Heredity, Growth, and the Dento-Facial Complex*

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MEMBERS of the Chicago Association of Orthodontists and Guests. This evening I would like to present before this group some of the findings of the research in heredity and development which has been carried on by the University of Michigan during the past ten years. I would also point out to you at this time that these results have not attained finality; they are presented for your consideration and discussion with the hope they merit serious consideration and critical appraisal. We abjure both acceptance or rejection of our theses on the grounds that they appear plausible or that they interfere with undocumented points of view. With these reservations then, I shall present to you our findings and shall not take recourse to such modifying phrases as: it seems, it appears, or we believe.

A review of the dental literature of the last twenty years furnishes adequate evidence that the inheritance and development of dento-facial structures is regarded as increasingly important in etiology, diagnosis and treatment of dental disturbances, particularly those which concern the Orthodontist. However, a stock-taking of the literature reveals the major obstacles to an understanding of the importance of hereditary traits to be a lack of adequate data upon which to formulate hypotheses and to draw conclusions. The majority of articles dealing with the role of heredity in occlusion have been based upon empirical and logical argument and are but little documented with supporting evidence. There are a few individual attributes of the dento-facial complex whose genetics are moderately well known, such as: absence of certain teeth or groups of teeth, opalescent dentin and mottled brown enamel. For the most part, the kinds of traits whose inheritance is moderately well understood, are aberrant, conspicuous, and poorly represented in the population at large. In addition, although these traits are important in the etiology, diagnosis and treatment of malocclusions which they engender, or of which they may be a part, they do not make up the bulk of malocclusions and certainly the majority of treated cases do not involve factors which can be attributed to these anomalies. As a matter of fact there seems to be a feeling that unless a character is conspicuous and unusual it is likely to be regarded as non-hereditary. In other words, there seems to be a feeling that the normal is immune to genetic laws; this obviously is absurd.

There is a fairly large body of literature which has utilized hearsay and unformulated observations to support a variety of genetic theses and ap-

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parently preconceived ideas as to how occlusion was or should be inherited. Time does not permit further discussion of these viewpoints here; it is sufficient to note that the conclusions have been extremely varied and, for the most part, erroneous. Consequently, they have had but little practical value to the orthodontic profession.

For some years, in the Orthodontic Clinic, we had been recording as much data concerning the parents and siblings of our patients as we could conveniently obtain, but never with much system. Our observations were concerned mainly with special characters, such as those previously mentioned and our notes on other attributes in the dento-facial complex were gross and descriptive of the whole rather than minute in respect to those component parts whose individual characteristics made harmonious occlusal relation impossible. An analysis of these data gave us general and often conflicting conclusions and clearly demonstrated to us the need for precise detail and for systematic record keeping if our materials were to be of any value in attacking the hereditary problem.

Many of the facial features, important in occlusal relation, are not amenable to measurement. These were observed and recorded in a graded series. Particular care was taken to record all doubtful observations as questionably present. For example, in the observation on asymmetry in the height of the mandibular rami it might appear that the left ramus was longer than the right; unless there was surety this were so the observation would be recorded as questionable, implying that the observer was unwilling to commit himself either to the absence or presence of the asymmetry. The utilization of this technique of control has made it possible for three independent observers to attain a fair degree of agreement (correlation —.897) and gives us assurance of working with real and not fancied data. A subsequent examination of lateral and antero-posterior roentgenograms, standardized and approximately equivalent to those taken by Dr. B. Holly Broadbent at Western Reserve University, by Dr. L. B. Highley at University of Iowa, and by Dr. Allan G. Brodie at the University of Illinois, show us to be over rather than under conservative in our appraisals. The observations were further checked by using detailed anthropometric measures of the head and face.

In brief, the following types of observations were appraised and analyzed:

1. The antero-posterior placement of the various parts of the face with reference to a plane dropped perpendicularly from nasion.
2. Inclination of maxillary and mandibular anterior teeth.
3. Various displacements and rotations from the mid-saggital and mid facial planes.
4. Differences in the dimensions of the bones on one or the other side of the face.
5. Absolute size of the several face bones.
6. Configuration of the maxillary and mandibular arches.
7. Numerous details on the dentition itself.
8. A statement of the type of occlusion according to the Angle system of classification.

Greater detail cannot be given, at the moment, and although this sum-

mary outline does not describe the data collection technique with sufficient detail, perhaps it will serve as a guide for some of the more important items which follow.

The data for this study include 554 individuals grouped in 150 families: 281 are parents and 273 are children. Dento-facial and anthropometric records were secured on each individual. Clinical records were taken on all family groups and operative records were maintained for all members admitted to the clinic for treatment. The complete battery of data including the above mentioned records plus oriented roentgenograms and dental casts were obtained on 26 families of whom 52 are parents and 82 are children.

This population sample is selected and is not presumed to be representative of the population as a whole in the community from which the clinic draws its patients. At least one child in each family was brought to the Orthodontic Clinic because the parents were concerned over a real or apparent dento-facial disorder. Although this selection fails to give us much evidence on total population, it does give the very important professional advantage of being representative of a group that seeks orthodontic advice and treatment. This is the group which primarily concerns us in problems of etiology, diagnosis and treatment.

The data for the analysis of growth were secured from the University Elementary School of the University of Michigan. From the orthodontic point of view this material is remarkably complete since it has always maintained an elaborate body of dental and orthodontic detail collected by *trained orthodontists* under the guidance of the Dental School and in addition has an equally complete battery of information collected by specialists in the psychological, sociological, educational, medical and anthropological fields. This added information enables us to refer the growth in the dento-facial complex to the growth of the organism as a whole and to ascertain more fully the amount of interrelationship or part independence evidenced by the several features.

From the point of view of development heredity becomes a part of a process that extends at least from conception to maturity. Most, if not all, hereditary features undergo vast changes between inception and adulthood. Frequently it is difficult to describe the end product in terms of its appearance during the process of development. Also, it is reasonable to assume that the longer environmental forces operate the more likely it is for nonhereditary factors to be interposed in the growing structures. At this time it is not possible to estimate more than roughly the susceptibility or resistance of a growing feature to nurtural or environmental modification. Certainly the stimulation or retardation of growth is not an easy process and in general it may be said that the more essential a part is to the well-being of the whole the more likely is that part to resist either acceleration or retardation by nurtual and environmental techniques.

This brings us to an important point. Is growth inherited? And, if so, is it inherited as a general factor which influences the attributes of the body as a whole or is growth different and distinct for each feature? In some individuals the growth of a single attribute is very much like that of any other attribute so that we may write a growth equation and have it generally

descriptive of the total organism. In other individuals the growth of one feature is considerably different from the growth of another and several growth equations would have to be written to describe the development of the whole organism. These diverse patterns of growth have a random distribution in the population and are definitely concentrated within familial lines. The evidence indicates growth to be strongly dependent upon hereditary factors and to follow the mode of inheritance of the particular feature. Growth and inheritance are parts of the same phenomenon.

The cranio-facial region is composed of many parts which exhibit a rather marked degree of growth independence.

Many of the apparent discrepancies in the dento-facial complex due to growth and the resultant malocclusions represent real genetic differences. It is pertinent to indicate a few of these: The individual teeth in both the deciduous and permanent dentitions as well as the way in which they grow and the order in which they erupt are primarily inherited. Further, the amount of modification induced by the environment is small. We would suggest that hereditary circumstances provide fully 85% of the variation shown in the dentition and in its growth. Equally striking are the various parts of the mandible—the condylar and coronoid process, the ramus, the angle, and the body. The familial distributions clearly attest to the hereditary nature of these parts—all multiple factors—and their growth continuities indicate that they are not easily shunted off of their developmental patterns.

The same conditions obtain for the maxillae, the premaxillae, the malars, and so on. The only parts of the dento-facial complex which appear easy to modify are the alveolar portions of the upper and lower jaws. Even here the amount of alveolar bone is largely hereditary and whether it can be stimulated to grow to a particular desired point is very much open to question. Only one other point need be mentioned here: many of the peculiarities in the "hafting zone" are hereditary and irregularities in this region frequently have a marked effect upon occlusal relation. The continued citation of various structures in the cranio-facial complex having an hereditary basis in formation and growth becomes wearisome—as the facts come in it becomes simpler to demonstrate the action of heredity than it does to exclude it.

We may be permitted another generalization: the closer to optimum the nurtural conditions become the more clearly shown are hereditary patterns in growth; conversely non-genetic variation becomes more extensive as nurture becomes less adequate. This in itself is important and indicates that one should not expect heredity to overcome all of the nurtural deficiencies any more than one should expect nurture to ameliorate many undesirable hereditary attributes. This citation is not an act of "fence-straddling" for the protection of the academic self, nor does it serve as an excuse for ignorance. The problems which it poses are real and difficult.

From the clinical point of view it means that each case must be examined on its own merits and that recourse to population statistics to decide the relative role of heredity and environment in the production of an individually observed malocclusion can leave the answer in high error. Some examples are pertinent: the continued practice of thumb or finger

sucking can and does produce Class I malocclusions in which the maxillary arch is elongated and constricted, the upper anteriors protruded, and the lower anteriors retruded; heredity can and does produce almost identical conditions without any evidence of habit. There are open bite cases equally difficult to distinguish. Some are entirely hereditary, some have little hereditary background, and some have genetic and environmental circumstances inextricably bound together. Class II and Class III malocclusions are less easy to produce environmentally than are several subtypes of Class I; the fact remains, nevertheless, that circumstances extrinsic to the organism can produce features which appear the same as those produced by factors intrinsic to the organism.

In the examination of the individual it is important to know whether 50% of a particular type of malocclusion can be ascribed to nurture, 20% to heredity, and 30% to an interaction between the two; or to know that another type of malocclusion has an 85% foundation in heredity. There is much of practical value in knowledge of probability. It should serve as a guide to individual appraisal and as an aid in prognosis and treatment; it is always desirable to make recommendations and act on the basis of the more rather than the less probable. Probability is a critical and sharp tool of science, to presume on it is unwarranted and dangerous. As an aside, I have more than a remote suspicion that the clinician's distrust of probability is closely akin to the distrust the small boy has for the sharp knife which just cut him. The source of the disturbance is the personality of the instrument (usually dishonest) rather than the lack of skill of the user.

Your present speaker has little or no business suggesting to you how heredity and growth facts should be used in the outlining of treatment procedures. It is better, perhaps, to summarize the evidence for heredity in the dento-facial complex and to give an estimate of the probable importance than to consider the problems of treatment which should be left to the competent hands of the orthodontic profession.

1. The individual teeth—probably 85% to 90% of the variability in both the deciduous and permanent dentitions can be ascribed to heredity. These variations include: absence of teeth, individual tooth anomalies, impactions and positions, rates of growth and patterns of eruption.
2. Enamel deficiencies—opalescent dentin and one form of mottled brown enamel are hereditary; other types of enamel hypoplasias and anomalies seem to be determined by environmental and nurtural circumstances.
3. Size and configuration of the several parts of the mandible and of the maxillo-facial bones—the majority of differences (70-80%) are hereditary; functional adjustments, if continued over long periods of time, can produce some extensive changes. How much growth can be stimulated in these areas by nurtural and by mechanical means is questionable. Certainly the task is not easy and until more precise techniques are known for the stimulation of growth, I have little faith in this as an effective form of treatment. The majority of features in this area result from the operation of multiple genes and the inheritance is very complicated. In addition the evidence is strong

for a partial dominance of the deficiency over the excess; i.e. of V-shaped arches over ovoid arches, of small mandibular bodies and rami over large ones, of obtuse mandibular angles over acute, of small maxillary apical bases over large ones, and so on. One need only point out that there are many Class II cases with V-shaped arches and crowded anteriors, with deficient maxillary apical bases, and with short mandibular rami and bodies; that frequently Class III cases present marked maxillo-facial deficiency and obtuse mandibular angles; and that many Class I cases show deficiencies in one form or another to realize this partial dominance of deficiency presents real orthodontic problems. Let me repeat: faith in mechanical exercise or nurtural provision to stimulate these areas to grow to adequacy is largely unfounded.

4. Alveolar processes—the amount of alveolar bone is largely hereditary as is its basic distribution upon the maxilla and mandible. It would take too long to list the many variations and changes which occur within the alveoli. Sufficient to say they are many and a very high percentage have little or no genetic basis. The bones are both nurturally and mechanically plastic and within the limits of amount many types of modification can be instituted.
5. Asymmetries and displacements—these have both hereditary and environmental sources of variation. Genetic factors appear to have the edge. The best estimate might be about 50% of each as a source of difference.

In conclusion let me say that I have been talking about heredity and growth. To call your attention to these phenomena and to stress their importance in the ascertainment of the etiology of a malocclusion or to emphasize their rôles in the formulation of treatment procedures does not imply that nurture and environment are unimportant. To omit a consideration of these latter features would be an error of the grossest kind. Successful treatment requires understanding of the individual. The only way an individual can be produced is through the operation of genetics and the only way he can achieve maturity is through utilization of materials provided in his environment. Heredity and environment, singly and in co-operation, provide many variations. Some of these are desirable. Others, including dento-facial disturbances are undesirable and need correction. The problem of the professional orthodontist is to correct. To do this he needs to know; precisely and in detail. The maintenance of the argument "heredity versus environment," or the pursuit of tenuous metaphysics, as "can nature make a mistake?" can gain the orthodontist little in any practical way. The examination of the individual patient and of the circumstances surrounding him provide the best bases for etiology, diagnosis and treatment. In this examination the facts of heredity and growth are vital.