of less than 49, short stemmed or long legged. From this point of view most Negroes are short stemmed at all ages.

Internal Structure

We know little of internal differences in structure corresponding with external differences in form. The female skeleton compared with the male is, as a rule, smoother. The same is true of the skeleton of the slender individual as compared with the stocky. The female body, compared with the male, has relatively more fat, especially subcutaneous fat, and less

* "The Respiratory System." *Growth and Development of the Child,* Part II.

muscle. The stocky individual usually has both more fat and more muscle than the slender individual. The long axis of the heart is usually more toward the vertical in the slender than the stocky individual, and the heart is more apt to be relatively small. The stomach in the slender individual is apt to be of the fish-hook type, extending to the pelvis. In the stocky individual its long diameter is more apt to approach the transverse. The transverse colon is more apt to loop down toward or into the pelvic cavity in the slender than in the stocky individual. The viscera of young children in general position more nearly resemble those of the adult stocky individual. In the metamorphosis which takes place about puberty, the general relations described for the slender become more frequent. A vast amount of work still remains to be done before we shall have much definite information on the relation of structure to external form. (See Mills,[32] Moody,[34, 35] Bryant,[17] Bean,[9] Bardeen.[6]) The changes in the shape of the stomach which take place during childhood are discussed in *Anatomy and Physiology.** Differences in posture associated with extremes of body build are discussed under "Body Mechanics" in this volume.

Graves [50] has made an extensive study of the origin and distribution of scapular types in human and other mammalian material, and has found an interesting relationship which he feels may have a bearing upon individual fitness. His classification is based primarily upon the character (convex, straight, or concave) of the greater portion of the vertebral-border contour below the scapular spine in its relation to a straight line. The classification is based secondarily on an assemblage of variations peculiar to or more frequently found in each type. It has been shown that the concave and straight types have twelve or more features in common, and therefore constitute *variant* types contrasting vividly with the convex type. Consequently Graves has combined the straight and concave forms and designated them the scaphoid types.

Scapular types are inherited morphological features; by the twelfth fetal week the human scapula has attained the

* "The Digestive System." *Growth and Development of the Child,* Part II.

general form it apparently ever after retains, and in this early period of development the same scapular types are found as in all subsequent periods of prenatal and postnatal existence. Mixed types may be found, that is, in the same person the scapular border may be convex on one side and concave on the other, or convex on the one side and straight on the other, or straight on one side and concave on the other. Such asymmetries are independent of right or left handedness, occupation, disease, or other environmental influences, and are found in some mammals other than man.

Graves believes that it is among persons disclosing innate defectiveness in adaptations, characterized mainly by definite asymmetries, disproportions and disharmonies in total make-up, that the straight and concave types of scapular border are most frequently found. The scaphoid types (straight and concave) predominate in frequency of occurrence in the young and relatively young and the convex types predominate in frequency of occurrence in the old and relatively old, regardless of the nature of the material (excellently, well or poorly adapted). As the evidence indicates that the type does not change in any given individual during the course of years, these differences in percentages could only be explained on the basis of greater morbidity and mortality among the possessors of the scaphoid than the possessors of the convex type, and good adaptations and decreased morbidity and mortality in many possessors of the convex type.

Correlation of the particular scapular type with other inherited variations coexistent with them may give a basis for correlation with various morbidities.

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THE DEVELOPMENT OF PHYSIOLOGICAL STABILITY

ONE of the most striking and fundamental characteristics of adult human beings is their maintenance of certain normal physiological conditions. This remarkable stability is automatically preserved. It depends proximately on the maintenance of uniform conditions in the blood and lymph, which form an internal environment, or fluid matrix, for the living cells. Lower animals which are incapable of keeping this internal environment constant are limited by changes in the outer world. For example, the frog, which is unable to preserve its body fluids and unable to maintain in them a uniform temperature, must remain near water and must spend the winter submerged in the mud at the bottom of a pool in order to continue living. Reptiles can preserve their body fluids but have not acquired a control of temperature, and therefore, like the amphibians, they must hibernate during cold weather. Furthermore, there are changes produced in the fluid matrix by bodily activity itself; and all animals, the higher as well as the lower, would be limited in their functions if these changes should persist. It is in the highest degree important, therefore, that the mechanisms which maintain stability of the fluid matrix should operate promptly and effectively to restore the normal state when it has been disturbed. Ordinarily they do so. Any condition which tends to shift the state of the blood in one direction or another is promptly met by righting or compensatory process which operates to bring back the former natural state.

Among the constants of the blood are its sugar content, its temperature, its water content and its acid-base reaction (hydrogen ion concentration). Thus if, as a result of a dose of insulin, the blood sugar tends to fall below its normal range between 100 and 170 mg. per cent and reaches a "critical level" at about 70 mg. per cent, the sympathetic system comes into action and liberates sugar from the liver so that the organism is preserved from the dangers of convulsion and coma which occur if the sugar is reduced to approximately 45 mg. per cent. On the other hand, if the blood sugar rises above 170 mg. per cent, it is ordinarily prevented from rising much higher by escape through the kidneys. There is evidence also that, as it rises to this higher side of the range, the internal secretion of the pancreas operates to bring about storage and to increase utilization of sugar. By these means, the sugar content of the body fluids is preserved at a fairly constant level. Again, strenuous muscular work produces acid substances in the blood. This appearance of acid is not without danger. As is well known, in pathological states a condition of acidosis may develop to such an extent that the functions of the nervous system are impaired, and if the situation is not rectified, coma and death supervene. Long before that stage is even approached as an effect of muscular effort, corrective and protective processes are started and are vigorously maintained. The non-volatile lactic acid is burned to volatile carbonic acid which can be rapidly discharged; the carbonic acid is driven off by deeper breathing, and simultaneously the extra oxygen needed to burn the lactic acid is supplied to the blood. The circulatory adjustments such as constriction of the splanchnic vessels, acceleration of the heart, and discharge of extra corpuscles from the spleen, are all directed towards supplying oxygen to the active regions where the lactic acid is burned and whence the carbonic acid must be removed. The respiratory processes are automatically augmented by the extra carbonic acid. It is probable that with the deeper breathing there is a dilation of the bronchioles which reduces the frictional existence of the to and fro movement of the air within them. Thus, by these natural automatic reactions, a fairly steady state of the acid-base relationship in the blood is maintained at times when it may be dangerously threatened.

It appears that the mechanisms which maintain uniformity in the fluid matrix of the body of adults are not fully developed in the early life of the human being. With respect to temperature, for example, the infant is much less stably organized than is the adult. This fact is well recognized by surgeons who have to operate on the very young. Infants not only have a larger relative surface through which to lose heat to the outer world, but they are less quick and less effective in the reactions which preserve the normal state when the temperature varies. As a result, there may be sharp drops in the body temperature on exposure to moderate cold. Also there are sharp rises of the body temperature to fever height in the presence of mild infections or digestive disturbances. The fair degree of uniformity which prevails in later life under similar circumstances has not yet been acquired. Recent observations have indicated that there are similar large variations in the blood sugar of the newborn. In the early days of infancy the sugar content may not infrequently be as low as 70 or 45 mg. per cent, and from day to day there are oscillations in a given individual which are considerably greater than in the adult. The way in which these regulatory mechanisms become more effective in keeping the conditions in the fluid matrix steady, is not yet understood. The stability of the adult may be due to exercise of the stabilizing agencies or may be a natural process of development as years pass.

The lack of organic stability in the newborn indicated by the observations mentioned may be characteristic of other states which are considered constant in the adult. It would be well worth while to study infants and young children with this idea in mind. Is the water balance preserved as well in childhood as in adult life? Are conditions which produce convulsive attacks more readily developed in the early years of life than later? A study of pulse and blood pressure might reveal that there are large oscillations in this important regulatory apparatus, much larger than are seen after adulthood is reached. In support of this suggestion, the occasional complaint by children of dizziness on rising from a chair may be cited. This is an indication of lack of prompt adjustment of circulation, which normally disappears as the individual grows older. May not the nervous system have analogous instability, for example, a deficient control of the lower emotional centers in the basal ganglia by the superior and more recently developed cortical neurones, so that the fits of temper, the emotional upsets, the turbulence and unrest which are characteristic of childhood and which slowly disappear as the child grows into youth and middle age, may be indicative of what occurs in other systems? The gradual development of various automatic stabilizing controls presents a largely neglected field of research. It is highly probable that, through an understanding of the processes by which effective stabilizing factors are gradually established, we should be in a position to judge more fairly the status of the growing child and to predict more reasonably what may be expected as time permits the slow stages of development to occur.

The foregoing facts and suggestions are set down with the idea that a primary and important aspect of the biology of man, his steady and stable states, should be examined with reference to their characteristics in the early years of life. This fascinating subject, which is not being studied in its more complete manifestations in adulthood, should be studied carefully also in its beginnings. Disease and disorder in the body are largely due to uncontrolled shifts of steady states beyond the usual range of recovery. It seems probable that an investigation of the oscillations of the normally constant states as they appear in exaggerated form in infants and children would throw light on the ways in which abnormal conditions arise, not only in the child but in the adult.

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TEMPERATURE REGULATION OF THE BODY

GENERAL CONSIDERATIONS

HEAT is produced within the body as the result of oxidation of food or body substances, and is the final result of the transformation of energy in the human being. Day and night it is being produced, sometimes more and sometimes less according to the needs of the body, but never less than a minimal amount in the warm-blooded matured human being. Since new heat is being continuously produced, the excess must be eliminated from the body. This is accomplished through the mouth and respiratory passages, excreta, and by means of the skin. The balance between heat production and heat loss is maintained by a very sensitive and complicated mechanism in such a manner that the temperature of the human body is kept at a very constant level. The importance of understanding this relationship was appreciated by Sir Francis Bacon in *Novum Organum*. Since then a large amount of painstaking and important work has been done, but there still remain many factors to be studied and explained.

There is a standard amount of heat production in every individual which varies with the height, weight, age and general conditions of the individual, but remains constant in that individual when it is determined under basal conditions. It results from the muscular activity of respiration, of the heart beat, general muscular tone, and probably the normal activity of other organs of the body. Under normal conditions the heat thus produced cannot fall below a minimal level, but it may be increased, particularly by muscular activity. When more heat is needed, as in cold environments, muscular exercise, voluntary or involuntary (shivering), can come into play to increase it, and thus counteract any fall in the external temperature. Heat production is also increased by food and more especially protein, the digestion of which results in a greater formation of heat than does either fat or carbohydrate.

The rate of heat dissipation from the body depends upon several factors. When this is considered solely from the standpoint of physics, it is obvious that the greater the relative amount of surface there is to the bulk of the body, the greater will be the loss. If this were the sole responsible factor involved in the loss of heat from the body, heat production would then depend solely upon the size of the surface area of the body. This, however, has not been found to be the case, as is illustrated by the heat production of infants and children of different ages. Other factors therefore come into play which influence the loss of heat from the body.

There are five main avenues through which heat may be lost from the human body: (1) radiation, conduction and convection of heat from the surface of the body, (2) evaporation of water from the skin, (3) vaporization of water in the lungs, (4) loss of heat in urine and feces (insignificant), and (5) warming food and air which enter the body. Heat loss may be increased by dilation of the peripheral blood vessels, and an increased rate of circulation in the skin and mucous membranes. Increased respiration carries more heat and water from the organs of respiration. Increased evaporation of water increases the cooling of the mucous membranes of the air passages; sweating increases the loss of heat from the skin. It is supposed that during health an increase in the temperature of the blood excites the centers of the sweat nerves and vasodilator nerves.[3] Sweating results in the adult when the rectal temperature is raised on an average of 0.34° C (0.61° F) and during exercise 0.43° C (0.93° F). No observations have been made on children.

Too great a loss of heat from the skin will either cool the body, or cause shivering, which will increase the amount of heat production and thus compensate for the heat lost. Shivering usually results in the adult when the rectal temperature of the adult drops 0.26° to 0.88° C (0.47° to 1.55° F). This problem has not been studied during infancy and childhood. The regulation of heat loss, however, is very sensitive so that when the surface blood is cooled there results a constriction of the peripheral skin blood vessels and a slowing down of the capillary circulation in the skin, accompanied by dilatation of vessels supplying the internal organs, thus conserving body heat.

This is summed up by Baylies [8] as follows: "The struggle against cold is *preventive* and obstructs loss of heat; that against heat is rather *curative* and increases the loss of excess heat produced, rarely being able to diminish production to an effective extent."

It is clear that a heat coordinating or a heat regulating center is needed to correlate all the functions which take part in maintaining the body temperature at a constant level. Evidence from animal experimentation places this mainly in or near the optic thalamus and corpus striatum. It is presumed, but not proven, that nerve endings in the skin which are sensitive to temperature changes are connected with some center, but it is possible that the regulation of heat dissipation may be referred directly to changes in temperature of the blood.

NORMAL BODY TEMPERATURES

Methods of Determining Body Temperature

No measurements have ever been made of the temperature of the body as a whole; the temperature 37.0° C (98.6° F) usually used to represent the temperature of the body as a whole is that obtained in the rectum. It is obvious that this represents only the temperature at that point and of the parts immediately adjacent. It does not tell what is the temperature of the heart muscle or the brain. It is probable that when the rectal temperature is correctly taken it gives a reading which does not vary much from the temperature of other parts of the interior of the head and trunk.

The rectal temperature, therefore, is usually taken to represent the temperature of the body. The accuracy of the rectal temperature readings depends upon the distance the thermometer is inserted into the rectum. The standard distance which a mercury thermometer should be inserted into the rectum of a child is 5 cm. (6 to 7 cm. in the adult). If the thermometer is inserted less than this, errors may result; the lower the body temperature the greater the possibility of error. When a mercury bulb thermometer is inserted 7 to 14 cm. within the rectum, the temperature is found to be 0.2° to 1.3° C (0.36° to 2.34° F) higher than readings taken at 2 to 6 cm. This is true in normal patients and those with fever, and applies equally to the infant and young child. Temperatures taken in the axilla and groin usually are lower than those taken in the rectum, but they may be higher. The temperature of the stomach has been found to be 0.12° C higher than that of the rectum. That this higher temperature may be due to the proximity of the stomach to the liver is suggested by the fact that in animals the temperature of the liver is more than one degree C warmer than that of the rectum.

Daily Variations in Temperature

Normal healthy individuals may have a difference in temperature in the same day of between 1.0° and 1.5° C (1.8° and 2.7° F). The minimum usually comes between 3 and 6 A.M., and the maximum between 5 and 8 P.M. The fall in temperature during the night to the early morning minimum is thought by some investigators to be independent of the mode of life, while others bring proof to show that the mode of living was the determining factor. No studies have been made on normal healthy children or infants to answer this question.

Seasonal Variation

Seasonal variation of the body temperature of school children was studied by the New York State Commission on Ventilation, and it was found that in summer whenever the outdoor temperature exceeded 18.3° C (65.0° F) there was a tendency of the body temperature to rise over its normal value of 37.0° C (98.6° F). This is also true of adults. Undoubtedly it would be of great interest to amplify the existing meager data on this subject.

Temperatures at Various Ages

Fetus. The only knowledge available which throws any light on the temperature of the fetus is indirect. The temperature of the pregnant uterus of animals is about 1° C (1.8° F) warmer than that of the non-pregnant uterus. The human fetus, as well as that of animals, has its own metabolism. The work of Murlin[10] seems to indicate that the heat is produced in the fetus in amounts which correspond with its development, which leads to the conclusion that the total amount of heat produced will increase with the progress of pregnancy. This heat must be excreted and carried away from the uterus mainly by the blood stream of the mother. It would, therefore, not be surprising if during the latter stages of pregnancy the activity of the fetus resulted in an increase in heat production. This would explain the higher temperature of the pregnant than the non-pregnant uterus. There are so far as can be ascertained no direct measurements of the temperature of the human fetus.

Newborn Infant. The average rectal temperature of infants during the first eight days of life is shown in Table 1.

TABLE 1

THE AVERAGE RECTAL TEMPERATURE OF INFANTS DURING THE FIRST EIGHT DAYS AFTER BIRTH. BENEDICT AND TALBOT[4]

Age	Number of subjects	Average temperature	
		°C	°F
1 to 12 hours	48	36.7	98.1
12 to 24 hours	26	36.9	98.4
1 day	74	36.8	98.2
2 days	65	37.1	98.8
3 days	62	37.2	99.0
4 days	51	37.0	98.6
5 days	41	36.9	98.5
6 days	22	37.0	98.6
7 days	16	36.9	98.5
8 days	9	37.1	98.8

Premature Infant. It is difficult to speak of the temperature of a premature infant in the same sense as we speak of the temperature of a fully developed infant or older child, for it is far more variable and more dependent on its surroundings. Regulation of body temperature involves many and complex physiological mechanisms and depends on a nice adjustment of blood flow to various parts of the body, and it is not surprising to find that the nervous adjusting mechanism of the human develops completely only during the final month of gestation. Previous to this there may be a more or less rudimentary control, but the function is only fully established after the normal time of birth. This gives rise to the practical necessity of guarding carefully the temperature of the surroundings of premature babies in order to prevent undue heat loss.

The younger the newborn the greater is the difficulty experienced in maintaining the body temperature at a constant level. This can only be accomplished in some newborn infants by using the same precautions as are used in premature babies.

TABLE 2

RECTAL TEMPERATURE OF AN INFANT TAKEN AT FREQUENT INTERVALS DURING EARLY HOURS AFTER BIRTH

	Rectal temperature °C	Rectal temperature °F
Time of birth 4 h. 01 m. p.m.	....	....
4 06 p.m.	37.0	98.6
4 17 p.m.	37.0	98.6
Bath 4 h. 20 m.–4 h. 45 m. p.m.		
4 46 p.m.	36.4	97.6
4 56 p.m.	35.2	95.4
5 23 p.m.	35.2	95.4
5 49 p.m.	35.4	95.8
6 17 p.m.	35.7	96.2
6 44 p.m.	36.0	96.8
7 09 p.m.	36.0	96.8
7 34 p.m.	36.3	97.4
7 59 p.m.	36.3	97.4
8 25 p.m.	36.4	97.6
8 50 p.m.	36.4	97.6

Temperature records in Table 2 illustrate how rapidly and profoundly exposure in the form of a water bath with the temperature of the water 102° F and the temperature of the room 71.0° F can affect the rectal temperature of a full-term infant.

It was found in these newborn infants that there was a distinct correlation between the body temperature and the total metabolism, for on the days with low body temperature the total heat production was likewise low. It is apparent that the balance between heat production and heat loss in the newborn infant had not been satisfactorily reached in the infants whose body temperatures were subnormal. It was observed that such infants did not shiver and cry to the same degree as the stronger infants, and in consequence it is inferred that sufficient heat was not produced to balance the heat lost. This did not occur in strong vigorous babies or when great precautions were taken to prevent cooling.

Older Children. The average temperatures found for children of different ages are given in Table 3.

TABLE 3

AVERAGE TEMPERATURES BY AGES

Age	°C	°F
6 to 8 days	36.8	98.4
4 to 5 weeks	37.1	98.8
2 months	37.1	98.8
6 months	37.2	98.9
2 to 5 years	36.9	98.5
18 to 22 years	36.9	98.5

INFLUENCES WHICH AFFECT BODY TEMPERATURE

Surrounding Temperature

The effect of cold on the temperature of the body depends upon the age, strength, and physical status of the individual. In adults exposure to temperature of 10.0° to 20.0° C (50.0° to 68.0° F) or less causes shivering and thus increases the heat production, which compensates for the excess heat loss from the body. The temperature of the body is thus kept at its normal level. Heat production must balance heat dissipation. It will be shown later in this section that the temperature of the skin does not react alike on all parts of the body, the extremities cooling quicker than the trunk. In the absence of muscular exercise, voluntary or involuntary, the body temperature eventually falls when exposed to cold.

Very few observations have been made on this point during infancy and childhood. It has been shown above that very slight exposure of the newborn infant will result in many instances in a lowered body temperature. Such infants react to external cold as do the cold-blooded animals. With increasing age exposure to cold is counteracted by muscular exercise in the same manner as in the adult. There is also good evidence showing that excessive loss of heat is associated with increased activity of the endocrine glands.[5] Bast and others[2] showed degeneration of thyroid and adrenal glands upon exposure to cold temperature.

Very few accurately controlled observations have been made during childhood. Talbot has found (unpublished data) that when the surrounding room temperature is between 21.0° and 22.0° C (69.8° and 71.6° F) the body temperature of some children is increased from 0.2° to 0.7° C (0.36° to 1.3° F) during exposure of between twenty-five and forty-nine minutes. In the majority of cases it is slightly decreased. There is no data available to show how and to what extent the body temperature would have been affected in cooler surroundings or after longer exposure. The increase in body temperature was not accompanied by visible or recognizable shivering, but goose flesh was noted over the body of many of these children.

With surrounding temperatures of between 24.5° to 29.1° C (76.2° to 84.5° F) no goose flesh or shivering was observed. Some of the children, however, perspired. If this latter group is eliminated it is found that in an equal number of children the body temperature rose or fell during exposure.

Other factors than surrounding temperature alone must be taken into consideration in estimating the reaction of the body to its environment. Some of these will be discussed later.

Humidity

Humidity has a very important influence on heat dissipation, especially in high temperatures approaching the temperature of the body. High humidity counteracts the effect of sweating or the cooling of the skin by interfering with the evaporation of water, thus diminishing heat loss from the surface of the body. If heat dissipation is interfered with sufficiently so that the amount of heat produced is greater than the amount of heat lost, there is an increase in the temperature of the body. Although comprehensive investigations have been made on adults in the Research Laboratory of the American Society of Heating and Ventilating Engineers, in cooperation with the United States Bureau of Mines and the Public Health Service at the Pittsburgh Experiment Station,[17] no work has been done on infants and children.

Exercise

Muscular exercise increases heat production.* Although the increase may be approximately 30 per cent in infants when distributed over twenty-four hours, it may be temporarily much greater than that. The amount of extra heat produced at any age is determined primarily by the severity of the exercise. During moderate to severe exercise there is usually an accumulation of heat in the child's body (unpublished data) which results in a temporary rise in the mouth temperature. Within a short time after a six minute period of exercise, usually less than one-half hour, other factors begin to compensate and the temperature begins to return to normal. The available data of the effect of exercise on the body temperature of children, and especially infants, are very sparse.

Sleep

It has been shown that the lowest diurnal range of temperature comes between 3 and 6 A. M. The only attempt discovered to connect this fall in temperature with sleep in childhood was made by Allix.[1] His results are shown in Table 4.

Clothing

The human being comes into this world entirely devoid of any protection against cold. In tropical countries this may be of little importance, but in temperate or colder climates

* "Metabolism." *Growth and Development of the Child,* Part III. *Nutrition.*

Table 4

Effect of Sleep on Body Temperature

Age	Normal Cases A			Abnormal Cases B			Greatest and Smallest Differences		Average of All Cases		
	Awake °C	Asleep °C	No. cases	Awake °C	Asleep °C	No. cases	A °C	B °C	Awake °C	Asleep °C	Difference °C
0 to 12 days	37.80	37.20	12	37.7	38.0	4	1.0 0.3	0.5 0.1	37.78	37.40	0.3
5 to 16 months	37.86	37.07	7	37.6	38.0	1	1.0 0.5	... ...	37.75	37.14	0.5
20 months to 4 years	37.70	37.12	8	37.2	37.8	2	1.0 0.0	0.8 0.4	37.60	37.26	0.3

some protection is needed during the entire lifetime. This is obtained by clothing. Loss of heat from the body depends in general upon the gradient between the temperature of the surface of the body and the surrounding air. This is modified by clothing which aids the body by preventing the loss of heat. Air is entangled and held stationary within its meshes and between its layers. As a result the temperature surrounding the skin is higher than that of the air outside the clothes. This still air is a non-conductor of heat, and gives the body what is called by some investigators the *private temperature*. The body is insulated against heat dissipation and as a result the amount of heat lost by radiation and conduction is diminished. Under certain conditions the heat lost by evaporation is increased by clothing.

The loss of heat through clothing is influenced by its thickness, character, and moisture. Dry cotton or wool have the same action, but moist wool prevents the loss of heat much better than moist cotton.

Although much well controlled work has been done on adults, there are few available data which give the effect of clothing on the body temperature of children. McClure and Sauer[9] made measurements, which have since been confirmed by Talbot, that substantiate the well known clinical fact that heat loss from the surface of the body is prevented by clothing. No studies have been made which are as complete as those made on the adult.

Nervous Influences

There is no collected group of studies of the nervous influences which affect the temperature of children, so that one has to turn to the adult for these data.

After injury to certain parts of the central nervous system there is a rise in body temperature. Although there is evidence that heat dissipation is interfered with by constriction of the capillaries of the skin, there is also evidence that in some cases there is an increase in heat production. Since many factors play a part in heat regulation it has been concluded that a heat coordinating center is a necessity.

It has been shown that puncture of the median side of the corpus striatum in the rabbit will cause a considerable rise in the body temperature and that the application of heat and cold to the anterior end causes a change in the body temperature. The application of cold causes a rise with shivering and vasoconstriction of the skin, and of heat, a fall in body temperature with vasodilation. This suggests that temperature changes of the blood, even though slight, may act upon this center.

The body temperature has also been affected by puncture of the tuber cinereum, which is believed by Ott[11] to be the ruling center in the heat regulation of fever. Injury to other parts of the brain and to the spinal cord in the junction of the dorsal and lumbar regions has also been followed by fever.

Food

Food may affect the body temperature in two ways, by adding heat or cooling the temperature of the body as a result of the temperature of the food itself, and by the increase in heat production which takes place in the digestion and metabolism of the food. The food components, fat, carbohydrates, and protein have different specific dynamic actions or costs of digestion.

Protein costs more to digest than either fat or carbohydrate, and has been held responsible for an increased heat production of about 25 per cent above the basal metabolism in children. In adults it has increased the metabolism 33 per cent. The size of meals plays a part in determining the extra amount of heat produced as the cost of digestion—the larger the meal the more it costs to digest.

Fasting

During complete fasting the body maintains its heat by burning the body tissues. If a complete fast is maintained over a long period, the tissues' supply of food in the body is largely used up, leaving a materially diminished source of heat, and the body temperature falls. The rectal temperature of three children fasted seven to fourteen days therapeutically in the treatment of epilepsy fell 0.2° to 0.8° C (0.36° to 1.4° F). At the same time there was significant lowering of the average skin temperature.[15] Such findings are consistent with the observations on adults and animals.

During partial fasting, such as is seen in severe illnesses, underfeeding, or failure of absorption of food, the same results are to be expected. Although no carefully recorded figures are available, it comes into the every day experience of clinical practitioners of pediatrics, as, for example, in the subnormal temperatures seen after typhoid fever or any other prolonged illness.

Obesity and Undernutrition

It is supposed that fat, which is a poor conductor of heat, acts as a buffer in the obese which interferes with the dissipation of heat and conversely, that the lack of fat, as in malnutrition, increases the ease in which heat reaches the surface of the body and is dissipated. Although many other factors play a part in regulating heat loss, clinical experience seems to substantiate the belief that fat does play an insulating part in maintaining body heat.

Dehydration

The newborn infant who has received too little liquid often has a rise of temperature on the second to fourth day of life. The temperature may rise as high as 106° F (41.0° C). After water is freely given the temperature rapidly falls to normal. This condition has received the names *inanition fever, thirst fever,* and *desiccation fever.* Although the condition is most commonly seen during infancy, it also occurs during childhood under circumstances in which there is a relatively sudden deprivation of liquid. It has also been noted in older individuals in the recently instituted dehydration treatment for epilepsy. It presents a picture very similar to that seen in sunstroke.

Salt Fever

The administration of concentrated solutions of sodium chloride subcutaneously to infants results after four to six hours in a rise in temperature, at times as high as 104° F (40.0° C). It rises rapidly and then falls so that at the end of twelve hours it has returned to normal. The skin becomes bright red and the temperature rises. The resulting fever is apparently due to interference with heat dissipation rather than to increased heat production. During the period of increasing temperature the skin is dry; after perspiration commences the temperature of the body falls. There are very few observations recorded of this phenomenon, and its mechanism has not as yet been completely studied.

The introduction of hypertonic solutions of glucose has also been followed at times by an increase in the body temperature.

Sunstroke

Sunstroke takes place in very hot weather and is accompanied by extreme rises in body temperature. It usually occurs when an individual performs hard work exposed to heat. When the surrounding temperature is close to that of the body, and when the humidity of the air is high enough to interfere with evaporation and the dissipation of heat, conditions are set for accumulation of heat in the body with a rising temperature. This results in a vicious cycle. An increase in body temperature leads to increased metabolism which increases the body temperature further, and this in turn increases still more metabolism and so on. There is suggestive evidence that heat stroke is the result of circulatory failure. This point is not as yet entirely cleared of controversy. When, on the other hand, there is excessive sweating so that the body becomes dried out, the same conditions may arise which bear the name of *desiccation fever* in infancy.

Other Influences

Diarrhea. In severe infantile diarrhea and in Asiatic cholera at all ages, the fluid stools may be so frequent and copious that the body becomes rapidly desiccated. The temperature may be elevated as a result of this.

Aseptic Fever. A certain number of infants who undergo trauma at birth, and older children who suffer from blows on the head, have elevations of temperature. These probably can be classified as neurogenic fevers. In another group fever follows hemorrhages and this type has been attributed to the absorption of blood proteins from the clot.

Drugs. Some drugs lower the body temperature and are therefore known as antipyretics. Among these are antipyrene and quinine. Their action is usually accompanied by vasodilation. B. tetrahydronaphthylamine causes a rise in temperature, some shivering, restlessness, and great vascular constriction of the skin.

THE MEASUREMENT OF HEAT PRODUCTION

The Energy Metabolism. Although a full understanding of the factors which influence the body temperature necessitates the consideration of the energy metabolism, this subject will not be discussed here, as it is taken up in *Nutrition.**

HEAT ELIMINATION

Although there are very few published investigations which give direct evidence concerning heat elimination in children, certain data are available in adults [17] which are

* "Factors Governing the Energy Requirements of Children." *Growth and Development of the Child,* Part III.

undoubtedly applicable to children. These data are obtained either by measurements of heat production by direct calo-

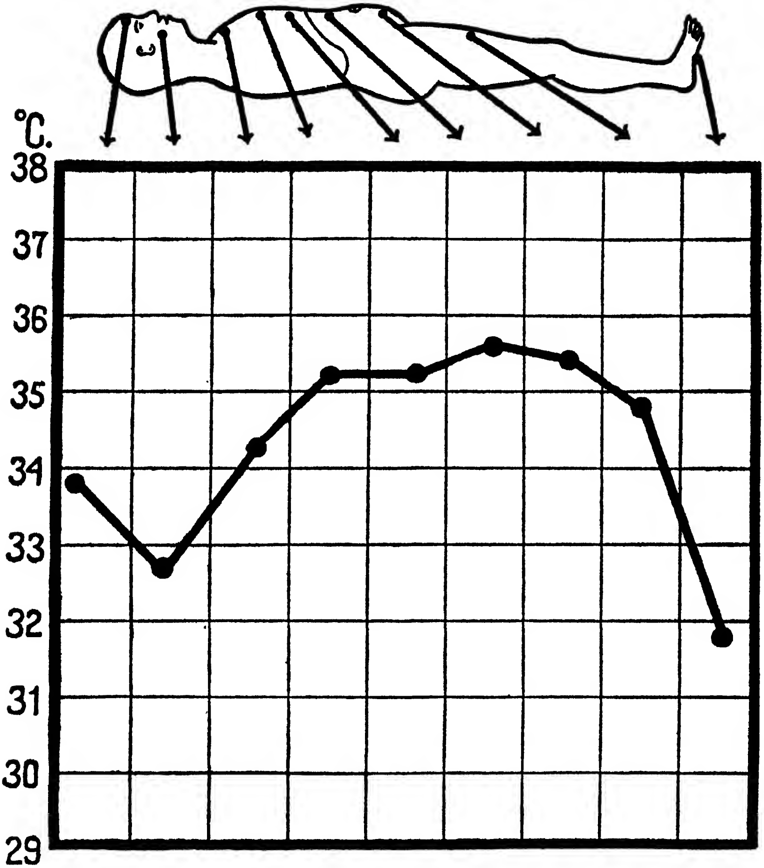

CHART I. AVERAGE SKIN TEMPERATURE OF NORMAL CHILDREN UNDER CLOTHES. (Talbot, Dalrymple and Hendry.[15])

rimetry or by measurements with a thermo-couple and galvanometer of the temperature of the skin.

TEMPERATURE OF THE SKIN

The temperature of the skin differs in different parts of the body. This is illustrated by Chart I.

Measurements of the temperature of skin show that its temperature is in direct ratio to the temperature of the air in contact with it. It is warmer under clothes and is cooler when the subject is unclothed. Different parts of the body react differently to cold; for example, the temperature of the skin of the trunk falls less than does that of the extremities when exposed to cooler air.

When clothing is removed there is a very sudden cooling of the surface of the body as the surface heat is dissipated. The temperature of the skin falls rapidly at first and later slowly until at the end of thirty to forty minutes of inactivity heat production and heat loss are balanced and the temperature of the skin is stabilized at its new level.

Exercise increases heat production so that at first there is a slight increase of body temperature and later an increase of skin temperature. During sleep there are some changes in the temperature of the skin but these have not been sufficiently studied to warrant any statement.

SUMMARY

During the first few days after birth the newborn infant must have special protection against cold, because in the majority the heat regulating centers have not become adapted to the changed conditions, in which the child is removed from surroundings which are kept at a uniform optimal temperature without any effort on his part to adjust to surroundings in which sudden changes of temperature are common. In the latter case heat loss should be prevented by suitable clothing, and the body heat be maintained by the application of external heat. If this is not done the infant must either compensate by increasing his heat production by shivering or crying (muscular activity), or lose heat and have a subnormal body temperature as does the cold-blooded animal. Since subnormal temperatures are dangerous to life, lower all the metabolic functions of the body, and make the baby more susceptible to infection, every means should be taken to prevent their occurrence. In many newborn infants, the functions of the heat regulating apparatus do not become developed for from one to several weeks, as in the case of prematurely born infants. Apparently the sensation of cold is not appreciated, the shivering reflex is not developed, or the muscles are not yet ready to undertake extra exercise to increase the heat production.

In malnutrition or convalescence from prolonged illness other factors come into play. In both instances the body is lacking in fatty tissues. Fat, which conducts heat poorly, acts as a buffer which helps the body to retain heat. In its absence heat may be dissipated more rapidly than is good for the individual and, in consequence, extra precautions should be taken to prevent heat loss in these two conditions. In severe grades of malnutrition and during convalescence from illness, muscle may be lost and muscular tone so diminished that the muscles cannot respond without great fatigue to the needs for greater heat production from exercise or shivering.

The effectiveness of the heat regulating mechanism in adapting the body to cold surroundings depends to some extent on the demands habitually made upon it. In a broad way we may speak of this function as improving with exercise and practice. No careful experimental work has been done on this subject, but from clinical and everyday experience one derives a very strong impression that this is the case. Specifically we are acquainted with the fact that habitual exposure to cool air or to outdoor atmosphere as opposed to artificial indoor surroundings tends to develop a hardiness and an indifference to temperature changes which may arouse the astonishment and envy of the habitually protected individual. The mechanism of this hardiness has not been analysed. In part it may depend on a higher metabolism associated with a higher general muscular tone, but it is not unlikely that the circulatory mechanisms actually become strengthened and more efficient through use.

Although in the normal average individual it may be possible and desirable to exercise the temperature regulating mechanism in this way, the principle should be applied with caution in the cases of very young infants and of convalescence after disease. In the first case the mechanisms which we would be attempting to exercise may not yet be developed to the point of full functional capacity; and in the second case the general bodily tone and the tone of the circulatory system in particular are often so depressed that adequate response to any severe burden is impossible. Furthermore, children may show considerable individual differences in their responses to such treatment, and the suddenness and extent of the temperature changes to which they are to be subjected must be considered in terms of the individual child.

A great deal has been written about fever, but the causes of it are not yet fully understood. Some investigators believe that it is due primarily to increased heat production and others to diminished dissipation of heat. It is probable that both factors are involved but in varying amounts under different circumstances. So many mechanisms can affect heat production and heat dissipation that many investigations will be necessary before the whole picture can be made clear.

Talbot has found that the temperature of the skin of untreated cretins is lower than that of normal children, and that after the administration of thyroid extract in amounts sufficient to raise the metabolism to normal, the temperature of the skin is also raised (unpublished data). Very little is known about the influence of other glands on the regulation of the body temperature of children.

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SLEEP AND REPOSE

"SLEEP is one of the biological rhythms stamped into the organisms by the movements of the planet on which we live." What actually occurs to the human body in sleep has been the subject for much speculation and experimentation, but no one theory is universally accepted. Howell maintained that at the end of the day's activity vasomotor fatigue occurred, and with this, a loss of tone of the nervous centers causing inadequate circulation in the brain. This theory of cerebral anemia has been quite widely accepted, and the fall in blood pressure and the decrease in brain volume during sleep would seem to lend weight to this hypothesis. Associated with the cerebral anemia there is some dilatation of the peripheral capillaries. These physiological findings have not been confirmed by all observers. In fact, some investigators have found that the capillaries of the brain during sleep share the general dilatation of the peripheral capillaries. The toxic theory of sleep is supported especially by Pieron, who maintains that, "Sleep is a suspension of the sensory-motor activities that bring the living into relation with his environment." Sleep, according to him, is induced by auto-intoxication with the products of wakefulness, and is induced by a reflex inhibition of the nervous centers. A third theory of sleep maintains that the terminal ramifications of the nervous system are capable of contraction and extension, and that during sleep contraction occurs which breaks the path of nervous impulses. There is no experimental basis for this hypothesis. Claparède advances a biological theory that the onset of sleep is due to the reaction of momentary disinterest in one's surroundings. This is facilitated by fatigue and the appearance of toxic substances in the blood. Consciousness is maintained by the succession of incoming nervous stimuli, and in sleep these stimuli are disregarded. Those coming from within the body, primarily from the muscles, disappear with complete muscular relaxation. When overfatigue is present the muscles give rise to painful stimuli which cannot be disregarded and sleep is prevented.

More recently Pavlov has proposed the theory that sleep results from a spread of a general inhibitory process through the cerebral cortex. The "central inhibition" is supposed to be one of the fundamental types of activity of the nervous system and to partake equally with excitation in the formation of conditioned reflexes. This interpretation of sleep is supported by a certain amount of experimental evidence, but the nature of the central inhibition is still far from clear, and his observations still require independent confirmation. Another type of theory is that of Hess, who believes that sleep depends on the specific activity of certain vegetative "centers" located in the brain stem. The experimental basis for this interpretation lies in the induction of sleep in animals by stimulating electrically a particular region in the floor of the third ventricle by electrodes introduced by a (previous) surgical operation. Certain clinical neurological observations lend additional support to this type of theory. At present no decision can be reached as between these various theories, but further experimental work will be awaited with interest. The status of the question from the physiological point of view is well reviewed by Kleitman.[1] Kleitman offers still another theory which attempts to reconcile many of the previous suggestions. Its outstanding feature is the emphasis which is placed on fatigue of the neuromuscular system, and on the close relationship between muscular relaxation and sleep.

Whatever the explanation for the phenomenon of sleep, there are certain physiological changes in the body which occur during sleep which have been fairly well established by experimental work. Campbell and Blankenhorn,[2] in observing 25 normal young men, found a drop in blood pressure during sleep from 110 to 101. The greatest drop occurred at about the fourth hour of sleep and this low level was maintained until waking occurred. There was a slowing of the pulse rate parallel with the drop in blood pressure, the rate falling from 75 to 60. These patients were in bed and at rest during the studies. Landis [3] also made observations on normal individuals, and also found a fall in blood pressure from 110/74 to 94/68, and an associated fall in pulse rate. If his subjects were awakened suddenly the blood pressure rose rapidly to the waking level. In order to produce a fall in blood pressure loss of consciousness was essential; the sensation of sleepiness had no effect. He was unable to determine that bodily position produced any influence on these findings. He believed that the changes observed were probably the result of sleep and not the cause of it, although this fact is not definitely determined. There is diminution in the deep reflexes and also in most of the secretions. Sleep is deepest soon after the loss of consciousness, reaching its maximum at about the end of the first hour. Czerny confirmed observations on the depth of sleep, which had been made on adults, by experimental work with children.

There has been a considerable amount of experimental work to determine the effects of loss of sleep. Manaceine [4] kept puppies awake for four or five days and found that loss of sleep was always fatal if prolonged for more than five days. There was a marked fall in body temperature, sometimes down to eight degrees below normal, a decrease in the red and white blood cells, and a loss of appetite with consequent loss of weight. At autopsy there was fatty degeneration of the tissues with collapse of the blood vessels and small capillary hemorrhages on the surface of the cerebral hemispheres. The spinal cord was dry and anemic. Kleitman [5] was unable to confirm all these observations. He did find a loss of weight and muscular power but no change in temperature, heart rate, respiration, hemoglobin, or white blood cells. There was, however, a marked decrease in the red blood cells. The blood sugar and alkaline reserve in the blood remained normal. There was a definite change in disposition. The dogs always became cross and unfriendly. They could be kept awake only by walking, that is, by stimulating constant contraction of the muscles. Study of the nervous system was negative, and the brains observed during the experiment showed no change in the vessels. Neuromuscular fatigue was believed to be mainly responsible for death in puppies.

Patrick and Gilbert [6] were the first to try this method of study on human beings. They kept three young adult males awake for ninety hours. The same difficulty was experienced in preventing sleep as in the experiments with puppies. They could be kept awake only by being very carefully watched and by repeated periods of walking, that is, of muscular activity. Some of them had dreams while they were performing some of the tests. They were unable to prevent sleep by their own will power if sitting down, and during the period of observation, even though they were performing a definite experiment, frequent brief periods of semiconsciousness occurred, that is, they took short naps despite the continuation of mental activity. One of the subjects had definite hallucinations of sight. Oscillating particles of various colors were seen on the floor and in the air. These did not move in apparent location with the movements of the eye, so that they were undoubtedly of central causation. Vision was not disturbed, and these hallucinations disappeared with sleep. Neither of the other subjects presented these hallucinations. All of them showed an increase in weight, an increase in the time necessary to memorize figures, and failure in many instances to perform the memory tests at all. There was inability to concentrate attention on the work, and a decrease in the ability to name a definite number of letters in a given period of time. As soon as the experiment was over the subjects slept from twelve to fifteen hours, waking spontaneously at the end of that time. One of them made up, in the forty-eight hours subsequent to the experiment, 25 per cent, another 16 per cent, and the third 35 per cent of the sleep lost. Sleep immediately after the period of observation was much deeper than normally. It required a very much stronger electric current to awaken them than under normal circumstances. Kleitman [5] repeated some of these experiments on human subjects, keeping them awake for even longer periods of time than Patrick and Gilbert.[6] He observed no gain in weight, no variation in the blood sugar or the plasma CO_2; the red and white cells, the hemoglobin, and the differential count of the white cells remained normal. The heart rate, however, was 17 per cent lower than normal. The blood pressure when the patients were in the horizontal position was lower than normal, but rose rapidly when they were seated. There was no variation in the basal metabolism but a decrease in the secretion of phosphates. This latter observation was consistent with the findings of Patrick and Gilbert[6] who observed an increase in the excretion in the amount of nitrogen and phosphoric acid, and relatively more of the latter when their subjects recovered from the period of insomnia.

Although there is no direct association between these experimental observations and clinical experience there are some suggestive inferences which are interesting. The failure to perform mental work with accuracy and normal speed is commonly observed in children who are constantly deprived of the amount of sleep usually taken. Whether long continued reduction of the customary hours of sleep has any resultant physiological effects we cannot state on the basis of experimental work. This would seem to be a matter worthy of careful study. The relationship of lack of sleep to fatigue is also a subject which should yield valuable information if subjected to experimental investigation. The irritability of children who sleep little is not unlike the bad temper of the dogs who were kept awake for many hours. The application of the physiological data to questions involving the health and well-being of children needs clarification.

SOUNDNESS OF SLEEP

Measurements of many kinds have been made to ascertain how the soundness of sleep varies under different conditions. Most of these tests determine the stimulus of one kind or another, such as sound, pressure, or electric shock, which is just adequate to waken the sleeper. It is unnecessary to recount these experiments, as many of them are unsatisfactory technically and they are adequately reviewed elsewhere,[1] but it is worth calling attention to a new approach to this problem which should yield interesting and significant results in the near future. Records are kept, automatically, either photographically or otherwise, of the movements made by sleepers. Such movements are found to be surprisingly frequent and extensive, and furnish a criterion of what may reasonably be called soundness of sleep. Preliminary results obtained at Ohio State University by such methods applied to children, indicate that such spontaneous movements rapidly diminish in frequency during the first hour in bed, are at a minimum during the next hour, and then progressively increase until morning. Younger children tend to sleep more quietly than older children, and the maximal activity is found at about the onset of puberty. There are also indications of sex differences, seasonal differences, and other points of interest which should be greatly illuminated by the research now in progress.

HOURS OF SLEEP

There have been many observations on groups of children to determine the number of hours of sleep which

TABLE 1

HOURS OF SLEEP OF 1,186 CHILDREN SIX MONTHS TO EIGHT YEARS OF AGE

Ages in years	Total	Night	Nap
6 mos.–1	14.01	11.14	2.48
1 to 1½	13.22	11.20	2.01
1½ to 2	13.21	11.23	1.57
2 to 2½	12.48	11.04	1.43
2½ to 3	12.29	10.57	1.29
3 to 3½	12.16	11.03	1.14
3½ to 4	11.57	10.59	.58
4 to 4½	11.48	11.07	.42
4½ to 5	11.36	11.00	.37
5 to 5½	11.22	11.13	.12
5½ to 6	11.09	10.57	.15
6 to 6½	11.04	11.02	.06
6½ to 7	10.57	10.55	.07
7 to 8	10.55	10.54	.05

children of various ages take. Foster, Goodenough, and Anderson[7] of the Institute of Child Welfare, University of Minnesota, sent a questionnaire to parents asking them to report the total hours of sleep, the hours of sleep at night, and the sleep at nap time. The ages of the children ranged from six months to eight years, and the results indicate the averages from 1,186 replies. No sex differences were observed. They reported the results shown in Table 1, the time being recorded in hours and minutes. They also made a detailed study of the mid-day nap. The length of the nap in minutes when taken, the number of naps a week, and the per cent taking no nap at all are given in Table 2. After two

TABLE 2

LENGTH AND NUMBER OF NAPS TAKEN BY 1,186 CHILDREN

Age in years	Length of nap (when taken) Minutes	Number of naps a week	Per cent taking no naps
2 to 2½	111	6.4	0
2½ to 3	113	5.3	7.4
3 to 3½	105	4.6	12.5
3½ to 4	102	4.0	16.7
4 to 4½	99	2.9	34.2
4½ to 5	90	2.5	31.7
5 to 5½	83	0.8	70.3
5½ to 6	87	0.9	72.1
6 to 6½	84	0.1	88.6
6½ to 7	54	0.3	90.5
7 to 8	...	0.1	....

years of age it was found that there was a slight tendency to sleep less at night among children who had taken a long nap during the day. It was also found that the children who took no nap at all or who took a nap only for a few minutes had a definite reduction in the total number of hours of sleep in the twenty-four hours, that is, the night sleep did not compensate for the loss of the nap.

TABLE 3

HOURS AND MINUTES OF SLEEP OF CHILDREN

Age in years	Hours and minutes
Under 1½	15.046
1½ to 2	13.20
2 to 2½	12.486
2½ to 3	12.486
3 to 3½	12.336
3½ to 4	12.258
4 to 4½	11.57
4½ to 5	12.006
5 to 5½	11.426
5½ to 6	11.00

Fleming also made a study of the sleeping habits of children with the results shown in Table 3, the time being recorded in hours and minutes.

Hughes in a study of the preschool child in Gary, Indiana, found that among 6,015 school children no day naps were taken as follows:

	No nap	*Per cent*
2 and 3 year olds		62
4 and 5 year olds		88
6 and 7 year olds		98

Of the 4,767 children without any day naps the per cents of those taking less than twelve hours' sleep at night were as follows:

	Per cent
2 and 3 year olds	42
4 and 5 year olds	66
6 and 7 year olds	80

Those taking less than ten hours' sleep at night were as follows:

2 and 3 year olds	1 in 17
4 and 5 year olds	1 in 12
6 and 7 year olds	1 in 7

Terman,[8] assisted by Hocking, studied the sleeping habits at night of 2,692 school children six to twenty years old in California and other western states and found the hours shown in Table 4.

TABLE 4

HOURS OF NIGHT SLEEP OF 2,692 CHILDREN SIX TO TWENTY YEARS OLD

Age in years	Hours and minutes
6 to 7	11.14
7 to 8	10.41
8 to 9	10.42
9 to 10	10.13
10 to 11	9.56
11 to 12	10.00
12 to 13	9.36
13 to 14	9.31
14 to 15	9.06
15 to 16	8.54
16 to 17	8.30
17 to 18	8.46
18 to 19	8.46

Studies in England, Germany, and Japan showed considerable variation from these American figures (Table 5).

TABLE 5

HOURS OF CHILDRENS' SLEEP SHOWN BY STUDIES IN ENGLAND, GERMANY AND JAPAN

		6 Years	7 Years	8 Years	9 Years
Riverhill, England..........	Boys	10.30	10.30	9.15	9.15
	Girls	10.45	10.30	10.15	9.30
Bernhardt, Germany........		10.20	9.50	9.25	9.20
Hayaski, Japan.............	Boys	10.05	10.07	9.56	9.40
	Girls	9.44	10.02	9.41	9.47

Although we cannot set up exact standards for hours of sleep, there seems to be quite general agreement that for the first three or four years of life children will take a nap during the day, and that with many children this habit of the day nap is continued to the fifth or sixth year. When the nap is taken at all it is usually on the all-or-none basis, that is, the children either sleep satisfactorily for the full period of time, or they do not sleep at all. Frequently children will sleep two or three times a week but not sleep the other days.

Up to the fourth year of age the day nap very rarely interferes with sleeping at night, and if the nap is omitted it usually means a reduction in the number of hours of sleep in the twenty-four. Beyond the fourth year of age, as a rule children should not be allowed to sleep more than one and a half hours during the day, because of the tendency to interfere with going to sleep at night. It is desirable, however, to continue the day nap as long as possible.

For the night sleep, children up to the seventh or eighth year should have twelve hours, and at the sixteenth year nine hours. Between the eighth and the sixteenth year the reduction in hours of sleep at night will vary with the individual child, but in general these figures may be adopted as reasonable:

Years	Hours
9	11½
10	11½
11	11
12	10½
13	10
14	9½
15	9½
16	9

We have not sufficient data to indicate variations in the quality of sleep nor do we know how great a margin of safety children have in relation to sleep, and we do not know whether there may be unfavorable results from loss of sleep which do not show until later in life. Further investigations along this line may yield interesting and valuable information.

A child cannot be made to go to sleep, but if good sleeping habits are established early he will probably continue to sleep well. There is undoubtedly considerable individual variation in sleep requirements, but we do not know what these variations are, nor do we understand fully the effect which physical disease or defects may have in interfering with sleep.

Good sleeping habits should be established early in life and should begin in infancy. Whatever the theory which explains the causation of sleep it seems to be universally accepted that muscular relaxation and the dissociation of the mind from external stimuli are the two factors which are primarily important. The infant at the beginning of life is relatively indifferent to his external environment and most of the stimuli reaching his brain come from within the body. Therefore, if the infant is free from unusual or abnormally intense stimuli, sleep will supervene easily. From experience we know that this happens. The newborn infant sleeps most of the time, except as the demands of nature, primarily the desire for food, cause him to wake, or painful stimuli either from the gastrointestinal tract or from external sources, produce waking or prevent the resumption of sleep.

The infant's sleeping habit may be aided by wrapping him in a blanket or pinning him in his crib to prevent muscular activity. It is essential also that he be free from discomfort of any kind, such as a stomach overdistended either with gas or food, excessive intestinal peristalsis, too tight clothing, or overheating. Regularity in the routine of bathing, feeding, and sleep should be instituted and rigidly observed from birth.

As children grow older they become more and more sensitive to external conditions, and it is important to develop in them the habit of disregarding these stimuli in order that the habit of sleep at regular intervals may remain uninterrupted. In the nursery school children observed by Chant and Blatz[9] it was found that the younger children who had not already established good sleeping habits were easier to train than the older children, and that after a short space of time children slept without any relation to the number of other children in the room and in spite of many external stimuli.

If from the early months of life children become accustomed to disregard the immediate environment during the sleeping period, they need not be protected from sound, from light and other changing conditions, nor will they become dependent upon identical immediate surroundings, the same bed, the same position of the bed in the room, the same covering, and as they grow older they will not rely upon a particular toy or object to be taken to bed with them or a repetition of motion, such as rocking, or of sound, such as singing, to produce sleep. Regularity in the hour of going to bed must never be broken, and when it has been ascertained that the child is comfortable he must be left alone to go to sleep by himself.

Emotional factors influence sleep as children begin to make adjustments to their environment. The attitude of children towards sleep should always be pleasant. They should not be punished just at bedtime, and there should be no suggestions given of fear connected with the dark or with being alone. Adults must not talk about sleeplessness before children. Too great excitement just before bedtime makes sleep more difficult. Oversolicitude on the part of the parents and constant demands by the children for attention after going to bed at night indicate poor training and always interfere with good sleeping habits. It is much easier to establish good habits than to correct bad ones.

From birth accustom the infant by regular routine to sleep in a room by himself, and in an immediate physical environment which may change, and in which a variety of stimuli may come to him. This can be done by freeing him from unfavorable sensations and insuring an absence of physical activity.

Regularity in the daytime nap should be continued for all children up to the fourth or fifth year, and longer if the child sleeps at this time. After the fourth year of age the child should be awakened at the end of one and a half hours if a longer nap interferes with the night sleep. There should be a regular time for going to bed at night, and this must be early enough to insure an adequate number of hours of sleep.

The child must cultivate independence of any particular environment or association with sleep, and must be able to disregard factors in his environment which, if they were allowed to do so, might prevent sleep. There must be freedom from undesirable emotional conditions which tend to produce wakefulness, such as excitement just before the rest period, fear associated with sleeping environment, or unpleasant associations of punishment.

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FATIGUE

FATIGUE, which every human being knows all too well by experience, is unfortunately far less well understood than it should be. We know that muscular fatigue is an inevitable consequence of activity, particularly of activity that is either strenuous or prolonged; and we infer, on the basis of considerable evidence, that it is due to chemical changes which underlie the obvious activities which the tissues of the body display. The nature of these chemical changes is known only in part, and only for the tissues which are most active, namely the skeletal muscles. With respect to these we can state with considerable certainty that acute fatigue is due primarily to the accumulation of so-called *fatigue products,* among which carbon dioxide and sodium lactate have been identified as important items. Acute muscular fatigue presents, therefore, a fairly clean cut and not over-complex picture. Even acute muscular fatigue is not purely muscular. It involves, in part, some of the nervous system, and possibly other organs.

Another type of fatigue, less clearly defined and about which we have very little scientific information, is acute nervous fatigue. It is the condition, well recognized in everyday experience, which results from severe emotional strain or intense mental effort. The presumption is that the central nervous system is primarily involved, but we cannot yet be certain that we are here dealing with a single definite condition, which can be clearly differentiated from acute fatigue of other parts of the body on the one hand and from chronic fatigue on the other.

Both of these types of acute fatigue are inevitable consequences of prolonged or vigorous activity. Children, as is well known, tend to be active physically and mentally. They are active of their own volition, under the stimulus of playmates, and at the instance of parent, teacher, or employer.

All this activity tends of necessity toward fatigue, yet everyone recognizes clearly that, within limits, physical and mental activity are good for children rather than harmful to them. The problem which confronts us in attempting to evaluate the possible harmful effects of acute muscular and nervous fatigue is to consider what conditions are likely to lead to overstepping the physiological limits of activity into the realm of injurious fatigue.

Acute muscular fatigue, injurious in its effects, undoubtedly can occur, and does occur when children are compelled to toil beyond their strength. We are unable to lay down at present, however, either for individual children or for given age or strength groups, any criteria which would enable one to judge whether given tasks are physically too severe for particular children or not. We must trust to the concern of parents, teachers, and employers for the welfare of children to draw the line on the side of safety, giving the child the benefit of the doubt rather than to run the risk of injuring him by demanding more of him than he is able to give.

Acute nervous fatigue arises in children perhaps more easily than in adults, for the reason that children have very little power of sustained attention. They soon show symptoms of fatigue when engaged in any type of mental activity of so limited scope that the nervous activity is restricted within narrow channels. Paradoxically, but equally significantly, they are also wearied by too frequent a shift of interest, when the shift is of such a character as to introduce the element of nervous tension. To avoid acute nervous fatigue in children, then, we need to guard against undue monotony, on the one hand, and undue nervous tension, on the other. To distinguish when acute nervous fatigue is actually harmful is much more difficult than to distinguish harmful muscular fatigue, and the positive proof that such nervous fatigue hinders growth and development has not yet been adduced. Yet there is the familiar observation that overtired or overexcited children who are otherwise in good health are likely to show loss of appetite or even severe gastrointestinal or vasomotor disturbances or in some cases a rise in body temperature. One is at least following the counsels of caution in inferring that such disturbances as these, particularly if repeated frequently, are likely to affect growth and development unfavorably.

CHRONIC FATIGUE

For forty years the attention of workers in education and school hygiene has been focused upon what is known as fatigue and its synonyms (overpressure, overwork, and overstrain). The literature is composed chiefly of presidential addresses, of popular talks before lay organizations, clinical case reports by physicians, and experimental studies of acute mental fatigue by psychologists. It is safe to say that at the present time one is not justified in drawing any categorical conclusions from the data at hand as to the clinical or physiological nature of this common disorder. Excluding the propaganda on the subject, most of what is left can be divided into psychological studies and clinical case reports.

The psychological studies comprise the testing of the efficiency of the school child by the so-called psychological and psychophysiological tests. We have been able to collect as many as thirty-four of these tests which have been advocated and used to determine acute mental fatigue. The presence and amount of fatigue is measured by the decrease in speed of performance and by the increase in the number of mistakes. As a result of five years' investigation of these various tests in different groups of children, both normal and abnormal, it appears that there are three chief criticisms that militate against the reliability of these tests in diagnosis: (1) There are too many factors that interfere with the consistency of the results in the same children at different times, as, for example, the interest of the subject, time of day, relation to feeding and other activities, the sex, age, race, motivation, emotional attitude, experience, and so forth. (2) The tests are not tests of general fatigue but are applicable only to the physiology of the particular organ or system for which they were designated. For example, the dynamometer measures the strength of the muscles of the hand and forearm and nothing else; arithmetical tests are limited to that special mental function, and so forth. (3) Individual differences are so great that it is almost impossible to establish a normal standard that can be used for diagnosis.

As to the clinical case reports, there is very little to be said. A child enters school, and within two or three months shows a loss in weight and a change in color. He undergoes disturbances of behavior and suffers from the symptoms of fatigue. The physician in attendance finds no physical defect upon which he can put the responsibility for these disorders, and he considers it a case of *school sickness.* Now there is no doubt in the mind of any pediatrist that such a syndrome exists. The important question, however, which has never been carefully studied, is the exact rôle played by the school. Any literature on this subject which does not give consideration to the responsibility of other factors in the child's environment, such as his health habits at home, his sleep, his food, his rest and play, as well as his physical condition before the onset of symptoms, is inconclusive and of doubtful value. The onset of symptoms after admission to school, the disappearance of symptoms upon removal from school, the improvement in the child's behavior and increase in efficiency during vacations, and a decrease or disappearance of fatigue following rest in bed during the weekend, all attest to the relation between these disorders and school attendance, but do not prove that it is one of cause and effect.

In conclusion, it may be said that the question of how far the school itself is to blame for what we call overpressure, overstrain, or chronic fatigue is still far from being settled. There is much in the literature on this subject that is more opinion than fact. The few carefully controlled studies are suggestive rather than conclusive. We cannot hope to make any definite permanent advance in the solution of this problem until we have, first, agreed on a definition of chronic fatigue. It is something quite distinct from the acute mental fatigue artificially produced by psychologists. Secondly, we must devise a more reliable objective method or methods of determining the presence and measuring the amount of chronic fatigue, and thirdly, we must include all of the factors which in any way influence the production of functional disorders in children and give each of these factors its deserved importance. The subject of chronic fatigue in the school child is a vast but uncultivated field for research.

When we speak of chronic fatigue we do not have reference to that form of fatigability which is one of the many symptoms in organic disease, nor do we use it as a synonym for acute muscular fatigue or acute mental fatigue which can be produced artificially in normal children by physical exercise or mental work. There is no experimental evidence that the chemical changes in the urine and in the blood which have repeatedly and consistently been found in acute muscular fatigue are also found in those states of chronic tiredness and irritable weakness in which there is no apparent organic disease. The theory that there is a gradual daily accumulation of fatigue products, such as lactates, which are not excreted from the body and which are responsible for the state of fatigue is without experimental proof. There is evidence, however, that chronic fatigue in the true physiological sense can be produced artificially in rats and in rabbits by compulsory exercise and lack of sleep. In the first case, forced exercise repeated day after day at a given rate of speed produced a decrease in voluntary activity.[1] This state of fatigue was preceded by a loss in weight or a failure to gain, and was accompanied by an increase in restlessness and nervousness. In the second case rabbits, who were prevented from sleeping by being compelled to change their positions at the rate of eight times a minute, also lost weight, then became irritable, and sooner or later (eight to thirty-one days) became fatigued to the point of exhaustion.[2] Such physiological data suggest the idea that in children what we call fatigue, nervousness, and certain types of malnutrition are not clinical entities but are merely functional disorders, each representing different stages in the same fundamental process and often appearing at the same time in the same child. In the absence of more definite knowledge of the chemistry and the physiology of this disorder, Seham has suggested, on the basis of his seven years' study of the subject,[8] the following tentative clinical definition and description:

> Chronic fatigue is a psychophysiological disorder, of more than one month's duration, characterized by complaints of "nervousness" or tiredness or by an actual impairment or decrement of one or more of the functions of the body. This impairment may be manifested by a hyperirritability and hyperexcitability or by an actual decrease in ability to work or a loss in muscular strength. Both of these states may be present at the same time. The symptoms, whether psychic, physical or mental, are varied, differing at times even in one and the same individual. In some children the psychic and in others the physical may predominate. The progress is slow and insidious. Some children are apparently born with an inferior constitution which predisposes them to such chronic fatigue.

There is hardly a physician who is not acquainted with this condition in children, whether or not he designates it as chronic fatigue, and yet it presents so little in the way of characteristic pathological condition or physical signs, and may manifest itself in such a variety of ways in different individuals, that it must always be a rather uncertain diagnosis. There is no single objective test which will determine the presence or the degree of chronic fatigue.

We may attempt a somewhat more detailed description of the appearance and behavior of the typical child suffering from this condition, although fully recognizing that some or many of the characteristic conditions may not be present in any particular case.

The chronically tired child usually shows poor posture. Whether sitting or standing, he slouches forward with drooping, often uneven shoulders, the head and abdomen forward and the chest flat. The muscles generally are relaxed and lacking in tone. When standing, he shifts frequently from one foot to the other, and leans against a support whenever opportunity offers. There may be a slight or definite tremor of the hands when he is asked to hold them out with the palms up. Any physical examination is likely to be somewhat unsatisfactory, as the child is usually restless. He does not stand or sit still of his own accord, and even finds it difficult to do so when requested. He often fails to cooperate during the examination and often exhibits a slow reaction time.

His face presents a dull, apathetic, tired expression, sometimes suggesting sadness, sometimes bearing the pinched expression usually associated with malnutrition or chronic disease. The muscles about the mouth and lips are tense, and often twitch. Frowns and grimaces pass frequently over the countenance, and the occasional twitches may develop in more extreme cases to the stage of definite tics. The eyes are restless, roving hither and thither. The eyelids droop and often flutter, dark circles are present around the eyes, and the sub-ocular space shows definite puffiness. The face is pale, but the skin of the face and the body may show indications of an unstable vasomotor system, passing readily from pallor to flushing and showing the *tache cérébrale*. These vasomotor signs are likely to be accompanied by a rapid fluttering pulse and perhaps complaints of palpitation.

The speech of the child may also betray the condition. He frequently hesitates, stutters, or stammers, or may show his nervousness and lack of inhibition by becoming very talkative and noisy.

These are all familiar signs and symptoms, and, as we have pointed out, are not necessarily all to be found in every case, but they are associated together frequently enough to justify regarding them as a clinical syndrome. In order to deal with the condition intelligently we may repeat that a knowledge of the home conditions and family life surrounding the child are of first importance. Sound habits of physical and mental health must be established, and obviously any organic disorders must be remedied. Perhaps infection or inadequate diet plays a part in the vicious circle, and any such conditions must be remedied. Emotional strain, and likewise subjection to acute fatigue, must be avoided. Beyond the obvious practical applications of these general principles it is difficult at the present time to go, but the problem requires both experimental and clinical consideration. A more extensive knowledge of the causes of chronic fatigue, of the relation between the objective and subjective manifestations, the development of objective means of testing and studying this condition, and further information as to the influences of chronic fatigue on growth and development, as well as on general health, would be of great value.

In applying the above considerations to children for the purpose of working out recommendations for practical procedure, children will be divided into three groups: preschool children, school children, and children in industry.

In Preschool Children

When children in this group display acute fatigue to a serious degree, it is usually found that they have been overdriven in play by older and stronger children, although some children in this age range will indulge in excessive play of their own initiative. The remedy is obvious, implying nothing more than a reasonable exercise of supervision and repression on the part of parents or nurses. Dire need or parental ignorance may lead to the overworking of an occasional preschool child, a situation to be met only by improving the economic status or by educating the parents.

Chronic fatigue is, on the other hand, perhaps fairly common among children in this age range. When it occurs, the chance is that it is due either to a bad routine, in other words, to improper apportionment of the hours of activity and rest, or to bad conditions during or immediately preceding rest periods. The investigations of Aron [4] and of Karger [5] show clearly what common experience has long indicated, that in young children a rest period, preferably with sleep, should be provided at or near the middle of the day, thus breaking the daylight hours into two intervals of activity, neither of which should be more than five or six hours in length, with a rest interval of an hour or two in between. Furthermore, the rest periods, both of the daytime and of the long period of night, should be free from distraction and should be ushered in by a period of emotional quiescence. Boisterous romping just at bed time, particularly by children prone to become excited, is objectionable, and so are scolding and nagging if the children have not yet learned to pay no attention to them. Taking young children to moving pictures in the evening is a very doubtful practice, to say the least. It should also be borne in mind that chronic fatigue in children may depend fundamentally upon an inadequate diet.

In School Children

Children in school are subjected to a discipline in which fixation of attention begins to assume prominence, and therefore nervous fatigue due to excessive concentration becomes possible. In considering fixation of attention in young school children, it is necessary to bear in mind that in addition to the necessity of concentrating on set tasks there is also the necessity of concentrating on the avoidance of prohibited activities. It is likely that in some school rooms and under some types of teachers, the second necessity imposes a severer strain on the nervous organization of the children than the first.

Although it appears reasonable to assume that concentration tends to produce chronic fatigue, in the absence of satisfactory objective criteria of degrees of fatigue in children, almost the only evidence one can cite indicating that school children actually do suffer from school fatigue to an extent to interfere with normal growth is the finding, reported by more than one observer, that properly fed and apparently healthy children who are below the physical expectation for their age sometimes make satisfactory gains when the school hours are shortened, after other remedial measures have failed (Veeder[6]). It must be admitted that this evidence is not conclusive, since children suffering from chronic mild infection would probably be benefited similarly by a corresponding change in regimen. The finding is sufficiently positive, however, to justify one in looking on school fatigue as a factor unfavorable to normal growth and development, and in recommending measures calculated to limit its occurrence.

These measures, which fortunately are in operation in a large percentage of modern and progressive schools, include such items as making periods of intense concentration brief; alternating such periods with periods in which the work is recreative in character; avoiding bad posture (which makes a vicious circle with fatigue, in that each tends to enhance the other); introducing bodily exercise at suitable intervals; and limiting the length of the daily sessions.

Even when such measures are in operation, school children are undoubtedly in a fatigued state at the end of the school day. To avoid chronic fatigue it is necessary that the recovery be complete by the beginning of the next school day. Measures designed to insure this are: provision of a diet adequate to meet the needs of the child; bodily exercise of a recreative character for an hour or two after school (whether team drill in preparation for organized competitive sport is recreative in this sense is a question for which at present there appears to be no authoritative answer); limitation of home work to reasonably interesting and not unduly taxing or time-consuming matter; avoidance of excitement or nervous strain due to social activity or to unwholesome home conditions, parental discord, and so on; avoidance of too strenuous play; a full night's sleep. Eyestrain produces fatigue very soon, both in school and out of it; hence children should be provided with suitable glasses if they suffer from errors of refraction.

In Children in Industry

Turning to the problem of fatigue of children in industry, we encounter a quite different background of attitude in respect both to theory and to practice. Public school education is expressly designed to prepare children for adult life, and no modern educational theory fails to scrutinize every detail of the process in relation to its effect on the end sought.

Hence the importance of guarding against fatigue is recognized from the outset, and probably more fully by those who administer education than by the public at large. Such improper practices as prevail may be due to ignorance or carelessness, but cannot be due to intent.

During the early decades of the industrial revolution, on the other hand, and indeed nearly down to the present time in some instances, exploitation of children in industry has occurred to a shameful extent. Pressure from an aroused public opinion and even legislation have been necessary to correct some flagrant abuses. At the present time the situation is much improved, but there is no gainsaying that the incentive to guard against fatigue is on a different basis in industry, as compared with education.

The effect of this difference is of particular moment in relation to growth and development, for such measures as are taken to minimize fatigue of children in industry tend to have as their primary motive the immediate welfare of the children and hence to give little or no consideration to possible future or indirect consequences. Thus it appears that physical fatigue is more likely to be guarded against in industry than nervous fatigue. It is probable that employers can often assert with perfect truth that children in their establishments make less muscular effort in a day than the same children would if allowed to play freely. There is little doubt that this argument has considerable force in the minds of parents who are questioning whether they should or should not put their children into industry. Admitting that many industrial tasks may not be physically beyond the powers of the children set at them, there still remains the vital question of whether these tasks are imposing undue strain on the immature nervous system. It would seem to be beyond question that tasks requiring continuous fixation of attention are not suitable for children. It is also questionable whether repetitive tasks should be put to them, even though the task be of a type that is soon performed semiautomatically. An adult at a repetitive task either submerges his mentality to such an extent that he becomes in effect an automaton, or has sufficient resources to occupy his mind more or less fully throughout the period of work. The occasional individual who can do neither of these things must either change jobs or suffer a nervous breakdown. The minds of children tend to be alert, yet they have a limited background of experience on which to base mental activities. Much more than adults do they require stimulation from the immediate environment. It is for these reasons that repetitive tasks should probably not be given children, at least not without frequent interruptions. It should be pointed out, further, that the industrial day is always longer than the school day by two hours or more. Certain considerations pointed out above indicate that the school day is about as long a period of restraint as can be imposed on children without danger of chronic fatigue. Although positive proof of this is lacking, the presumption is nevertheless raised that a working day of eight hours or more may tend to produce chronic nervous fatigue in children, whether the actual tasks be hard or easy.

Specific recommendations for minimizing nervous fatigue among children in industry may include avoidance of tasks involving intense concentration; avoidance of repetitive tasks, or at least alternating short periods of such tasks with periods in which the factor of interest enters to a significant degree; and shortening the working day to not more than six hours.

A point applicable to all active children, and predominantly to children doing physical labor, is stressed by L. E. Holt[7] to the effect that the energy required to sustain strenuous physical activity is likely to make such demands on the total intake of food as to leave insufficient quantities available for normal growth.

In conclusion we may point out some of the possible lines of inquiry and further research which are applicable primarily to the problem of fatigue in preschool and school children. The whole problem of chronic fatigue, its nature and its causes, and its possible relation to acute muscular fatigue and to acute nervous fatigue, requires careful study and consideration both by physicians and by physiologists and psychologists. From the practical point of view we should inquire into such factors as the amount of sleep required by children of various ages and also the matter of the most effective distribution of sleep. The quality of sleep and the question of factors inducing restlessness at bedtime also deserve consideration. The relation of chronic fatigue to other definite factors, such as eye strain, bad posture, and perhaps the dependence of bad posture upon fatigue, should be inquired into with care.

In relation to children in industry we require more knowledge as to the actual physical demands of various types of work for which children are employed. We must determine also the importance of the factor of monotony in work, with special reference to the length of shift, to alternation of periods of work and of rest, and to the presence or absence of features of intrinsic interest.

These are only a few specific suggestions which make no pretense of covering the entire scope of the field. They have been selected as illustrations because in each case some beginning has been made, and methods of promise seem to be available.

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ORGANIZED ATHLETICS DURING SCHOOL AGE

THE marked expansion in recent years of organized athletic competition in the secondary schools, and the possibility in the future that it may also involve the grammar schools, makes it important to consider most seriously the question of whether the growth and development of the competitors is promoted or hindered by such athletic competition. No estimate, either detailed or general, has yet been made of all the effects on participants of organized athletics during school years. Therefore, all that we may attempt at the present time is to list all of the various consequences which are generally accepted as occurring frequently enough to be significant, and to offer one or two suggestions as to procedure in dealing with the practical situation as it exists.

Athletic training means literally *the strengthening of vital organs and skeletal muscles,* but in the present discussion it is assumed to include all of the other activities connected therewith, and particularly the emotional excitement which is incidental to the participation in athletic contests. It is well known that exercise of the skeletal muscles leads to an increase in their size and strength, and it is equally true, although not quite so generally understood, that athletic training increases the efficiency of certain metabolic processes, notably those concerned in the oxidation and disposal of lactic acid. The improved wind of the trained athlete depends upon just this increased efficiency. It is probable that the great majority of those who undergo athletic training emerge with these benefits, which enable them to undertake more strenuous and more prolonged physical activity.

It is most important, particularly in these days of increasing urbanization, that every child should have opportunity for adequate exercise of his large muscles. Our cities have relatively little opportunity for vigorous activity involving these muscles except in play and athletics. Chores, errands, and household tasks no longer occupy a large part of the child's life, and space for free play is restricted, and yet either these or some other activities involving the large muscles are essential to his normal development. Not only the growth of the muscles, and possibly the skeleton as well, is involved, but also coordination of the nervous system. The necessity for sound physical education and opportunities for play and exercise are so well recognized that they need not be further stressed. Our present concern is rather whether the organization of athletics for the older child may not bring with it certain disadvantages which should be remedied.

The greatest benefits of athletic training should accrue to those who are in the poorest condition at the beginning of the athletic training, while the least gain will come to those who are nearest to the peak of their powers at the beginning. Unfortunately, however, it is usually true that those who train athletes concentrate their interest on those who are most able and fit, and for whom, in consequence, less can be done. The physical weaklings, who might benefit most from intelligent care and supervision, are likely to escape attention or to be rejected completely. On the other hand, it must be remembered that the spectacle of interscholastic and intercollegiate contests may induce the relatively unfit to take up athletic activities and training which they would otherwise find unattractive and uninteresting. It is perhaps unfortunate that the sports which attract most attention as intercollegiate contests, such as football, track, and field sports, basketball and baseball, are precisely those which are not usually indulged in after the period of collegiate or scholastic competition. Sports having the widest general appeal, such as golf and tennis, are seldom encumbered by the paraphernalia and routine of athletic training such as generally exists in schools and colleges.

It is not surprising that the professional coach in the larger schools should concentrate attention on the strong and neglect the weak, for his effort is usually concentrated upon building up a winning team, and unless the coach is also in charge of physical training in the school generally, the consequences of athletic training to the individual members of the squad do not concern him unduly. In the effort to produce a winning team, certain emotional factors may be introduced into athletics which can hardly be considered beneficial. Among these are the elements of excessive nervous tension, the sense of heavy responsibility, and likewise the feeling of inferiority which is sometimes deliberately induced by coaches on the theory that boys who have it will strive harder. In many cases it is quite possible that these undesirable elements may go far to offset the desirable features of vigorous muscular exercise and the genuine fun of competitive sport.

Another aspect of organized athletics might be characterized as personal safety. It is well known that interscholastic athletics are resulting in more sprains, cuts, fractured bones, and even deaths each year. As to permanent aftereffects, there has been considerable controversy, notably in regard to heart strain. The present situation of this question must be summed up by saying that research has so far failed to make a positive case either for or against athletic training.

Without attempting to answer the question of whether organized athletics are more beneficial than they are harmful, we may note certain specific shortcomings which are common to many of our present programs of physical education and which might well be remedied. In the first place, the particular skills and sports which are most frequently learned in scholastic athletics are learned for themselves alone and are not useful in later life. Secondly, those who need physical education most tend to be the ones who are most neglected; and finally, there is all too frequently such inequality of ability among the competitors that there is little joy to the losers, little pleasure to the winners, and frequently real physical danger to the weaker players. To remedy this situation it has been suggested that emphasis be placed upon types of exercise which can be continued after the boy has left school, and furthermore that in team games the equality of the competing individual should be secured by means of suitable tests of physical strength and fitness. Such tests of physical fitness if applied to school children as a matter of routine would also indicate which individuals require particular attention from the point of view of building up their physical strength and health.

To provide such an index of physical fitness and capacity Rogers[1] has devised a battery of six tests including capacity of the lungs, strength of grip, strength of back and legs, push-ups on parallel bars, and pull-ups on chinning rails. The *strength index* is merely a composite score made up on the basis of these individual tests. The *index of physical fitness* is the ratio between the individual's strength index and the average strength index for all boys of the same age and weight. On the basis of such scores it is possible to classify junior and senior high school boys according to the types of physical education and athletic activities best suited to their individual capacities.

When the separate tests comprising the strength index are compared, it is found that a high score in one test such as lung capacity will be fairly indicative of a high score in other tests, such as strength of the back. Therefore the separate scores may be legitimately combined as a strength index. The tests have the advantage of being objective, and it is also found by actual experience that they are quite reliable; that is, scores made in one year by a series of individuals indicate quite accurately the scores which will be made by the same boys the year following. When the strength indices of a series of boys are compared with the scores which these same boys made on a series of athletic tests, there was found to be a reasonably high degree of relationship. The tests of athletic ability included the 100 yard dash, running broad and high jumps, putting the shot, and throwing the baseball and football.

Such tests of physical fitness and capacity seem to afford a basis on which to subdivide boys into classes for athletic competition. It is a matter of familiar experience that if individuals are classified merely by age, the resulting selection will be only roughly accurate in regard to athletic ability although better than classification by school grade. Weight is a more accurate basis for selection than age or than height, but it has been found by experience that even the best mathematical combination of age, height, and weight, is only about half as accurate in making a selection of individuals according to athletic ability as the index of physical fitness described above. One reason for this situation is that while weight is ordinarily an advantage to a high school boy up to about 170 pounds, weight above that figure is usually due to fat, and is therefore a liability rather than an asset to the individual. Younger boys of smaller stature may also be relatively too fat and thus be under a handicap.

It has been suggested that all students be given such strength tests at the beginning of each school year and the result tabulated for classification of the boys in respect to gymnastic exercises or athletic competition. Boys with a low index of physical fitness could then be assigned to special work to remedy their defects. Those with a middle range of physical fitness could be assigned to an intramural athletic program in which they could compete at their own level and secure at the same time the maximal benefits of team play. Those boys who rank highest on the physical fitness index would be permitted to participate on school teams where they would meet other boys of their own level of ability.

Such a program, based upon objective tests, has much to commend it, and it is to be hoped that attention and study will be given in the future to the development and testing in practice of such indices of physical strength and ability as are here indicated. Intelligent direction and supervision, and the elimination of undesirable emotional features of interscholastic competition, should go far toward allaying much of the present criticism of organized athletic training.

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THE RELATION OF BODY MECHANICS TO HEALTH

BODY mechanics may be defined as the mechanical correlation of the various systems of the body with special reference to the skeletal, muscular, neurological and visceral systems. Optimal body mechanics may be said to exist when this mechanical correlation is most favorable to the function of these systems. In recent literature the term *posture* is commonly employed synonymously with body mechanics, but in our opinion is less descriptive and less inclusive.

In discussing the morphological and functional aspects of body mechanics in relation to the growth and development of children, it is pertinent first to review briefly the evolution of the curves of the spine from birth to the assumption of the erect posture.

Schwartz,[1] in a résumé of the literature relating to body mechanics has discussed this evolution of the spinal curves in human beings. The important points in this discussion are the following: Mammals, except man and perhaps certain anthropoids, exhibit only a single kyphotic (dorsally convex) curve of the spinal column. In the lower races of man the several curves of the spine are less developed than in the European, especially the lumbar lordotic (ventrally convex) curve. The several curves of the spine as later developed are adapted to balancing the trunk on the femora and lower extremities, resulting from the effort to place the center of gravity behind the sacro-iliac joints and the hip joints.

The spine of the child in utero has only a single kyphotic (dorsally convex) curve and at birth the spine still exhibits a single slightly kyphotic curve, soon becoming straight as the child assumes a recumbent posture. At the age of three or four months as the child begins to lift its head, the cervical spine begins to exhibit a lordotic (ventrally convex) curve. As the child begins to assume a sitting position, this becomes more marked, and with the assumption of an erect position when the child begins to walk at about twelve months, the muscles of the back arising from the sacrum and inserting into the low thoracic spine begin to mould the lumbar spine into slight lordosis—a ventrally convex curve. The thoracic spine retains a slight kyphosis, dorsally convex. The sacrum and coccyx exhibit a dorsally convex curve, the prominence of which is dependent upon the acuteness of the lumbosacral angle. Under normal conditions, the dorsally convex curve of the twelve thoracic vertebrae has a longer arc and is more gentle than the ventrally convex curve of the seven cervical vertebrae and the ventrally convex curve of the five lumbar vertebrae. Exaggeration of these curves beyond normal limits is associated with bad body mechanics and poor posture. Normal limits will be considered in the following paragraphs in relation to weight-bearing lines.

The range of motions of all joints including the spine is greater in infancy than in childhood. Individuals vary greatly in their degrees of flexibility. After adolescence, while individual variations still exist, there is very gradual decrease in the individual's degrees of flexibility. Between the contortionist and the muscle bound individual the variations in flexibility are so great that there can be no standard norm. There are many variations in the shape and arrangement of the bones, ligaments, articular facets, muscles and visceral relations in different individuals. There is no single type of individual which can be taken as a standard norm. If these two premises are allowed, it is undesirable to formulate any exact mathematical statement as to the normal curves of the spine in relation to weight-bearing lines.

If the spinal curves which are associated with the habitual posture of the individual are not so extreme as to produce joint and muscle strain or disturbance of visceral relations, if the posture is such that there still remains a margin of safety which allows more mobility in all directions, the spinal curves and the weight-bearing lines of the lower extremities may be said to fall within normal limits for the individual under consideration.

Certain approximate statements may be made as to body mechanics or posture. Unless the requirements which these statements suggest are met, good body mechanics cannot be said to exist in the individual under consideration.

The head with the chin in is balanced above the shoulders, hips, and ankles. (By chin in is meant drawing chin backwards until its point is nearly over the sternal notch.)

The thorax with the costal angle made wide by drawing in the lower abdomen is poised in such a position that the sternum becomes that part of the body farthest forward.

The lower abdomen is held in and flat.

The lower extremities are so aligned with the trunk and head that the lower end of the femur and the upper end of the tibia oppose each other in such a manner as to support the body weight with the minimal amount of muscular exertion or tonus.

Good body mechanics does not exist unless the balance of the muscles of the lower extremities is favorable to weight-bearing lines which will protect the joint mechanisms of the feet. The supinator muscles of the lower legs and feet are normally slightly stronger in pounds pull than the pronator muscles.

Children exhibit numerous variations in body build. There are two extremes, between which fall all gradients of variation and the textbook theoretical normal. These two contrasting extremes are represented by the stocky, placid child who in the literature is variously called the *herbivorous* child or the *hypoontomorph,* and the slender, highstrung child who has been termed the *carnivorous* or the *hyperontomorph.*

Investigations which have been made as to the characteristic anatomical variations in the shape and arrangement of the viscera in these contrasting extremes need confirmation and extension before it is justifiable to accept them as bases for any exact formulation of therapeutic rules. Clinical experience, however, indicates very definitely that different types of body build, especially the extremes we have mentioned, present somewhat different problems of correction when bad body mechanics exists. The difference is often quite as much psychical as anatomical.

We must not attempt to draw too hard and fast lines. Certain variations in body mechanics fall within what may be spoken of as normal limits, dependent upon variations in body build and upon the integrity of postural tonus. The body mechanics of the stocky child differs from that of the slender child. Different individuals who must still be considered normal vary greatly in the laxity and tightness of their supporting joint ligaments and in their degree of muscular development and tone. The silhouettograph charts illustrate variations in weight-bearing lines and body mechanics in erect figures.

A approaches an ideal posture and represents excellent body mechanics; B, good; C, poor; and D, so very poor that it may be said to approach the pathological. These charts, published by the Children's Bureau of the United States Department of Labor, and by Department of Hygiene and Physical Education, Harvard University, illustrate variations in weight-bearing lines in the extremely stocky, the extremely slender and in a child neither overfat nor overthin. The charts suggest, and clinical experience shows, that the most marked departures from good body mechanics are encountered among slender, delicately built, poorly nourished, weak muscled, visceroptotic children.

There are also various congenital anomalies of the spine and extremities and numerous disease processes which are responsible for frankly pathological variations in body mechanics and posture and which affect profoundly the extent and symmetry of body growth and development in proportion to the nature and extent of the lesions which they produce. Such congenital anomalies are represented by anatomical variations in the shape and number of the vertebrae and ribs, congenital dislocation of the hips, inequality in the length of limbs, absence or lack of development in the bones of the extremities, torticollis, congenital defects of vision, and so forth. The disease processes include rickets, poliomyelitis, tuberculosis, lues, coxa plana, myotonia, and other muscular dystrophies. The variations are so numerous that it is unprofitable to attempt any detailed description of these pathological variations, much less to attempt any standardization of them.

It seems possible theoretically, and from clinical experience probable, that congenital and acquired skeletal abnormalities may engender abnormalities of function and bear a causal relation to certain dysfunctions of the skeletal, muscular, visceral and perhaps of the nervous system.

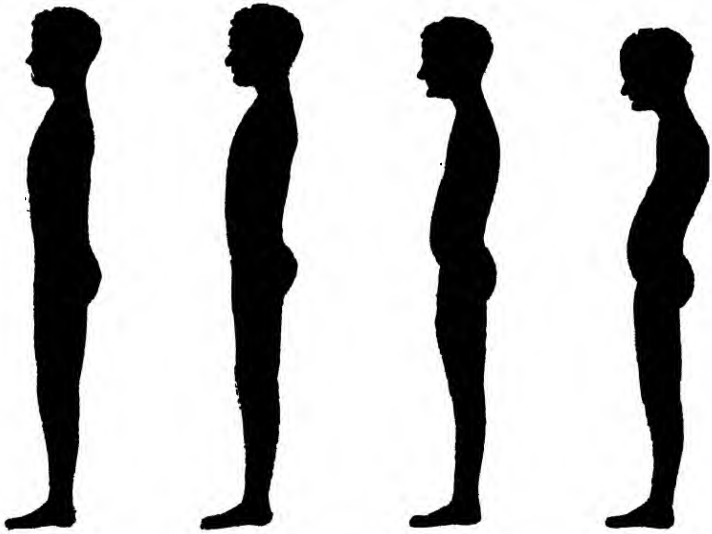
A trained observer is usually able to make a fairly accurate estimate of the habitual body mechanics and grade of posture which a child exhibits by a mere visual examination and by testing the ranges of motion of the spine and of the extremity joints. The visual examination should be made when the child is unconscious of the purpose of the observation and not when the child is, so to speak, on parade. Eventually the child's clothing should be removed and his natural standing and sitting postures noted. He should then be asked to stand and sit straight, in order to ascertain the child's own ideas of good body mechanics.

Methods of grading the body mechanics and posture of an individual are of practical importance for purposes of surveys of the incidence of good and bad body mechanics and in order to evaluate the importance of special training methods in relation to success or failure and the permanence of the results obtained. The present methods in common use are admittedly inadequate and unscientific and are by no means fool proof. The most practical method of recording and grading of which we are aware is the photographic or silhouettograph method, which may be described as follows: The unclothed standing figure is first photographed in two positions, from the back and in profile, in the posture which the individual naturally assumes. He is then requested to stand in the position which he considers to be the best possible posture and a third photograph or silhouette is taken in profile. He is then placed by the trained recorder in the best posture which it is possible for the individual momentarily to assume and the fourth photograph or silhouette is taken while he maintains this corrected posture.

POSTURE STANDARDS

Thin-Type Boys

Excellent | Good | Poor | Bad



A | B | C | D

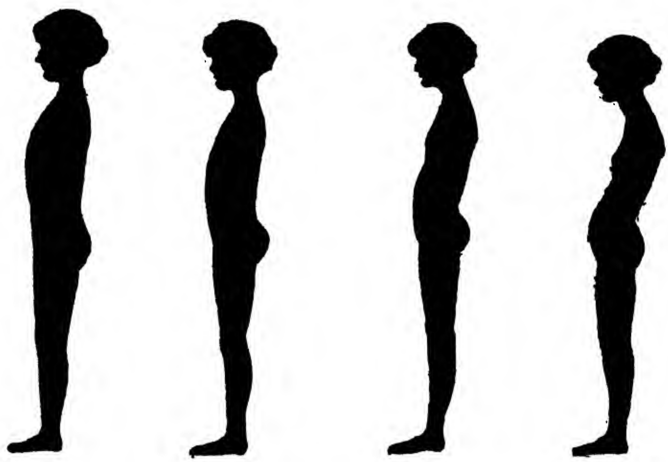
EXCELLENT POSTURE	GOOD POSTURE	POOR POSTURE	BAD POSTURE
1. Head up—chin in (Head balanced above shoulders hips, and ankles.)	1. Head slightly forward.	1. Head forward.	1. Head markedly forward.
2. Chest up (Breast bone the part of body farthest forward.)	2. Chest slightly lowered.	2. Chest flat.	2. Chest depressed. (Sunken.)
3. Lower abdomen in, and flat.	3. Lower abdomen in (but not flat.)	3. Abdomen relaxed (Part of body farthest forward.)	3. Abdomen completely relaxed and protuberant.
4. Back curves within normal limits.	4. Back curves slightly increased.	4. Back curves exaggerated.	4. Back curves extremely exaggerated.

Children's Bureau, United States Department of Labor, Washington, D. C., 1926

POSTURE STANDARDS

Thin-Type Girls

Excellent Good Poor Bad



A B C D

EXCELLENT POSTURE	GOOD POSTURE	POOR POSTURE	BAD POSTURE
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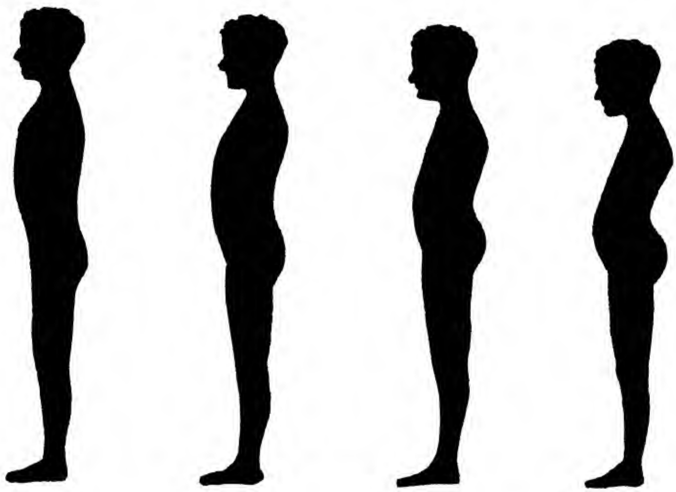
3. Lower abdomen in, and flat.	3. Lower abdomen in (but not flat.)	3. Abdomen relaxed (Part of body farthest forward.)	3. Abdomen completely relaxed and protuberant.
4. Back curves within normal limits.	4. Back curves slightly increased.	4. Back curves exaggerated.	4. Back curves extremely exaggerated.

Children's Bureau, United States Department of Labor, Washington, D. C., 1926

POSTURE STANDARDS

Intermediate-Type Boys

Excellent | Good | Poor | Bad



A | B | C | D

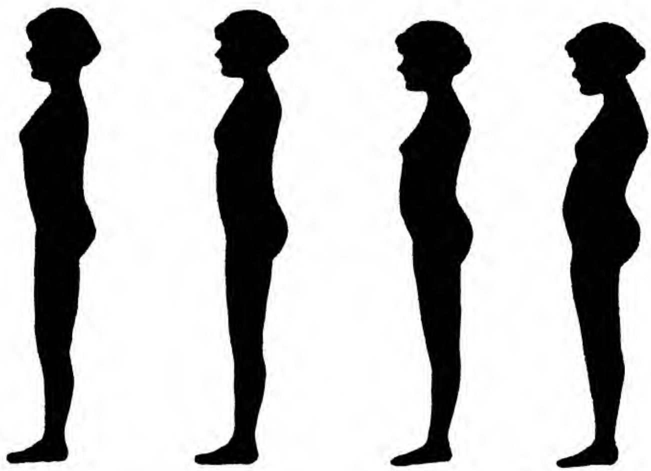
EXCELLENT POSTURE	GOOD POSTURE	POOR POSTURE	BAD POSTURE
1. Head up—chin in (Head balanced above shoulders hips, and ankles.)	1. Head slightly forward.	1. Head forward.	1. Head markedly forward.
2. Chest up (Breast bone the part of body farthest forward.)	2. Chest slightly lowered.	2. Chest flat.	2. Chest depressed. (Sunken.)
3. Lower abdomen in, and flat.	3. Lower abdomen in (but not flat.)	3. Abdomen relaxed (Part of body farthest forward.)	3. Abdomen completely relaxed and protuberant.
4. Back curves within normal limits.	4. Back curves slightly increased.	4. Back curves exaggerated.	4. Back curves extremely exaggerated.

Children's Bureau, United States Department of Labor, Washington, D. C., 1926

POSTURE STANDARDS

Intermediate-Type Girls

Excellent Good Poor Bad



A B C D

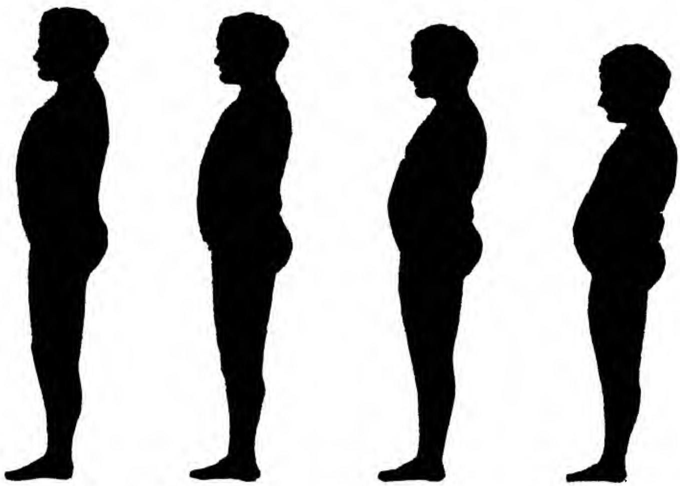
EXCELLENT POSTURE	GOOD POSTURE	POOR POSTURE	BAD POSTURE
1. Head up—chin in (Head balanced above shoulders hips, and ankles.)	1. Head slightly forward.	1. Head forward.	1. Head markedly forward.
2. Chest up (Breast bone the part of body farthest forward.)	2. Chest slightly lowered.	2. Chest flat.	2. Chest depressed. (Sunken.)
3. Lower abdomen in, and flat.	3. Lower abdomen in (but not flat.)	3. Abdomen relaxed (Part of body farthest forward.)	3. Abdomen completely relaxed and protuberant.
4. Back curves within normal limits.	4. Back curves slightly increased.	4. Back curves exaggerated.	4. Back curves extremely exaggerated.

Children's Bureau, United States Department of Labor, Washington, D. C., 1926

POSTURE STANDARDS

Stocky-Type Boys

Excellent | Good | Poor | Bad



A | B | C | D

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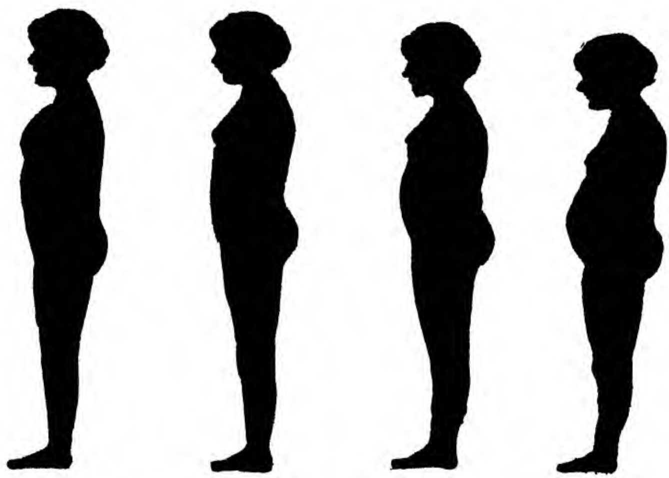
POSTURE STANDARDS

Stocky-Type Girls

Excellent Good Poor Bad

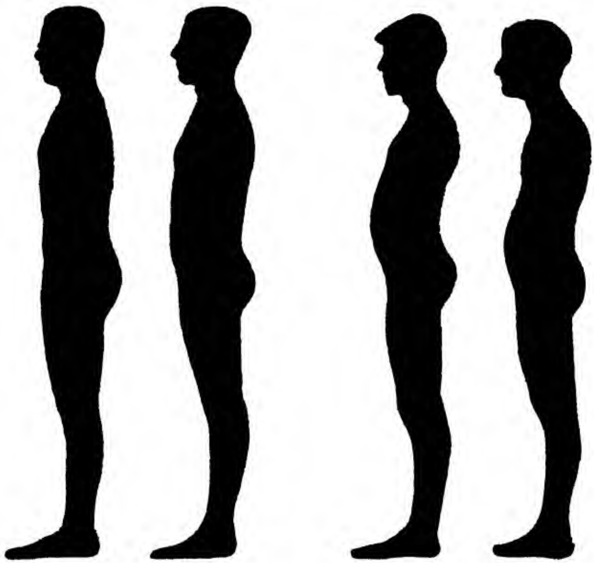


A B C D

EXCELLENT POSTURE	GOOD POSTURE	POOR POSTURE	BAD POSTURE
1. Head up—chin in (Head balanced above shoulders hips, and ankles.)	1. Head slightly forward.	1. Head forward.	1. Head markedly forward.
2. Chest up (Breast bone the part of body farthest forward.)	2. Chest slightly lowered.	2. Chest flat.	2. Chest depressed. (Sunken.)
3. Lower abdomen in, and flat.	3. Lower abdomen in (but not flat.)	3. Abdomen relaxed (Part of body farthest forward.)	3. Abdomen completely relaxed and protuberant.
4. Back curves within normal limits.	4. Back curves slightly increased.	4. Back curves exaggerated.	4. Back curves extremely exaggerated.

Children's Bureau, United States Department of Labor, Washington, D. C., 1926

THE RIGHT WAY THE WRONG WAY



A B C D

POSTURE CLASSIFICATION

(A) EXCELLENT MECHANICAL USE OF THE BODY

1. Head straight above chest, hips and feet.
2. Chest up and forward.
3. Abdomen in or flat.
4. Back, usual curves not exaggerated.

(B) GOOD MECHANICAL USE OF THE BODY

(*Compare with Fig. A.*)

1. Head too far forward.
2. Chest not so well up or forward.
3. Abdomen, very little change.
4. Back, very little change.

(C) POOR MECHANICAL USE OF THE BODY

(*Compare with Fig. A.*)

1. Head forward of chest.
2. Chest flat.
3. Abdomen relaxed and forward.
4. Back curves are exaggerated.

(D) VERY POOR MECHANICAL USE OF THE BODY

(*Compare with Fig. A.*)

1. Head still farther forward.
2. Chest still flatter and farther back.
3. Abdomen completely relaxed, "slouchy."
4. Back, all curves exaggerated to the extreme.

Used by Courtesy of Department of Hygiene and Physical Education, Harvard University, Cambridge, Massachusetts.

Such records afford not only bases for grading, but also serve as illustrations to the individual under consideration which enable him to understand the purpose of training and furnish a strong incentive to betterment of his body mechanics.

Body mechanics and posture may be thus roughly classified into four grades, A, B, C and D. A represents excellent or nearly perfect posture; B good, but not ideal posture; C poor, but not the worst possible posture; D bad, and very possibly symptom-producing, posture. Most of the surveys which have been made of body mechanics and posture have employed this method of recording and used A, B, C and D grades. The terminology is used in this discussion.

A complete determination of the status of a child in respect of body mechanics should include the following procedures:

Relative measurements of the length of the legs and the circumferences of the thighs and calves are important in order to discover a short leg or an unequal development of muscles which might explain peculiarities of weight-bearing function or asymmetrical spinal contours.

The flexibility and muscle balance of the feet and their weight-bearing lines should be determined at rest and in both standing and walking, in order to discover potential or existing signs and symptoms of foot strain.

Measurement of the chest expansion and perhaps of the vital capacity should be taken, in order to determine the flexibility of the costal articulations. The observer may thus also obtain a rough idea of the habitual aeration of the lungs and of the functioning of the diaphragm.

Roentgenological examinations of the bony skeleton are often necessary; the thoracic viscera, including the relation and function of the heart, lungs and diaphragm, comparing the function especially of the diaphragm in the erect position with its function in the supine position; the abdominal viscera following the ingestion of a barium meal. This roentgenological examination of the alimentary tract makes possible the determination of the contours, position and relations of the stomach, small intestines and colon in the erect and supine positions. If roentgenological examinations of the intestinal canal are repeated for three successive days without the administration of cathartics or enemas, light may be thrown upon the habitual function of the individual's alimentary system. In seventy-two hours after the ingestion of the barium meal, a barium enema may be given and additional information obtained as to the size, contours, relations and function of the colon.

The importance of a general medical examination of the circulatory, pulmonary, renal, alimentary and nervous systems and often including tests of the basal metabolism is evident in order not only to discover congenital or acquired aberrations, but to furnish information upon which the nature and amount of corrective effort may be based.

The foregoing discussion of the morphological and functional aspects of body mechanics has been made more clinical than anthropological because, with the paucity of statistical anatomical data, anthropological discussion is bound to be unconvincing. The clinical data and what little anatomical data we possess suggest that the subject is worthy of consideration and of further careful study.

INCIDENCE OF BAD BODY MECHANICS AMONG ADULTS

Rough statistics gathered during examinations of men coming within the age limits of the universal draft during the World War suggest that considerably less than 50 per cent of the male youth and early manhood of the United States can be considered to exhibit or practice good body mechanics. It has been estimated that over 40 per cent of the rejections were ordered for poor general physique, in the absence of any organic disease or defect.

In a postural survey of the entering classes of Harvard University made in 1916 by Brown, to which reference will again be made, 6.7 per cent of these supposedly healthy youths were given A grade in posture, 12.1 per cent were given B grade, and 80.3 per cent were placed in the C and D groups. Other similar surveys (Cook [2] at Yale and Thomas [3] at Smith) have yielded similar figures.

In a postural survey of 2,200 public school children of Chelsea,[4] Massachusetts, of both sexes and varying in age from five to eighteen years, 86 per cent fell into the C and D groups. Apparently from the middle of the second decade of life to, and perhaps through, the third decade there is a slight but unfortunately insignificant tendency for the youth of the nation to show an improvement in their body mechanics. There were never less than 80 per cent of these children exhibiting the C and D grades of posture on the first examination.

EVIDENCE THAT GOOD BODY MECHANICS IS FAVORABLE TO GOOD HEALTH

From the earliest to the latest depictions of the human body, good body mechanics have represented physical efficiency and mental alertness. If a sculptor or an artist desired to express depression, fatigue or poor health, he has modelled or drawn the drooping, relaxed, weak figures of poor body mechanics. On the other hand, elation, fitness and good health have been expressed by the erect, well poised, strong figures exhibiting good body mechanics: The armies of the centuries have been drilled to perform their tasks with the least possible waste of physical exertion. The athlete at rest or in action must satisfy the essentials of good body mechanics or else he lacks his supreme competing ability. The decapitated Nike, the Winged Victory, needs no head to convey the impression of beauty and power. The strength of St. Gaudens' Lincoln is conveyed by his effortless poise.

One of the most complicated and yet mechanically efficient products of the age is the automobile. It is incomparably less complicated and less efficient than the human body, yet the driving public are frequently made aware of the fact that slight disturbances of alignment in an automobile's working parts and slight dysfunctions of its electrical organs, may interfere with its function and cause it to develop chronic diseases. Lack of perfect alignment in an automobile causes friction, and friction means unnecessary wear and tear. While the margins of safety are wider in the human body, it is demonstrable that tasks performed with less effort cause less fatigue. The more perfect the equilibrium, the less reflex muscle tonus is required to maintain the poise and the less fatiguing the voluntary muscle effort to change from one position to another.

It would seem reasonable to suppose that combustion within the body would be favored by continuous adequate aeration of the lungs; that circulation would be favored by providing sufficient space for unimpeded action of the heart; that the functions of the abdominal and pelvic viscera would be favored by a free excursion of the diaphragmatic pump and by a sufficient support of the abdominal wall to keep the stomach from sagging and the intestines from being crowded into the pelvis.

Keith [5] is convinced that the acquirement of good posture tends to correct enteroptosis. James [6] maintains that the erect posture keeps up the spirits and tends to banish fear, despondency and depressing thoughts; that bodily postures definitely influence the emotions. Mackenzie [7] is convinced that, "if generalizations were to be made about the causes of human diseases it would be along the line of failure of accommodation to the erect posture." It is the opinion of the writers that the development of many chronic diseases, the causes of which are undetermined, may be favored by continued dysfunction of these various systems of the body, which dysfunction may be induced by continuous bad body mechanics.

Sherrington [8] has elaborated the theory of postural tonus and has demonstrated its existence even in decerebrate animals. In discussing the posture of any individual, it would seem fair to assume that the greater the departure from effortless equilibrium, from balance and counterbalance, from good body mechanics, the greater will be the amount of the reflex muscular action or postural tonus required to maintain the body in an upright position. There is a fairly constant ratio between the amount of reflex contraction required and the amount of muscle fatigue induced. The obvious point we are making is, that bad body mechanics is more fatiguing than good body mechanics, and that if fatigue exerts an unfavorable influence upon the growth and development of children, a certain amount of fatigue may be obviated by the attainment of good body mechanics.

Clinical evidence is often uncertain and unconvincing. It becomes more impressive if it is cumulative. Clinical evidence has been steadily growing that good body mechanics is favorable to health and that bad body mechanics is unfavorable to health. The following strong impressions are derived from this evidence:

Failure to gain weight, and digestive disturbance, although the diet be appropriate and adequate, are frequently associated with bad body mechanics.

The weight tends to increase and the digestive disturbance to cease, if there be no organic lesion, when bad body mechanics is changed into good body mechanics.

Bowels which are sluggish tend to become more regular in action with improvement in body mechanics.

The cessation of cyclic vomiting and certain presumably toxic crises which have been concomitant with the correction of bad body mechanics seem to have resulted from this correction.

An increase in vigor and alertness is usually noted in connection with an improvement in posture and muscle tone.

Evidence of a more definite and convincing character may be found in the few surveys and studies which have been directed toward this subject. Brown,[9] under the auspices of the Department of Hygiene of Harvard University, made examinations of freshmen in relation to posture. They were graded A, B, C, D, as already described. These students were presumably healthy and represented an educated group of young men who, as a group, had not been subjected to either mental or physical hardship; yet this survey showed that about 80 per cent fell in the C and D classes. In reviewing the past history and present condition of these men, it was evident that there was a definite positive correlation between good health and good body mechanics.

In the first division of United States combat troops sent to France in the World War, an alarming proportion of soldiers were discovered who broke under the regular training designed to fit them for actual service. Very few of these men showed organic lesions. Inability to develop sufficient physical stamina to put them into the A and B class of soldier was the difficulty. At this time little attention was paid by the regular army trainers to body mechanics as we now understand them or to the individual requirements of the soldier. At the suggestion of General Goldthwait, several reconstruction camps were established to which were sent inefficient soldiers of the class described above. Training along the lines of body mechanics was instituted and in an average period of two months it was found possible to return to active duty of the A and B class approximately 80 per cent of these otherwise almost worthless men. An improvement in body mechanics seemed to be the essential factor in their rehabilitation.

EFFECT OF GROUP TRAINING IN BODY MECHANICS IN A PUBLIC SCHOOL

In 1923 to 1925, the United States Children's Bureau of the Department of Labor engaged in a survey of certain phases of the health of children. One of the conditions which they wished to investigate was the incidence of poor body mechanics in a group of over two thousand grade school children. Up to this time, as far as we know, except for the suggestive studies of Lee and Brown with the Harvard students and similar studies with groups of Smith College students carried out by Goldthwait and Thomas (unpublished), there had been no attempt to determine whether reasonably healthy growing children exhibiting good body mechanics possessed any favorable handicap over reasonably healthy children exhibiting poor body mechanics. The method of conducting the survey may be outlined as follows:[4]

The Williams public grade in Chelsea, Massachusetts, was selected for the experiment. The school has an attendance of about three thousand children ranging in age from five to eighteen, the majority being between nine and fifteen. The district is largely Russian Jewish. The master of the school assigned for the first year 26 rooms, the Grades ranging from I to IX, with an attendance of approximately one thousand children.

The rooms in each grade were equally divided into two groups and to one group during the course of the year special instruction in body mechanics was given and to the other the regulation calisthenics prescribed by the department of physical education. During the second year of the survey, the master assigned 36 rooms for a similar study, the Grades ranging from I to IX, with an attendance of approximately one thousand two hundred children.

Lectures on the teaching of body mechanics were given to the regular school teachers whose instruction was supervised by an orthopedic surgeon especially interested in body mechanics, who acted as director of the survey, and a physical therapist of long training in posture, acting as supervisor and assisted by senior students of the Boston School of Physical Education acting as assistant supervisors who supplemented the daily instruction given by the regular grade school teachers. The body mechanics exercises were taught formally ten minutes each day. The exercises taught may be found in *Posture Exercises*.[10]

The school teachers entered into the experiment in a most cooperative manner and gave most excellent instruction considering the meager training they themselves had received. Each child in both the body mechanics groups and the regular physical exercise groups received a physical examination at the beginning and end of the school year. In this examination significant facts were noted and recorded on cards. Body measurements were taken and silhouettographs of posture were made. Height, standing and sitting, and weight were recorded each month. School attendance was recorded every quarter and the reasons for absences were noted. All medical attention required out of school was recorded. The grade room teacher marked the children each quarter on scholarship, deportment and concentration.

Of the 2,200 children thus studied, the schedules of only 1,708 were completed, 961 in the body mechanics or posture group and 747 in the physical exercise group. Seventy-six children in the body mechanics group received training for two years and 68 the regular physical exercise only. Both groups contained about 75 per cent Russian Jews, and the sexes were about equally divided. Sixty per cent of the children were classified as of the intermediate or neutral body type, 25 per cent as stocky and 15 per cent as slender. On the first examination of the 1,708 children whose records were complete, less than one per cent of the children showed A posture, less than 10 per cent B posture, about 60 per cent C posture, and about 30 per cent D posture. The girls showed a somewhat poorer posture than the boys. The poorest grades of posture were in the lower school grades. The results of this two year survey may be briefly summarized:

Nine times as many children improved in body mechanics under special training as those without training.

Poor body mechanics was not outgrown to any marked degree.

The stocky children had the largest percentage of good posture and the slender children the smallest percentage of good posture.

Improvement in body mechanics was associated with improvement in health and efficiency (the latter being judged by scholarship and deportment) and the regularity of attendance was much greater.

The groups given training in body mechanics decreased in rate of absence due to illness during the year so that their percentage of absence was considerably lower than that of the children who did not receive training in body mechanics, whose rate of absence increased during the year.

Training in body mechanics had no significant effect upon vital capacity.

Training in body mechanics improved the tone of the abdominal muscles and reduced the fat deposited in the abdominal wall, as shown by a decrease in the circumference of the abdomen without decrease in depth.

The average increase in the costal angle in inspiration was greater in the trained than in the untrained children.

Postural, functional, or habitual lateral curvature of the spine almost constantly disappeared with the acquirement of better body mechanics and remained usually unchanged in the untrained group.

In the small group of children (76) surveyed for two years, the posture grade attained during the first year was in the majority of cases retained or bettered during the second year.

The conclusions of those reporting the results of the survey may be quoted. The results were studied statistically and reported by the Children's Bureau, which did not conduct the survey:

In this study we attempted to ascertain first whether the average school teacher and the average school director of Physical Education being taught the rudiments of good posture (body mechanics) could impart the general principles to the school children without disorganization or undue increase in curricular work. This study shows that these members of the regular school staff are able to give the children posture training which they have learned from experts without undue rearrangement of the school activities. Secondly, we wished to ascertain whether such training carried out during one school year would bring greater evidence of improved health, nutrition and morale among children who were trained than among control groups receiving no posture training. Analysis of the records shows that favorable results may be attributed to posture training. Posture training and the maintenance of correct posture contributed to the health and efficiency of normal grade school children.

METHODS EMPLOYED FOR ATTAINMENT OF GOOD BODY MECHANICS

A brief outline of the methods employed for the attainment of good body mechanics is germane. Good body mechanics should require no artificial methods for their attainment in a sturdy, intelligent race faced with the necessity of existence under favorable conditions of food, climate and labor. The examples of the North American Indians selected as typical of their races will suffice. These warriors exhibited almost without exception nearly perfect body mechanics in action and in repose. Under conditions of modern civilization and education, new conditions are imposed, less life in the open, less physical exercise, less natural food.

The result is read in the surveys of the body mechanics of supposedly normal and healthy children and adults. Poor body mechanics heavily predominates. The attempt to change poor body mechanics into good body mechanics is not an attempt to impose abnormal standards, but to restore normal standards, to make physical and perhaps mental life easier, not harder, to change influences unfavorable to growth and development into influences favorable to health and well-being.

Faced with conditions which surveys reveal, methods must be devised to improve these conditions. The discussion of these methods may be arbitrarily divided into the methods applicable to the stages of infancy, childhood and adolescence.

Methods Applicable to Infancy

Congenital Deformities of the Skeletal, Muscular, Nervous and Visceral Systems. These congenital or birth deformities, examples of which are wry neck, club foot, congenital dislocation of the hip, spastic palsy, birth palsy, pyloric stenosis, aberrations of the genitourinary system, and the like, demand little discussion. The methods of their alleviation are the methods of physical therapy and surgery.

Acquired Postural Defects. From birth to a year of age, the spine is undergoing its most rapid change of curvature from the single slightly dorsally convex curve to the normal compound curves at a year of age or when the baby assumes an erect posture. The range of all joint motions including the spine is also greater in infancy than in childhood.

If the growing skeletal bone is subject to abnormal stresses, it will develop abnormalities of growth. Proper positions of holding infants and symmetrical positions in recumbency should, therefore, favor normal symmetrical development of the skeletal, muscular, and visceral systems. The Indian papoose tends to straightness. The habit of carrying the baby on the arm tends to crookedness. The common practice of letting the infant sleep in a baby carriage with soft pillows and uneven floor is to be criticized. Bassinets and so-called "kiddie-koops" with a board or firm springs beneath the mattress are obtainable, and provide sufficient room for any symmetrical position, prone or supine, and assure fresh air.

As the baby is reaching six months, he needs a hard surface and plenty of space unhampered by blankets in which to develop his muscles, so that he can eventually learn to gain his sitting position and later creep and stand.

It is quite as important to remember that a baby is seriously hampered in the use of his muscles when his diapers are pinned tight to band or shirt and to stockings so that he cannot stretch out straight without pulling his shoulders down or his legs up. He should be so clothed that his garments will not be too thick for him to have full control of his arms and legs.

Considering these factors, the child will be better able to sit up when he is ready and maintain his balance, for his muscles will have a chance to develop normally without restriction. With properly balanced food to guarantee normal nutrition, one is then laying down the best possible foundation for the prevention of the faulty body mechanics which so often begins to be evident in early childhood.

Methods Applicable to Childhood

Early Years (*Two to Six*). In the years when the faulty body mechanics begins to be evident, the chief method of attack is by means of education in the direction of good body mechanics by appropriate games which involve good body mechanics. Imitative play is surprisingly successful in changing poor body mechanics into good body mechanics. The personality and resourcefulness of the trained parent or teacher is the all important factor.

Later Childhood (*Six to Twelve*). Purposeful exercising, sometimes aided by light apparatus and always by corrective positions to be assumed during rest periods in recumbency, are the methods employed during this stage. *Body Mechanics and Health*[11] will furnish the details of these exercises and positions in recumbency.

Adolescence

When the child enters the adolescent stage, the same exercises and positions are applicable as in later childhood, but other motives than obedience may be counted upon to stimulate effort. Two of the most powerful of these motives are personal appearance and athletic prowess. The favorable influence of good body mechanics upon both attractiveness and athletic skill may be demonstrated by paintings and sculpture and by snapshots of successfully competing athletes. Another incentive for the acquirement of good body mechanics may often be furnished by offering as a reward for such acquirement freedom from some other task of physical exercise which is less agreeable and less essential. During the later years of childhood and in adolescence, sufficient time should be spent with the subject to assure his cooperation and stimulate his desire to acquire good body mechanics, in order that the unfortunate family nag may be eliminated. Unless this cooperation and desire is present, the results are likely to be disproportionate to the effort. Teaching spirit and routine training in body mechanics in schools aid greatly in the acquirement of good body mechanics.

PERMANENCE OF RESULTS

Permanence of results is difficult to estimate accurately. In older patients whose restoration of health is associated with the attainment of good body mechanics, the permanence of results is fairly well assured. In younger subjects, whose health is not seriously impaired, the postural tonus of good body mechanics is easier and more natural to maintain than the postural tonus of poor body mechanics. There is evidence to suggest that once acquired it is largely maintained in the majority of cases unless continued fatigue, worry, or ill health exists. This evidence is presented by the statistics in the Army reconstruction camps, by the follow-up of college students after vacation periods, by the two year cases of the Chelsea Survey,[4] and by some recent studies made at Smith College by Leah C. Thomas and Amy Lindner of the Department of Hygiene.[3] The following is a quotation from the studies of Thomas and Lindner:

> At the time of the physical examinations of the Freshman class in September 1929, it was noted by various members of the Physical Education Department that there was an unusually large number of students with A and B postures. This fact stimulated the ensuing procedures: 1. To gather as many details as possible regarding previous posture training in order to determine whether or not this specific training was the chief factor in bringing about the excellent showing of A's and B's. 2. To gather information regarding all of their previous activities in athletics, gymnastics, dancing, sports and organized games in order to determine whether or not these activities are important factors in acquiring good posture. We used to list all the A's and B's in the Freshman class and considered those as one group (a sum total of 150 students); the C group involved the same total number of students, and in order to obtain an average C group we selected the C's from one advanced Danish gymnastic class, two regular gymnastic classes, one *light* gym class and two corrective classes; the D group included all the D's in the entire Freshman class (61 students).

Lindner and Thomas sent out questionnaires to determine (1) the previous postural training and (2) their previous athletic training. Some of the conclusions reached from the two questionnaires follow:

That a small number of A's and B's are natural postures, but the large majority of A and B postures are acquired through understanding and training in body mechanics. In contrast 85 per cent of A's and B's had training, while only 32 per cent of D posture had training.

The large majority of A and B posture students came from private schools while the large majority of D postures came from public schools. The difference in the number of students per instructor in private and public schools probably accounts in this instance for the higher record of work done in private schools.*

The number of years of activity in athletics and gymnastics was about the same in each group. If any, very little effort on posture seems to be evident through previous athletic and gymnastic training.

This year, for the first time, a special privilege was granted to the Freshmen who were given a ranking of either A or B on the posture pictures which were taken in September directly after they entered college. These students were permitted to elect their activity for the winter instead of being required to take the regular gymnastic work. Posture pictures were again taken in January 1930 to find out whether or not this posture was maintained. If the grade in any instance was lowered to a C, that student was assigned to her regular gymnastic section so that she might have at least one quarter of a year of training in the posture work which is introduced into all gymnastic classes.

As a result of this study, these observers were led to the following conclusions: "that the two following factors are of equal importance, (1) an understanding of the principles of body mechanics and (2) an incentive to create a strong desire to acquire habits of correct body mechanics. The tendency in the past has been to place more importance on the incentive than on actual knowledge of body mechanics. We believe that a thorough understanding of the principle of body mechanics is necessary as a foundation for good posture and that this understanding plus the incentive will seldom fail to bring about satisfactory improvement."

* It is also true that private schools, by and large, pay much attention to posture and provide training in posture. Only the occasional public school pays attention to posture or provides training.

A follow up was made of a considerable group of students who started in their preparatory school in the C and D grades but had attained A and B grades on entrance to Smith College. Because of the exhibition of these high grades, these students were excused from special training in body mechanics in college. They were followed throughout their college course and almost without exception retained for the four years these high grades without continuing special work in body mechanics. By actual count a larger number of grade B students of this group changed into A grade students than the number which changed from the A to B grades.

CONCLUSION

It is obvious from this brief interview that much more information must be gathered before any conclusive statements can be made in scientific terms as to the effect of good and bad body mechanics on the growth and development of children. Such evidence as now exists seems to suggest that good body mechanics may favorably influence the growth and the health and well-being of children. Research into the causes of the high incidence of poor posture among children is urgently needed if prevention is to succeed. Nevertheless, whatever its causes are, poor body mechanics is not inevitable, and the conversion of poor body mechanics into good body mechanics and the maintenance of the latter seem possible of attainment in the vast majority of individuals by adequate training.

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PHOTODYNAMIC ACTIVITY OF LIGHT AND ITS USE AS A THERAPEUTIC AGENT

LIGHT AND ITS SOURCES

The Spectrum

WHENEVER radiation is used for treatments it is necessary to consider which parts of the spectrum are represented and what intensity each region has. The different wave lengths may very well have different physiological actions. Although light ordinarily refers to the radiation which is visible we shall include the ultraviolet and the infrared radiations under this heading. The main divisions of the spectrum are: (1) the ultraviolet, approximately between 200 and 400 mμ *; (2) the visible, from 400 to 800 mμ; and (3) the infrared, from 800 to about 10,000 mμ. It is, however, not enough to differentiate merely between these three regions, and for experimental purposes *monochromatic* radiation, which means any very limited portion of the spectrum, would be the ideal condition. A monochromator can be used for this purpose, but for most purposes it reduces the intensity too much and makes the beam of radiation very small. Such an ideal arrangement is therefore limited to exceptional occasions. Filters can be employed to cut out certain regions of the spectrum and if the light source radiates primarily a line spectrum it may be possible to limit the radiation by means of filters to approximately one line. But, for treatments, as well as for numerous biological experiments, it has been customary to use rather large regions of the spectrum.

* The millimicron (mμ) used to measure the wave length of light is 0.000,000,001 (10^{-9}) meters. It is equal to a millionth of a millimeter.

Light Sources Available for Therapeutic Use

The light sources which have found application in medicine are: (1) the sun; (2) carbon arcs; (3) mercury vapor arcs in quartz; (4) metal arcs; (5) high tension disruptive electric sparks between metal electrodes; (6) electrical discharge through certain gases; (7) chemical lamps which burn certain fluids in oxygen (seldom used, as they are difficult to operate and possess a limited field of radiation); (8) ordinary electric bulbs with a heated filament; (9) electrically heated carbons or metal wires yielding a radiation especially rich in infrared rays.

Of these sources, 1 to 7 inclusive, give off ultraviolet of shorter wave lengths than 310 mμ. The first three have been used the most and we shall therefore consider them more in detail.

Sunlight.[1] On entering the earth's atmosphere the total solar radiation amounts to about 1.93 small calories a square centimeter a minute. Five per cent of this radiation is ultraviolet, 52 per cent visible and 43 per cent infrared. Since the atmosphere reflects, scatters and absorbs radiations of different wave lengths to different degrees, the relative as well as absolute amount of radiation is considerably modified by the time it reaches the surface of the earth. It also varies with the season, with the height of the sun above the horizon, and with atmospheric conditions such as cloudiness and the amount of ozone, smoke, or dust in the air. At an average height of the sun, about 75 per cent of the radiation reaches 1,800 meters above sea level and about 50 per cent reaches the sea level. The proportions of ultraviolet, visible, and infrared are then about one per cent, 40 per cent, and 59 per cent respectively. The proportion of ultraviolet in the light reflected from the sky is rather high, as much as 2 to 4 per cent. According to some other measurements sunlight at sea level contains one to 4 per cent ultraviolet, 42 to 53 per cent visible, and 57 to 43 per cent infrared; at Mt. Wilson (1,750 meter altitude), 2 to 5 per cent ultraviolet, 50 to 55 per cent visible, and 48 to 50 per cent infrared; on Mt. Whitney (4,420 meter altitude), 2 to 6 per cent ultraviolet, 54 to 55 per cent visible, 45 to 50 per cent infrared. Sky light may be of considerable importance, due to the relatively large proportion of ultraviolet radiation present in it. The intensity of solar radiation is a very variable factor, changing momentarily, daily, seasonally, and geographically.

Carbon Arc Lamps. These are of two distinct types. (1) When solid carbons are used the radiation is mainly a result of the heat, which produces a continuous spectrum. The positive electrode is heated up the most and the lamp is much more efficient on direct current than on alternating current. The greater the current, and especially the denser the current (amperes per sq. cm.), the hotter the crater becomes and the more intense the radiation and the greater the proportion of ultraviolet. The temperature also determines how far into the ultraviolet the spectrum extends. The Finsen lamp is of this type. (2) The carbons may have a core impregnated with certain metal salts, which give a so-called *flame arc*. The main part of the radiation is produced in the flame between the two carbons. The metal salts are evaporated and radiations characteristic of the different metals present are produced. These radiations consist of bands and lines of great intensity at certain regions of the spectrum. Investigations of different types of cored carbons have been made at the Bureau of Standards by Coblentz.[3] The National Carbon Company have several such types of carbons. Their "C" carbon is quite rich in the ultraviolet region. The total energy from a 65 volt, 28 ampere flaming "C" arc at one meter distance is about one small calorie a square centimeter a minute with about 15 per cent ultraviolet, 59 per cent visible, and 26 per cent infrared. A combination of the two types has also been used where both the positive crater and the flame contribute to the radiation. The distribution of radiation can be made to approximate that from the sun quite closely if the density of the current is made very great, if the proper salts are used, and if some of the rays are filtered away.

Mercury Arc Lamps. These produce a line spectrum rich in the shorter ultraviolet rays. Most of the mercury arcs used for treatments are enclosed in quartz tubes which permit rays as short as 200 mμ to pass through. The amount of radiation depends upon the current, upon the construction of the lamp and its age. As it gets older the quartz becomes coated and the intensity falls off. A new lamp drawing about 4 amp. at 65 volts has at 40 cm. distance a total intensity of about 0.1 small calorie a square centimeter a minute with 30 per cent ultraviolet, 53 per cent visible, and 17 per cent infrared.

A new type of lamp is the so-called *sun-lamp* which utilizes the radiation from the mercury arc as well as from the white glowing tungsten electrodes. The bulb is made of a special kind of glass which transmits a fair amount of ultraviolet down to 280 mμ. The intensity of rays of 300 mμ wave length is about one seventh of that from a mercury quartz lamp.

If ultraviolet is desired without much other radiation, the mercury quartz arc seems especially suitable. It is well to remember that this is not a continuous spectrum but that energy is concentrated in certain wave lengths. If more visible radiation is required, or a greater total intensity, then the carbon arc seems more suitable. Very often the sunlight is the most desirable type, even though the variation in its intensity makes it difficult to apply in exact dosage. The carbon arc seems to be the best substitute for the sun.

Radiation is used both for local and general treatments. For local treatments special lamps or applicators have been constructed. Finsen adopted the direct current carbon arc of high candlepower, concentrating the light by means of a series of quartz lenses and absorbing part of the infrared radiation by means of water. In this way patches of lupus could be treated with intense ultraviolet radiation. Another type of lamp constructed for local treatments with ultraviolet light is the water cooled mercury quartz arc. The light source can be brought very close to the area to be treated. Quartz rods can be attached to the lamp and as the light passes through the full length of the rods and is reflected back in from the sides by total reflection (even if the rods are bent), different areas inside of cavities such as the mouth or nose can be reached in this way by the rays. Recently a high voltage mercury arc in a thin quartz tube has been put on the market. This tube can be inserted into cavities, as it does not heat up appreciably. The light is radiated from the whole length of the tube. The line 253.7 mμ is especially strong.

Ordinary window glass absorbs radiation below 320 mμ to a very great extent and, as this particular part of the spectrum seems to be of great importance, special kinds of glass have been made which are more transparent to these rays. Quartz is best in this respect, but far too expensive for most purposes. Corex D., Neuglas, Uviol-Jena, and Helioglass let through a fair percentage of radiation between 280 and 300 mμ and may be used in windows. The shortest rays of the sunlight present at the surface of the earth can thus be made available indoors.[3]

Reflectors are used to a great extent to concentrate radiation in one direction. It must be remembered that ultraviolet radiation may be absorbed to a great extent by many surfaces which reflect visible light very well. Metal surfaces reflect ultraviolet rays quite well, especially reflectors made from polished aluminum, magnesium, nickel, and some alloys of these metals. Jesioneck utilizes reflection to a great extent in his sanatorium at Giessen. Several lamps are used in a room which is so constructed that the walls, ceiling and floor reflect the rays. The patients walk or stand during the treatments, being irradiated simultaneously on all sides.

The Absorption of Light

Radiation can produce a direct effect only where it is absorbed. It is, therefore, important to know to what extent the light is absorbed by different tissues as well as by definite organic compounds. Though there is still some discrepancy in the literature, most of the measurements which have been carried out with due precautions are in agreement. They show that tissues absorb light to a varying degree, depending on the wave length, and on the whole are most transparent to rays of wave length of about 1,000 mμ in the near infrared. To ultraviolet radiation they are quite opaque, and more so the shorter the wave length. Rays of wave length 260 to 310 mμ are so completely absorbed by the skin that practically none passes through, and the direct action of this radiation, therefore, undoubtedly is limited to the skin unless the underlying tissues are denuded.[4] Some recent biological experiments by Miescher[5] indicate that a thickness of 9 μ * of the stratum corneum reduces the intensity of this radiation to one-half and 100 μ reduces it to 0.1 per cent. The most penetrating radiation around 1,000 mμ, on the other hand, is reduced but slightly in intensity by the skin and according to Danforth[6] about 20 per cent passes through the cheek. It is interesting to note that the amino acids with a phenol ring, and consequently most proteins, have an absorption band in the ultraviolet around 280 mμ, and that hemoglobin has several absorption bands in the visible region as well as an intense band in the region around 400 mμ.

PHYSIOLOGICAL AND BIOLOGICAL ACTION

Light has a considerable influence on certain tissues and organs and on their activity. The action seems to be complex and is difficult to study. Numerous investigations have been reported in the literature but many of them are contradictory to each other, and more exact and clean-cut experiments must be performed. Most of the effects have been attributed to the ultraviolet portion of the radiation. As this radiation is absorbed mainly by the skin, it seems that the primary action must take place there. Certain diseases such as tuberculosis seem to be influenced to a greater extent by total solar radiation than by ultraviolet alone, and it is therefore possible that the visible and infrared portions of the spectrum also are responsible for specific actions. Many of the compounds present in tissues and body fluids are directly affected by light, at least if the exposure is intense. Proteins have absorption bands in the ultraviolet region. Beribrin,

* The micron (μ) is a millionth of a meter and is equal to a thousandth of a millimeter.

lecithin, and chlorophyll, all complex basic substances, have photogenic properties after irradiation or exposure to the sun.

Effect of Irradiation of Foods and Vitamins

Numerous studies have been made upon the effect of irradiation on foodstuffs, with particular reference to their vitamin content. In fact aside from the influence on the vitamins no definite effect on foodstuffs has been determined. And most of the work can be summed up briefly in the statement that vitamins A, B, and C are apparently not influenced by ultraviolet radiation, either in the direction of destruction or of formation of more of the vitamin in question.

Vitamin D, the antirachitic factor, which is more fully discussed in *Nutrition,** occupies a unique position in this respect. The antirachitic properties associated with this substance can be imparted to foods by exposing them to ultraviolet radiations, as shown by Steenbock and Black [7] and by Hess and Weinstock.[8] If the fodder of cattle be sufficiently irradiated by sunlight, the milk acquires definite antirachitic properties. This activation of foods depends on the presence in the food of a lipoidal substance closely related to cholesterol, known as ergosterol. This material is widely distributed, but is found with fats and oils. Only minute quantities need be present in order that the food may be activated. Akin to this effect is the possibility of protection of animals against rickets by irradiation of the animals themselves. The protective action of sunlight against rickets and its curative value in this condition are touched upon elsewhere in this volume.

It should be noted, however, that if vitamin D is exposed to a considerable amount of ultraviolet radiation it can be completely destroyed. Wave lengths below 280 $m\mu$ seem to be responsible for this destruction. Marshall and Knudson [9] have, however, found that the same wave lengths which activate ergosterol cause deactivation if the exposure exceeds certain limits. They found rays between 230 and 302 $m\mu$ to be responsible for both effects.

* *Growth and Development of the Child,* Part III.

Reactions of the Skin to Light

The skin reaction known as erythema is produced by radiation between 260 and 313 mμ.[10] It is well known that a protection against such action can usually be obtained by a gradually increased exposure to these rays. The nature of this protection has been extensively debated. At first it was assumed that the pigmentation that usually results from the exposure was responsible, but it has been found that considerable protection can be obtained without much pigmentation and also that very little protection may be present in spite of intense pigmentation, as in Negroes. Recently Miescher[5] has shown the stratum corneum thickens after exposures to these rays. The opacity of this layer to ultraviolet rays has been mentioned before. It seems, therefore, rather convincing that the thickening of this tissue is mainly responsible for the protection. The pigmentation undoubtedly contributes somewhat to the protection, but may have other functions as well. For example, it absorbs longer waves to a great extent and influences the temperature regulation. Recent investigations by Uhlmann[11] indicate that pigmentation is produced by ultraviolet rays of wave length 313 and 366 mμ as well as by the rays responsible for the erythema. It should be mentioned that both erythema and pigmentation are also produced by roentgen rays, and rays from radium and cathode rays. Pigmentation produced by sunlight is of different quality and lasts longer than that produced by either mercury or carbon arcs.

The clinical value of pigmentation is not understood and the question as to whether it is or is not beneficial cannot be regarded as settled. A fact that is not sufficiently emphasized, but which is apparent to all clinicians who use radiation therapy, is the enormous variation in the response of the skins of individual patients to light. It is impossible to make any arbitrary classification into those who tan and those who do not, or to attach any importance in prognosis to the formation of pigment.

Effect of Irradiation on the Blood

Ever since the photodynamic action of light began to be understood, the impression has prevailed that it is peculiarly effective in altering the blood in various ways. This is a reasonable expectation, inasmuch as light can act only on the surface of the animal, and if systemic effects are to be brought about they would presumably be mediated by changes in the composition of the blood. Numerous experiments have been directed toward the detection of such changes, using in some cases animals under experimental conditions and in other cases patients under treatment for various conditions. In still another type of experimentation the blood itself has been directly exposed to irradiation. This is accomplished by introducing into the arterial circulation of an anesthetized animal a length of quartz tubing and thus making it directly accessible to the light.

Unfortunately the findings of various investigators have not been in entire agreement, and further work is needed in this direction in order to gain an insight into the mechanism of the action of light upon the organism as a whole. A few of the observations in this field may be mentioned briefly for purposes of illustration.

Following direct irradiation of the blood of experimental animals Reed[12,13] and his collaborators found a marked increase in the uric acid content of the blood, but no change in the blood calcium. He noted an increase in the hemoglobin content and the red cell count, and often a marked fall in the general blood pressure. Harris[14] reports changes in the affinity of the blood for oxygen after exposure of ultraviolet light, but the significance of the changes reported is not clear.

Irradiation of entire animals for various lengths of time has been variously reported as causing an increase in calcium and the inorganic phosphorus of the serum (Brown[15]), the proteins and the sugar of the blood (Laurens, Mayerson and Gunther[16]), and of hemoglobin and red cells in normal animals rendered anemic by venesection (Osato and Tanaka [17]).

Exposure of the human body is said to cause transitory changes in the alkalinity of the blood (Barkus and Balderry [18]) and changes in the water, the chlorides, the potassium, the sodium, and the alkali reserve are variously described (Kroetz [19]; Paquiez, Coste and Solomon [20]). Beneficial effects on the hemoglobin and cell count of infants who were deficient in these respects have been obtained (Sanford [21]) not only by irradiation but by the feeding of irradiated milk. Normal children did not show this effect, but in some cases showed a decrease. Changes in the bactericidal powers of the blood have been found (Gonce and Kassowitz [22]), but the direction of the change is variable and seems to be correlated with the leucocytic reaction of the body. Genner [23] was unable to find significant changes after irradiation with the Finsen or a quartz mercury vapor lamp.

These scattering and sometimes contradictory results indicate the nature of the work which is in progress in this field. They also indicate that radiation from various light sources can and does have definite chemical and physical effects upon the blood. The preponderance of evidence suggests that such action is generally beneficial and may be of distinct therapeutic value.

The evidence presents a number of weaknesses. It is not consistent or conclusive and is in some instances confused by negative findings. There is at present no definite differentiation between the effect of the various sources of light used and no accurate measure of dosage or the limits and ranges within which this obviously powerful agent could be safely and beneficially used. Carefully controlled animal and human experiment must assay the effect of the various ranges of the solar spectrum which are characterized by photochemical dynamic activity. The safe limits of this activity must be much more clearly defined than they are at present. This should be a fruitful field of investigation and one which offers great possibilities for therapeutic advance.

Effect of Irradiation on General Metabolism and Growth

Some clinical observation and a moderate amount of experimental work on animals seem to indicate that radiation has a definite effect on the general metabolism of the organism and growth.

Certain reflexes in the autonomic nervous system on which normal health depends seem to be controlled by climatic factors. Wind and sun seem to be the chief factors (Jakowenko [24]).

The general rate of metabolism of both adult and child does not seem to be appreciably increased even after prolonged and repeated exposure. There was in some of the cases a notable lowering of heat production and a slowing of the pulse rate. In no case was there an increase in the rate of metabolism (Fries [25]; Mason and Mason [26]).

There is considerable experimental proof obtained in animals of the effect of irradiation upon the general metabolism. Of a series of rabbits born and raised in a dark cellar, some were systematically rayed with ultraviolet light and a control group not. The irradiated group thrived and gained. The control group steadily declined (Springes and Tardieu [55]).

Rabbits kept under conditions of constant light, but without particular limitation to ultraviolet, gained more and were freer from disease than animals kept in constant darkness (Pearce and Van Allen [27]).

Chickens exposed to full sunlight grew better than a series exposed systematically to ultraviolet light. Both series of animals grew much better and were in better condition than a series kept under glass which cut off the ultraviolet (Bovie [28]).

The fertility of hens irradiated for short periods daily was doubled over that of an unirradiated control group. The eggs from the irradiated group had 30 per cent more calcium in the shell and 5 per cent more in the contents. The hatchability of the eggs was doubled. These percentages were reversed when the control group was irradiated and the irradiated group was changed to the control group (Hughes and Payne [29]).

Irradiation of normally growing organisms showed greater calcium content of tissues in the irradiated than was found in the control group. Ultraviolet rays can convert negative calcium and phosphorus balances to positive balances (Orr, Magee, and Henderson [30]).

Ultraviolet irradiation had favorable effects on the calcification of the teeth of young animals placed on a defective diet. When the diet alone produced very defective teeth, the improvement produced by exposure to radiation was less. If the diet was very unbalanced, the irradiation made the teeth worse (Mellanby [31]).

Effect of Light and Irradiation upon Disease Processes

Radiation has in recent years had widespread use in the treatment of disease. The discovery of its value in the cure of certain diseases has let in a flood of popular enthusiasm which has run ahead of scientific knowledge and which threatens to destroy by indiscriminate use the value of the treatment. At the present time the value of radiation treatment is discredited by some and overemphasized by others.

There are certain general criticisms which apply to nearly all of the clinical reports on the use of radiation therapy. There is an almost complete lack of control experiment. The treated cases are usually uncontrolled by untreated cases. The radiation therapy is often used as a last resort in intractable or practically incurable cases. There is lack of information, or very unreliable information, with regard to the source of light used.

Only the ultraviolet portion of the solar spectrum generally seems to be regarded as important. There is comparatively little information about the possible effect of the other portions.

Sonne [32] studied in some detail the mode of action of radiation on human skin. He felt it illogical to attribute the whole therapeutic effect of general light to radiations in the ultraviolet region and made a special study of the biological action of visible and infrared radiations. The results seemed to point to a heating effect of subcutaneous tissue and blood under the action of visible and near-red radiations. Sonne regards this production of heat in the skin and blood as being of positive therapeutic value, and recommends the use of the carbon arc rather than the mercury vapor quartz lamp, the former being a better source of visible and heat radiations.

Tuberculosis. Of all disease processes for which light per se has been primarily thought of as a therapeutic agent, tuberculosis stands at the head.

Mayer,[33] in 1921, published a critical review of the subject of sunlight and light from artificial sources in the treatment of tuberculosis, with an extensive bibliography. Since this review was written, very little has been added to our knowledge on the subject from the clinical standpoint.

The foundation of Rollier's Clinic in Leysin in 1903 gave great impetus to the use of heliotherapy in the treatment of tuberculosis. Reading the second edition of his book,[34] one is profoundly impressed with the clinical results obtained, especially in bone tuberculosis, by treatment in which heliotherapy is one of the factors employed. The results given in this book are the fruit of twenty-five years' experience. Rollier says that the scientific aspect of the effects of heliotherapy are bound up in finding the answers to the three following questions: What rays bring about the cure? In what way do they act? What physiological process is involved in cure? None of these questions has been satisfactorily answered. Rollier from his clinical observations regards the effect as due, in the main, to ultraviolet radiation. He finds that pigmentation of the skin predisposes to cure, that ultraviolet radiation alone will bring about pigmentation, and argues from this that the curative radiations are in the ultraviolet region.

It may possibly be just the reverse. Peacock[35] gave evidence that pigmentation of the skin is a protective mechanism against the action of ultraviolet radiation.

It would seem more likely that Rollier's best results have been obtained in cases where the skin of the patient is most effectively protected against radiations in the region of the ultraviolet. While heliotherapy undoubtedly plays a large part in the results reported at Leysin, we must recognize that it is only a part, not the whole, of the regimen. Other factors are exposure to air exceptionally dry and pure in quality, freedom from fog, dust, winds, and rain, combined with ideal conditions of feeding, prolonged periods of rest, orthopedic treatment, and pleasant occupational therapy.

Rollier regards the formation of pigment as of great prognostic importance on the theory that pigment acts as a transformer which changes rays of short wave length into rays of longer wave length with deeper penetration. This view has been refuted by Clark [36] and is questioned by many others.

Mayer [38] regards the rôle of pigment and its mode of formation as still obscure; also the specific powers possessed by pigment as unproven. He emphasizes the need for more extended research on the penetrating power of different rays and their effect upon tissues.

Much has been written in the clinical literature as to the benefits of heliotherapy in various forms of tuberculosis, and as to the various degrees of success attending its employment in various types of the disease. It has been used successfully in the lowlands as well as at the high altitudes advocated by Rollier and by Finsen.[37] The consensus of clinical opinion seems to be that heliotherapy is an excellent form of treatment if it is given with reasonable precautions and under exact supervision, but that it must be used only sparingly in active febrile cases. It should preferably be given in the open air.

Contrary to the view of Rollier, Lo Grasso [56] and other enthusiastic advocates of heliotherapy, there are many who favor the use of artificial light sources in the treatment of tuberculosis. However, ultraviolet treatment is ineffective in meningeal tuberculosis and must be used with some caution in active pulmonary tuberculosis. In all forms of skin tuberculosis irradiation with light from artificial sources, especially the carbon arc, is uniformly beneficial. In general, ultraviolet light is a logical substitute for heliotherapy. Radiations from either the mercury quartz lamp or the carbon arc should be used. Fresh air should always be an adjunct if artificial light therapy is used.

Since the earlier work of Rollier on the effect of heliotherapy, interest in its use and effects has been alive and fairly active, but waned during the period when observation and experimentation with ultraviolet light held the stage. There is considerable return now to investigation, observation, and appraisal of the effect of heliotherapy. Practically all observers are agreed that it should not be used, or at least should be used with much caution, when tuberculous processes are active. This is particularly true of pulmonary tuberculosis. Its best effects are obtained when the process is stationary.

Gauvain,[38] in raising the question of why the results of light treatment in surgical tuberculosis are so variable, why in some instances so brilliant, in others so disappointing, attempts to explain this on what he calls his "theory of varying stimuli and varying response." He regards sunlight as a non-specific aid to other forms of treatment, and thinks that the important thing for the heliotherapist to study is not the source of light used, but the response of each individual patient to it. He insists that the patient should not be stimulated beyond his powers of response and finds that his best results are obtained by the use of a combination of different stimuli, sea bathing, spraying, cool sea breezes, as well as heliotherapy. He describes the use of heliotherapy in the treatment of surgical tuberculosis as "more an art than an exact science," and this probably sums up well the present state of knowledge on the subject.

Skin Diseases. It is obvious that with advance of knowledge in the field of photodynamics, the use of light as a therapeutic agent in skin diseases would be thought of and would receive its earliest application.

The value of Finsen's radiation treatment in the cure of lupus vulgaris has been confirmed by many writers. The treatment on the whole, however, has not yielded such a high percentage of cures in the hands of other workers. A combination of local with general irradiation seems to give the best results.

In seborrhea and acne rosacea radiation therapy has proved a useful addition to other remedial measures. In eczema the results are variable and inconstant. There is often temporary improvement, a relief of itching and a drying up of exudate, but the disease is apt to recur even during periods of treatment.

In lupus erythematosus the value of the treatment is extremely doubtful. In alopecia areata the treatment is probably of little use, except in the incipient stage of the disease. In psoriasis the results are on the whole good, some writers advocating radiation as the treatment of choice.

In vitiligo it has been found possible to produce definite pigmentation in the vitiliginous patches by exposure to radiation. In furunculosis irradiation appears to be the treatment of choice, and in acne the results of radiation treatment are uniformly good.

The skin conditions described have been treated with full radiations from the source of light used. This includes a range of radiation from the ultraviolet through the visible to the infrared regions of the spectrum. Very little clinical work has been done with filtered light.

Ultraviolet light has been used with some success for the treatment of erysipelas, but is not as effective as the roentgen ray.

Indiscriminate light treatment for skin conditions is not without danger. Definite pathological conditions due to overexposure have been observed and reported by Rasch [39] and Castle.[40]

Clark [36] in discussing the early experimental work of Hasselbach, Henri and Glitscher on the extent to which light of different wave lengths penetrates the skin, concludes as a rough estimate that light of shorter wave length than 300 $m\mu$ is absorbed by the epidermis in a layer 0.1 mm. thick, and that the shorter the wave length, the thinner the layer that will completely absorb the rays.

Effect of Light on General Nutrition and Resistance to Infection

Many claims have been made for the beneficial effects of artificial light therapy in promoting growth and resistance to infection in children. These claims would appear to be rooted in subjective rather than objective evidence.

Mackay[41] made observations extending over a period of thirteen months on the effects of treatment with the mercury vapor quartz lamp on the health of infants. During the course of the investigation, two groups of infants were studied from the standpoint of weight, percentage of hemoglobin in the blood, resistance to infection and general clinical condition. It was found that the rate of gain in weight in the light treated cases was approximately equal to that of the controls. Treatment by light did not cure or prevent the development of anemia and it seemingly did not protect against the occurrence of respiratory infections.[42] No objective evidence was obtained for the value of radiation therapy in improving the general clinical condition of the children.

A similar study with the use of the carbon arc lamp, made by Barenberg and Lewis,[43] gave, on the whole, similar results. They found that radiation treatment had no effect in reducing the incidence of respiratory infections. Growth in weight and height was greater in the irradiated than in the non-irradiated group for a time, but with prolongation of the treatment changed to the reverse.

Blood counts showed that the number of erythrocytes and leucocytes did not seem to be affected by irradiation. It would seem that radiation produced an initial stimulating effect which may be followed by a depressant action of the rays, so that the initial benefit may be lost by overradiation. There is no very weighty evidence that the changes observed confer any exceptional or lasting benefit.

Problems in Light Therapy

Following a consideration of the present state of knowledge in regard to the action of light on the normal organism and its benefits in various diseases, it is evident that many questions still remain unanswered and would well repay the efforts of investigators. Fundamental among these is the whole problem of the mechanism of absorption of light by the skin and by various organic substances. What are the particular substances involved, and what is the specific effect of light upon them? Furthermore, in all directions we need more exact knowledge as to the effects upon the organism of particular wave lengths of radiation in accurately measured dosage. There are also a great number of clinical problems, among which we may suggest:

- Bactericidal effects of light
- The tonic effect of light after various diseases
- The effect of light in preventing infectious diseases such as colds
- The effects of light on the skin, including erythema, protecting against ultraviolet by previous exposure, the significance of pigmentation, wound healing, scar formation after smallpox and in other conditions, stimulation of hair growth, the effect on the capillaries
- The effects of light on the blood composition, pressure and volume
- The effects of light on various other bodily functions, such as sleep, appetite, growth in weight, the internal secretions, and, finally, mental activities.

INFRARED RADIATION

By the term *infrared radiation* we mean radiation at the long wave length end of the spectrum beyond the range of rays that are visible to the human eye. These invisible rays begin at a wave length of about 700 m. Certain sources of light are rich in these rays, notably the sun and the carbon arc lamp.

In recent years attention has been focused upon the therapeutic effect of ultraviolet radiation. It should be remembered, however, that when full radiations from a source of light such as the sun and the carbon arc are used, it is not altogether logical to attribute the effect to radiations in the ultraviolet, and to discount the possible effect of radiation of longer wave lengths.

Since something like 50 per cent of the solar radiations are in the region of the infrared, it is a problem of some practical importance to discover the function, if any, of these rays. Although infrared radiation is being used extensively in clinical work, and many infrared generators are on the market under different trade names, the treatment must at the present time be regarded as empirical.

There is a small, but growing, literature on the subject of infrared radiation. Most of it is concerned with the question of a possible antagonism between the action of ultraviolet and red or infrared rays. Very little work has been done to show that infrared radiation, when used alone, exerts any specific action upon the animal organism.

Does Infrared Radiation Antagonize the Action of Ultraviolet? One of the earliest observations with a bearing on this subject was that made by Bovie in 1913,[44] who showed that egg white, after exposure to the rays from a mercury vapor quartz lamp, was so sensitized to heat that it coagulated at a lower temperature than did the non-irradiated control. In 1918 Bovie and Klein[45] showed a similar heat sensitizing action of fluorite rays upon paramecia.

In 1923 Hess and Weinstock[46] suggested that the antirachitic value of ultraviolet radiation was inhibited by the presence of visible and infrared radiations. They used two glass filters G 86 B (a Corning white glass filter), and G 586 A (a Corning blue glass filter), both of which by a comparison of spectrograms appeared to transmit ultraviolet of the same wave length and intensity. They found that a partial protective effect was produced against rickets in rats rayed behind the blue glass, while the radiations filtered through the white glass were without effect. Their argument therefore was that the ultraviolet radiation, although partially active alone, is inactive wnen mixed with light of longer wave length.

Recent experiments [47] lend support to this theory of Hess. Luce-Clausen has shown that 18 rats receiving a short daily exposure to a band of radiation in the infrared (between the limits of 720 to 1,120 mμ, the energy being 0.122 small calories a minute a square centimeter) in addition to a daily exposure to a filtered and measured band of radiation in the ultraviolet, had a slightly lower ash content of bone for each unit of body weight than 18 litter mates receiving ultraviolet only.

Azuma and Hill [48] criticized the results of Hess and Weinstock [46] on the ground that they might equally well be explained in terms of unequal intensity of ultraviolet transmitted by the two filters. This criticism is not valid, since careful spectrophotometric measurements of samples of the same thickness of the two glasses show that the white glass transmits slightly more ultraviolet, and at least seven times as much total energy in the infrared as the blue glass.

D. T. Harris,[49] in 1925, found that the addition of visible radiations nullified the stimulating effect of ultraviolet on the metabolic rate of small animals and on the smooth muscle of the frog. He states definitely that this phenomenon is "one of physiological antagonism, rather than physical interference." Azuma and Hill [48] were unable to confirm the experiments of Harris.

Sheard and Hardenburgh [50] in 1927 claimed that the simultaneous use of ultraviolet (from a mercury vapor quartz lamp) and infrared (heat) energy produces lethal effects on *demodex folliculorum* more rapidly than does the consecutive application of these two types of radiation. They also found that irradiation of the parasites with ultraviolet light followed by dry heat or infrared irradiation causes lethal effects at temperatures considerably below those at which death takes place normally. This last observation confirms the observations of Bovie already referred to.

Pech [51] found that the effect of ultraviolet radiation in bleaching cotton, or in the production of erythema of the skin, was delayed in its action on the addition of red, or infrared radiation.

Ludwig and von Ries [52] found that red light inhibits the germination of wheat, while ultraviolet promotes it. Furthermore, ergot after irradiation with red light loses its power to contract the uterus of the virgin guinea pig, but a subsequent irradiation of ergot with ultraviolet light causes it to regain its power. In more recent experiments [53] these authors claim to have inactivated active *viosterol* by exposing it to radiations from a 200 watt lamp. If true this would be an extremely important observation. In Luce-Clausen's opinion, the experiments described by Ludwig and von Ries are open to several criticisms: lack of measurement of the radiations used both as to distribution and total energy of the rays, lack of data as to biological technique, the number of animals used in biological tests, and so forth. The conclusions reached by these authors seem more sweeping than their experimental data permit.

Recently Hirsch and Kellner [54] have published more convincing results along the same lines. These authors found that ergosterol, which had been activated with ultraviolet radiation, could be deprived of its activity by a subsequent exposure to infrared rays (Nitro-lamp, hot sun, Nernst pencil). Furthermore, this loss of activity was accompanied by a change in the absorption spectrum of the ergosterol, as shown by increased absorption in the ultraviolet. These authors conclude: "The infrared possesses an effect upon irradiated ergosterol by depriving it of its power to protect against rickets. That, however, is no demonstration of an antagonism between ultraviolet and infrared, for the appearance of entirely new absorption bands in the shortest ultraviolet region shows that by means of infrared no simple revision is produced, but rather that a new substance with new properties is formed."

The evidence as to an antagonistic action between infrared and ultraviolet radiation is conflicting. The chief criticism of most of the published work is that the radiations used are not controlled, and no definite data can be obtained as to their limits in the spectrum or the total energy value they represent. Also a clear definition as to what is meant by the term *antagonism* is needed. It has been loosely used to imply a process whereby infrared modifies or annuls the action of ultraviolet. In the strictly chemical sense a true antagonism implies more than this. It implies an action whereby a substance formed under the action of ultraviolet radiation undergoes a definite chemical change when exposed to infrared. Probably also a true antagonism implies that infrared radiation causes a reversal of the chemical reaction produced by ultraviolet. Further studies along this line are needed in view of some of the biological results already obtained.

Does Infrared Radiation, Used Alone, Exert a Demonstrable Action on the Animal Organism? In 1921 Sonne[32] in a series of papers studied the effects of visible and infrared radiations upon the human skin. He divided the infrared rays into an external and an internal group, the latter being what are usually termed "near infrared rays," that is, those continuous with the red end of the spectrum. He found that near infrared rays penetrate the human skin, while the far, or external, group are strongly absorbed. The rays that penetrate produce a rise of temperature in the skin which Sonne regards as being of positive therapeutic value. He recommends the use of the carbon arc over the mercury vapor quartz lamp, on the ground that the former is richer in these effective rays.

Wade Brown[15] made a careful study of the effect on normal rabbits of continuous exposure to radiation from a neon light. This lamp emits a band of radiation between the limits of 337 and 362 mμ, but by far the greater part of its radiation lies in the visual red and near infrared, 580 to 760 mμ. He found that rabbits kept in this light environment showed a remarkable gain in weight, a gain which was approximately three times that of an unirradiated control group. This gain in weight was accompanied by increased proliferative activity of hair follicles over shaved areas of skin and increased functional activity of certain organs.

Luce-Clausen[47] has shown that rats fed on a rickets producing diet and exposed for ten minutes daily to an isolated group of radiations in the near infrared (720 to 1,120 mμ, at an energy of 0.122 small calories per minute square centimeter) show a marked acceleration of growth as compared to the unirradiated controls. Also the period of survival of the rats receiving infrared radiations was markedly prolonged as compared with unirradiated controls fed the same diet. This growth is not accompanied by protection against rickets, and therefore, the effect of infrared radiation on these animals is different from that of ultraviolet. Also as it was produced, not by continuous, but by a short daily exposure to the rays, the results suggest the interesting possibility of a hitherto unsuspected photochemical effect of infrared. This at the present time cannot be regarded as proved.

It appears that infrared radiation may be regarded as possessing a demonstrable effect on the living organism. This effect may be due merely to a heating of the subcutaneous tissues and blood by penetration of the rays beneath the skin. There is still the possibility, as yet unproven, that the rays may have a more specific effect. This field is comparatively unexplored.

SUMMARY

A critical review of the literature, both clinical and experimental, on light and its action on the animal organism, reveals the fact that we are doubtless dealing with a powerfully dynamic agent, but one about which our knowledge as to its mechanism, mode of action, and effect is amazingly limited. An excellent review, with bibliography of the entire subject, is given by Laurens and others.[16]

We are in possession of a large amount of information, but are not ready for explanations and generalizations. No single hypothesis as to the mode of action of light can yet be formulated.

We still stand in need of facts obtained under definite, controlled conditions of dosage, intensity, wave length, and so forth, on normal and abnormal organisms. There has been inadequate differentiation and separation of the various portions of the solar spectrum, although there is abundant evidence that great differences do exist in action and effect

and that these may perhaps be limited sharply to specific regions.

Much evidence, both in the experimental animal and the human, indicates that light can be harmful if used to excess. It is positively dangerous to the individual with active pulmonary disease, such as tuberculosis.

All clinical evidence seems to show that excessive use of any form of light has effects quite the reverse from those anticipated and desired, and rather harmful than beneficial. These facts and considerations are important when one considers how little is actually known about exact dosage of light and then observes the inordinate, senseless, and ill-advised enthusiasm with which the public has seized upon this agent for the cure of all sorts of ills and for the insurance of its well-being.

There is abundant proof and every indication that light, if properly and sensibly used, is beneficial to health and is probably a powerfully curative agent for disease. There is considerable evidence to show that its action is affected by associated factors such as air movement, temperature, humidity, activity or rest, food, and so on. No well controlled experimental work has so far been done to analyze these factors and correlate them with the effect of light.

Many of the claims made for the use of radiation are still based upon empirical evidence, and practical applications are made without scientific support because the fundamental principles of the biophysics and physiology of radiation are still unsolved and the actual effect of radiation on the living cell is still unknown.

Ultraviolet radiation seems to produce primarily a surface effect. It is very unlikely that ultraviolet irradiation acts directly on deeply seated organs. It seems that, following ultraviolet irradiation, some photochemical substance is formed in the skin and is carried by the blood stream to various organs, there bringing about the observed changes.

The sun bath, by dilating the capillaries, activates the circulation and may induce a continuous tonic action on the sensory nerve termination in the skin, thus restoring tone to muscles and promoting physiological processes throughout the body. Reflex action may explain in some cases how internal organs are influenced by the action of radiation on the skin. There may also be some change in the capillary blood which has absorbed the energy, but the greater part of the effects of irradiation must be produced by chemical means, by substances formed in the skin by the action thereon of radiation.

The rôle of the skin pigment with reference to the action of radiation is not understood and is a subject which requires much experimental analysis. Pigment seems to assist in the absorption of energy. Pigmentation of the skin seems to accelerate and augment the action of radiant energy passing through parts of the human body, but the degree of pigmentation is not a safe index of the effectiveness of radiation therapy.

Again we must emphasize the fact that light in any form by itself is not a cure for disease but comprises only one of the important adjuvants in treatment. To believe that sunlight or artificial radiant energy will cure; to be unduly optimistic about this treatment and to consider it a specific form of treatment; to use it without sound medical guidance and adequate equipment; and, finally, to employ it to the exclusion of rest and hygienic and dietetic regimen is bound eventually to dishearten many and to bring discredit to an otherwise desirable method of treatment.

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THE INFLUENCE OF ATMOSPHERIC CONDITIONS

GENERAL CONSIDERATIONS

CLIMATIC influences upon the organism have been recognized since the time of Hippocrates, but our knowledge of the specific causative factors and of the physiological and biological principles involved is still very limited. Whatever the mechanism of the action may be, it is now well known, from numerous statistical, laboratory and field researches at home and abroad, that atmospheric conditions in general, and temperature in particular, have a direct effect upon health, growth and activity, as well as indirect effects through food, disease, and mode of life.

Young children, especially infants under one year of age, are much more sensitive to the effects of heat and cold than adults, because their mechanisms for regulating the temperature of the body are less stable than those of adults. In no other age group are morbidity and mortality so immediately and markedly affected by atmospheric conditions. The sensitivity decreases as the children grow older.

The whole subject of atmospheric influences is extremely involved and the literature lacks uniformity. An enormous amount of work is needed in all directions in order to segregate the effects of the various factors and to gain an insight into the mechanism of their action, first upon man, second upon the organisms causing infectious diseases, and third, upon the means of transmission of disease. The present report deals largely with the effects of atmospheric conditions upon health and growth, as well as with methods suitable for the control of these conditions.

CLIMATE AND SEASON

Seasonal Variation in Morbidity and Mortality

The most conspicuous climatic influence is the effect of season upon the morbidity and mortality of infants. In the temperate climates of the United States, seasonal changes occur principally in two groups of diseases, (1) diseases of the respiratory tract (including acute bronchitis, pneumonia of all forms and influenza), which run high in cold weather and (2) diseases of the intestinal tract (including diarrhea and enteritis), which are prevalent in warm weather. Other seasonal diseases, not readily associated with these two specific groups, have declined in recent years without affecting appreciably the two seasonal peaks. Further to the North, the long and extremely cold winter constitutes the only unfavorable season, while further South the long hot summer is the only unfavorable season.

As a means for measuring health, records of the sickness of children are inadequate because the actual morbidity is not expressed in statistics. Accurate infant mortality rates, on the other hand, are available for the Birth Registration Area of the United States, and these offer a very sensitive index of the incidence and severity of the two specific groups of seasonal diseases.

Chart I shows the seasonal variation in infant mortality from these diseases in the United States Birth Registration Area. It will be seen that the mortality from diseases of the respiratory tract reaches a minimal value in July and August, which are the warmest months in the year. With onset of cool weather in September, the mortality from these causes rises, attaining peak values between January and March. The mortality from diarrhea and enteritis follows just the opposite course. It begins to rise early in May, reaching its maximum in August or September, and it subsides to its normal level in December. It is of interest to notice that the peak values in both groups of diseases occur a little later in the year than the extremes of temperature.

The most striking feature in Chart I is that the summer peak in mortality from intestinal diseases is gradually being

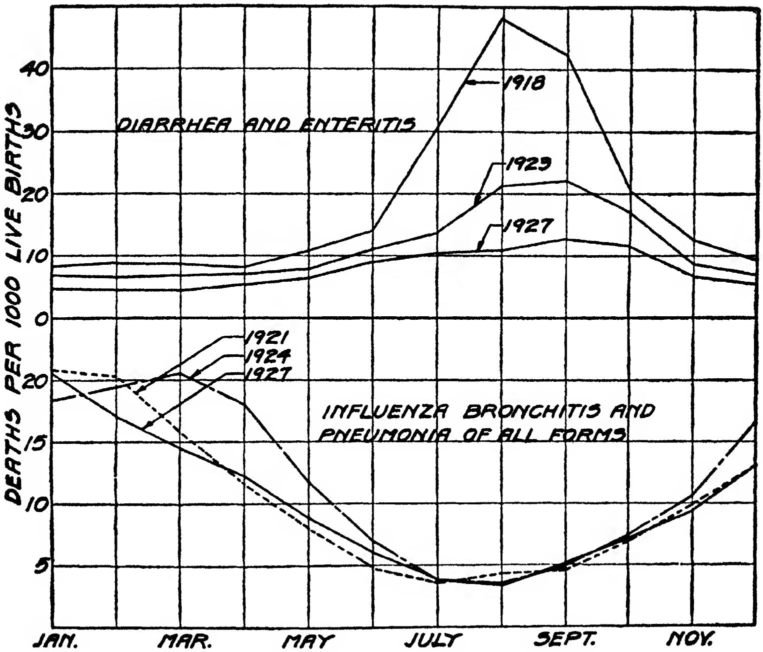

CHART I. SEASONAL VARIATION IN INFANTILE MORTALITY FROM RESPIRATORY AND INTESTINAL DISEASES IN BIRTH REGISTRATION AREA OF CONTINENTAL UNITED STATES.

reduced, but the winter peak still remains unaffected by medical methods. About fifteen years ago the chief cause of infant mortality was diarrhea and enteritis. Since 1927, the winter peak of mortality from respiratory diseases has been the dominant feature of the general mortality curve.

Respiratory Diseases

Although it is well known that the increase in morbidity and mortality from respiratory diseases follows almost exactly the occurrence of cold weather, little is known of the specific causative factors, except when the death ocurs as a terminal condition of one of the contagious diseases, such as measles or whooping cough. The prevailing belief is that the increase in cold weather of the incidence of both respiratory and contagious diseases is associated with overcrowding of buildings, close personal contacts, lack of ventilation and overheated rooms. Certain special circumstances, such as chilling and fatigue, are considered to be contributory factors, but the experimental evidence on this point is somewhat contradictory.

North[1] ascribes the prevalence of respiratory diseases in winter partly to the lessened resistance of the mucous membranes of the nose and throat which results from the vasomotor shifts of blood to the internal organs upon exposure to cold and to change in temperature. Others suggest that the cold air in itself may cool the blood to such an extent as to diminish the bactericidal activity of the phagocytes and the vitality of the cells which line the respiratory tract.

It is questionable whether these influences would significantly affect infants under one year of age, since these infants are usually protected from cold weather. However, a certain amount of the cooling effect may result from the rapid evaporation of moisture from the skin and mucous membranes owing to the excessively dry indoor atmospheres prevailing in winter. The usual changes in the indoor temperature may also have some effect on these infants. The deprivation of moisture from the mucous membranes may be another factor in the situation, as some believe. Recent evidence[2] indicates that the incidence of respiratory diseases among premature infants can be reduced considerably by proper control of temperature, humidity, and ventilation rate, and by control of contact infections.

A popular belief is that in winter we lose a great portion of the ultraviolet rays of the sun as explained in the preceding section. Several attempts, however, to control the seasonal outbreak of respiratory diseases among children by the use of artificial ultraviolet radiation proved ineffectual.[3, 4] Abramson and Barenberg[5] secured much better results by control of contact infections among children than by ultraviolet radiation.

The majority of the foregoing beliefs are based largely upon impressions and are held tentatively. The problem is a highly complex one, and little exact knowledge is available on the etiology and treatment of respiratory diseases. This explains the persisting high mortality from these diseases in spite of intensive public health efforts and laboratory investigations. The most fruitful field of research seems to lie in clinical and pathological studies dealing with the entire group of respiratory diseases including the common cold. Current epidemiological studies by Frost and Doull in Baltimore, by Rosenau in Massachusetts, and by Smillie in well chosen isolated communities will probably throw considerable light upon this obscure problem.

Intestinal Diseases

The influence of heat upon food and other disease transmission agents is now well recognized, but the direct effects of summer heat upon the human body are not fully appreciated. Evidence shows that high environmental temperatures, especially when they are accompanied with high humidities, cause a rise in the internal temperature, and this induces vasomotor shifts of blood to the peripheral vessels leaving the intestinal wall in an anemic condition.

Salle[6] reports that exposure to temperature of 84° to 86° F diminishes the secretion of gastric juice as well as its acidity and digestive activity. The stomach loses some of its power to act upon the food, and there is a corresponding loss in the antiseptic and antifermentative action of the gastric juice, which favors the growth of bacteria in the intestinal tract. Ample confirmation of this is found in the works of Arnold[7, 8, 9] and Medowikow.[10] The latter reports, in addition, that in 9 cases out of 10, *B. Coli* was also present in the spleen and liver of young rabbits after an exposure of twelve hours to incubator temperature.

The peculiar susceptibility of young infants to diseases of the gastrointestinal tract is attributed to their inability to adapt themselves to the climatic environment. According to Arnold,[11] although the disturbances due to lack of adaptation can partly be offset by altering the diet, the factors of weather and food cannot be separated, and one can influence the other.

The deleterious action of heat is, of course, a function of the indoor temperature to which the infants are exposed, but in summer this temperature depends to a considerable extent upon the outdoor temperature. Numerous studies of housing conditions in relation to infant mortality all agree that the factors leading to high indoor temperatures, such as narrow streets, overcrowding, and lack of free circulation of air due to inadequate building construction, bear heavily upon infant and child mortality.

Recent unpublished data by Blackfan and Yaglou show that, other factors remaining the same, the incidence of diarrhea among premature infants can be controlled by artificial control of the environmental temperature, humidity, and ventilation rate. By properly conditioning the air with reference to these factors, the incidence was markedly reduced and it remained fairly stationary at all seasons of the year.

In the light of the evidence presented here, a campaign against seasonal diseases should include, in addition to the control of the food supply and general sanitation work, the control of the indoor air conditions, particularly in the institutions for sick infants and children. Protection against excessive summer heat is still a rare exception in institutions of this kind, but the number of new hospitals providing for artificially cooled rooms for infants is gradually increasing.

Geographic Distribution of Seasonal Diseases According to Seasonal Temperature

The literature on the geographic distribution of morbidity and mortality from respiratory diseases is quite contradictory. The consensus seems to indicate that there are no marked differences in the various parts of the United States.

In a very thorough study of the local and sectional characteristics which affect the infant mortality, Holland and Palmer[12] came to the conclusion that climatic factors, such as temperature, rainfall and sunlight, are relatively unimportant in their effect on urban infant mortality. Race, nativity, and economic and educational status are claimed to be the chief factors.

Huntington,[13] on the other hand, finds a definite relationship between temperature and daily deaths in New York City for all ages as well as for children under five years of age. In this latter age group, the deaths were found to decline progressively as the temperature rose to 55° F, but increased portentously with every rise of temperature above 60° F.

It must be conceded that the causes of infant mortality are very complex, and so closely related to community life and general environment that it is difficult to separate and evaluate the effects of the various climatic factors. Nevertheless, it would be equally difficult wholly to explain on any other grounds the fact that some cities on the Pacific Coast, which are blessed with a climate approaching the ideal for infants, have and have had for many years the lowest infant mortality in the United States.

Recent public health efforts were successful in reducing the infant mortality, but the decline has not altered appreciably the relative geographic distribution of mortality.

In order to test for geographic distribution of infant mortality on the basis of climate, a special study was undertaken for these reports. Owing to the complexity of the problem, exact mathematical methods were not justified, but certain empirical methods had to be used for the purpose of eliminating and balancing, as much as possible, the unwanted factors. To begin with, the powerful influence of race was eliminated by considering white infants only. The method of analysis used is based upon the fact that, in the temperate climates of the United States, the weather at some period in the course of a year is apt to approach a more or less favorable state. Under this condition the influence of climate would be at a minimum, and the actual mortality at this particular period, or a little later on in the year, would depend largely on other local and sectional factors which affect the infant at all times. Starting with this as a basic level of infant mortality for a given community, the increase in mortality above

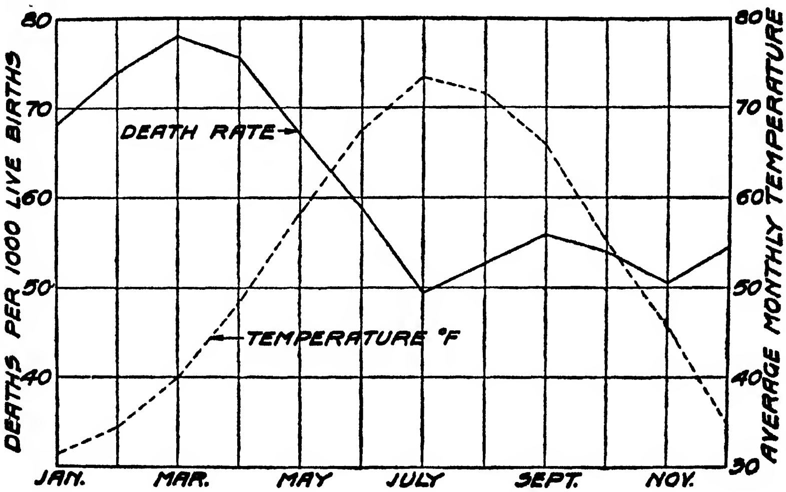

CHART II. SEASONAL VARIATION IN INFANTILE MORTALITY FROM ALL CAUSES IN NEW YORK CITY, 1925 TO 1929.

this basic level to the crests of the winter and summer waves must be largely due, either directly or indirectly, to the unfavorable weather condition prevailing in that locality. The seasonal excess in infant mortality computed in this manner was found to bear a fairly close relation to the seasonal temperature, regardless of whether the lag between the extremes in temperature and the extremes in death rate was one or two months.

To take the city of New York as an example, Chart II shows the characteristics of the seasonal trend of mortality there. As a general rule, the minimum of infant mortality in New York occurs in July and the peaks of mortality occur two months later than the month of extreme temperatures. For the group of cities used in this study, the average lag between the extremes in temperature and the extremes in death rate was found to be about one month.

If now the mortality rates for the peak winter months (usually February, March and April, as in New York) are averaged, and from this average the minimal mortality (usually that of July) is subtracted, the difference gives the winter excess in mortality. This is tabulated in Chart II against the average temperature for January, February, and March (one month lag). In the same manner, the minimal mortality is subtracted from the average mortality for the peak summer months (usually August, September, and October) and the difference tabulated against the average temperature for July, August, and September.

Altogether, 41 cities were used in this analysis. The infant mortality rates for 38 of these were secured from the weekly reports of the United States Public Health Service (1925 to 1929), and for the remaining 3 cities, namely, Birmingham, Alabama, Memphis, Tennessee, and New Orleans, Louisiana, from city health departments. The 38 cities represent those in the Birth Registration Area of continental United States since 1925, or earlier, for which Weather Bureau data are available. An exception had to be made for the city of Des Moines, Iowa, which was excluded from the analysis because the mortality rates varied so much that it was difficult to decide with any degree of certainty upon the maxima and minima. Unfortunately, it was impossible to secure data on more than 41 cities, on account of limitation of time.

Concerning the years to be investigated, there was little choice. The five consecutive years, 1925 to 1929, had to be studied because the mortality data for white infants prior to 1925 are meager. Our results, therefore, include the effects of the epidemics of influenza and pneumonia which occurred in the years 1926 and 1928 to 1929.

In deriving the general trend, the cities were first classified according to their seasonal temperature, as in Table 1. The weighted average seasonal excess in mortality was then computed for each temperature group by multiplying the seasonal excess of mortality in each city by the corresponding number of births for the year 1927 (1928 and 1929 birth statistics not available) and dividing the sum of the products by the sum of the births. In the same manner, the weighted average seasonal temperature was computed. Table 1 shows the results.

TABLE 1

GEOGRAPHICAL DISTRIBUTION OF SEASONAL EXCESS IN INFANT MORTALITY ACCORDING TO SEASONAL TEMPERATURE

Temperature groups, °F	Number of cities	Weighted seasonal	Average temperature, °F	Weighted seasonal in infant rate	Average excess mortality
		Winter	Summer	Winter	Summer
10 –14.9	1	12.4		15.1	
15 –19.9	2	17.8		22.6	
20 –24.9	0	....		....	
25 –29.9	7	27.2		30.3	
30 –34.9	15	32.2		26.3	
35 –39.9	6	35.5		26.3	
40 –44.9	4	42.2		13.0	
45 –49.9	2	46.7		9.9	
50 –54.9	1	52.2		21.0	
55 –59.9	4	58.3		12.9	
60 –64.9	5		62.6		3.2
65 –67.4	6		67.8		7.0
67.5–69.9	12		69.0		9.6
70 –72.4	7		70.3		7.0
72.5–74.9	6		73.1		18.8
75 –77.4	4		75.4		23.6

The following three main features are to be noted in this table: (1) minimal infant mortality appears to correspond to a seasonal temperature, as computed in this study, between 60° and 65° F; (2) the mortality increases for temperatures above and below this apparent optimal range; (3) there is an indication that very low temperatures may be associated with a relatively low mortality.

On the whole, the general trend is fairly clear, but there is some distortion for temperatures between 50° and 60° F, which may be due to the small number of cities involved. The chief cause, however, is found to lie in the three California cities used in this study, namely, San Francisco, Los Angeles, and San Diego, all of which for some unknown reason have excessively high mortality rates from respiratory diseases for their climate. Chart III shows the crude trend excluding the three California cities, and the relative position of these cities with reference to the general trend.

With one or two exceptions, the general characteristics of Chart III agree fairly well with those found by Huntington[13] for children under five years of age in the city of New York. The relatively low death rate for temperatures below

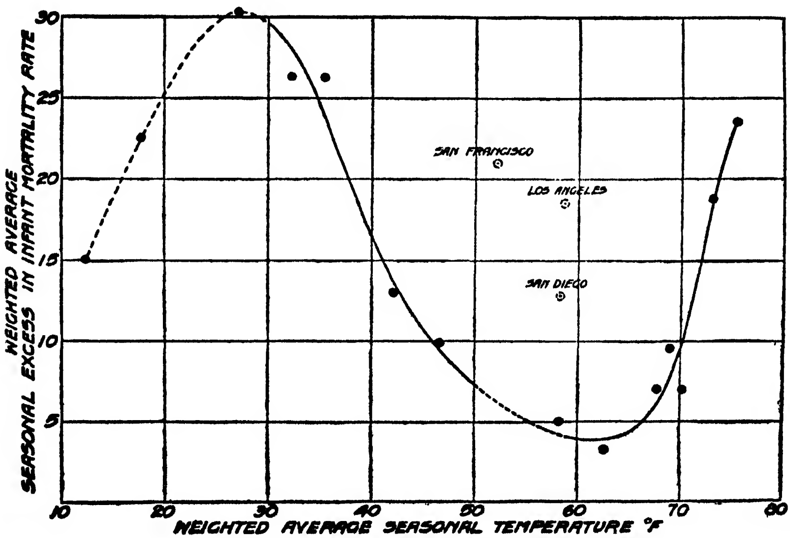

CHART III. GEOGRAPHIC DISTRIBUTION OF SEASONAL EXCESS IN INFANTILE MORTALITY RATE ACCORDING TO SEASONAL TEMPERATURE IN FORTY-ONE LARGE CITIES IN THE UNITED STATES, 1925 TO 1929.

25° F has been observed by Huntington also, but his curves do not show an actual drop in mortality as does Chart III. Huntington attributes the flattening of his curves chiefly to the small number of observations, an explanation which may also hold true in the present study. It is possible, however, to explain this by the effects of extreme cold either upon the parasitic cause of disease or upon the human organism itself.

Although infants under one year of age are, as a general rule, protected from cold weather, Chart III shows a progressive decrease in mortality with progressively increasing seasonal temperatures, from 30° to 60° F. This is an unmistakable characteristic of the respiratory group of disease, for which temperature appears to be the best known index of the effects of changing seasons.

In summer, as the seasonal temperature of the localities increases above 65° F the mortality, chiefly from diarrhea and enteritis, appears to increase sharply almost in direct proportion to the temperature. An exception to this is to be found in the excessively warm cities of the South where the mortality, after reaching peak values early in May and June, begins to decline while the temperature is still high, or even rising. In the light of Arnold's studies [11] these facts may be explained partly by the adaptive changes which take place in the defensive mechanism of the intestinal mucosa, after a period of exposure to high temperatures, and partly by changes in diet.

According to Chart III, not only the effects of cold but also the effects of heat upon infants, whether direct or indirect, or both, are still large and far from being under adequate control. This holds true particularly in cities in which little public health work is being carried on for the control of the intestinal group of diseases. As a general rule, these cities lie above the general trend shown in Chart III.

In spite of the apparent definite relationship between seasonal temperature and seasonal variation in infant mortality, it should be made clear that we are relying on meager data and upon massed averages in which the effects of many other factors, directly or indirectly associated with temperature, are imperfectly separated from those of temperature. For this reason Chart III may be of little value in so far as quantitative data are concerned. Its value lies chiefly in showing the prevailing crude trend of climatic influence, for which temperature appears to be the most significant index.

The recent introduction of several more states to the United States Birth Registration Area may yield sufficient data to separate the effects of some important factors which affect the infant mortality, and to derive a revised trend which would be more truly representative.

Humidity, Variability, Wind, and Other Factors, and Infant Mortality

According to Huntington,[13] atmospheric humidity plays a minor rôle for children under five years of age as compared with older persons. He believes that if it were possible to eliminate the effects of all other climatic factors, one should find that at all temperatures up to the optimum (55° F according to his data), the best relative humidity exceeds 80 per cent. Above the optimal temperature, the humidity must be progressively lowered as the temperature rises.

The present study discloses a significant humidity effect when individual cities are considered by themselves. In Table 2, the monthly infant mortality rates for New York City are classified in two groups according to the average monthly relative humidity. Although the range from high to the low humidity groups is quite small, it can be seen that for temperatures up to our probable optimum of 65° F (Chart III) the higher humidities are, as a general rule, associated with the lower infant mortality. To some extent, this confirms Huntington's finding to the effect that a moist atmosphere is more favorable for respiratory diseases than a dry one, but it is diametrically opposite to what some persons held and taught for many years. In July and August, when the temperature exceeds 65° F, the reverse holds true as in Huntington's data. These general tendencies for New York City are more or less representative of several other large cities studied. Unfortunately the number of cities we are dealing with and the range in the seasonal humidity between the various cities are too limited for the purpose of separating the effects of humidity from those of temperature in the general trend shown in Chart III.

Aside from these statistical data, accurately controlled studies on premature infants[2] also show that a fairly high degree of moisture in the air is associated with a lower mortality among these infants.

Variability in wind and temperature did not appear to exert any significant influence upon infant mortality when the data for large cities were analyzed by a method similar to that

TABLE 2

EFFECT OF HUMIDITY UPON INFANT MORTALITY

DATA FOR NEW YORK CITY FOR THE YEARS, 1925 TO 1929

Monthly groups	Number of months in		Average temperature °F	Range in relative humidity,	Average relative humidity,	Average infant mortality rate
	High humidity group	Low humidity group		*Per cent*	*Per cent*	
January and	5		32.8	67–69	66.8	68.5
February		5	32.8	58–64	62.2	73.4
March and	4		45.4	62–68	64.7	69.7
April		6	44.3	57–59	57.6	81.5
May and	4		63.8	67–70	67.8	58.2
June		6	63.2	56–63	60.8	65.2
July and	3		71.6	73–75	74.1	52.8
August		7	73.0	67–69	67.7	50.2
September and	4		63.6	71–73	71.7	55.5
October		6	58.6	66–69	67.9	54.5
November and	3		43.6	69–74	73.6	49.6
December		7	39.1	63–67	65.5	53.9

used for humidity (Table 2). For persons over five years of age, however, Huntington [13] states that a moderately high degree of variability in temperature from day to day, and variable winds of moderate intensity are stimulating and are associated with a lower death rate.

The Probable Optimal Climate

Both statistical and experimental studies indicate that there can be no ideal climate to suit every purpose. The state of health, state of civilization, race, type of disease, medical methods, age, and so forth, are all factors which may alter the optimum of climate to a considerable extent.

For inhabitants of New York City over five years of age, Huntington's optimal climate consists of a temperature of 65° F, a relative humidity nearly 90 per cent, and a moderately high degree of variability from day to day.[13]

For children under five years of age, which means mainly for infants under one year of age, Huntington tentatively sets the optimal temperature at 55° and the humidity at 80 per cent.[13]

According to the present study the probable optimal temperature for infants under one year of age appears to be about 63° F (Chart IV) or about 8° F higher than Huntington's value. If this is true, the optimum for these infants is substantially the same as that of Huntington's for persons over five years of age.

The apparent difference between Huntington's and our own optimum for infants may be due to the fact that his data

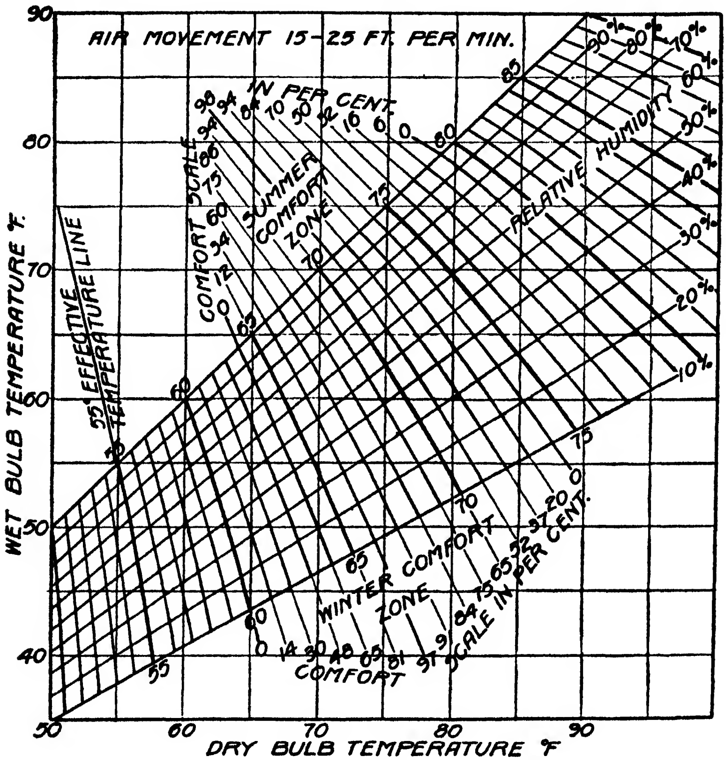

CHART IV. EFFECTIVE TEMPERATURE CHART WITH COMFORT ZONES SUPERIMPOSED.

deal with deaths in 1882 to 1888, whereas ours include deaths in 1925 to 1929. The recent significant reduction in infant mortality from diarrhea and enteritis by control of the parasitic cause of the disease may be responsible for the apparent increase in the optimal climatic temperature. This stands to reason if one considers that the optimal temperature, as determined statistically, is mainly a compromise between the physiological optimum for the human organism itself, the optimum for the respiratory group of diseases, and the optimum for the diarrheal group. Further advances in medical methods and improvements in general sanitation work may alter the optimum from year to year until it may finally approach the physiological optimum for the human organism itself.

We must now distinguish between indoor and outdoor atmospheres. The infants we are dealing with are not, of course, exposed to the rigors of cold but are well protected in artificially heated rooms. Nevertheless, they are affected by adverse weather because the outdoor climate modifies the indoor atmosphere and the mode of life. Temperature by itself may not be the primary causative factor, but it is the most conspicuous characteristic of the changing seasons, and the best index we have, at present, of the climatic effects upon the organism. Overcrowding and lack of ventilation accompany cold weather. An optimal climatic temperature of 60 to 65° F may in reality mean that the weather is mild and pleasant enough to take the infants out of doors or to secure good ventilation indoors by opening windows.

The solution of the general problem of climate and health requires extensive studies of the effects of many other elements, such as atmospheric ionization, sunshine, barometric pressure, precipitation, wind, frost, and perhaps other factors all of which may have an important bearing upon the health.

SEASONAL VARIATION IN THE GROWTH OF CHILDREN

Statistical studies reveal a seasonal periodicity of growth in children. Porter[14] has shown, from measurements of thousands of Boston school children, that the months of July to December are especially favorable for growth in weight. The most rapid gain was found to occur from September to January, the average gain during the period being four times that during February to June.

In Johannesburg, Transvaal, South Africa, where the seasons are reversed, Cluver[15] found a corresponding reversal in the period of rapid increase of weight of infants. The infants gained nearly twice as rapidly in the cool months, April to September, as in the warm months, October to March.

Nylin's observations[16] are of special interest. His evidence indicates that school children in Spänga and Stockholm, Sweden, grow fastest in height in spring, but gain in weight most rapidly in late autumn and early winter. Thus when the children gain in height their growth in weight is retarded, and vice versa. On the whole, the weight increase seems to vary inversely with the height increase. Nylin does not agree with the prevailing view that the seasonal variations in growth are due to variations in the water content of the body. Although he appreciates the influence of sunlight upon growth he points out that his findings do not confirm this connection and that further studies into unidentified endogenous factors are needed in order to clear the situation.

ATMOSPHERIC POLLUTION

The most important atmospheric pollution at present is that due to the smoke and soot discharged from household and industrial chimneys in many large cities. In addition to the suspended carbon, dust, and ash particles, the exhalations are charged with unconsumed hydrocarbon gases, sulphur dioxide gas, and other industrial fumes, capable of injuring property, vegetation and health.

Aside from specific industrial processes which produce harmful dusts and fumes, the consensus of opinion is that most of the mischief attributed to general atmospheric pollution is fictitious and generally indirect. The objection is considered to be largely economic.

Dust may affect health in two ways, by inhalation, and by obliteration of the sun's rays. While these facts are well recognized, there is no proof that the effect of dust in ordinary air is sufficient to cause demonstrable injury to health. The effects may be slow, cumulative, and insidious in their manifestations, but for the time being direct evidence is lacking.

Dust borne bacteria are sometimes held responsible for the transmission of disease microbes through the medium of air, but the epidemiological evidence weighs on the negative side. Bacteria of the pathogenic variety were found to constitute but a very small proportion of the total dust borne bacteria.[17] The non-pathogenic bacteria in air are, in general, considered harmless, but it is not known whether the constant inhalation of these organisms may eventually produce harmful effects.

Another prevalent contamination of air is automobile exhaust gases. The most important of these is carbon monoxide. During heavy traffic hours, the air of congested streets and boulevards is found to contain enough carbon monoxide to menace the health of those exposed over a period of several hours, particularly if their activities call for deep and rapid breathing. Under ordinary conditions, however, the concentration of carbon monoxide in city air is believed to be insufficient to affect the average city dweller or pedestrian. Stevens,[18] on the other hand, finds that infants and young children are peculiarly susceptible to small but repeated amounts of carbon monoxide gas in the air they breathe. His studies seem to disprove the long accepted theory that carbon monoxide is not a cumulative poison, and they suggest the desirability of guarding infants and young children from unnecessary exposure to such atmospheres, either in the home or in congested city streets. So far as the domestic hazard from carbon monoxide is concerned, the flueless gas heating stove is responsible for most of the poisoning in this country, and of these the so-called *radiant heater* has been found to be the most dangerous.[19] In order to prevent the occurrence of asphyxiation, the gas heaters must be provided with flues to carry off all combustion products.

In the light of our meager knowledge of the effects of atmospheric pollution on health, it is fair to say that any conspicuous air pollution constitutes a liability to property and health, and that steps should be taken to reduce the pollution to a minimum. This would require the concerted efforts of the fuel engineer, the public health officer, and the public itself.

INDOOR ATMOSPHERIC CONDITIONS

Changes in Composition and Vitiation of Air by Respiratory and Metabolic Processes

Under the artificial conditions of indoor life, the air undergoes certain chemical changes and a vitiation which are brought about by the occupants themselves. The oxygen content is somewhat reduced, and the carbon dioxide slightly increased by the respiratory processes. Organic matter, which is usually perceived as odors, is given off from the mouth, teeth, skin and clothing, and to some slight extent, perhaps from the lungs. The temperature of the air is increased by the metabolic processes, and the humidity raised by the moisture emitted from the skin and lungs. Both the dust and the bacteria of the air increase.

Contrary to old theories, the usual changes in oxygen and carbon dioxide are of no physiological concern because they are much too small even under the worst conditions of ventilation. The carbon dioxide in air is often used in ventilation work as an index of odors of human origin, but the information it affords rarely justifies the labor involved in making the observation. Little is known of the identity and physiological effects of the organic matter given off in the process of respiration. The former belief that the discomfort experienced in confined spaces was due to some toxic volatile matter in the expired air is now limited, in the light of numerous researches, to the much less dogmatic view that the presence of such a substance has not been demonstrated. The only fact that does appear certain is that expired and transpired air is odorous and offensive, and it is capable of producing headache, nausea, loss of appetite and a disinclination for physical activity. Experiments have shown that the growth of young guinea pigs is retarded by exposure to odors from decomposing organic matter.[20] These reasons alone, whether esthetic or physiological, are sufficient to warrant adequate ventilation.

A certain part of the dissemination of disease which occurs in confined spaces is caused by the continuous emission of pathogenic bacteria from infected persons. According to the weight of opinion, infections by droplets from coughing and sneezing constitute a limited mode of transmission in the immediate vicinity of the infected person. Experiments have shown that the mouth spray is a coarse rain which settles down quickly. The contamination is local and the problem is considered to be largely one of contact infection rather than air borne infection. This view does not dismiss from consideration the whole problem of air borne infections and its relation to ventilation, as some persons believe. Our present knowledge of infectious diseases and their manifestations is too limited to justify such a broad assumption.

It is now believed that the primary factors in ventilation work, in the absence of any specific contaminating source, are temperature, humidity and air movement. Upon these factors depends the loss of body heat by radiation, conduction, and evaporation. As compared with these physical factors, the chemical factors are, as a general rule, of secondary importance.

The principal object in general ventilation work is to keep down the temperature and humidity of occupied spaces within proper limits, to remove odors, and to prevent stagnation of the air surrounding the body.

Physiological Effects of Temperature, Humidity and Air Movement

Although the human organism is capable of adapting itself to variations in external temperature and humidity, its ability to maintain heat equilibrium is limited. Numerous studies[21, 22] have shown that high environmental temperatures, particularly when they are accompanied by high humidities, produce a rise in body temperature, owing to interference with the normal loss of body heat. The pulse rate increases, the blood pressure decreases, and a feeling of depression and general discomfort is experienced. In extreme conditions the metabolism is markedly increased, due to the excessive rise in body temperature and a vicious circle results which may finally lead to serious physiological damage.

One of the most deleterious effects of high temperatures is that the blood is diverted to the surface capillaries at the expense of the internal organs. This lowers the tone and nutrition of the vital organs. The victim may lose appetite and suffer from indigestion, headache, and general enervation. The alterations in gastric secretions and the loss of tone in the intestinal tract may be the potent factors in the heightened susceptibility to gastrointestinal disorders in warm atmospheres.

Physical work under such conditions is a great effort. Experiments show that men can produce twice as much work at an effective temperature of 70° F as they can at 93° F.[23] Even a temperature of 75° F, with a relative humidity of 50 per cent, is capable of reducing appreciably the physical work.[24]

Moreover, habitual exposure to such abnormal conditions tends to lower the tone of the heat regulating mechanism, and according to Mills[25] the function of the adrenal glands is also depressed. This general depression may lead to an inability to respond to later demands for increased activity.

The literature in regard to the action of cold on human beings is very meager. Extreme cold seems to be borne better than extreme heat, probably because the effects of cold are largely mitigated by artificial control. Cold affects the human organism mainly in two ways: through its action on the body as a whole, and through its action on the mucous membranes of the upper respiratory tract. Very little exact information is available on this latter action.

Within certain limits, compensation for increased loss of body heat is affected by increased metabolism and decreased peripheral circulation. The rectal temperature often rises upon exposure to cold. The blood pressure increases, but the pulse rate and surface temperatures decrease. In extreme exposures compensation fails. The body temperature falls and the reflex irritability of the spinal cord is markedly affected.[26] The organism may finally pass into a sleepy unconscious condition which ends in death.

Changes in temperature are significant. A moderate amount of variability in temperature is known to be beneficial to health, comfort, and the performance of physical and mental work. On the other hand, extreme changes in temperature, such as those experienced in passing from a warm room to the cold air out of doors, appear to be harmful to the tissues of the nose and throat, particularly in the case of infants and young children.

Experiments show that chilling causes a constriction of the blood vessels of the palate, tonsils and throat, which is accompanied by a fall in the temperature of the tissues. On rewarming, the palate and throat do not always regain their normal temperature and blood supply, and this anemic condition is believed to play a part in the inception of the common cold and other respiratory disorders.

The effect of humidity upon the organism has been the subject of many studies, discussions and controversies, but the whole problem still remains open. With one or two exceptions, the experiments were too limited in duration and other conditions were generally so variable as to yield contradictory results. Dry air is known to produce an excessive loss of moisture from the skin and respiratory tract. Owing to the cooling effect of evaporation, higher temperatures are necessary, and this condition may lead to discomfort and lassitude. Moist air, on the other hand, interferes with the normal evaporation of moisture from the skin, and again may cause a feeling of oppression and lassitude, especially when the temperature is also high.

Just what is the optimal range of humidity is a matter of conjecture. There seems to exist a very general opinion, supported by some experimental and statistical data, that warm dry air is less pleasant than air of a moderate humidity, and that it dries up the mucous membranes in such a way as to increase our susceptibility to colds and other respiratory disorders.[27, 28, 29, 13]

The recent works of Blackfan and Yaglou[2] also indicate that a fairly high degree of moisture in the air is favorable to the health and growth of premature infants.

Air movement also plays an important rôle in ventilation, not only because it disperses the envelope of warm and humid air in contact with the body surfaces, but also because it produces a pleasant and stimulating sensation upon the skin.

METHODS OF MEASURING ATMOSPHERIC CONDITIONS AND THEIR EFFECTS

No single instrument has yet been devised accurately to indicate the suitability of the thermal environment for comfort and health. Two arbitrary methods are used at present for measuring approximately atmospheric conditions and their probable effects on people, the katathermometer method, and the effective temperature method. The katathermometer [30, 31] is a physical instrument, and it is used extensively in Great Britain. The American standard is the effective temperature [32] index. This is a relative index of the degree of warmth or cold felt in response to temperature, humidity and air movement. It combines these three factors into a single value, which is fairly well correlated with physiological responses to heat and cold. An atmospheric condition is said to have an effective temperature of 65° F, for instance, when it induces a sensation of warmth like that experienced in a saturated atmosphere of 65° F in still air.

When the dry-bulb and wet-bulb temperatures and the rate of air movement are known, the effective temperature can be computed from charts or tables. Chart IV gives one of these charts, that which is most commonly used in general ventilation work, for persons normally clothed and for sedentary conditions.

Optimal Indoor Air Conditions

No single comfort standard can be laid down which would meet every purpose. There is an inherent individual variation in the sensation of warmth or comfort felt by persons when exposed to an identical atmospheric condition. The state of health, age, sex, clothing, activity, and the degree of acquired adaptation seem to be the important factors which affect the comfort standards.

The optimal temperature for the fetus is the temperature of the mother's uterus. The optimum for prematurely born infants varies from 100° to 75° F depending upon the stage of development. The optimal relative humidity for these infants is placed at 65 per cent (Blackfan and Yaglou [2]).

No data are available concerning the optimal air conditions for full-term infants and for young children up to grade school age. The satisfactory conditions for these age groups are usually assumed to vary from 75 to 68° F in temperature with natural indoor humidities.

For school children, the studies of the New York State Commission on Ventilation [24] place the optimal air conditions at 66° to 68° F temperature, with a moderate humidity and a moderate but not excessive amount of air movement. Allowing for the influence of room occupancy upon the optimal temperature,[33] the data of the commission are fairly in accord with the winter comfort zone determined by the research laboratory of the American Society of Heating and Ventilation Engineers for men and women over eighteen years of age, under sedentary conditions.[34]

Chart IV shows this zone, and its seasonal variation from winter to summer. According to the consensus of the experimental subjects, an effective temperature of 66° F is the most popular in winter time, whereas in summer one of 71° F is the most desirable. The relative humidity in these experiments was varied, from about 30 to 75 per cent, but the optimal range has not been determined. For general ventilation work, a range of 40 to 70 per cent is assumed, the former representing a maximal winter condition and the latter a maximal summer condition. Relative humidities higher than 40 per cent are impractical in cold weather on account of condensation of moisture and frosting on the window glass.

The optimal air conditions for health are not so well known as those for comfort. To solve the question, it would probably be desirable to make observations in institutions of confinement where the living conditions can be controlled over a considerable length of time.

CONTROL OF INDOOR AIR CONDITIONS

Natural Methods of Ventilation

Residences and office rooms, where there is no overcrowding, are usually ventilated by opening the windows top and bottom. This is the simplest of all methods. Transoms and sash ventilators are often provided to assist in the circulation of air, and to reduce the drafts due to the cold air entering through the partly open windows. Such places are usually heated by direct radiation from steam or hot water radiators beneath the windows, or by means of a warm air furnace. This latter method may in itself provide for ventilation when part of the air circulated is taken from out of doors.

For the more crowded offices, for schoolrooms and hospital wards, window ventilation is too uncertain and makes proper heating difficult. Such rooms are usually ventilated by the so-called *gravity exhaust* method, in which the outdoor air enters over slanted boards or deflectors on the window sills, and the vitiated air is removed through exhaust ducts or flues, at or near the ceiling on the wall opposite the windows. These flues lead to the roof. The circulation of air is induced largely by the difference in density between the cold air out of doors and the warm air indoors. Ventilation may be accelerated by placing a roof ventilator on the top of the exhaust duct, which acts as an aspirator under the action of wind.

In places ventilated by natural methods the problem of humidity control is a rather difficult one, particularly in cold weather. Not infrequently the relative humidity is lowered to 20 per cent or less as a direct result of artificial heating. A large quantity of water must be evaporated to raise the relative humidity to 50 per cent. For an average home this may vary from five to fifteen gallons a day, depending upon the weather conditions. Pans of water on the radiators and plants in the room may help to furnish moisture, but at best, the amount of water evaporated by these means is slight. It can be increased by the use of rather inexpensive household humidifying devices, some of which are fairly effective. The objectionable features to these devices are noise and dripping of water at the air outlet.

Some warm air furnaces are equipped with water pans around the fire pot or in the top of the combustion chamber. When these pans are of adequate size and the water supply is automatically controlled, the results are quite satisfactory and the system requires little attention.

In warm summer weather, natural methods of ventilation afford little or no control of temperature and humidity, except when they are supplemented with special cooling apparatus. Such apparatus is now rapidly coming into common use, though at present it is largely confined to theaters and to certain industrial plants, on account of its high cost. In the home, office, and hospital rooms, the effects of summer heat may be alleviated to some extent by the use of portable desk fans.

The chief disadvantage of natural ventilation methods is the lack of control. They depend largely on weather and upon the velocity and direction of the wind. Rooms on the windward side of the building may sometimes be difficult to ventilate on account of drafts, while rooms on the leeward side may not receive an adequate supply of outdoor air. The partial vacuum produced on the leeward side under the action of wind, may even reverse the flow of air, from the rooms and corridors to the out of doors, through the open windows and gravity exhaust ducts.

The advantages of natural ventilation methods are simplicity, low cost, and the fact that they are psychologically more natural and pleasant to the occupants than the mechanical systems. The claim that they are healthier than the mechanical systems is not well founded in the light of present evidence.

Mechanical Systems of Ventilation and Air Conditioning

In densely occupied spaces, such as theaters, auditoriums and crowded schoolrooms, or where there is a specific source of vitiation calling for a constant supply of pure air, resort must be made to mechanical methods. In these systems, the air circulation is maintained by means of fans which either force the air into the space to be ventilated through a system of metal ducts, or remove the vitiated air by suction. In many instances a combination of these two methods is necessary.

The heating is often accomplished by a combination of direct and indirect methods, the so called *split system,* in which the ventilating current is merely tempered to about room temperature or slightly below. In some instances no direct radiation is provided and the ventilating current furnishes all the heat necesary.

In the past, the practice has been to supply each occupant with 30 cubic feet or more of air a minute, and this was made the basis of ventilation laws in many states. The present tendency is to furnish a smaller amount of properly conditioned air, the volume depending upon the actual requirements of the particular problem.

Mechanical systems of ventilation are especially adaptable to complete air conditioning. This involves filtering, washing, heating, humidifying, cooling and dehumidifying the air circulated through the system. All these processes are usually accomplished by means of a central air conditioning apparatus from which metal ducts branch off to the various rooms.

In dusty and smoky localities, the air is filtered by placing at the intake opening some filtration medium like cloth, or oil coated metal screen, to which the coarse dust particles adhere.

Where humidification, or cooling and dehumidification, is desired, the air is passed through a rectangular chamber where it comes in contact with a finely atomized spray of water emerging under pressure from spray nozzles. This procedure washes off some of the dust in the air and removes soluble impurities. At the same time the air absorbs or gives up moisture, according to the temperature of the spray water. In winter, when humidification is desired, the spray water is heated. In warm and humid weather the air is cooled and dehumidified by contact with the cold water spray. The water is cooled in a separate chamber by trickling over cold pipes through which brine is circulated under pressure. Finally, on leaving the spray chamber, the air is forced through heaters, which in winter warm it to the desired temperature. A system of metal ducts, running through, or along the walls, carries the conditioned air to the different parts of the building. The various processes are controlled automatically by means of thermostats and humidostats, which are set to maintain any desired air condition in the rooms.

Systems of mechanical ventilation and air conditioning are usually equipped for reconditioning and recirculating part of the air in the interest of economy. The popular belief regarding the alleged virtues of ozone in recirculated air is entirely unfounded. Concentrations permissible in ventilation work were found to exert no effect whatever on pathogenic air borne organisms.[35] It is also a question whether ozone at such concentrations actually destroys odors by oxidation, or whether it merely masks them by olfactory compensation.

The chief advantage of mechanical ventilation systems is the flexibility in control, regardless of weather conditions, and their adaptability to complete air conditioning. The chief disadvantages are that they are more costly and more complicated than the natural systems, and they require periodic supervision by experts. No matter how perfect they may be in design and construction, their success depends largely upon the manner in which they are operated.

Both natural and mechanical systems have a fairly well defined field of application. Resort to mechanical methods should be made in those cases only in which the requirements, in so far as they are known, cannot be secured by natural methods.

Schoolroom Ventilation

The problem of schoolroom ventilation in relation to the health of the school children has been the subject of many studies and controversies, and some important points are still considered debatable.

The first studies of the New York State Commission on Ventilation [24] indicated that systems of mechanical ventilation lead to higher rates of respiratory illness among the pupils than do the simpler natural methods, with window supply and gravity exhaust. The inferiority of mechanical systems was attributed mainly to the higher room temperatures necessary on account of the more rapid change of air in the rooms supplied by fans. Subsequent studies [36, 37, 38] repeated by the commission and by others under somewhat more comparable conditions, yielded similar results, so far as the incidence of respiratory illness is concerned.

The latest studies of the commission which are much more thorough,[39, 40, 41] however, do not entirely confirm the earlier findings, and they seem to contradict them on some of the points at issue. Neither the temperature, nor the rate of change of air, nor the velocity of air in the classrooms were found to affect the incidence of respiratory or other forms of illness among pupils. The apparent superiority of the window gravity methods in the earlier studies is attributed in these last reports largely to uncompensated variables, such as race, age, sex, social and economic status, the distance the pupils had to walk to reach school, and the inability of the observers to diagnose respiratory illness.

An important conclusion reached in the last studies of the commission is that respiratory illness is not a satisfactory criterion for judging the effects of air conditions on the health of school children. Special tests on the ability of several school nurses to diagnose respiratory illness in a given group of children disclosed that the best agreement between any two nurses was in the ratio of one to three and the worst agreement in the ratio of one to nine. Presumably, this ratio was even smaller in the commission's first study, in which the diagnosis was made by teachers and parents.

In the light of our present knowledge of the requirements for schoolroom ventilation, it is fair to say that natural methods are to be preferred wherever they can be safely and economically applied.

The heating and ventilation of rural schools constitutes a distinct problem. The majority of these schools consist of one or two rooms heated by means of a stove, and inadequately constructed with respect to sanitation and ventilation. Studies of air conditions in relation to the health of the pupils in one or two room schools of Cattaraugus County, New York,[42] reveal that the average total absenteeism and the absenteeism due to respiratory diseases were twice as high as those found in the Syracuse Schools studied by the New York State Committee on Ventilation. The rooms heated by stoves showed a very uneven distribution of heat both laterally and vertically, as represented by differences in temperature as great as 30° or 40° F in different parts of the room.

The simplest method for securing a certain amount of ventilation in rural schoolrooms is to remove the upper glass pane of some of the windows and cover the opening with very fine mesh copper screen or cloth. In this way objectionable drafts are avoided and some of the dust in the entering air is caught by the screen.

OUTDOOR VERSUS INDOOR LIFE

In spite of recent advances in ventilation and sanitation, we have not as yet learned the secrets of reproducing indoors the natural climatic elements as they exist in open country under ideal weather conditions.

We are now living in an age when the value of outdoor life is realized more than ever before. It is believed that certain reflexes of the autonomic nervous system are associated with health and they are controlled by climatic factors. This is discussed at some length in the preceding section. Whatever factors are involved, there is no question whatever that, under favorable weather conditions, living out of doors is more healthful than living indoors. This is attested by gains in weight and marked improvements in the general health of children living under tents or in summer camps. The present mechanical systems of air conditioning, even at their best, cannot equal the wholesome natural atmosphere of an ideal day. They are corrective under adverse weather conditions, or in crowded places, factories and the like, where they constitute the only means by which an adequate supply of pure air can be procured.

We must admit that in guarding against cold, we usually create indoors an overheated and dry atmosphere which affects susceptibility to respiratory diseases and lowers the general vasomotor tone. A room temperature between 60° and 70° F, on the other hand, with ample ventilation but without harmful drafts, is a vasomotor stimulant and it lessens the contrasts of transition from the indoor to the outdoor atmosphere.

Some physicians still believe in the potency of outdoor air as a cure-all for human ills, regardless of weather conditions. This belief has led to the establishment of certain schools in which in winter subnormal children are heavily clothed and exposed to unmodified weather, on the assumption that the breathing of cold air is a tonic to general health. Recent work by Vernon and Bedford [44] shows that in cold weather the efficiency of children attending unheated open-air schools in England was only about half that of children in ordinary heated schools. The absenteeism was greatly influenced by temperature, as much as 50 per cent during a very cold period of time, owing largely to the restraining influence of parents.

Presumably other factors, such as proper nutrition and opportunity for extra rest and individual medical care, are in themselves sufficient to counteract the effects of unfavorable exposure. In the light of our recent knowledge of the physiology of ventilation, open-air schools of this extreme variety are dangerous in winter, but they are of great value when the weather is favorable, particularly if the schools are located in clean and quiet districts.

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DIFFICULTIES IN RELATING THE BEHAVIOR OF CHILDREN TO HOME ENVIRONMENT

THAT emotional stress resulting from unwise parental handling or from unfortunate conflicts of personality within the home exerts a marked and frequently lasting effect upon the development of the child is commonly believed, but objective evidence on the subject is exceedingly meager and hard to secure. Although examination of the literature reveals a list of titles on the subject which runs well up into the hundreds, their content is almost uniformly disappointing to the seeker after verifiable facts. The data, if such they may be called, consist chiefly of descriptive accounts of individual cases. Although these cases are frequently presented in an interesting and colorful manner which makes them valuable material for illustration (if the underlying assumptions can be accepted), they are in themselves inadequate evidence for the truth of these assumptions.

One of the most common sources of fallacy in popular and semiscientific thinking is the failure to distinguish between concomitance and etiology. The fact that in an individual instance A occurs concurrently with B does not demonstrate either that A is the cause of B, that B is the cause of A, or even, unless it can be shown that they occur together with more than chance frequency, that A and B are related at all. The citation of individual cases in which the facts appear to be in accordance with some preconceived theory affords no evidence as to the frequency of these cases in comparison with others in which the contrary conditions are present. Since the cases described in the literature are rarely, if ever, chosen at random, and are commonly selected with reference to some particular point of view, they may illustrate the possible working out of a theory but cannot, in themselves, demonstrate its truth.

If we turn from the purely expository materials to the attempts to secure more objective data from groups of subjects chosen without reference to any particular theory, we find ourselves on sounder ground but not much further advanced toward our goal. Some method of measuring, or at least of describing and defining, the personal and social behavior of individuals in such a way as to make useful classification possible is needed. Many attempts at securing devices for this purpose have been made, some of which appear promising for further development. It is doubtful, however, whether any of these are sufficiently reliable or valid, in their present state, to warrant much confidence in their use for the study of individual cases. And because of the complex nature of the phenomena involved, even the interpretations or conclusions which are based upon group results must be advanced with extreme caution. Since most of the test methods involve the use of paper-and-pencil substitutes, rather than actual examples of the behavior which it is desired to predict, the soundness of the inferences which can be made from such indirect evidence (the validity of the test) must be demonstrated as well as the consistency of the responses on the test itself (the reliability of the test). The former may still be low, even though the latter is satisfactorily high.

This brings us back to the old question of a criterion. We need to secure some sort of measure, definition or description of actual behavior as manifested by the individual in his everyday life, in terms of which the more convenient test method may be evaluated. Such a criterion is difficult enough to secure when the behavior of only a single individual is involved. In the present instance the measure needed is one which takes into account not only the behavior of a single individual, but the social interaction taking place within a group of individuals. The problem is complicated, first of all by the fact that there is but little general agreement as to what facts it is pertinent to observe and record in the study of social interaction; secondly, by reason of the transitory and rapidly changing character of the overt reactions which makes the task of recording very difficult;

thirdly, by the fact that so many of the cues to which the subjects are responding lie so close to the threshold of discriminative perception that they are almost certain to be overlooked unless the observer is specially set for responding to them. To the person who is prepared for an emotional reaction on the part of another, very slight changes in posture, in contraction of the facial muscles, in rate or depth of breathing, and the like may be far more potent stimuli to a counter reaction than the gross movements in the skeletal muscles which are so much more obvious to the naive observer. Minor changes in the quality of the voice or in tonal inflection may be full of meaning to one who, through previous experience with the individual concerned, has learned to respond to these small cues, although they may be quite unnoticed by another who lacks this specific experience. Nor does the difficulty end here. Social interaction, like all other forms of reaction, involves responses, not only to the immediate stimuli existing at the moment, but also to many previously experienced stimuli now existing only in the form of the meanings which the present stimuli take on through their agency. In this way many inappropriate as well as appropriate responses to a particular social stimulus may appear consistently in the behavior of any individual subject. It is, accordingly, unsafe to infer the nature of the stimulus (in any sense of objective reality) from the form of any given individual response. The voices heard by the paranoiac usually have some degree of objective reality. Noises exist, and constitute the immediate stimulus to which the subject is responding, but the costimuli resulting from past experiences of one sort or another which give meaning to the immediate stimulus are of such a nature as to give rise to an exceedingly inappropriate response.

Herein lies the difficulty of attempting to infer the nature of home conditions from the subject's verbally expressed reactions toward those conditions, as is sometimes done. If properly interpreted, these verbal statements may possibly furnish useful suggestions as to the meanings which certain stimuli have come to take on for the subject. To confuse these individualized meanings with objective reality as experienced and interpreted by the world in general is analogous to accepting the hallucinations of the paranoiac at their face value. This does not mean that such statements are valueless. Quite the contrary, the hallucinations of the paranoiac are highly significant for the study of the paranoiac himself, so long as we do not invest them with objective reality. Just so, the expressed reactions of the child toward the home may furnish valuable data regarding the child himself, but they do not constitute a direct measure of the home. The extent to which they may be relied upon as an indirect measure must, as in the case of other indirect measures, be determined by investigation.

This unsolved question of a criterion of the adequacy of inter-family relationships appears to be at once one of the most difficult and one of the most important problems in the study of child behavior in the broad sense. Had we such a criterion, many problems which are now subjects for dogmatic assertions and heated controversy might be investigated in an objective manner with more hope of a useful solution. Such a general criterion, however, particularly if it is to be based upon a concept of social values, is not likely to be arrived at save through the medium of a long series of patient examination and evaluation of such partial or specific criteria as lend themselves to study by objective techniques.

It has been an unfortunate characteristic of much of the work in the prediction and control of human behavior that the desire to solve problems runs far ahead of the attempts to develop sound methods for their solution. In our desire to reach the goal on the opposite shore, our efforts have been directed almost wholly toward attempts to swim the stream. In view of the strength of the current and the many hazards which await even the most skillful swimmer, it is greatly to be hoped that the future may bring more concerted attempts at bridge building.

SOCIO-ECONOMIC FACTORS INFLUENCING GROWTH AND DEVELOPMENT

THE purpose of this report is, first, to summarize the results of studies that have been made of the effect of social and economic factors influencing growth and development, and second, to outline the types of research which are most likely to prove fruitful in extending knowledge in this field.

Although bibliographical study and examination of published material are of great importance, only a comparatively small number of the subjects investigated are profitable for summary. Among the factors which will be considered are race, war, housing, child labor, family income, social and economic class, institutional care and maternal employment. It is obvious from mere statement that these factors are closely associated one with another, that families in the lower wage scales have less adequate food and poorer housing conditions; that child and maternal employment are frequently associated with economic pressure, and that some racial and national groups are more apt to be in certain types of occupations than others, which brings selective factors into play in regard to economic class and family income. Family income and wages are among the fundamental determinants of the situation in which the child is reared, but in this report it has seemed advisable to consider the social and economic environment which varies with income rather than the amount of income available for expenditure or the amount expended per se.

From the outset it must be recognized that association is not causation. For instance, infectious diseases have been shown to be more prevalent in back-to-back houses. However, although the type of house and living conditions are a factor in the spread of the disease they do not cause it.

Examination of the literature impresses one with the numerous panaceas that were thought from time to time to mean the salvation of the human race, its liberation from poverty, sickness and ill health. One investigator has thought this factor to be fundamental; another has settled upon a less obvious factor. This difficulty has operated throughout all time, not only in studies of growth and development, but in every type of social and economic investigation. There has long been general appreciation of the distinction between association and causation, but the development and critical use of statistical technique to show fundamental causal relationships is of comparatively late origin.

RACE

Racial and ethnic differences in physique were apparent from the early days when trade, travel and wars first brought men in contact with individuals who did not belong in their immediate community. These differences, striking the eye of the most casual observer and forming the basis of early investigations, are today an old story. Studies showing similarities and differences in growth curves and rate of growth, and studies showing the alterations in measurements formerly considered typical of a race or nationality but lately associated rather with change in environment are of more current interest in a country which has been the melting pot of all ethnic groups and has afforded markedly different racial and economic environment to the immigrant. The mass of material on this subject is so great that only a few contributions, indicating the general tendency, can be mentioned.

The most impressive evidence of alteration in physical characteristics following change in environment was brought forth by Boas [11] in 1911. Based on the measurements of tens of thousands of native-born children whose parents had come to the United States and comparing them with measurements of siblings born abroad and other comparable statistics gathered in Europe, the study showed a definite tendency of the native-born children to exceed the parental type in stature and to alter in physical characteristics, such as cephalic index, color of hair, eyes and skin. The effect of environmental change upon physical measurements and the various physical indices, as pointed out by Huntington,[40] had been previously noted by many observers and by such recent anthropographers as Ratzel [77a] and Semple,[88] but the quantitative approach and qualitative description of the degree and kind of change undergone in a given period was new. Moreover, it had generally been believed that the influence of environment only became perceptible after a considerable period of time.

Less well known investigations have shown that the changes demonstrated by Boas for the European nationalities are not confined to the white race. An investigation carried on by the Japanese Educational Association of San Francisco, based on Japanese children from seven to sixteen years of age in 20 different grammar schools in California, and comparable Japanese data reported by Iyenaga and Kenoske,[42] showed that Japanese children born and reared in America were appreciably larger than children of the same ages in Japan. Spier,[90] from a careful statistical study of 320 Japanese in the schools of Seattle, all of whom were born and reared in the United States, and 521 children born and reared in Heroshima, a prefecture in Southern Japan, from which a large proportion of the parents of the children had migrated, found superiority of the American-born Japanese at all ages. The length of the mother's residence in America prior to the birth of the child was also shown to have its effect upon the degree of change in the physique, particularly in the case of boys. The measurements of these children were further compared with averages, height, weight, and chest girth of 869,014 school children from all parts of Japan prepared by the Japanese Department of Education and with 17,075 Tokio city children, from which the lower classes had been excluded, reported by Misawa,[62] and the American-born children were found to be distinctly taller, to have larger and wider heads and wider faces than the Japanese, and to exceed the Japanese children in certain other physical indices. Comparison of the Japanese children of Seattle with those of California showed some superiority on the part of the Seattle children.

Differences in the growth of Chinese children born in China and in Hawaii have been shown by Appleton in a series of studies.[2] The 1926 Appleton study compares the height, weight, arm span, sitting height, and a number of other measurements of 345 Chinese boys nine to twenty-four years of age in Fukien, China, with a similar group of 242 Chinese boys born and reared in Hawaii. The Hawaiian Chinese were found superior in many ways to those in Fukien. Similar results were found for a group of 388 Chinese boys measured in Honolulu and 596 boys born in the Kiangsu province of China (1927). Comparison of the measurements of 354 Chinese girls six to twenty years of age in Hawaii with girls of Kiangsu, a province of China, showed that in girls, as in boys, growth between six and twenty years of age was more rapid and regular in this group of Chinese in the more favorable environment of Hawaii than in their native Chinese province.

Study of the similarities and differences in growth of the white and yellow races, based on the fragmentary studies found in the literature, shows no obvious differences in the general form of the curves, although those of the Mongolians are invariably on a lower level than that of the whites and there is some difference in the critical period and a flattening of the curve at an earlier age. The similar, though lower, level of the Mongolian curves is mentioned by Hammond and Sheng,[34] who found the growth curves of orphans and waifs of Northern China paralleling those of American children given by Baldwin.[5] They are again mentioned by Appleton,[2] who suggests, in addition, differences in the critical periods of growth. Roberts,[80] in a review of recent literature on certain phases of nutritional research presented at the third conference on Research in Child Development in Toronto in 1928, stated: "Both Japanese and Filipino mothers nurse their young late . . . both the average weight and the curves of growth of the Japanese infants are approximately the same up to six months as for children of

European ancestry but after this time there is a general flattening of the curve due to retardation."

Studies of the growth of Negroes are largely based on material gathered in the United States and no material is available to show whether differences in measurements follow change in environment. Herskovits[35] shows that the few studies that have been made have given conflicting results. Whereas the general shape of the growth curve is the same for the two races, some students find the Negro, others the white, to be superior. The conclusion reached by Herskovits is:

> To sum up the state of our knowledge of the influence of race on growth, therefore, it may be stated that scarcely a beginning has been made in the investigation of this problem. What, for example, is the influence of environmental differences on children of each race? When we find that children of one race grow faster than the other, is it race that is the cause, or food, or housing, or general economic well-being? Will similar differences in environmental set-up act in the same manner on children of different races?

In addition to this material we would cite the results of an unpublished comparison prepared in the United States Children's Bureau by Tandy and Phillips of the growth of Negro and white children twelve to seventy-two months of age. The basis of the comparison is the distribution of 125,707 white boys and girls measured in Children's Year (1921) about the average weight for height for age estimated from a multiple regression equation specific for sex which had been prepared as a base for judging the similarity of divergence of groups of preschool children examined under special circumstances. Comparison of a distribution of 3,334 Negro children collected in Children's Year showed that the Negro children tended to weigh less than the whites of the same age. Since this group of Negro children were, on the whole, in good physical condition and probably representative of the race in the United States, it would appear that the weight, height, age standards for white children in the preschool period are, in general, too high for Negro children of those ages.

Although there has always been admixture of races, the extent of intermarriage has been far less than among the different nationalities. The lack of purity of national stocks obviated many of the findings in regard to growth and renders statistical treatment of such material extremely difficult. The influence of intermixture of nationalities upon the physique of the inhabitants of the industrial sections has been brought out by Wissler,[102] Davenport[21] and others. In another guise it has been discussed by Elderton[26] who feels that in large towns, non-native elements such as Italians, Irish, Jews, and Poles, are often found in the poorer sections of the town so that the inferior physique in these districts may be due, in part, to the ethnic elements. Military statistics and extensive studies of school children have established in most cases significant national differences, many of which are doubtless associated with economic and environmental conditions, as well as the differential factors based on nationality.

Although a vast number of studies contribute information concerning ethnic differences, no group of studies attempts systematic analysis of growth differences within the national group. Many American investigators, like Bowditch,[14] Porter,[73] Boas,[11] West,[100] Putnam,[75] Dublin and Gebhart,[25] and Woodbury[103] have divided American children according to the national groups from which they were derived. These studies almost invariably show that children of American parentage are superior in size to children of foreign parentage and that the American-born are superior to children of the same ethnic stock in Europe. They show no significant differences in the shape of the growth curve but do show variations in the rate of growth in various groups.

WAR

The shortage of food during the World War provided a large scale experiment as to the effects of undernourishment upon the growth and development of young children.

Investigations were carried on in practically every country affected by the upheaval. The pertinent studies dealt with the effect of war upon birth weight and length, the regain of birth weight after the initial drop, and the height, weight, and rate of growth of children.

In Germany, Kettner [46] issued an alarming report concerning the newborn children in his clinic at Charlottenburg, ascribing their diminished size and increased nervousness to the insufficient food received by their mothers. This immediately gave rise to much controversy and a large number of statistical investigations, most of which showed that there had been no significant change in the birth weight of infants. Mossmer [63] in Posen, analyzing the birth weights and lengths of infants born in the Women's Clinic and Midwife School showed an average birth weight of 3,350 gm. and 50.9 cm. in length for 1,093 infants born April 1, 1913 to March 31, 1914, as compared with 3,340 gm. and 50.8 cm. for 825 infants born from April 1, 1915 to March 31, 1916. Rüge,[83] working with data from the Women's Clinic in Berlin (1916), found the average birth weight of 1,685 infants born in 1913 to be 3,349 gm. as compared with that of 3,319 gm. for 1,508 infants born in 1915 and 1916. Rabnow,[77] with very small numbers of cases, 68 boys and 59 girls born April 1913 to March 1914, and 153 boys and 142 girls born April 1915 to March 1916, showed birth weights by sex which were again not significantly different for the war and peace periods. Schmidt,[87] with data collected at the University Women's Clinic in Tübingen, found for 745 births occurring in 1913 an average birth weight of 3,384 gm. and for 475 births occurring from November 1915 to November 1916, an average of 3,338 gm., the difference of 46 gm. in favor of the year before the war being non-appreciable. Most of the women cared for came from the country, where food changes were not fundamental, and Schmidt felt that the question arose as to whether this district had suffered as much as some others. Linke [53] presented figures on 1,078 births occurring in the Women's Clinic at the Academy of Practical Medicine in Düsseldorf from 1915 to 1918 inclusive, showing the average birth weight for each year as follows:

1912–1913......	3,393 gm.
1915......	3,409 gm.
1916......	3,353 gm.
1917......	3,348 gm.
1918......	3,404 gm.

The figures from which the individual averages were derived are not presented but it is evident that they are insufficient to establish definite conclusions concerning trend. Lande [50] compared the distribution of birth weights of legitimate and illegitimate infants born in the Empress Augusta Victoria House in Berlin and found that 16 per cent of the legitimate infants born in 1909 to 1913 weighed less than 3,000 gm., as compared with 18 per cent in 1915 to 1918 and that 23.2 per cent of the illegitimate infants born during peace years had birth weights of less than 3,000 gm., as compared with 21.5 per cent of those born 1915 to 1918. Lande's number of births, a total of 1,221 legitimate and 707 illegitimate, suggest that these small differences are non-appreciable. Other authors of the time, either with exceedingly small numbers of cases or failing to present the basic material in their reports, similarly claimed that the war had not affected the birth weight and length of infants who came under their observation.

The majority of these early studies presenting statistical material based on a fair number of cases indicated that no significant change had occurred in the birth weight. Taken as a group, however, it is noteworthy that practically all the differences are in the same direction, pointing toward lower birth weights during these years. Although differences were insufficient to be statistically significant, the general tendency seems to suggest that average birth weight and length were tending toward lower values.

Studies made during the later years of the war showed definite evidence of lower birth weights in war than in peace. Binz [10] in Munich, using the records of 8,000 births of infants over 48 cm. in length, found that there was no difference in the average birth weight in 1914 and 1916, but that the average for 1917 was significantly smaller than that of

1914 and that the difference in both city and country amounted to a 3 per cent decrease. DeMoor and Slosse,[24] in 1920, showed the average birth weight in Belgium had decreased from 3,000 to 2,500 gm. David[22] in the University Women's Clinic in Budapest presented averages based on 15,025 births in the years 1909 to 1919 and showed that, whereas neither the percentage of primiparae nor the sex ratio of births had changed, the average birth weight for the war years was 3,123 gm. as compared with 3,218 gm. for peace years and that average birth length was less, being 50.2 cm. for the war period and 51.5 cm. for the years of peace. Peller and Bass,[69] using the records of 14,500 newborn infants in Vienna from 1912 to 1922 inclusive, and dividing the cases into four groups according to mother's marital condition and according to the care she received in the antenatal period, found that decrease in weight of the infants amounting to about 350 gm. had taken place since the war in each group. Bondi[12] in Vienna found decreases in the average birth weights during the years following 1914, as follows:

Year	1913	1914	1915	1916	1917	1918	1919
Number of cases.....	169	213	236	252	250	276	304
Average birth weight in grams..........	3,201	2,317	3,172	3,126	3,082	3,028	3,023

In England, where the universal shortage of food was not as marked as in Germany and Austria, Murray[64] found no successive falling off of average birth weight and length among approximately 1,000 cases of multiparae for which it was possible to coordinate medical and social records at St. Thomas Hospital and the General Lying-in Hospital, London. His figures are as follows:

Year	1914	1915	1916
Average birth weight (lbs.)...............	7.16	7.16	7.11
Average birth length (inches).............	19.93	20.07	20.20

This report of the British Medical Research Council presents a very able summary of the findings of the early European investigators of the effect of war on birth weight. These investigators are indeed "astonishingly unanimous," "all find that there is no question of war children having a definitely lower birth weight." The reports, however, are rather difficult to evaluate from a statistical standpoint. The numbers of cases, particularly those used by early investigators, are, in general, small, and the findings are seldom presented in a form permitting further analysis. Differences in the figures for the first years are generally statistically insignificant. It is the findings of the later investigators, based on large numbers of cases and pointing positively toward lower birth weights and lengths, that lead clearly toward the conclusion that war with its attendant shortage of food leads to general reduction in the birth weight.

Evidence of the effect of war conditions upon regain of birth weight within a certain time, similarly seems to depend upon the date the study was made. Mossmer [63] reported that his study extending from April 1, 1915 to April 1, 1916, showed normal peace time progress for infants during the nine or ten days after birth that they remained in the hospital. Schmidt [87] also reported that there was no appreciable difference in the number of days needed to regain birth weight. Lande [50] stated that his infants usually thrived well for about the first three months, especially those who were breast fed. Linke,[53] as late as 1919, stated that the quality of milk had not changed to any appreciable degree and that infants were faring as well the first months of life during war years (1915–1918) as during peace time. The quantity of breast milk produced by the mother, however, he found had diminished by 1918 as compared with 1915. Beninde,[9] however, found that the ability of the mothers to nurse their infants had decreased and that it took infants much longer to regain their birth weight due to this impoverishment of the mother's milk. DeMoor and Slosse [24] reported that mortality of infants from "congenital debility" had increased in Belgium. Kütting,[49] with a total of 2,445 births for the period 1914 to 1918, found the percentage of children who lost more than 10 per cent of their birth weight after birth increased each year after 1916, indicating that the mother's ability to nourish the child had been impaired and that after 1916 a decreasing percentage of infants regained their birth weight by the tenth day. Hofmann,[37] from a study of infants in the Roslock maternity clinic for 885 prewar and 849 war born infants, found that it took longer for infants born during war years to regain the weight lost immediately after birth.

One of the first physicians to raise an alarm of danger as to the influence of food shortage on growth of school children was Kettner.[46] Comparing the heights and weights of some 5,000 school children with their previous records, he reported an appreciable decline in weight and height of school children in North Charlottenburg, Germany, and warned against measures which curtailed the rations of growing children. Among other studies on the influence of war on German children are those of Gohde,[32] who on the basis of 6,391 weighings of 913 pupils in Bochum, weighed once in every two weeks, reached the conclusion that, on the whole, growth of children was progressing normally in spite of the war. Lommel[54] from some 3,500 weighings reached a similar conclusion to that of Gohde, though admitting that there was a slight decrease in weight.

With the continuation of war, the evidence of malnutrition and underdevelopment became more and more pronounced; Oschmann[66] compared the growth curves of more than 300 school children during the years 1913 to 1914, 1914 to 1915 and 1915 to 1916, finding the average increase in height and weight definitely smaller for 1915 to 1916, though without definite signs of weak physique. In a study of another group of more than 300 individuals for the year 1916, in this case school entrants of ages five and one-half to six and one-half, an inferiority of growth was noted, besides a higher fatality from disease, which Oschmann attributes to negligence of parents, rather than to malnutrition. Thiele,[94] studying health conditions and growth indices in country and city, came to the conclusion that in country districts the German children showed no marked malnutrition nor retardation of growth, whereas, in larger cities both malnutrition and retardation of physical development were evident. Contrary to these, Bachauer,[3] from his measurements of over 1,200 infants and 1,600 children one to eighteen years of age inclusive found no clear cut evidence that the growth or development of these children had suffered. Pötter[74] compared measurements of some 3,000 school children in Leipzig from March 1917, to February 1918, with norms obtained from measurement of all the school population of the city prior to the World War. He found a reduction in weight, some reduction in height, and a decided increase in girth of chest.

Pfaundler,[70] from a study of growth indices of 2,500 Munich school children as compared with prewar standards, found considerable retardation with a marked leveling of the rates of growth of various social classes, the well-to-do children showing the retarding influence of war more than the poorer children. Schlesinger[86] from a study of 5,000 boys from infancy to eighteen years of age, representing all classes of society, found that 1,916 showed no decrease in height, as compared with children in the same schools before the war. Stunting in stature first became evident in 1917, after which time children of all ages were affected to the extent of from one to 3 cm. on the average at various ages. In 1918 conditions were about the same. Schlesinger, like Pfaundler, found the children of the well-to-do suffered more than children of the poor, so that growth in different socio-economic groups tended to become more uniform. Nervousness had increased. There was a lowered resistance to infection and a marked increase in rickets and in the incidence and fatality of all forms of tuberculosis. These conclusions were based on some 300 case studies and confirmed by later investigations. In his subsequent study (1919) he used children from 2 large infant homes and boys from 6 private polytechnic schools, comparing with measurements of children in the same institution in 1911 and 1913. As on his previous investigation, he found a marked decrease in growth at all ages including infancy from 1917 on. The most marked retardation was found among children fourteen years of age and above, attending private schools, that is, among the children of the well-to-do. Using the *index ponderalis,* he found little change in children of the lower and middle classes and an increase among the well-to-do and the rich, since the retardation of stature was greater than that of weight in upper classes. In his study of 1919, Schlesinger [86] presented fresh data and concluded that the effect of malnutrition was relatively more pronounced in older than in younger children and that retardation in stature was more marked than that in weight. He also reported an increase of osteomalacia, osteoporosis, and other deficiency diseases, and dwelt at some length on the retardation of puberty in German boys associated with retardation of general body growth. Stefko [91] and others have also found a marked delay in pubescence both in males and females suffering from severe malnutrition.

In 1922 Schlesinger [86] found that the height and weight of Frankfort School children were still subnormal; he attributed the malnutrition to the fact that these children suffered during the war and in subsequent years on account of severe economic depression. He found that decrease in stature continued after the war, reaching a maximum for most ages in 1920, when the average stature was approximately 4.3 per cent below normal. An improvement began after 1920, but suffered another reverse in 1923. This reverse was reflected also in an increase in tuberculosis.

Beninde [9] found health conditions in 1918 markedly worse than in 1917; an increase in general mortality, especially mortality from tuberculosis, a general decline of height and weight in all ages and in all sections of the country, and an increasing inability of mothers to nurse their young. The condition of children one to five years of age especially was below that reported in 1917. There was an increase in the incidence of scrofula, rickets, enlarged glands, tuberculosis, skin diseases, anemia, stomach ailments, and so forth.

Although the German evidence, of which only a portion has been cited, is not unanimous, the bulk of it confirms the view that a retardation in the growth and development of the German youth was associated with the war.

Austrian evidence is positive and definite concerning the effect of war. Numerous studies show a decided retardation of growth, and increase in morbidity and mortality associated with the deprivations. Lebzelter,[61] who studied more than 5,200 apprentice workers in Vienna and compared their measurements with comparable data he had secured in 1919 and 1921, found that these workers were subnormal for their age. The subnormality was least in 1921; it was greater in the years 1919 and 1923 on account of severe economic depression similar to that experienced in Germany.

Evidence of the Russian experience is presented by Nicolaeff [65] who, working largely with infants and children, found that body weight of these children one to sixteen years of age was 20 to 40 per cent and in some instances 50 per cent below that normal for their age. There was a general atrophy varying in degree in different individuals, and an enormous increase of various deficiency diseases such as edema, osteoporosis, and osteomalacia. Stefko [91] in his large number of investigations on various phases of Russian famine found marked retardation of growth in youth accompanied frequently with atrophy and deformities of vertebrae, leading to an actual dimunition of stature. Stefko described skeletal and other dystrophic growth and found that the changes in the skull tended toward brachycephaly rather than the contrary. As late as 1926, a study of 148 girls fourteen to eighteen years of age, and a study of 851 boys seven to sixteen, showed a marked retardation in pubescent growth and interference with sexual development. These investigations show not only physical retardation but serious functional deficiencies among all age groups. Sorokin [89] also cites evidence of physical and functional retardation caused by the famine.

DeMoor and Slosse,[24] investigating Belgian conditions, found a marked retardation of the young. The average retardation of children was more than a year. There was a marked increase in deficiency diseases, especially in rickets, with increase of the mortality of almost all diseases and at all ages. Calmette,[16] from a study of children at Lille, France, found that in younger children the retardation was one to two years, while in older children it amounted to four or five years.

Studies in America, where the influence of war was less pronounced than in most countries of Europe, indicate an increase in malnutrition. An investigation by Chapin[18] showed a great increase of malnutrition among the school population of New York City. The writer believes that the greater prevalence of malnutrition is to be attributed to scarcity of food and higher prices caused by war. Reports by Baker,[4] giving results of routine examination of some 1,000,000 or more school children in New York City schools, confirmed the findings and the interpretation of Chapin.

HOUSING

Objective quantitative studies of the squalor, misery and pathos in the lives of the less fortunate inhabitants in every country, such as those by Rowntree[81, 82] and Booth[13] in England, by Chapin[18] in New York City, by Breckinridge,[15] and hundreds of others have definitely shown income and type of dwelling.

Housing * is not an isolated factor but a general term covering many factors. It is in its turn correlated with many other phases of family life. Various studies have demonstrated appreciable correlation between housing and employment, housing and food, housing and education of parents, housing and child labor, housing and heredity, and many other conditions inextricably associated with housing on one hand and growth and development on the other.

In various studies on housing and growth no one has measured or adequately controlled this multitude of associated conditions and consequently no one has fully demonstrated the actual factors in home conditions which are fundamental to growth and development. Most of the available investigations are comparative studies of well-to-do and poorer classes; comparison of occupational groups, comparative studies of various types of areas, such as industrial versus non-industrial, rural versus urban, and prosperous versus less prosperous, and so on.

The criterion of housing generally used is the number of individuals a room or the number of rooms in the home.

* See also: *The Home and the Child.* A Publication of the White House Conference. New York, The Century Co., 1931.

Less frequently the measure is the amount of air space for each individual. It is important to emphasize, however, that the number of rooms and the air space for each individual do not fully represent the environmental factors that constitute housing, for they are not actual indices of ventilation, dampness, lighting, sanitation, the amount of time spent inside the dwelling, or the many other things that are elements of the physical environment of the individual.

One of the earliest pioneers in pointing out the intimate relation between housing and vitality was Farr.[28] Chalmers,[17] another pioneer, pointed out the disparity of height and weight between children coming from one-room, two-room, and three-or-more-room houses.

Grading the girls according to one, two, three, or more room apartments, the following averages were found (from tables prepared by Kay, 1904); one room 43.4 in., two room 49.2 in., three or more room 50.0 in. The weights for these were 48.8 lbs., 56 lbs. and 58 lbs. respectively. The corresponding measurements in stature and weight for boys were: 47.7 in., 49.0 in., and 50.0 in.; 52.9 lbs., 56.6 lbs. and 59.6 lbs. Chalmers [17] interpreted his findings as follows: "All this suggests that when we talk of one, two and three room conditions of living we are dealing largely with the conditions of an economic standard, that just as people live in a one room house, so it might be said that they are clothed and fed in a one room manner. That is, they are deficient in house room and in food, but as affecting the children, at least, this latter is of most importance, although the evidence would seem to point to unsuitableness rather than lack of quantity in food stuffs as most requiring attention."

Other studies (MacKenzie and Foster [59]; Macgregor [58]) apparently confirmed the relationship established by Chalmers between the height and weight of children and the number of rooms in which the families lived. In all of these studies cited so far the evidence is conclusively in one direction, that children from homes with fewer rooms are inferior to children from homes with more rooms. The evidence would have seemed adequate if it had been corroborated by studies with more thorough and painstaking analysis. On the whole, these more thorough studies show that the relation between number of rooms or air space and height-weight, is at most very slight.

In the study by Karn and Pearson[44] the correlation coefficient between cleanliness of house and health of baby was found to be .168 ± .029 (more than 500 cases). The correlation coefficient between number of individuals for each room and health of baby was .116 ± .023 for boys and .130 ± .025 for girls (839 boys and 730 girls). Again, correlating the health and weight of the baby respectively with the amount of rent paid, the following coefficients are obtained: rent and health .078 ± .033 for boys and .099 ± .036 for girls; rent and weight .054 ± .042 for boys and .382 ± .038 for girls. It is thus seen that there is hardly any correlation between rent and health, for what little correlation there is disappears when the influence of weight is taken into account by partial correlation. Thus, while in general the crude facts of this study are similar to those in previous studies of housing, refined analysis shows that the early findings are of little significance. There is only a small correlation between the health and size of infants and the crowding at home. Another extensive and exhaustive study by Paton, Findlay, et al.[67] in the three Scottish cities of Glasgow, Edinburgh and Dundee, including some 2,200 households, shows the correlation between air space for each individual and height-weight in children to be very low and often significant. From an exhaustive and careful analysis the writers conclude: "From these results it would appear that the effects of overcrowding are not apparent till after the first year of life, after which the weight and height of children in the more overcrowded homes are, on the whole, lower. But the size of the correlations does not justify the suggestion that in these homes overcrowding is a dominant factor in influencing the nutrition and growth of the child."

These two studies raise a doubt as to the true significance of earlier studies in which the findings were of considerable magnitude but in which no refined analysis was attempted. On the whole, it would seem that there is general association between the height-weight of children and the number of rooms for the family; this apparent relation, however, is probably due largely to other factors that are associated with housing rather than space itself.

The great body of housing literature in every language has to do with the relationship of housing to morbidity and mortality and to the improvement in general health subsequent to an improvement of sanitary conditions or a movement to better districts. A vast number of investigations show the high incidence and fatality of disease in back-to-back houses, houses on alleys, houses of small numbers of rooms, and the like as compared with houses situated in better neighborhoods and homes having more rooms and so forth. Others show the great frequency of rickets in homes and neighborhoods where little sunlight penetrates. Infant mortality has been repeatedly demonstrated to be high in overcrowded districts and the expectation of life shorter in houses having a small number of rooms. Certain types of infectious diseases transmitted from person to person have been shown quite naturally to have greater incidence and higher mortality rates in districts having a high density of population.

These studies show the association between housing and the various ills, but fail to demonstrate that housing conditions are the fundamental causative factor. The thoroughgoing careful statistical investigations which take into account the many conditions associated with housing, such as general social or economic class, family income, occupation of the father, cleanliness of the home, health of the mother, and the quality of the care she gives the child, as well as the housing conditions, show that a multitude of factors are bound together and that no single factor is responsible for the sum total of the differences in health and growth of children living in less favorable neighborhoods, as compared with those in the more favorable. Number of persons for each room, the air space, the situation of the house per se and the characteristics of the neighborhood unquestionably have their influence upon health and growth. The importance of housing was, however, unquestionably overestimated in the early days. Careful statistical studies have pointed out the multitude of factors that are to be considered, and carried the warning against overestimating the importance of obvious elements. They suggest the necessity for a more thorough and critical analysis and evaluation of this multitude of factors which influence the growth and development of children.

CHILD LABOR

Investigations concerned with the effect of child labor * on the health and growth of children antedated the demand for protective legislation which originated in England and gradually spread throughout the civilized world. The first material was generally of a descriptive character, but quantitative studies soon began to be presented showing the effects of long hours of labor in the factories and mines. The investigations of the child in agricultural employment were later in origin. Since those early days child labor laws and regulations have been developed and working and living conditions have materially changed in most countries. Because of these developments and changes, investigations which are pertinent for other than historical purposes are largely confined to those made in the twentieth century.

At the present time in the United States almost all states have fourteen years as a minimal age for employment, at least in factories and often in many other employments. Seven states have a minimal age of fifteen or sixteen but many exemptions are permitted and there are many limitations upon the application of the laws. Employment certificates are required by law in most states for the minor's first job and for these proof of age is required. Employed children of certain ages are required to attend part-time schools. Night work and work in certain dangerous trades are generally prohibited by law. Offsetting these legal restrictions is a demand on the part of the family and the child that the individual should work; because of these conditions the problems of child labor, are, and probably always will be, with us. It is these conditions, and questions concerning

* See also: *Child Labor* and *Vocational Guidance.* Publications of the White House Conference. New York, The Century Co., 1932.

the advisability of part-time work, that render pertinent a summary of material concerned with the effect of child labor on growth and development. In reviewing the statistical material on the subject, it is necessary to keep in mind that child labor, like housing, is not a completely isolated economic or social factor but one bound up with the other myriad conditions which have their influence on growth and well-being.

Numerous studies show that working children are inferior in size to non-working children. Sack[84] studied the height and chest girth of some 7,000 boys from eight to twenty-two years of age attending the high schools and polytechnics of Moscow and, comparing the measurements with those of Russian boys in factories, found a decided advantage in favor of the school population. He noticed also that the pubertal growth spurt in the school population came earlier, being in the years twelve to sixteen for the school population and in the years fourteen to eighteen for the factory group. Allaria[1] in 1912 in Italy studied the height, weight, strength, lung capacity, and other physical measurements of 652 girls employed in urban industrial establishments, 420 in rural cotton factories, and 158 unemployed girls of well-to-do families. In all measurements the well-to-do exceeded the working group.

A recent study in Russia by the Public Health Service of the Ukraine[95] based on 11,000 workers from fourteen to eighteen years of age, showed that the general physique of young workers is inferior to that of school children. Another recent study in Sweden[71] (1926) of the repeated examinations of 9,186 working boys thirteen to seventeen years of age and 2,315 girls fourteen to seventeen, all of whom had been at work at least three years and had at least three medical examinations, sets forth the comparison with measurements and annual gains of non-working children in Sweden, Norway and England and shows that young workers do not reach the standard height of school children, and that even at the end of their period of development, they have a relatively low average height. In a study of Japanese children Kose and Itani[48] compared the measurements of

1,683 working children (882 boys and 801 girls) with the measurements of 45,000 non-working children and with measurements from a separate study by Kose, including 12,500 children from the well-to-do and 13,400 from the poorer classes. At all ages the working boys were found inferior in length and weight to the non-workers. The same held true for working girls with the exception of those seven years of age. Greenwood,[33] studying the measurements of about 800,000 British school children, some of whom were part-time workers found in most districts where part-time work was prevalent, a marked slowing down of the growth curve at the age of twelve when part-time work was first allowed, whereas in the districts with few part-time workers the flattening in the curve failed to appear. A comparison of average size in part-time and non-part-time districts, however, showed the half-time worker excelling the whole-time school child in both height and weight. Following a careful analysis of his own material and examination of the material and findings of many other British investigators, Greenwood concludes the physique of half-time workers suffered in consequence of their employment.

Although the findings of some investigations in the United States [97] have been similar to the majority of the findings in foreign countries, for example, those based on the heights of approximately 4,000, fourteen and fifteen year old Fall River cotton mill workers, showing at both ages stature markedly below the accepted standards, other carefully planned and analyzed studies have been in less complete accord. Safford [85] compared the height, weight, lung capacity, and so forth of 679 males under eighteen years of age working in the cotton mills of Massachusetts with similar measurements of 6,232 boys of Manhattan, New York City, fourteen and fifteen years of age, applying for employment certificates between July 13, 1914 and April 13, 1915, with 770 white boys of American parentage studied by Stiles and Wheeler,[93] and with Bowditch's [14] measurements of 10,000 school children. The Massachusetts mill children in general rated low, even in comparison with the New York City group, which included a larger proportion of short statured nationalities. Boys of fourteen were particularly inferior in size, when compared with the standard. This, the investigator thought to be due to falsification of age in order to obtain work permits. At ages fifteen and sixteen the mill boys compared favorably with the other series, but from sixteen onward, the average of the mill boys was increasingly unfavorable. A study of the Iowa Bureau of Labor Statistics [41] of 4,382 boys and 2,637 girls to whom employment certificates had been issued July 1, 1918 to June 30, 1920, gave averages which compared favorably with the Baldwin and Bowditch figures. Boys and girls beginning work at fourteen were usually larger and heavier than the usual average for the age, but at age fifteen the advantage was not so marked and at fifteen and one-half the working children were slightly below the standard. The report suggests that employers in hiring children under fifteen years of age pay more attention to physique, but that over that age they tend to use less discrimination. Woolley and Fischer in 1914 and Woolley in 1926 [104] in studies of physical and psychological tests given to working and school boys found the school group in general superior to the working group except that at age eighteen the working group excelled the school in tests for steadiness. Thus Woolley found school children reached maturity in size and skill at least a year earlier than the working children.

The influence of work on the physical growth of children is difficult to evaluate, for selective factors operate both before and after entrance into industry. In interpreting the findings of her report Woolley [104] states: "The great superiority of school children over working children might be taken as proof of the bad effects of industry upon working children were it not for the fact that the differences are present in marked form at fourteen years, before any of the children have actually entered industry. . . . Differences at this point must be due to the selective effect of whatever factors are determining early elimination from school." Safford [85] felt that the higher averages of his Massachusetts mill boys in the younger ages was due to the fact that up to sixteen the better occupations were closed but that after sixteen the more capable boys were found more profitable jobs and the reverse type of selection operated. Greenwood [33] attributed the difference in average size of part-time workers and whole-time school children to the tendency of stronger children to go to work and the weaker ones to remain in school longer, and moreover, to the fact that the workers were better fed than the school children in the same home. Frankel and Dublin [29] show evidence that the stronger children in the family are the first ones sent to work while the more delicate ones are sent to school for a longer period.

Many investigators have found physical defects more prevalent in working than in non-working children. For instance, Greenwood [33] found far more physical defects in the half-time than in the whole-time school children. In his 1914 report he dwells on the retarding influence of fatigue on growth and development and the increased susceptibility to disease that accompanies it. Ball [6] in an intensive study of 100 newsboys in Cleveland showed 34 per cent in poor physical condition. Roach [79] in a report based on Chicago data, on children leaving school to go to work, found only 11 per cent free from physical defects. Gladston [31] in a study of 2,000 working boys selected from the East Side Continuation School found more than one third undernourished, 27 per cent with impaired vision, 45 per cent with decayed teeth, and a large percentage with other defects and diseases. McGill,[61] reporting the findings of a Children's Bureau study comparing the physical defects present among newsboys and other boys who did not sell, showed that heart disease was three times more prevalent among the sellers than the non-sellers; 38 per cent of the newsboys as compared with 17 per cent of the non-sellers, had aggravated throat conditions, and 11 per cent of the newsboys, as compared with 5 per cent of the other group, had orthopedic defects. Certain defects have been shown to be particularly prevalent among boys working in the metal trades, others among children working in bake shops, still others among children in sedentary occupations such as clerical work and so on. Part of these are undoubtedly due to the selective factors operating in the entrance of the individual into the occupation. Others are doubtless associated with the type of strain and the special activities associated with the occupation.

Evidence in regard to the effect of child labor is inconclusive. Certain studies indicate that harm has been done; others that working children are no worse off than those who do not work. The selective factors which enter into the choice of the job on the part of the child, the discrimination of the employers in favor of children best adapted for their special use, and the economic pressure which tends toward falsification of age, operate to render statistical analysis of the basic differences difficult. Study of the investigations, however, leads one to urge thoroughgoing enforcement of regulatory and supervisory measures. Employment certificate issuance should be handled with great care, opportunity for falsification of age should be reduced to a minimum, the hours of labor should be carefully watched, employment in dangerous trades eliminated, and physical examination of the child should be given great emphasis.

OTHER FACTORS

Family Income, Social and Economic Class, Institutional Care and Maternal Employment

Numerous other factors have been shown to be associated with the growth and development of the child. For the most part they cannot be isolated and are difficult to treat statistically. Such factors as family income,* economic class, institutional care, the employment and the health of the mother, and the maternal intelligence which reflects itself in the feeding of the child, in the regularity of its habits, and in the cleanliness and order of the home, are among the most important. Urban and rural differences in growth unquestionably exist. There are also differences in growth in the different sections of the country.

Scarcely a study from the time of Quetelet[76] fails to mention economic class and family income as a basic influence. Children of the well-to-do have been repeatedly demon-

* *The Home and the Child,* op. cit.

strated to have better health, and exceed the poor in height and weight and rapidity of growth. Children of the professional classes have a more favorable showing than those of artisans and industrial workers. One effect of the World War mentioned in a great many studies was the leveling of the classes. Children of the poor seemed to lose less in rate of growth than the children of the families which were generally better off. In some instances, of course, the economic condition of the poorer classes was improved, owing to regularity in the family allotment for men in the armed forces and changes in industrial conditions. The association of growth with family income is obvious. Studies of family budgets show the actual expenditure is higher for each person in the higher income levels. The findings of these studies and those of supplementary feeding experiments indicate the value of better adapted and more adequate diet. To make up for quantitative and qualitative deficiencies in diet, special additional food is often given to the undernourished child in the more poverty stricken neighborhoods.

Comparison of the studies of representative groups of children in the different sections of the country, and children in urban and rural districts shows variation in the average height and weight constants. Some of the differences are undoubtedly associated with the ethnic stock which settled in the region, others may be due in part to differences in the environmental surroundings. The bulk of the studies comparing the growth of urban and rural children show the superiority of the country child. Comparison of the characteristics of weight-height curves and the values of the constants is a major study in itself, but that differences do prevail must be recognized here.

Evidence of differential birth weights is almost invariably in favor of the non-employment of the mother for a period prior to confinement. Pinard,[72] for instance, found the average birth weight of 500 infants born of mothers who worked until the time of delivery to be 3,010 gm. as compared with 3,290 gm. for another group of 500 infants whose mothers rested at least ten days prior to delivery and an average of 3,366 gm. for 500 infants whose mothers sojourned at the Clinic Baudelocque before confinement. A later study of Pinard, in 1898, based on some 4,500 newborn infants presents similar findings and shows that women who withdraw from active occupation two or three months prior to confinement give birth, on the average, to children averaging 300 gm. more than those who continue working up to the time of confinement. Peller,[69] with records of 5,784 infants born in Vienna, demonstrated that in cases where the expectant mother stayed at the maternity home from two to eight weeks before confinement heavier and larger children were born. The findings of these studies are similar to those of a great many other investigators. Some few studies have apparently negative results, but the statistical significance of these findings is almost invariably questionable on account of the small numbers of cases investigated.

There is a good deal of fragmentary material available regarding the nature of the mother's employment and on the whole these studies demonstrate that in the occupations which are generally considered lightest, the birth weights are heavier, particularly if economic class and family income are taken into account.

The mortality of the first year has repeatedly been shown to be lower for infants whose mothers are not employed. Verrill[98] from his study in Fall River, Massachusetts, came to the conclusion that the much higher mortality among children of the mothers who went to work after childbirth was plainly due to the abbreviation of breast feeding, to improper feeding, and the additional evil influence of the withdrawal of the mother's care. Hibbs[36] found that, in general, maternal employment meant higher infantile death rates except for special cases where the amelioration of dire poverty more than compensated for the evils of maternal employment. Studies of the Children's Bureau, based on 8 cities and including more than 23,000 births which were summarized by Woodbury,[103] show a significantly higher death rate among infants whose mothers were employed outside the home as compared with infants whose mothers were employed at home or were not employed.

The infant mortality rates per 1,000 live births are:

Mother employed away from home	176.1
Mother employed at home	114.6
Mother not employed	98.0

Many studies of foreign investigators corroborate these findings. Occasional investigators both in this country and abroad have presented opposing results but these are generally explainable in terms of maternal health or the additional comforts or necessities attained when the mother works, or the inadequate numbers of cases in the sample. Pearson[68] and Elderton[26] set forth evidence on both sides of the question and conclude that parental health, particularly that of the mother, is more important than parental occupation or maternal employment.

Although much of the material is fragmentary and statistical safeguards and methods of analysis inadequate, the bulk of the evidence points toward the adequacy of maternal care as the most significant factor involved.

Evidence in regard to the growth of children in institutions as compared with children outside is confused by factors operating both prior to and during the period of institutional life. Such factors as race, nationality, and the economic and social status of the family unquestionably influence the development of the child both temporarily and permanently. The food and sanitary arrangements and the regularity of meals and the hours of rest in institutions are usually very different from, and often superior to, those in the homes from which the children come. Group care in itself, as contrasted with individual attention, unquestionably has its influence on the growth of the child. The studies in general show that in countries having low standards of living infant mortality is lower and the growth of the infant better in the institution than in the community, but that in countries such as the United States, which have a high standard of living, the institutional child tends to be inferior in physique to the child reared at home. On the other hand, child health activities, such as those conducted in cooperation with the

American Red Cross and the Commonwealth Fund and those conducted by states cooperating with the federal government under the Shepard-Towner Act, in fact every child health activity sufficiently well organized to present results, demonstrates better health and lower mortality among the infants whose mothers attend the clinics and receive instruction in infant feeding and care. These experiments place the responsibility for the education of the mothers upon the community, the state, and the nation.

Similarly, the studies of the growth of older children in institutions deal mainly with nutritional problems. In general, the findings indicate gain in height and weight and more rapid growth during the period of care. They also show that supplementary feeding of children in institutions results in more rapid gain. Studies of the effects of supplementary feeding upon ordinary school children similarly indicate the possibilities of gain. As a rule children both in and out of institutions receive diets either quantitatively or qualitatively inadequate. The evidence in favor of institutional life merely demonstrates the value of adequate diet during the years of growth and the importance of training mothers in this field. The results of the studies of institutional care demonstrate the great need for more adequate and more intelligent feeding of children and for the development and fostering of activities directed toward the education of mothers in methods of caring for their children.

The results of the comparison of the findings concerning the institutional versus the child reared at home can almost always be explained away in terms of nutrition or other differences characteristic of the groups. No studies have demonstrated that institutional life is preferable to life in an intelligent, well regulated home.

CONCLUSION

All of these factors, war, housing, race and nationality, child labor, social and economic class, and employment of mother and maternal care and general intelligence of the parents, have been shown by one investigator and another to be associated with growth and development of the child. Some have found negative results but the mass of the evidence is positive and leads to the conclusion that certain fundamental relationships exist.

Stating the exact nature of the relationship and the most profitable method of improving child health and development so far as these factors are concerned is, however, another matter. Few investigations have been sufficiently broad in scope and thoroughgoing in analysis to more than hint at the problem. We are far from any exact knowledge of the effect of many of the socio-economic factors on growth and development. Because the same causes are so frequently associated, it is impossible to judge the importance of any one factor, or to determine the relative influence of the combined elements which enter into the situation.

Hundreds of thousands of dollars are spent annually in this country and abroad for child health and protection. Much of it is well spent and the results of the expenditure indicate improvement, but who can say what is the best method of promoting health and who can designate the most fundamental approach?

In fields of investigation touching the pocketbook of industry, facts have been made available through collection of large bodies of data and through thoroughgoing analysis. Investigations, particularly those in England, made by the Eugenics Laboratories, have demonstrated that the methods of financial and economic statistics are applicable to general social and environmental questions. The next step in the program for human welfare should be thoroughgoing analyses of the factors underlying the growth and development of the child.

Because of the differences in ethnic stock and environment in the various parts of this country a series of studies rather than a single study would be advisable, each study to include a representative sample of the group under investigation and each planned to furnish material comparable with the other studies of the series. The schedules for the investigation should include inquiries regarding all pertinent social and economic aspects. This would mean a very large number of inquiries and a great deal of detail. Great care should be taken and a great deal of preliminary work would have to be done before the final schedule is adopted, for it is upon the clarity and comprehensiveness of the schedule, and the concepts involved and accuracy of entry that the statistical possibilities of the material and the value of the ultimate findings largely depend. Statistical analysis of such material as this, planned and executed in accordance with the latest biometric methods, would mean more exact knowledge of the character and relative importance of the factors influencing growth and development. Following such an investigation it would be possible to discuss growth in terms of the underlying causes and to plan intelligent programs for the physical well-being of the child.

In the attempt to ascertain the relative importance of the various social and economic factors which influence growth and development, statistical research is necessary. Research, however, without experimentation and testing of methods and a clear definition of factors to be studied has proven futile in practically every scientific field and it is of the greatest importance that investigation should be accompanied by social experimentation. This social experimentation should be planned on the basis of the approaches indicated by research. It must include careful and intensive studies of individuals extending over a period of years. Child health activities must both follow and point the way for increase in knowledge of the intricate factors involved in growth and development.

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IMMUNITY AND AGE

CONSIDERATION of infectious diseases during the period of growth and development reveals many variations in relation to age. These cannot be explained on purely anatomical or physiological grounds, and many do not fit in with the conventional ideas of immunology. The variations which are related to age may be grouped under three categories, variations in incidence, variations in manifestations or course, variations in allergic reactions. The purpose of this review is to consider the nature of these differences.

FIRST CONTACT WITH BACTERIA

Shortly after birth the intestinal tract acquires its bacterial flora. Ordinarily, no disease attends the first contact with these normal inhabitants of the intestinal tract. The relationship of colostrum to immunity in the early weeks of life has received considerable attention since the discovery that newborn calves deprived of colostrum develop a septicemia due to the colon bacillus, and that the pathogenesis of this disease is related to deficiency of serum globulin. The serum globulin content of the blood is very low at birth but rises rapidly in nursing calves.[1,2] Kuttner and Ratner[3] found colostrum to be of no importance in the transmission of diphtheria antitoxin in man. In explanation they refer to Grosser's studies on the variation in thickness of placental membranes in different species, and mention that in animals in which antibodies have been found in the fetal circulation, a thin layer of cells separates the maternal and fetal blood, while in those in which colostrum has been proved to be of importance in the transfer of immunity, a thick layer of cells occurs. However, the fact that infants have been observed with abnormally low serum globulin indicates that the relation between serum globulin content and resistance to infection in man deserves further study.

Kneeland[4] found that infants in a maternity hospital acquired much of the normal adult flora of the respiratory tract in the first two weeks of life. During this period there was a significant absence of pneumococci, hemolytic streptococci, and influenza bacillus. After discharge from the hospital the infants were followed from time to time, and by six to eight months they had acquired these organisms also. Infants four to six months old were studied during the first common cold, but in no case was a great predominance of any particular organism found. In other infants with a recurrent purulent nasal discharge, pneumococci and influenza bacilli were often seen as the predominating organism.

SUSCEPTIBILITY TO INFECTION

In many infections there is a definite relation between age and susceptibility to infection. In general, young animals are considered highly susceptible, but this is not invariably true. The term susceptibility is generally used to connote not merely the establishment of infection but also its course and outcome. These meanings may be roughly parallel, but they are not identical. There is little knowledge of the real incidence of infection. We may feel fairly confident in the case of measles or smallpox that infection and disease will follow the exposure of a susceptible individual, regardless of age, but in other cases, as in infection by pneumococcus, hemolytic streptococcus, meningococcus, and typhoid, the exposure of susceptible individuals is followed sometimes by clinical disease, sometimes by the carrier state, and sometimes by neither. There are at present few data on the proportional incidence of these three events. It is recognized that some viruses are capable of initiating infection without obvious predisposing cause, while others require some predisposing influence before infection can develop. As far as we know, the concurrence of two factors was first clearly demonstrated by Theobald Smith in his study of blackhead in turkeys. In this disease the principal lesions are caused by a protozoan which is of itself incapable of initiating infection with regularity. When turkeys are exposed to it and a second infectious agent, the embryos of a round worm of chickens, disease regularly follows.[5,6] A similar mechanism seems to obtain in the genesis of epidemics of hemolytic streptococcus pneumonia after measles. In other instances, in which the preliminary disease is less easy to diagnose than measles, the recognition of both predisposing and inciting agents may be extremely difficult. Although the extent and distribution of carriers in the population may be important, nevertheless clinical experience indicates the frequency of predisposing infection. At present there is no practical test for susceptibility to infection. The tuberculin test is an indication as to whether or not infection has occurred. The Schick and Dick tests show the presence or absence of immunity to the toxic phase of infection. They are by no means tests for susceptibility to tissue invasion.

Much remains to be learned about susceptibility to infection. One of the most promising methods of approach to this problem has been initiated by Topley, and consists in the study of experimental epidemics of natural diseases in small laboratory animals. Attention has been given to infections of the intestinal and respiratory tracts, in which the effect of crowding, previous infection, season, race, diet, and the bacteriophage have all been studied. The influence of age has not yet been considered. A review of this subject can be found in the book by Topley and Wilson.[7]

TISSUE INVASION

There are two recognized ways in which tissue is invaded by bacteria, one by direct extension of infection to adjacent tissues and one by invasion of and dissemination by the blood stream. Regarding the former, definite age variations exist, as is exemplified in tuberculous and streptococcal infections. There seems to be less resistance to direct spread of infection in early life. There appears also to be less resistance to blood stream invasion in the infant, but there are few statistical data available. Since much clinical significance attaches to cultivating pathogenic bacteria from the blood, it is remarkable to find so few data on the relation of bacteremia to age. However, the influenza bacillus was repeatedly sought in blood cultures from adults in the great influenza epidemic and was practically never found.[8, 9] In children, particularly in those under two years of age, both in meningitis [10] and in pneumonia [11] bacteremia is not infrequently found. Cole found pneumococcus in the blood of 30 per cent of his cases. No one, in any considerable series, has been able to corroborate Rosenow's findings of pneumococcemia in the active stage of almost all cases of pneumonia.

CAPACITY TO ELABORATE ANTIBODIES

In man, guinea pigs and rabbits the capacity for making antibodies and for becoming sensitized is low in infancy. The meager literature on this subject has been reviewed by Freund,[12] who confirmed this general idea. In addition, he found that young rabbits produced a precipitating serum of higher titer when immunized with a simple antigen (crystalline egg white), than when immunized with a complex antigen (horse serum), but did not develop the Arthus phenomenon in either case.

The most extensive studies on the relation of age and the development of antibodies are concerned with the development of hemagglutinins and with antitoxic immunity to diphtheria. The reader is referred to Mitchell [13] and Topley and Wilson [7] for reviews of these subjects.

No illuminating data have been found on the relation of cellular or local immunity to age.

AGE INCIDENCE OF INFECTIOUS DISEASES

The age incidence of an infectious disease should be an index of the susceptibility of the different age groups comprising the exposed population. If every individual were either susceptible or immune, and immunity were dependent upon a single factor, these two variables could adequately explain the incidence of the disease. In fact, this situation does seem to obtain in the case of measles, and age differences in measles are a matter of severity rather than of type of symptom. In many diseases, however, the various immunological reactions show disproportionate development, giving only partial immunity, and hence one finds clinical types of disease characteristic of certain ages. This is conspicuously true in the case of tuberculosis.

In seeking light on the processes by which immunity is developed and the stages through which these processes pass, we may hope for more assistance from a study of those diseases in which the full clinical picture is different at different ages than from those in which it is the same.

TABLE 1

COMMON INFECTIOUS DISEASES IN WHICH THE CLINICAL PICTURE AT VARIOUS AGES IS:

	Group 1 *Identical*	Group 2 *Different*	Group 3 *Unclassifiable*
Filterable viruses	Chickenpox German measles Measles Smallpox Poliomyelitis	Mumps	
Specific toxemia	Tetanus	Diphtheria Scarlet fever	
Invasive bacteria		Colon Bacillus infections Gonococcal infections Influenzal infections Meningococcal infections Pneumococcal infections Staphylococcal infections Streptococcal infections Syphilitic infections Tuberculous infections Typhoid infections	
Other bacteria	Whooping cough		
Etiology unknown	Encephalitis	Rheumatic fever	Common cold Epidemic influenza

Table 1 presents the common infectious diseases classified on this basis, but of necessity contains a third column for those diseases which cannot be thus differentiated.

This division of diseases brings into relief the thought that there are a group of immunological reactivities and that these develop somewhat independently and differently in different individuals. Depending upon the degree and combination of these reactivities, we may have after exposure either typical disease, no disease at all, or some special modification. This conception focuses our attention upon the ability of individuals and their various tissues to resist the establishment or spread of infection at a given age, or to withstand its effects rather than upon the mere number of cases occurring at that age.

The diseases which obviously belong in the first group of the table represent three types, those acute exanthemata probably caused by filterable viruses, certain bacterial diseases, and certain diseases of unknown etiology. Since such diseases present no age differences it will be necessary to pass to diseases of the second group. Among these, certain are chosen for discussion on account of their richness in age variation.

Tuberculosis

The course of tuberculosis at any age will depend in large measure upon the number and virulence of the invading organisms and their chance location within the body. After infection is acquired, the development of the disease may follow one of several courses, and the type of involvement which results has a direct relation to the age of the infected child. In early infancy there appears to be less resistance to the spread of the infection and therefore in many instances there is overwhelming of the body and death. At some period during this spread, the organisms usually reach the blood stream, either through the lymphatics or by direct ulceration into a vein, and a generalized tuberculosis results. This period of total lack of resistance persists for a varying amount of time, and is most marked during the first year of life, although a similar spreading may be noted later. In only a small percentage of infants infected during the first six months at least, does the disease become arrested and healed.

Infiltration of the Lung of Childhood Type. The childhood type of tuberculosis is characterized by a primary tuberculous focus beginning as tuberculous bronchopneumonia in any part of the lung and accompanied by caseous tuberculosis of the adjacent lymph nodes. The focus in the lung may heal with calcification of caseous material and encapsulation with fibrous tissue (calcified nodule) or less frequently progressive tuberculosis produces new areas of tuberculous pneumonia and tubercle formation. In roentgenographic chest films this primary lesion is seen as soft, ill-defined, occasionally flocculent opacity. Unfortunately small caseous lesions of the lung substance are not sufficiently opaque to cast a visible shadow on the film and are recorded only when they have undergone some calcification. These lesions persist as calcified scars of a first infection throughout life.

Tuberculosis of adjacent tracheobronchial lymph nodes is seldom recognizable unless the lesion has undergone some calcification, but this has occurred to a sufficient extent to cast some shadow in more than half of the children in whom this type of pulmonary infiltration is found. But calcified foci that cast a well defined shadow are not necessarily healed, since a tuberculous lesion may be calcified in one spot and progressive elsewhere. The affected nodes are in contact with the bronchi at the hilum of the lung, below the bifurcation of the trachea, best seen in oblique chest films, and on one or the other side of the trachea.

Observations made at autopsy have shown that lesions of the adjacent lung parenchyma accompany foci in the tracheobronchial lymph nodes but in chest films these are invisible because they are small or covered by an opaque organ. Nevertheless in one half of instances of recognizable tuberculosis of tracheobronchial lymph nodes a calcified focus or less frequently an infiltrating lesion of the lung is evident.

In a few instances caseous tuberculosis of tracheobronchial lymph nodes that have undergone no calcification is recognizable because the enlargement of the nodes is so great that their outline is clearly defined against the lung field at the hilum of the lungs or in contact with the mediastinum. These lesions may accompany evident infiltration of the lung and may be followed by general dissemination of the disease.

Dense opacity in the lung field occasionally seen in school children indicates that pneumonic consolidation has affected a fairly wide area of lung substance. McPhedran [14] has found that the consolidated lung may undergo resolution and gradually becoming less opaque may be reduced to strands and spots in part calcified. In young children the lesion usually appears to be progressive but in children over fourteen years or fifteen years of age its strand-like character, often with calcification, indicates that it is in process of healing or completely arrested.

In younger school children this lesion is often associated with symptoms such as cough or slight fever (99° to 100° F) and physical signs are revealed by râles or diminished resonance over the affected area. In such instances the disease has been regarded as clinically manifest.

Younger children with infiltrating tuberculous lesions of the lung reacted to .01 mg. of tuberculin and in most instances the reaction was intense (++ or +++ plus).

Infiltration of the Lung of Adult Type. The adult type of tuberculosis is characterized by a lesion that has its origin in the apex of the lung. It is the result of reinfection and is often accompanied by visible scars of a first infection. It does not cause tuberculosis of the adjacent lymph nodes. This type of tuberculosis seldom appears before the age of twelve and increases in frequency during adolescence. Its occurrence is determined by previous infection and not by age.

Apical lesions make their appearance as soft shadows or mottling below the border of the second rib. Wedges or salients projecting downward from below the rib are to be seen. The extent and density of the lesion vary widely. Obvious infiltration may occupy the entire apex above the clavicle or occasionally may extend below it.

Symptoms and physical signs of pulmonary tuberculosis may accompany the roentgenographic changes that have been described. There is cough in a few instanes. The temperature is seldom elevated. Râles are less frequently found with these lesions than with the childhood type of infiltration but diminished resonance over the affected apex and deficient expansion occur. These children react to 0.01 mg. of tuberculin and the reaction may be intense (++ or +++ plus). In a much greater number of children recognizable lesions of the apex were accompanied by no symptoms or physical signs but in some instances were no less advanced. The tuberculin reaction was as a rule less intense than with manifest tuberculosis.

These different types of response to tuberculous infection seem to be dependent on two distinct factors, tissue resistance and specific immune response. In the young infant, the tendency to rapid and unhindered spread of the infection may be attributed to the absence of an inherent cellular resistance to bacterial invasion, together with the lack of any specific cellular or humoral antibody immunity. After infancy, the body cells have apparently developed the ability to resist to a considerable extent the invasion of the tubercle bacillus. There are apparently tissue differences in the adequacy of this cellular defense, the regional lymph nodes being quickly involved but forming an excellent barrier to further spread, and the bone cells being poorly resistant. Specific antibodies only develop subsequent to infection. In spite of these defenses the normal mechanism may at times completely break down after recovery from first childhood infection. In experimental studies this event has been most clearly reproduced by excessive dosage. It is obvious that this important question of dosage is extremely difficult to measure in the natural disease either at the time of the initial infection or when the local spread or general dissemination of an old lesion occurs. Among other factors which are difficult to measure are the relative virulence of the bacilli and the embolic plugging of small arteries.

Syphilis

Syphilis occupies a unique position in childhood infections since it is the only infectious disease which occurs with any frequency in prenatal life. The characteristic differences between the congenital form and that acquired in later life are seen in the early stages of the infection, and may be attributed in large measure to their occurrence in an immature and rapidly developing organism. The high mortality from infantile and fetal syphilis is in marked contrast to the lack of mortality and the low degree of morbidity in the secondary stage of syphilis in the adult. These differences may in part be attributed to poorly developed immunological processes, and in part to the interference with the normal development of parenchyma.

Some of the late, or tertiary, lesions of syphilis are quite rare before puberty. Cardiovascular changes, so common in syphilitic adults, are almost unknown in childhood. Certain visceral changes, such as cirrhosis of the liver, are rare. Tabes and paresis occur as a result of the inherited infection but in the form typical for adults they are uncommon. Here again the differences may be explained on the basis of immunological development. The common occurrence of keratitis in childhood as compared with adults is more difficult to explain on this basis.

Infections by B. Diphtheriae

There are several rather important relations between diphtheria and age. The incidence of infection is in general dependent upon two factors, the antitoxic immunity of the individual, and the exposure to the virus.

Antitoxic immunity is related both to age and environment. At birth this immunity is relatively high and is due to antibodies transferred from the mother. This immunity quickly decreases, so that by the sixth month children are usually susceptible to diphtheria. Following infancy there is a continued gradual increase in antitoxic immunity, so that older children and adults are far less susceptible. The environmental factor is related to the chance of exposure to diphtheria and there is a tendency for the proportion of immune children to be considerably higher in congested districts in urban communities than in less thickly populated districts. Other factors beside age and environment are almost certainly concerned in the production of antitoxic immunity, but at present their nature is unsuspected. As an example of such unexplained presence of specific antibody may be quoted the report of Heinbecker and Irvine-Jones [15] who demonstrated diphtheria antitoxin in the blood of Eskimos on the southwest coast of Baffin Island, where clinical diphtheria is unknown.

The type of clinical disease is, in certain instances, definitely affected by the age of the patient. Wound infection of the umbilical stump is infrequent, and is limited to the newborn. In early infancy diphtheritic infection of the larynx is more common than the faucial type. The reason for this variation in site of infection is not certain.

The greater severity and the higher mortality of laryngeal diphtheria in infants and younger children is probably attributable in part to both anatomical and immunological considerations. The greater difficulty in establishing early diagnosis, with its consequent delay in administering antitoxin, is also a factor.

Infections by Streptococci

Infections by streptococci are probably more frequent than infections by any other single group of bacteria. Of the different types of streptococci those belonging to the hemolytic group are far more prevalent as producers of acute disease than those of the non-hemolytic group. Indeed, while non-hemolytic streptococci occasionally produce infections of the upper respiratory tract or elsewhere in children, they are so far outnumbered by infections with hemolytic streptococci as to be almost insignificant. It is possible that certain non-hemolytic streptococci produce types of chronic infection which are more difficult to identify, but at the present time no definite statement can be made on this point.

Although hemolytic streptococci may cause infection at times in almost any tissue of the body, in the majority of instances the primary focus is in the mucous membrane of the upper respiratory tract. In infants and children, this is extremely common and a large number of the acute infections of the nasopharynx in infants are due to this organism. During infancy there is a well marked lack of resistance to the direct extension of such infection, and acute otitis, mastoiditis and the like are far more frequent than in older children and adults. Such infections during infancy, also, are accompanied by severe general intoxication and many of them are fatal. It is thought that their greater severity in infancy is part of a general lack of ability to resist infection in early life. Scarlet fever is one type of acute streptococcus infection in which there are characteristic toxin symptoms. It is essentially a disease of children although it is not uncommon in early adult life. It occurs rarely during the first year, becomes more frequent up to the fifth to seventh years, and less frequent thereafter to puberty. The mortality from the disease is highest during the first year and falls rapidly during the next five, being relatively low in later childhood. These age relations apply only to scarlet fever accompanied by the characteristic skin rash. Colored children are apparently much less susceptible, even taking into account the greater difficulty in diagnosing mild cases. There are no available data to indicate the relative occurrence of *scarlatina sine exanthemata.*

Erysipelas, another condition resulting from infection with the hemolytic streptococci, may also occur at any age. The disease appears with greater frequency in earliest infancy than later. In the majority of these early cases the process starts at the umbilical wound, is associated with maternal puerperal infection, and is usually fatal. Here again it seems probable that the severity of the infection is related to the general lack of resistance to bacterial infection and the relative inability to produce immune substances at this early age.

Certain features in the preceding sections which illustrate striking differences in infection at different ages may be summarized as follows:

In tuberculosis an apparent lack of tissue resistance in early infancy allows a spreading infection; a later acquisition of tissue resistance limits infection in older children; following a first infection the development of specific cellular immunity tends to localize a later reinfection.

In syphilis an infection of growing tissues in an immature individual produces changes which could not occur in adult life.

In diphtheria there is a severe specific toxemia in which the morbidity and mortality are greatest in early childhood primarily because of a lack of specific humoral antibodies at this period of life.

In streptococcus infection there is invasion of tissue. In scarlet fever there is also a specific toxemia accompanied by a variety of characteristic sequelae.

The curve of incidence of some diseases, such as erysipelas and pneumonia, exhibits a rise in infancy, a decline in adolescence and a rise again during adult life. In contrast to this the curve of others, such as diphtheria, shows almost its entire rise and fall in childhood, and the common cold continues to be of frequent occurrence throughout life. Whether these indicate the presence of special antigens in the infecting parasites, or whether they reflect the presence of peculiar immunological responses is not known, but the construction of a scheme of comparative immunology might throw light on this subject. There are insufficient data to do this at the present time.

Allergy

Two main groups of allergic conditions are recognized, those artificially produced in laboratory animals, and the natural, often familial idiocyncrasies of man. The classification of these main types of hypersensitiveness in man and animals is not clear cut. Some features of each point to marked similarities while others point to differences. It seems likely, however, that the same mechanism is involved in both. Certain conditions such as serum sickness in man present analogies to each group but cannot be satisfactorily classified in either. Similarly the hypersensitivity of infection, as exemplified by tuberculin reactivity, while belonging in the general category of allergic conditions presents unique features found in neither of the two main groups.

The development of allergic states shows variations dependent on age and species.

Individual and Species Variations. Although there are indications that very young guinea pigs and rabbits are not readily sensitizable, guinea pigs can be sensitized in utero, and in some case, according to Ratner and others [16] this is an active sensitization, since the sensitive state may pass to yet another generation.

Different species of animals vary in the ease with which sensitization can be accomplished and also in the type of anaphylactic response. The ease with which sensitization can be accomplished has been studied by Opie [17] by means of the Arthus phenomena in rabbits, goats, dogs, cats and rats. He found them sensitizable in the order named. This was also the order in which the animals developed precipitins. The rats were not sensitizable and developed precipitin only irregularly.

Anaphylactic response in guinea pigs is characterized by pulmonary emphysema, in rabbits by dilatation of the right heart and obstruction of the pulmonary circulation, while in dogs it is characterized by engorgement of the liver and lesions in the gut. The different pictures are in relation to the respective distribution of smooth muscle, which in guinea pigs is outstandingly in the bronchial wall, in rabbits in the pulmonary vessels, and in dogs in the hepatic vessels. Other species have been studied to see if anaphylactic shock could be produced. Anaphylactic shock, or the equivalent of it, has been reported in horses, goats, birds, mice and frogs. Longcope [18] and Spain and Grove [19] could not produce it in rats. In monkeys Zinsser [20] could not produce anaphylactic shock, although a few animals developed a syndrome like serum sickness.

One of the chief difficulties in believing in the similarity between experimental sensitization in animals and the natural idiocyncrasies in man to non-antigenic substances like aspirin, luminol and the like has been removed by the demonstration by Tomcsik and Kurotchin,[21] Lancefield,[22] and Avery and Tillet [23] that animals, passively sensitized, can be shocked by purified bacterial polysaccharides. These substances are not antigenic when purified but only antigenic when part of the bacterial cell.

The possibility of obtaining this insight into the chemistry of immune reactions has arisen from the work of Zinsser and Parker,[24] Heidleberger and Avery,[25, 26] Avery and Morgan,[27] and Avery and Neill [28] on the relation of the chemistry and immunology of pneumococcus. The future and wider application of this important work at present represents the field of greatest promise in immunology. If the promise of these advances is fulfilled it is easy to imagine that the immunological principles underlying the experimentallly produced and naturally acquired allergic states of man, may ultimately be proved identical. But in the absence of this proof the marked quantitative and qualitative clinical variations of the latter states, unquestionably favor the thesis of those who maintain that these states are the manifestations of a unique property (Coca and Cooke [29]).

Age and Allergic Disease. The life of individuals who suffer from the common allergic conditions, such as asthma and hay fever, is naturally divided into three periods, (1) birth to onset of symptoms, (2) period of disease, (3) stage of natural recovery.

The usual duration of the first period has been found by Cooke and Vander Veer [30] to be one to five years in cases with a bilateral family history, ten to fifteen years in the presence of a unilateral history and twenty to twenty-five years in absence of family history. That sensitization can be accomplished in early infancy has been shown by Schloss [31] and Ratner.[16] In the light of their finding the individuality of allergic disease is remarkable.

There are no satisfactory data on the predisposing influence to allergic disease of peculiarities of infant feeding or the infectious diseases of infancy.

The incidence of sensitivity to foods and inhalents in asthmatic children has been studied by Stuart and Farnham.[32] Food sensitivity was most common before the third year, while inhalants were in great predominance in later childhood.

Without definite information about the relation of allergic disease to age we can only make the general statement that eczema is relatively frequent in early life, whereas the other common allergic manifestations are much more frequent after infancy. It is also evident that allergic individuals, as they grow older, tend to recover spontaneously. But we are ignorant of the mechanism by which these changes take place.

Serum Sickness and Age. No significant differences in the incidence of serum sickness in a large series analyzed according to age were found by Coca.[33] This is in accord with the experience of other observers, although it is usually believed that serum sickness is less severe in early infancy. The type of serum used is known to influence the severity of the serum sickness. By type is meant its age, concentration and the like as well as the disease for which it is antitoxic.

Age and Tuberculin and Similar Tests. In laboratory animals a positive tuberculin test can be elicited two weeks after infection. In tuberculous guinea pigs, infected shortly after birth, Freund[34] observed that occasionally relatively weak cutaneous tuberculin test could be obtained at three weeks of age. These animals could readily be killed with intraperitoneal injections of tuberculin. In man one knows that positive tuberculin tests can be obtained in infants under three months of age.

Recently skin tests with material from streptococci have been carried out in extenso. These tests, as well as the typhoidin test of Gay and similar tests, are presumably analogous to the tuberculin test. At present the test materials are not sufficiently standardized or controlled to permit interpretation of the results. But it is safe to say that with increasing age there is more and more tendency to give cutaneous reactions to heat stable substances from the bacteria in question.

Tuberculin Hypersusceptibility in Different Species. We have found no systematic study of tuberculin hypersusceptibility in different species. Practical experience indicates that skin reactivity to tuberculin develops with great regularity in tuberculous men, guinea pigs and cattle. Tuberculous rabbits give this reaction with much less regularity,[35] an interesting comparison in view of the fact that rabbits are the most satisfactory laboratory animals for showing the cutaneous Arthus phenomenon.[17]

Racial Variations in Allergic Disease and Serum Sickness. By means of circular letters to physicians, Coca and others [36] found that asthma and hay fever are extremely uncommon in full-blooded North American Indians. He and his co-workers attempted to determine the capacity of the Indians to develop serum sickness following the intravenous injection of 25 to 110 cc. of normal horse serum. The Indians developed much less serum sickness than Mackenzie and Cole observed in pneumonia patients treated with antipneumococcus horse serum in the Presbyterian and Rockefeller Hospitals of New York City. This evidence is merely suggestive on account of the fact that different types of horse serum were used in the two groups.

There seems to be a natural willingness to accept the general idea that variations in immunological capabilities are inherited. Studies of Hirszfeld and colleagues [37] suggest these hereditary factors are linked with the blood groupings. For contradictory reports see Levine [38] and also Rosling.[39]

SUMMARY

Variations in infections and allergic disease have been discussed to call attention to the immunological potentialities that many may possess at different periods of life. Concerning the development of these potentialities some investigators have stressed hereditary factors while others have stressed immunological experiences or even environmental factors. Excellent discussions of these points of view appear in Vol. II, Topley and Wilson,[7] from which we quote the following:

> Hirszfeld and his colleagues have done good service in emphasizing the possible importance of genetic and evolutionary factors in determining both the antibody content of the blood of various animal species, or individuals and the capacity of those species, or individuals to respond to the immunological stimuli they receive from without. We should, however, regard the character and frequency of such stimuli as playing an important, probably the predominating part in

the distribution of resistance among the members of any one species, at any particular period of time.

This expresses ideas which find similarities in the well known thesis that the clinical features of disease are the resultant of a reaction between host and parasite, and that some diseases require a certain amount of immunity before a host can develop them.

It is obvious that a wide view of infectious disease cannot be obtained by limiting oneself to pediatric practice or to practice among a particular group of adults. Indeed, it is unfortunate that the exigencies of medical education limit our experience to infectious disease in one species. The mechanism of infectious disease is poorly understood. The diseases seen by physicians are natural phenomena, only elements of which are reproducible by artificial infection. It is the task of physicians to use immunological techniques to recognize, analyze and synthesize these elements. For this purpose the use of comparative methods of study is suggested by the age variations seen in the infectious diseases of man.

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DISEASE IN RELATION TO GROWTH AND DEVELOPMENT

IT is our purpose to consider here the extent to which disease interferes with normal growth and development. No attempt will be made to consider each individual disease, but certain examples will be briefly presented to indicate the types of effect encountered.

It has been seen that there is considerable individual variation in the rate and regularity of growth. Certain phases in the growth cycle are common to all children, but the individual spurts vary greatly in their time of occurrence and duration. The causes and significance of these differences are little understood. There are obviously inherited differences in individual patterns, but external factors undoubtedly play their part. We may consider that growth and development are the result of hereditary factors working themselves out in favorable or hostile environments. It is hard to estimate the relative importance of these factors in the individual case, but more light could be thrown upon them by intensive study of individuals over the entire period of growth and development. Our object should be to allow growth to take place according to its inherent potentialities, to provide the nutritive elements and the environment most suitable for this progress, and to remove all influences which are known to interfere. There is ample evidence that the number of the handicapped may be tremendously lessened by the application of all of our present knowledge and that further study should greatly add to these possibilities. Disease may affect the glands of internal secretion directly and stunt the individual in mind and body by destroying his thyroid, may make a giant of him by increasing his pituitary secretion, may deform him by disordered function of his adrenal cortex or gonads. Allowing for a wide range of variability in their function, we can say that actual disease of these organs represents a very small part of disease in general. But it is probable that most disease processes occurring during the period of growth modify its course in one way or another.

As almost every individual suffers from one or more diseases during the growth cycle, it might at first appear that no one perfectly consummates his original possibilities of growth. As we do not know the possibilities in any given case, we cannot determine whether or not this is universally true, but we do know that the effects of disease are not necessarily permanent. We know that an acceleration in growth beyond the normal rate usually takes place following a period of retardation. This is a general physiological adaptation, probably always operative to some degree and reasonably successful in most instances. After some diseases the acceleration in certain growth factors often much more than compensates for the earlier retardation, and there is a resulting period in which development is advanced beyond the normal level. This has been shown by Todd to occur in epiphysial maturation following measles. Those who reach maturity with no scars of defects and with growth unmodified in any particular by past diseases are most fortunate.

TUBERCULOSIS

Tuberculosis of children may remain concealed for a considerable period before it manifests itself by such conspicuous symptoms that it attracts the attention of parents or teachers or is evident to physicians and nurses concerned with medical inspection of school children. Indeed it is now well recognized that advanced lesions, evident by roentgenographic methods, are often unaccompanied by physical signs. In the absence of significant symptoms and physical signs, tuberculous infection can be recognized by the tuberculin test and roentgenographic examination. The latter determines within certain limitations the position, character, and extent of lesions of the lung, and hence is a measure of the severity, as well as of the presence, of infection.

It is not possible to give figures that show the frequency of tuberculous infection in different parts of this country. Systematic surveys by accurate and comparable methods have not been made. The frequency of tuberculous infection increases from birth until adult life in children who give no history of contact with tuberculosis, but the incidence is much higher in children who are known to have been in contact with open tuberculosis. Over 90 per cent of children in large cities are infected before they reach adult life. In rural districts the frequency of infection is much less.

Tuberculosis and Malnutrition

Loss of weight has been so long recognized as a characteristic symptom of tuberculosis that it has determined the nomenclature of the disease (consumption, phthisis and so forth). The further inference that loss of weight is almost constantly associated with tuberculous infections has been widely accepted. Malnutrition is often regarded as presumptive evidence of tuberculosis and has been widely used to select children believed to be suitable for care in preventoria, open-air schools, and summer camps maintained to combat tuberculosis.

The evidence that is now available indicates that minor tuberculous infections produce no loss of weight. The attempt will be made to define the conditions under which malnutrition following tuberculous infection makes its appearance, and to determine in what degree the widespread infection of children impairs normal development. Information on this subject is conspicuously defective. What is available has been obtained by the examination of school children, since examination of children attending dispensaries or under treatment in hospitals gives no trustworthy information concerning the general population.

The effect of tuberculous infection on body weight of school children has been studied by Hetherington.[1] The weight of children was compared with the normal weight for varying height at different ages, as determined by the tables of Baldwin and Wood.[2] Intracutaneous tests were made with 0.01, 0.1 and 1.0 mg. of old tuberculin.

	Number	Normal or overweight, *per cent*	Under-weight, *per cent*
Children who reacted to tuberculin..	1.443	63.8	36.2
Children who did not react.........	556	62.6	37.4

It is noteworthy that the frequency of underweight is practically the same in children with tuberculous infection and in those with none. In children below eight years of age the number with underweight equal to 10 per cent of normal is relatively small, but in the next year it reaches 12 per cent and subsequently remains at approximately this figure. The number of children who react to tuberculin, on the contrary, increases continuously until adult life.

Children with tuberculosis of tracheobronchial lymph nodes recorded in roentgenograms have, as a group, insignificant reduction of weight. Of 219 children who were normal or overweight, 8.2 per cent had lesions of tracheobronchial lymph nodes, whereas of 192 children who were underweight 12 per cent had similar lesions. Of 41 children with tuberculosis of tracheobronchial lymph nodes, 18 were normal or overweight, 12 were within 5 per cent less than normal, 7 were within 10 per cent, and 2 more than 10 per cent below normal. It is evident that underweight cannot be used for the recognition of tuberculosis of tracheobronchial lymph nodes. When advanced malnutrition is associated with this lesion it is probably due to other causes.

Recognizable infiltration of the lung of childhood type does not produce noteworthy loss of weight in children well enough to attend school, even though there are associated symptoms or physical signs, necessarily of mild character.[3]

Of 10 school children with clinically manifest tuberculosis accompanying infiltration of childhood type, 5 were normal or overweight and 5 were underweight, only one being less than 10 per cent below normal.

Of 12 children with latent tuberculous infiltration of childhood type that had not healed, 10 were normal or overweight and 8 were underweight, 3 being 10 per cent below normal. Of 24 children in whom similar lesions were in process of healing, the number of children with underweight was somewhat greater, namely 14, doubtless due to their greater age.

Pulmonary tuberculosis of adult type occurring in adolescent children may cause noteworthy loss of weight, although with the lesion many children remain well nourished. Of 11 school children with pulmonary tuberculosis of this type, one was normal in weight and 10 were underweight, 4 being more than 10 per cent below normal.

Of 20 school children with latent apical lesions (adult type) 7 were slightly overweight and 13 underweight, 7 being more than 10 per cent underweight.

Tuberculosis of adult type making its appearance in adolescence produces greater disturbance of health and nutrition than tuberculosis of early childhood, and in most instances has graver prognosis.

Knowledge concerning the metabolism in tuberculosis has been reviewed by Wells [4] and some of his conclusions will be briefly stated:

> We have little accurate knowledge concerning changes in metabolism produced by uncomplicated tuberculosis, because few observations have been made on patients who did not suffer from some disturbing factor such as mixed infection. Basal metabolism in tuberculosis without fever closely approximates the normal. Severe pulmonary tuberculosis usually causes an increase of 20 to 40 per cent in the metabolism, calculated from the body surface; with high fever the increase may be 50 to 75 per cent. Since the respiratory quotient in tuberculosis is usually unaltered, there is no noteworthy change in the proportion of protein and non-protein combustion. Reduction in lung volume decreases vital capacity, but does not produce recognizable interference with oxidation save perhaps in the terminal stage of the disease. Although there is some evidence of decreased gastric motility and secretion and diminished pancreatic activity, digestion and assimilation are unimpaired unless there are definite intestinal lesions. It seems probable that in tuberculosis as in other febrile diseases destruction of tissue protein is due to toxic influences and not to elevation of temperature. Fever itself is chiefly at the expense of non-protein elements, notably carbohydrates, provided these are furnished in suf-

ficient amounts to protect the protein. Evidence of the toxicogenic destruction of tissue protein in tuberculosis is the increased urinary excretion of purin nitrogen, creatinine, organic phosphorus, and neutral sulphur and the increased ratio of potassium to sodium.

Conclusions and Recommendations

Children with grave latent tuberculosis should receive prophylactic care to prevent further progress of the lesion. Children with clinically manifest tuberculosis should receive sanatorium treatment or its equivalent. Advanced tuberculous infection among school children is one of the gravest problems of school hygiene and suggests a promising and untried attack on tuberculosis, since the lesions that are most frequently followed by fatal disease occur in adolescent children and are the precursors of much of the tuberculosis of early adult life.

The discovery of school children with advanced tuberculous infection requires a staff adequately trained in the use of technical procedures applicable to its detection. A simple procedure such as the tuberculin test is laborious, subject to many errors, and in the absence of essential precautions may give misleading information. Roentgenographic examination applied to the recognition of latent or clinically manifest lesions in children well enough to attend school requires procedures specially adapted to the examination of the chest. Routine methods are insufficient and repeated examinations are occasionally necessary. Stereoscopic films are essential and their interpretation requires intimate knowledge of the pathogenesis and clinical course of tuberculosis.

In the search for tuberculous infection in school children preference may be given to those known to be exposed to open tuberculosis. Tuberculin tests and roentgenological examination of those who react will reveal grave tuberculous infection in a large part of the children who have lived in contact with the disease. Effective tuberculosis registration will aid the discovery of children exposed to it. If tuberculin test and roentgenological examination are widely applied to school children, preference may be given to certain groups, such as adolescent girls or colored children, in whom the disease is unusually common.

CONGENITAL SYPHILIS

The effects of syphilis upon the fetus may be summarized as those which cause miscarriage or stillbirth, and those which lead to premature birth and inadequate development at birth. While a high mortality rate continues to be an important problem with syphilitic infants after birth, in groups of infants who have received adequate treatment the rate has now been reduced to 25 per cent or less.

An important danger awaiting the syphilitic child is the development of neurosyphilis. This may lead to mental deficiency or paralyses which frequently render the child totally unfit as a useful social unit. A large proportion of the difficulties caused by neurosyphilis could be prevented if proper measures for its recognition and treatment were undertaken early. Clinical experience indicates that all cases of neurosyphilis show changes in the cerebrospinal fluid characteristic of this infection very early in the course of the disease; and that if the cerebrospinal fluid of a syphilitic child is found negative, it will not in the future become positive, nor will neurosyphilis develop. If the cerebrospinal fluid of a group of syphilitic infants aged more than two or three months is examined, evidence of the presence of syphilis will be found in approximately 40 per cent; in three-fourths of them symptoms are not manifest. By proper and sufficient treatment it is possible to prevent the occurrence of cerebrospinal syphilis.

Permanent damage to the special senses as a result of syphilis is relatively infrequent. Involvement of the eye frequently occurs. The chief lesion is a keratitis which, in most instances and with proper treatment, may heal without permanent damage to the eye. Deafness, as a result of modern methods of treatment, is not so common as it was in Hutchinson's time. It is usually a late manifestation of syphilis and therefore is easily prevented by early recognition and treatment, but once it has occurred it does not respond readily to therapy.

A certain amount of evidence exists as to the effect of syphilis upon the body weight, but little if any has been obtained concerning its effect upon the body length or skeletal growth. However, an impression, gained from clinical experience after examining large numbers of syphilitic children, is that body length is rarely, if ever, affected.

It is generally accepted that syphilis, like other infections, affects body weight. In order to gather more evidence on this point, the weights before and after treatment have been tabulated for groups of syphilitic infants and children in St. Louis, Missouri, and Iowa City, Iowa. The results are summarized in Tables 1 and 2. As in other groups studied, approximately 70 per cent of the infants weighed less than accepted standards when they came under care. At the conclusion of treatment, while the group as a whole approximated more nearly the accepted standards, there were many who remained underweight. The degree of underweight, however, was not so extreme as it was at the beginning of treatment. The effect of active antisyphilitic therapy may at first be loss of weight, but when the infection is under control and the treatment stopped, the syphilitic baby should be expected to gain like any other infant. Quinn has tabulated the weights of 228 newborn well babies of well mothers and of 115 newborn babies of mothers with a strongly positive Wassermann reaction. The babies of syphilitic mothers averaged 260 gm. less in birth weight than the babies of nonsyphilitic mothers. The usual loss in weight following birth occurred in both groups and was approximately the same in both groups until the fifth day, when the loss amounted to about 3 per cent of the original weight. By the tenth day the well babies had more than regained their birth weight, while in the babies of syphilitic mothers the loss had progressed to 7 per cent. The effect of syphilis upon the nutritional status of older children is not so marked. The group of older children studied averaged 3.6 per cent underweight at the beginning of treatment, and 3 per cent overweight after treatment. Although the degree of overweight and underweight varies according to the standard accepted as average weight, the relative standing of the groups before

TABLE 1

WEIGHT OF SYPHILITIC CHILDREN UNDER ONE YEAR OF AGE AT THE FIRST OBSERVATION

	Before treatment	After treatment
Number studied	56	56
Number underweight	39	38
Per cent of total number underweight	69	67
Per cent underweight of those underweight	25.5	16.8
Number neither under nor overweight	11	14
Number overweight	6	4
Per cent overweight of those overweight	20	15
Number showing relative decrease in weight of more than 5 per cent	....	21
Number showing relative increase in weight of more than 5 per cent	....	28
Number more than 15 per cent underweight	27	24
Number underweight who improve to normal	....	10
Per cent underweight of entire group	15.4	10.2

TABLE 2

WEIGHT OF SYPHILITIC CHILDREN THREE YEARS OF AGE AND OVER AT THE FIRST OBSERVATION

	Before treatment	After treatment
Number studied	73	73
Number underweight	36	20
Per cent of total number underweight	49.3	27.4
Per cent underweight of those underweight	12.3	10.5
Number neither under nor overweight	15	21
Number overweight	22	32
Per cent overweight of those overweight	12.2	15.1
Number showing relative decrease in weight of more than 5 per cent	....	8
Number showing relative increase in weight of more than 5 per cent	....	31
Number more than 15 per cent underweight	10	5
Number underweight who improve to normal	....	17
Per cent under or overweight of entire group	3.6	3.0

and after treatment is apparent from the figures cited. The fact that the older syphilitic children are found to be more nearly of normal weight suggests that those syphilitic infants who survive finally grow to average size.

The tabulations presented represent data for white infants and children exclusively. It is known that in many respects syphilis does not affect the Negro as severely as it does the white child. Clinical neurosyphilis, for example, occurs ten times as often in the older white syphilitic child as in the older Negro syphilitic child.[5] An impression based upon such knowledge and upon clinical experience is that the effects of syphilis upon the nutritional status of the Negro child would be no greater, and probably would be less, than the effects stated here for the white child.

The effects of syphilis are the same at all socio-economic levels. The frequency of the infection varies widely at the different levels; the incidence is largest at the lowest levels; at the highest, it is negligible.

In order to prevent the various difficulties which may arise as a result of syphilis, early recognition of the infection is essential. It is fully as important to recognize the latent case as the one which is manifest. The only certain means of recognizing many active cases and all latent ones is the Wassermann reaction or some other equally reliable serological test. Certain facts concerning the reliability of the Wassermann reaction need emphasis. Occasionally a non-syphilitic infant has a positive Wassermann reaction at birth, which always becomes negative within a few weeks. The reaction represents the passive transfer of Wassermann bodies from a syphilitic mother. Approximately 40 per cent of syphilitic infants have a negative Wassermann reaction at birth. By two months of age, or at least before the fourth month, all syphilitic infants should be expected to have a positive Wassermann reaction. A negative reaction after two or three months of age constitutes good evidence that the infant is not syphilitic. After two months of age, and for a number of years, the Wassermann reaction of syphilitic children is strongly positive. Occasionally in adolescence or later the reaction will disappear, though rarely in the presence of any active manifestation. Clinical manifestations of syphilis in the young child are always accompanied by a positive Wassermann reaction.

The most effective means of preventing the transmission of syphilis to the second generation is the treatment of the mother before or during pregnancy. In a high proportion of instances proper treatment of the mother will result in the birth of a non-syphilitic child. Often treatment is necessary only during the last few months of pregnancy. Treatment during one pregnancy will not protect the child of a subsequent pregnancy unless the treatment of the mother is continued until the disease is arrested.

RICKETS

Rickets occurs with greatest intensity in temperate zones, and is mild or absent in the tropics. There is a marked seasonal factor, as shown by an increased incidence in the autumn which becomes more marked in winter and reaches a peak in March; from March on the incidence decreases and new cases rarely develop after June. The disorder, although not absent in rural districts, is found largely in cities and large industrial centers, and affects Italian and Negro babies most profoundly. Children between six and eighteen months of age are most often afflicted. Rickets may occur earlier, but rarely with clinical manifestations. The premature infant is notably predisposed to rickets, perhaps because of the exceptionally rapid rate of growth in comparison with the average infant. There is a late form of rickets, called *rachitis tarda,* which occurs about the time of puberty. It is very rare except under conditions of such extreme privation as occurred during the World War.

In the absence of preventive measures, about two-thirds of bottle-fed babies and one-third of breast-fed babies show signs of rickets. It is characterized by a faulty nutrition rather than an undernutrition, as is demonstrated by the fact that it occurs commonly in overnourished infants. The more rapid the growth, the greater the tendency to develop the disease.

Etiology

Although the incidence of rickets is in large measure dependent upon the presence or absence of an adequate amount of vitamin D in the diet, the primary factor determining this requirement is related to hygiene. Although fresh air, exercise, cleanliness, and so forth should be considered, the most important single factor has been proved to be sunlight. The protective influence is ultraviolet radiation. The ultraviolet rays have very slight power of penetration, and are absolutely filtered out by ordinary window glass, so that a baby can receive none of their protective properties if he is kept in a room with the windows closed, notwithstanding the fact that he may be in a flood of sunlight. The effect of the sun's rays is probably due to an activation of the ergosterol in the superficial layers of the skin. The chemical basis for this conclusion is presented in *Nutrition.**

The most important advance in our knowledge of the metabolism in rickets is a realization of the importance of phosphorus. It has been found that the most characteristic chemical alteration of the blood is a reduction in the percentage of inorganic phosphorus. The normal amount of this substance in the blood in infancy is about 4.0 to 4.5 mg. per 100 cc. of plasma. In the active stage of rickets the percentage falls to 3.5 or 3.0 mg., or even lower in the severe forms. This observation is in harmony with that of Hess and Lundagen,[6] that there is a seasonal variation in the content of inorganic phosphate in the blood of infants, an ebb in the winter and early spring, and a flood in the summer. This variation runs parallel with the seasonal curve of the incidence of rickets. The calcium content of the blood in this disease is normal, or but slightly diminished. Up to the time of this discovery attention had been focused solely upon calcium. In the bones the ratio of calcium to phosphorus is normal, even in severe cases of rickets, in spite of a diminution in the total amount of ash. The chemical nature of the dietary defects which lead to these changes in the blood and bones is as yet not well understood. Evidently it is not a simple deficiency of calcium or phosphorus, for if it were the disease would occur more often in children living on human milk than in those receiving cow's milk. In addition to the changes in content of calcium and phosphorus, the blood often shows a moderate secondary anemia with some reduction of hemoglobin percentage and number of red cells.

* "Vitamin D." *Growth and Development of the Child,* Part III.

Effects on Growth and Development

The effects of rickets are manifested in most of the tissues of the body, but abnormal growth is produced primarily through its effects upon the bones and muscles. Lesions which may result in permanent handicap are chiefly associated with the pelvis, extremities, spine, thorax, and feet, and are due primarily to softening caused by inadequate deposition of calcium. This softening interferes with the normal function of support, and a compensating hyperplasia of abnormal tissue takes place in the regions of bony growth. The characteristic resulting changes are enlargement of the epiphyses, angulation of the long, weight-bearing bones, compression changes in the skull with resultant enlargement, and contraction deformities of the chest. These changes are progressive only during the activity of the disease, but may produce permanent deformity.

Deformities

Pelvis. Deformities of the pelvis are of prime importance in women because of their interference with the normal progress of labor. The pelvic growth is affected in various ways. First, an interference with the general growth makes the pelvis small and therefore leads to generally small outlets. Second, a disproportionate pelvic growth may occur, commonly resulting in a decrease in the anteroposterior diameter of the pelvic cavity. Third, pressure deformities may result from weight-bearing during the active stage of the disease or from the pull of various ligaments. Fourth, cartilaginous enlargements comparable to those occurring in the epiphyses of the long bones may result in deformities, especially in the regions of the iliac crests, symphysis pubis, and acetabula, all causing encroachment upon the pelvic canal. The most typical picture is that of rachitic flat pelvis, in which the entrance is narrowed both by short ilia and by projecting sacrum and sometimes the outlet is also narrowed by a forward drawn sacrum. This deformity is one of the common causes of resort to cesarean section. Such deformities in this country are much more frequent among Negro than white women; rachitic pelvis occurred in 0.64 per cent of white and 11.03 per cent of Negro women in Williams' series.

Extremities. Enlargement of the epiphyses of the long bones with softening, and hence bowing, bending or breaking of their shafts, accounts for the typical deformities of the extremities. Fractures of the long bones are not infrequent, and may be overlooked until demonstrated by the roentgenogram. These changes are not often apparent until the second year of life. A great variety of individual and combined deformities may occur, but the chief pictures of common occurrence which may become permanent are enlargement of the wrist, knock-knee, and bowleg. These deformities must, however, be extreme or the causative deficiency operative over a long period to persist as permanent characteristics, for there is a strong tendency toward the correction of such abnormal developments during the period of growth. Rickets may undoubtedly contribute to the development of flat-foot, but that it is a chief cause of this condition has not been established.

Spine. Spinal curvature may constitute important residual deformity. Even in mild cases of rickets the vertebral column may be found to bow unduly when the infant sits, due chiefly to the laxity of the supporting ligaments. In severe cases kyphosis, usually in the thoracic region, results from pressure of body weight on soft vertebrae. Scoliosis may develop, but this is more commonly found later in childhood, associated with juvenile rickets. The term *rachitic posture* is used to describe the combination of exaggerated lordosis, pot-belly, and flat-foot often found in severe cases.

The changes which take place in the lower extremities and spine are largely responsible for the interference with growth in height. The bending of the extremities, coxa vara, bowing of the spine, and flat-foot may together induce a condition of false dwarfism. It is possible that in severe rickets there is also some impairment of the growth impulse, but this is at least not an important factor in limiting height.

Thorax. The thorax is almost always involved in rickets. There is enlargement of the costochondral junctions of the ribs, chiefly apparent in the fifth to the eighth inclusive. The softness resulting in the line of diaphragmatic attachment at times allows the formation of a transverse depression commonly known as Harrison's groove. This is often accentuated by the flaring of the lower costal margins produced by abdominal wall relaxation and abdominal distention. The groove often persists into adult life and, when extreme, may interfere with the normal function of the lungs and other intrathoracic organs. Other deformities associated with that of the thorax, but of less clinical significance, are those of the shoulder girdle.

Tooth Structure. Rickets occasions a delay in dentition, but a more important effect is the change which it occasions in tooth structure. This change results in hypoplasia and caries, and is most significant in those permanent teeth in which the enamel is laid down and calcification takes place during the period of active disease. In the temporary teeth these processes are usually complete at or soon after birth, so that rickets rarely causes important changes in them. The permanent lateral incisors, the tips of the canines, and the crowns of the first molars are being laid down during the first two years of life, and it is therefore these teeth which are most commonly inadequately developed and subject to decay. It should be pointed out, however, that rickets is not the sole, or even the most common, cause of dental hypoplasia and caries. Other dietary factors as well as disease factors are operative in both the prenatal and the postnatal periods. These considerations are discussed more fully in *Anatomy and Physiology.**

Prevention and Treatment

When it was discovered that cod liver oil had antirachitic properties it was thought that the prevention and treatment of rickets would be simple. Although under reasonably adequate hygienic conditions rickets can be prevented through the administration of cod liver oil, it is now evident that

* "Development of the Face and the Dentition." *Growth and Development of the Child,* Part II.

the problem is far more complex. Cod liver oil alone will not completely and under all circumstances prevent or cure the disease. The newer knowledge regarding the relationship between sunlight and vitamin D, and their combined relation to rickets, is discussed in *Nutrition.** The experience of the next few years will no doubt furnish valuable information as to the measures best adapted to practical use in the prevention and treatment of rickets.

SCURVY

The effects of scurvy upon growth are largely quantitative, in contrast to the qualitative changes produced by rickets. During the activity of the disease the whole growth process is apparently inhibited, or at least retarded, so that the child will fail to grow normally in height, weight, and other body measurements. By the time the usual clinical manifestations have become apparent this retardation in growth is well marked. Although great improvement is usually manifest four or five days after instituting treatment for scurvy, in an occasional case of long standing a prolonged period of treatment may be required. During the period of healing there is usually accelerated growth, which may, and probably usually does, compensate for the previous delay. In some instances the disease may be present in a mild chronic form for a long period of time, and the resulting limitation of growth may be more serious.

HOOKWORM DISEASE

Infection with hookworms produces definite, measurable retardation of the growth and development of the normal child. The injury produced is directly proportional to the intensity of infestation. Smillie and Augustine [7] studied a group of some two thousand children in southern Alabama, comparing the height, weight, and stem length of infested children with Clark's standards [8, 9] of normal growth curves for white children in the southern states. The hemoglobin

* *Growth and Development of the Child,* Part III.

was also estimated. The children were divided into five groups: no hookworms, carriers (1 to 25 worms), light infestations (26 to 100 worms), moderate infestations (101 to 500 worms), and heavy infestations (500 worms and over). The results showed that light hookworm infestation produced no measurable retardation in the normal growth of children of school age, but infestation of 100 worms or over caused a retardation in growth in height and weight, and a slight but measurable reduction in hemoglobin.

The same authors[10] measured the height, weight, and stem length and estimated the amount of hemoglobin of some 500 white and Negro children, and then treated part of the group, leaving the remainder untreated as controls. Three months after treatment the group was reexamined. It was found that children who had formerly harbored 100 or more hookworms showed a definite rapid gain in weight and height and an increase in hemoglobin when the hookworms were removed. Children that had had light infestations showed no deviation from the normal.

A third study[11] was made of the intelligence quotient of a group of 127 children infested with hookworms. The authors compared these results with the intelligence quotients of children in the same schools who harbored no hookworms. The Otis scale was used, checked by the National Intelligence Tests. It was found that rural white school children with heavy hookworm infestations showed a marked degree of mental retardation. Children with a hookworm infestation of a moderate intensity had a slight but measurable degree of mental retardation, whereas the lightly infested children showed no variation in intelligence quotient from normal children.

Hookworm disease in the United States is limited in great part to the sandy coastal plane below the fortieth parallel and west to the point where the annual rainfall is below approximately thirty inches. In these areas it is a disease of rural white children of school age. It is primarily a disease of children living on farms. Negro children show a much lighter degree of infestation than white children. The disease imposes a measurable, often severe, mental and physical handicap upon the growing child. The ravages from the disease are decreasing rapidly year by year, and the successes achieved in the control of it represent a happy and striking illustration of the utility of organized intelligent public health effort.

DIABETES

Since the discovery of insulin, the relationship of diabetes to the growth and development of the child has taken on a new aspect. The death rate in children with diabetes has fallen to the vanishing point since 1922, but cure of these surviving children has not taken place, so that the number of cases in the community has increased each year with great rapidity. New and important phases of the disease have thus arisen, namely, the course of diabetes in childhood and the effects of the disease upon the growth and development of the young organism.

The attainment of normal growth and development is as characteristic of diabetes today as retardation of growth was characteristic of diabetes previous to the discovery of insulin.[12] With few exceptions the causes of failure of growth are today preventable.

Condition Prior to Onset

The kind of child in whom diabetes most frequently occurs deserves consideration. Certain factors should be taken into account, such as inheritance, environment, infection, and the glands of internal secretion. For instance, overheight in the past history of the diabetic child is even more common than obesity in the history of the adult, for 90 per cent of a group of children whose height at the onset is known (200 cases), were above the Wood standard for age. In the first 100 cases this excess averaged 2.7 in., and in the second series, 2.4 in. This series of children includes patients seen from the year 1898 to 1930. Overheight was as common in the first decade of this period as it is today. Therefore, this group does not seem to represent the product of modern nutrition. Overgrowth has been an almost constant finding. It has been reported in 88 per cent of Ladd's juvenile diabetics in New York, in the majority of the children studied by Spencer at the Children's Hospital, Boston, and in the 71 cases studied by Rabinowitch in Montreal. Moreover, the skeletal development of the diabetic child at the onset of his disease, according to the roentgen investigations of Bogan and Morrison,[14] is eighteen months in advance of his chronological age. The mental equivalent to the bodily endowment is indicated by the fact that the mental age is in advance of the chronological age by eight months.

Growth After Onset

Although since the introduction of insulin the assurance of adequate growth and development has replaced the probability of retardation of growth and premature death, diabetic dwarfism still exists today in those cases which have not had the advantage of proper insulin treatment. Among children whose growth has been retarded none of the three methods of treatment in common use today had had any influence in aiding them to regain their normal stature. In this small group of stunted children not only has the growth of the bones been retarded, but there is evidence of delay of epiphysial closure as demonstrated by the roentgenogram. In those stunted children under observation for a long time increase in growth and density of the bones has been demonstrated by the roentgenogram, so that we may conclude that the growth impulse has not been lost. Whether or not growth in height in these patients will continue to after twenty years of age, one can only surmise, because up to date only one patient of the series described has reached this age.

The duration of diabetes in the past has affected the attainment of body growth and skeletal development. The effect of undernutrition cannot be ruled out, and is undoubtedly of more importance than the duration of the disease. Forty-four per cent of 412 cases were slightly below height for age in 1930. When these groups are divided into those children in whom the onset of diabetes antedated 1926 and those in whom the onset followed 1926, 54 per cent of the former group fall below expected height, in contrast to 21 per cent of the latter. Since 1926, diets of distinctly higher caloric value have been employed.

Present Status of Diabetic Children

Because a single standard for measurement of growth and development is not available, the growth in height and weight of the diabetic child, for purposes of fair analysis, is compared with standards which represent average values. The attainment of a stature which is the equal of the normal standard average is the rule. For his age the diabetic boy exceeds the average of the Wood standard except at the ages of ten, eleven, and fifteen years. The diabetic girl fares nearly as well, but falls slightly below the average of the Wood standard height for the ages from nine to twelve years and again at fourteen years. The retardation of growth exceeds one year's development in but one group, namely the girls of fourteen years of age. The average height of boys over sixteen years is 67 in., and of girls over sixteen years it is 62.5 in.

The stature of the diabetic child after the onset of the disease does not equal the ideal growth of the private school child as measured by the Benedict and Talbot standard. Excess of stature at the onset of the disease and no apparent excess at maturity give evidence that the rate of growth in height has been slightly below the average. The effect of undernutrition cannot be eliminated.

> The present weight status of the children in Joslin's series shows that 70 per cent are within 10 lbs. of the normal average, 4.5 per cent are more than 20 lbs. below the average, and 8.5 per cent are more than 20 lbs. above the average, based on height and age. Growth in weight has not, at any time since the discovery of insulin, been as difficult a problem as growth in height. Losses are easily made up and excesses can easily be decreased, particularly after catamenia is well established.

The delay in epiphysial development apparent in cases of long duration is not apparent in patients whose diabetes is of short duration or in the entire group treated by modern methods. In 1927 Bogan[14] found that after two years' duration of diabetes 70 to 100 per cent of the yearly groups were retarded. Bone atrophy occurred only in the children under nine years of age.

Mental growth in the series of children studied by Joslin has continued normally. At the onset of diabetes the children were, on the average, eight months in advance of the chronological age. An analysis of fifty normal children, compared with a group of fifty diabetic children (consecutive outpatient and hospital cases), showed that the average intelligence quotient of the diabetic children was 110, as compared with 97 in the normal group.

Sexual maturity of the diabetic child is now assured. Before the insulin era the establishment of catamenia in girls was delayed. Of the girls who are twenty years of age not one has failed to mature. Five pregnancies have occurred; three have come to term, but all in the same patient and all the births have been stillbirths. The patient was not under observation at any hospital during pregnancy or labor. Of the five boys who are married, the wives of three have had children. Up to date there is no history of diabetes among the direct descendants of diabetic children in the series.

Causes of Failure of Growth

The theoretical possibilities for failure of growth during the course of diabetes are evident: one is confronted with a child who, by the time he has attained maturity, has combated a chronic disease for from 25 to 85 per cent of his life, a disease which interferes with the taking and assimilation of the substances required for growth. One must therefore question whether the caloric requirements of the child with diabetes vary from those of the normal child and how the partition of his diet contributes to the success or failure of his growth, or the development of degenerative processes.

Premature Degenerative Changes

Degenerative processes associated with diabetes have occurred even in children. The skin of diabetic children at the onset of diabetes is of fine texture; their eyelashes, long and silky. As a result of treatment, xanthemia sometimes occurs, producing characteristic yellowish pigmentation of the nasolabial fold, the palms of the hands, and the soles of the feet. Lanugo hair is common. The eyes undergo but few changes. Muscular unbalance is a little more common in the diabetic child than in the normal child. Cataracts in the lenses of the eyes have occurred in two living girls and in three dead fetuses. No abnormalities of the central nervous system or of the gastrointestinal tract have occurred in the children of the series, although they are not uncommon complications of diabetes in the adult. No severe anemias have been noted. Calcification of the blood vessels of the legs has occurred in 11 diabetic children. In each case the onset of diabetes antedated the discovery of insulin. Sugar, fat, and non-protein nitrogen (the latter only with grave acidosis) are the only three constituents of the blood which, at intervals, are known to exceed the normal values. Thus, although it is evident that degenerative processes usually associated with advancing age occur in the diabetic, they occur under treatment by the inadequate methods of yesterday.

Conclusions

Precocity in stature, bone development, and mentality seems to be characteristic of the diabetic child at the onset of his disease, and the problem of growth seems to be inherently associated with the problem of diabetes in the child. The potentiality for growth in the diabetic child may be concluded to be good, for at the onset of diabetes stature is in excess of the standard average. Establishment of normal growth phenomena follows the use of insulin, and is apparently directly correlated with the increase in calories.

Diabetic dwarfism is an entity associated with the preinsulin era. Although the prognosis for growth is not assured, and no one method of treatment has resulted in immediate restoration of growth, the growth impulse is not lost.

The respiratory metabolism of the diabetic child is essentially normal. Degenerative processes usually associated with age occur in the diabetic child, they appear only in those patients in whom the diabetes is of long duration and in whom undernutrition or forced unnatural nutrition without insulin have played a part. With approach to normal nutrition, normal body functions are restored.

It is among physically and mentally precocious children that diabetes is most likely to occur, and therefore one can hardly expect the incidence to fall. For the present we must recognize this fact and offset it by better and better treatment of the disease when it develops. This is quite possible even with the measures now at our disposal. For the future it can be expected that intensive study of existing practices will disclose far better methods of treatment, and we can hope for measures which will actually further prevent the development of diabetes.

COELIAC DISEASE

Coeliac disease manifests itself by rather striking metabolic disturbances which lead to undernutrition and defective growth. Although the disease is not very common, cases are seen frequently enough so that the disease must be considered a problem by all physicians who deal with children. The literature has been thoroughly reviewed by Lehndorf and Mautner.[15] Fanconi [16] reports the experience of Feer's Clinic in Zurich, Switzerland, with 53 cases of fatty diarrhea and gives the most complete clinical description of the disease. The essential picture is fatty diarrhea and stunted growth. Although there are probably several types of similar disturbances which are grouped under the general syndrome, it is not possible to differentiate these types clearly because of lack of a clear understanding of the basic pathological physiology and pathological anatomy. The syndrome has been described under the following names: *coeliac disease, coeliakie, pancreatic infantilism, intestinal infantilism, schwere Verdauungsinsuffizienz beim Kinde jenseits des Säuglingsalters,* and *chronic intestinal indigestion.* Those especially interested in the symptomatology and metabolic and pathological studies of the disease are referred to the reviews mentioned.

Some cases of coeliac disease are clearly instances of pancreatic steatorrhea, and since the symptoms of most of these cases date from birth they are probably due to congenital anomalies of the pancreas. The classical cases with onset at the age of about one year show definite pancreatic lesions in about one-third of the cases reported. However, other cases are recorded which do not show evidence of pancreatic lesions either grossly or by the usual microscopic sections. The autopsies show no lesions of the intestines which may be clearly related to the metabolic disturbances. The liver cells are filled with fat but not otherwise abnormal. Other lesions described in single autopsies do not seem to be related to the disease per se.

The most characteristic physiological disturbance is the large bulky, foul, pale stools which contain an excess of fat. The fat of the stools may be in about the normal concentration but the increased bulk of the stools leads to excessive loss of fat in all cases. In clear-cut pancreatogenous steatorrhea the fat may be present in increased amounts as unsplit fat, but this is by no means always the case. In the classical type of the disease, nitrogen is said to be well absorbed but this is not universally true. Starch and polysaccharides are poorly absorbed and as a result of their fermentation frothy stools usually occur.

The chief disturbance of the mineral metabolism is failure to absorb calcium. Accompanying this disturbance there may be failure to absorb phosphate, and both phosphate and calcium show minimal or negative retention.

Pancreatogenous steatorrhea may show a diabetic sugar tolerance curve. Like sprue, classical cases of coeliac disease seem to show a flat sugar tolerance curve (Thaysen,[17] Svensgaard,[18] McLean and Sullivan,[19] Fanconi [16]) ; the cause is not known but it does not seem to be due to defective absorption.

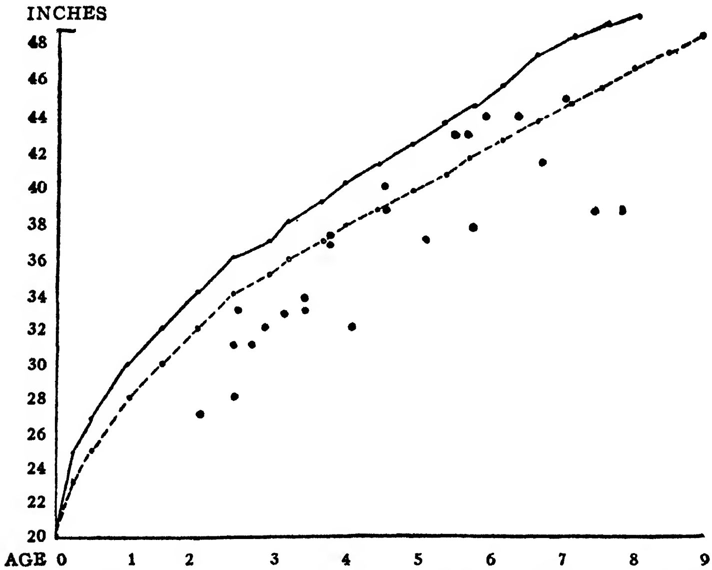
Cases of coeliac disease frequently show a low concentration of free HCl, but true gastric achylia is rare. Studies of the duodenal ferments cannot be interpreted at present because of the lack of an adequate evaluation of the techniques used (Magni and Pirami,[20] Greiner,[21] Davison,[22] Bauer,[23] Thaysen,[24] Okada and others [25]).

This brief summary indicates that coeliac disease is characterized by failure to utilize fat, calcium and phosphate, and to a lesser extent polysaccharides and proteins. It is not clear whether the absorption of vitamins is much affected, though this seems likely. In some instances lack of external pancreatic excretion is the cause of these metabolic defects, but in other instances neither physiological nor pathological studies have clearly explained the underlying cause of the metabolic disturbances. However, it is not surprising that such gross metabolic defects should lead to defective growth and nutrition.

In about one-tenth to one-fifth of the cases, the children do not reach adult life. Others go through a period of severe undernutrition, during which growth is practically stationary and which lasts several months to several years. Some of these patients recover entirely, resume growth and become adults of normal height, weight, and vigor. Those whose symptoms last over a year or two are apt to remain short, although their weight may become normal for their height. Chart I shows the scatter of heights of ten girls at various ages studied by Neale. A similar distribution was found for boys. Chart II shows the relatively normal scatter of weights for height in this same series.

The defective absorption, or perhaps the increased elimination of calcium leads to osteoporosis in all cases. Pathologically the changes in the bones seem to be like those produced by calcium deficiency rather than rickets. It is unknown what effect activated ergosterol has on this phase of the disease. Administration of calcium by mouth has not been effective. Many cases show the tetany characteristic of low calcium intake. The lack of epiphysial growth indicates that the defective calcium absorption is not the primary cause of the lack of growth of the bones.

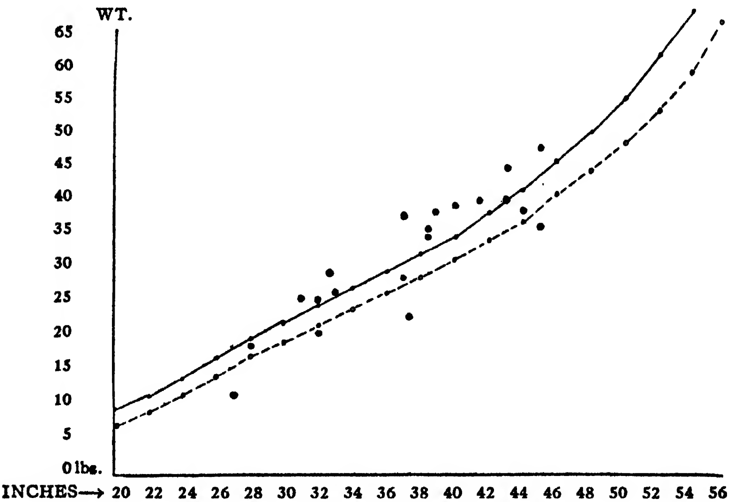
Even during the severe phases of the disease, the mental development seems strikingly normal in contrast to the stunted physical growth and marked undernutrition. While the patients are so ill, they are very irritable, and this has led many German authors to list a psychopathic constitution



Medium height range of normal girls (Includes 50% of total.)
Computed by Bardeen from Woodbury and Boas figures.
Measurements at various ages on ten girls having coeliac disease (Neale and Blackfan.)

CHART I. STATURE FOR AGE IN COELIAC DISEASE.

as one of the causes of the disease. However, when symptoms abate, the patients appear so nearly normal mentally that the psychopathic constitution must be considered a manifestation brought about by the disease rather than a predisposing cause of the coeliac affection. After recovery, the patients sometimes show abnormal mental reactions, but the long period of illness seems to be a sufficient cause for the development of such traits. The impression of most authorities is that mental development is normal, but Kerley and Craig[26] report that the three patients whom they have seen after passing the fifteenth year were high grade morons. Psychometric examination by the Yale-Psycho Clinic of one case of pancreatogenous steatorrhea at nine months, who died at twelve months from the disease, seemed to indicate



Medium weight range of normal girls (Includes 50% of total.)
Computed by Bardeen from data of Boas and others.
Measurements at various ages on ten girls having coeliac disease (Neale and Blackfan.)

CHART II. WEIGHT FOR HEIGHT IN COELIAC DISEASE.

an approximately normal mental development in a child who had shown very little physical growth. There is need of study of this phase of the problem by the more objective mental tests.

The severity of the gastrointestinal symptoms in coeliac disease has led to the extensive use of limited diets based on the assumption that the metabolic defects indicate a need to protect a weakened function. This has caused the development of many cases of scurvy and perhaps other deficiency diseases. There is some evidence that severe steatorrhea may be accompanied by defective absorption of vitamin A. Although defective diets seem to lead to coeliac symptoms in some cases, it is not clear that deficiencies of any of the known dietary essentials lead to coeliac disease, although

CHART III. MORTALITY FROM ALL CAUSES. UNITED STATES BIRTH REGISTRATION AREA. RATE PER 100,000 ESTIMATED POPULATION BY AGE PERIODS 1927.

under certain circumstances lack of vitamin A (Wolbach and Howe[27]) may cause gross pancreatic lesions. Careful study is needed to demonstrate whether the gross metabolic disturbances of coeliac disease lead to any special requirement of any of the dietary essentials, whether they are proteins, fats, carbohydrates, minerals or unidentified substances.

SUMMARY

The effects of either acute or chronic disease may be transient, progressive or fixed, and their health importance will depend upon these factors as well as the location and degree of their involvement. Owing to the great number of disease processes and the variability in severity, extent and duration of each, an exhaustive consideration of the possible effects of each disease would be out of place in this report.

Disease manifests itself differently at different ages, depending largely upon differences in anatomical, physiological and immunological development. Due to these differences the study of disease in the early years is of special interest and importance, and the separation of pediatrics as a special branch of internal medicine is justified. There is a striking difference in the incidence and severity of disease as shown by death rates for different ages (Chart III). The period from ten to fourteen years has the lowest rate of any in the life cycle, whereas the high rate of infancy is not again approximated until the seventy-fifth year or later. There is a sharp contrast between the types of disease commonly encountered in infancy and those in adult life, and there are also marked age differences in the course and manifestations of those diseases which occur at all ages. To exemplify the differences in type we need only call attention to the diseases of importance in the first month of life, and compare them with those of later childhood. The profound adaptations

TABLE 3

SIX CHIEF CAUSES OF DEATH IN ORDER OF IMPORTANCE BY CERTAIN AGE PERIODS. UNITED STATES BIRTH REGISTRATION AREA, 1927

Order	Under one year	One to four inclusive	Five to nine inclusive	Fifteen to nineteen inclusive
1	Prematurity	Pneumonia and bronchitis	Accidents	Tuberculosis
2	Pneumonia and bronchitis	Diarrhea + enteritis	Diphtheria *	Accidents
3	Diarrhea + enteritis	Accidents	Pneumonia and bronchitis	Heart disease
4	Malformations	Diphtheria *	Heart disease	Pneumonia and bronchitis
5	Injury at birth	Whooping cough	Appendicitis	Appendicitis
6	Whooping cough	Tuberculosis	Tuberculosis	Typhoid + paratyphoid

* Absolutely preventable.

which must be made by the newborn infant have been considered earlier in this report. It is not surprising that many of the diseases occurring during the early weeks should be dependent upon failure in this adaptation. Developmental anomalies and diseases due to prenatal and natal influences are then common. During infancy and early childhood diseases dependent upon poor hygiene and improper food occur much more commonly than in later life. Table 3 shows the six leading causes of death at different age levels and demonstrates the fleeting importance of some causes.

As examples of the differences in a given disease at different age levels, we may note that obstruction due to laryngeal diphtheria occur most commonly under three years, owing to the small size of the larynx, which allows easy occlusion by membrane and edema. Again, brain tumor and meningitis often fail to produce in the infant the classical signs of increased intracranial pressure, owing to the bony union at the sutures of the skull and the consequent ease of expansion.

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INADEQUACY OF PRESENT KNOWLEDGE

THE study of the growth and development of children in the past has dealt in large measure with groups of individuals at different ages, and the concepts of growth and development have been largely based upon averages derived from these studies. For these averages certain general trends have been recognized. We have come to look upon the newborn infant as a highly unstable organism, particularly through the first few weeks of adjustment to independent existence. It is apparent that during the first ten to thirteen years the changes resulting from growth and development become progressively more gradual until a fair degree of stability is attained. Shortly before puberty this relatively stabilized organism again exhibits active signs of change, of which an increase in bodily dimensions is the most apparent, and which also involve marked alteration in structure and function. Following this, there is a final but gradual movement toward the steady state of maturity. It is obvious, however, that this averaging of individual variations in group studies necessarily masks the finer fluctuations in the rate and magnitude of change in the individual. It is evident that further studies of growth and development should follow the course of events in the same individuals over a series of years. Such consecutive studies, commonly referred to as *longitudinal,* are made necessary by the varying degrees of development of individuals of uniform chronological age.

Further studies of growth and development should also be more comprehensive in character and concerned rather with the child as an entity than with the relation between any two variables independent of other aspects of the child's life. To conduct such comprehensive studies it will be necessary to canvass the various biological and social sciences for techniques, and to secure the cooperation of individuals working in these various fields; for each of these sciences may be regarded as an instrument for the study of this broader problem of growth and development. This will call for a considerable shift in the attitude and interest of the participating sciences. Instead of concentrating on their individual problems they will be expected to lend their skill and knowledge to a joint enterprise addressed to the systematic exploration of development. Such broad cooperative studies are relatively new, but it is becoming clear that more must be known about the organisms concerning which data are gathered, in order that these data may be properly interpreted. Such a concerted attack, therefore, may yield fruits of large significance to the cooperating sciences themselves.

Although the entire period from conception to the eighteenth year deserves individual, comprehensive and continuous observation of all aspects of growth, this mode of investigation has been particularly neglected in the neonatal and adolescent periods. The progress from fetal existence through birth, neonatal adjustment and infancy into childhood, and the effects of factors operative during one of these periods upon growth and development in later periods, require much further attention. Embryological and fetal development have been intensively studied from the anatomical standpoint but further knowledge of their pathology is needed. The relation of heredity to these findings has received considerable attention, but our knowledge of their relation to maternal or paternal health or to maternal diet and hygiene is very inadequate.

The meaningless diagnoses commonly encountered in statistics as to the cause of death in newborn infants are impressive indications of our lack of knowledge. Much more extensive and detailed study of neonatal deaths is required by pathologists trained in clinical pediatrics, and a closer correlation of these findings with maternal health and habits in pregnancy is indicated. The chemistry of the blood and tissues of the newborn, and the adjustments which take place during the early days of life have received even less attention than the morphological changes. Maternal toxemia, for example, profoundly affects the infant *in utero*, but the nature of these effects should receive more thorough chemical and bacteriological study. The immediate effects of delivery upon the infant have been discussed at some length in the literature in recent years, but the ultimate influences of these factors upon physical and mental growth are still matters of speculation. Individual differences in growth curves, and the influence of common occurrences of infancy upon these curves, require more exact definition. Furthermore, the relationship between one growth factor and other possible related factors is frequently unknown because of the limited information obtained in most studies other than that directly relevant to the subject under investigation. The reasons for the failure to study the newborn and relate his condition to parental and natal factors are not difficult to discover. The newborn infant has been looked upon as a by-product of delivery in maternity hospitals and attracts attention only if he develops manifest disease. Only in recent years, and in relatively few institutions, have the well newborn received more than routine nursing care and passing notice by the physician. On the other hand those interested in the child, and particularly those interested in the study of growth and development, have started their efforts at some time after delivery. The sources of case material have usually been hospital clinics, to which normal children are rarely brought in the early weeks of life. Thus has arisen a break in our knowledge at the period of most rapid change and critical adjustment. Although growth and development are continuous from the moment of conception, we have come to separate arbitrarily fetal from infant existence in our thought and study.

The second period particularly requiring extensive and continuous study is adolescence. Various branches of science have studied adolescence but with few exceptions their interest has been focused upon particular problems for which the adolescents have been convenient sources of data. In these studies the individual adolescent has been lost sight of in the statistical aggregates necessary for the investigations. Data should be collected, using all relevant scientific techniques pertaining to the growth and development of individual adolescents, over the entire period from beginning puberty to full maturity.

There is already available a considerable body of scientific techniques and measures applicable to the study of adolescents which may be briefly reviewed to show where we now stand. The psychologists have developed a number of tests and measures of intelligence, motor abilities, aptitudes and performances, with age norms based upon chronological age groupings. The need for a measure of developmental age has been expressed by a number of psychologists, which will call for concerted effort with anatomists and physiologists. Various tests of emotional stability and personality characteristics have also been constructed and are available. The group engaged in educational research, largely drawn from psychology, have investigated the educational capacities and interests of adolescents in the search for evidence upon which to base a sound curriculum. They have also studied various aspects of character and ethics and the moral development of youth. Under this head, reference may be made to a few studies of sex interest and activities of adolescents, more particularly college men and women. From this same group have come studies of height and weight norms among school children. Long-term studies of children which will run into adolescence, since they involve consecutive tests and measurements of the same children for ten years, are in progress at Stanford and at Harvard. Data have also been collected at Iowa University. The psychiatrists have collected a large volume of case histories of adolescents who, because of delinquency or behavior problems, have been subjected to examination. The generalizations made upon this body of case records are in need of amplification and, especially, of being checked with an adequate control group composed of adolescents who have not exhibited such overt signs of maladjustment. A number of promising leads are available from this field. The sociologists have been studying adolescents with particular reference to their social behavior and the neighborhood backgrounds. For the most part these studies have been concerned with gangs, delinquents, and other aspects of adolescent behavior in which the interest comes from the social difficulties they have created. They have developed techniques for studying the social or group backgrounds which are of value in reenforcing the individual case records of the psychiatrists.

There are a few medical studies dealing specifically with adolescents. They deal with functions such as blood pressure, basal metabolism, and the onset and effects of menstruation. Physical education and age norms on performance tests for athletics and games have received attention. There are large quantities of data on physical measurement and the medical examinations of high school and college students, but not much has been done with these records. The attention of pediatricians has been focused largely upon the periods of infancy and childhood and their characteristic diseases. Practically no work has been done to determine what is a desirable routine of living for adolescence, and consequently we have little knowledge of the specific requirements for sleep, exercise, rest and nutrition for adolescents.

Practically nothing has been done by physiologists on adolescence and the possibility of large advances in this direction awaits exploration. The investigation of the stabilizing processes, or homeostatic functions, as Cannon has termed them, during the adolescent period is particularly in need of attention. The participation of biochemists and students of nutrition is also needed to discover the nutritional requirements of adolescence and possible optimal diets.

In conclusion, it may be repeated that the longitudinal study of individual children, especially in the early months and again during the years of adolescence, using all relevant scientific techniques to obtain data on structure, function and behavior, is the greatest need today. This calls for a program of research involving joint cooperative efforts by a wide variety of scientists in order to adequately canvass these various data on growth and development.

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