American Journal of ORTHODONTICS

VOL. 44 AUGUST, 1958 No. 8

Original Articles

DENTAL DEVELOPMENT AND THE CHILD AS A WHOLE

BYRON O. HUGHES, PH.D., ANN ARBOR, MICH.

THE evidence on growing children that has been collected at the University School of the University of Michigan for the past twenty-seven years has now accumulated to the point where we can say with assurance that the child grows as a highly individualized and extensively interdependent whole. Furthermore, it may be stated that a child grows in a lawful, orderly, and predictive way within himself, irrespective of how much his individual growth pattern may or may not conform to that of another child or group of children.

When we use a multidiscipline, longitudinal approach to the problems of growth, the implications of the statement that the child is a highly individualized and extensively interdependent whole become much more impressive and meaningful than the conclusions that we can develop by studying only one part at a time. To illustrate this, one may point out that orthodontists have been much interested in bone growth and, therefore, should study bone; but bone growth and muscle growth have an unbreakable and exceedingly close and continuous correlation, and muscle growth and muscle use are of necessity interdependent. Then we cannot continue unless we recognize that muscle use and behavior are, again, continuously and inseparably associated. Dr. Shehan has shown me one of his cases in which the kind of necessary association outlined above went into action to produce a developing Class III malocculsion.

From the University of Michigan.

Presented before the Great Lakes Society of Orthodontists, Detroit, Michigan, Oct. 20-23, 1957.

Here an aggressive emotional state was brought into action by muscles to become a mandibular thrusting habit, which finally became stabilized as a developing Class III malocclusion through the adaptability of bone and the locking action of the primary teeth in cross-bite relation.

Further illustration of the individuality of growth is given by the growth figures of five of our University School children. These figures are constructed by using thirty-six measures of growth: three from the intelligence area; eight from the school achievement field; two from the growing skeleton; seventeen from the dentition; and one each from height, weight, strength of grip, behavior, personality structure, and social maturity. Each of these figures is computed in the same manner by generalizing all of the measures into density bands in such a way that the heavy line in the center is the least squares fit of the equation, $Y = AX^{n+1} + C$, to the arithmetic means of the several measures listed above. These means are taken on both the vertical axis (ordinate) and the horizontal axis (abscissa) at one-year and half-year intervals. The central line so obtained has been termed the organismic age, and it is a much better statement of how old the child is at any given time than is his chronological age. The dense band distributed on either side of the mean is obtained by a least squares fit of the above equation to the roots of the variances, computed on both axes, at one-year and half-year intervals. The area obtained by this method is called the organismic area, since it represents the central two-thirds of the child's total growth pattern. Furthermore, the computation shows the extent to which the child is growing in a unified or in a diversified way: the narrower the band, the greater is the uniformity of all growing items; the broader the band, the lesser is the interrelatedness of growth.

These two growth trajectories—the organismic age and the organismic area—may serve as a reference system for particular growth values that we may wish especially to emphasize. These figures present two particular lines of interest in the field of orthodontics—bone growth and dental growth. The measures used to develop the bone growth line are obtained from readings taken in the elbow, the wrist and hand, and the mandible. (Let me say here that a much better bone growth line for orthodontic purposes would be one using measures taken primarily from the craniofacial complex. However, our present data do not permit the more desirable presentation. A serial cephalometric x-ray program was added to our research when Dr. Moyers came to the University, and in another five or six years we shall be able to add these data in giving further interpretation to the individuality of growth.) The line showing dental development is computed from measures on the growth of each permanent tooth, using an appraisal system developed by Drs. Lewis Pinney and Carmen Nolla, and in addition, using measures of the clinical eruption sequence of the permanent teeth. This latter line has excellent technical precision and appears satisfactory for the professional purpose of orthodontics.

In brief review, the figures present a generalization of the total growth with a heavy central line, called organismic age, to show how old the child is in terms of growth age rather than chronological age. Then the extent to which the child is growing in a unified or diversified fashion is presented by a shaded area, labeled the organismic area. For the special interest purposes of orthodontics, two growth areas—bone and dentition—are shown. Finally, the average growth of children is presented as the straight diagonal line which traverses the figure at a 45 degree angle between the growth-age and the chronologic-age axes.

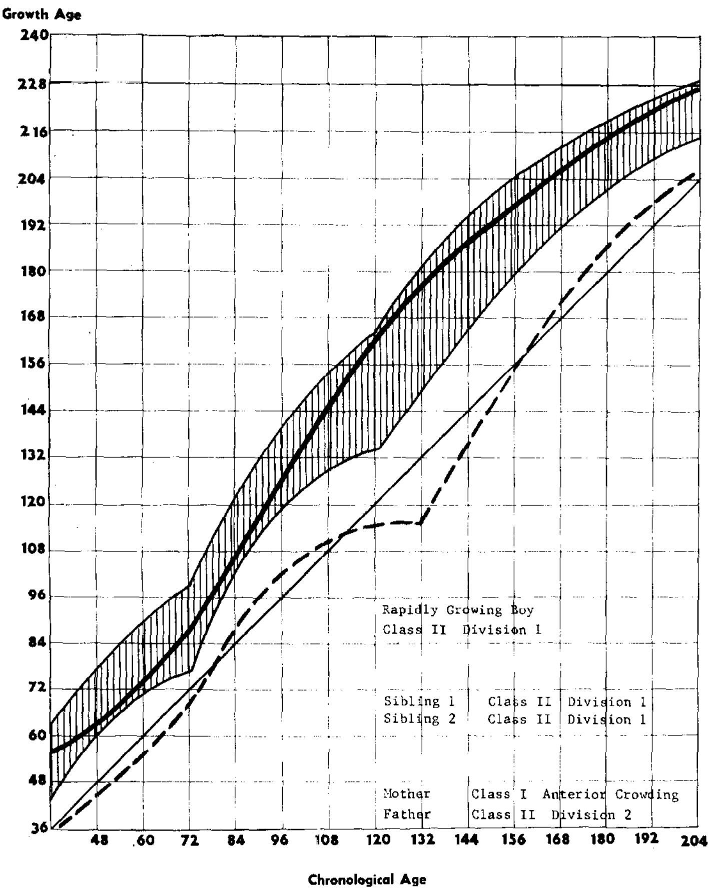

Fig. 1.

The boy whose growth is shown in Fig. 1 may be classified as a rapidly growing boy, since the organismic age exceeds the chronologic age at all times and since the rate of growth is faster than the average rate. The general growth is strongly rhythmic, with three major periods shown. The first extends from 36 to 72 months of age; the second from 72 to 120 months; and the third, from 120 to 204 months of age. It may be noted further that the rate of growth shows marked change during each cycle, with the beginning accelerated and the end retarded. As we follow the organismic area, we note that the width of the area is nearly twice as great at 120 months of age as it is at 36 months and at 204 months. In other words, the unity of growth within this boy is significantly reduced during the period of the mixed dentition, and in this case it appears to be a contributory etiological factor to the developing malocclusion. As we follow the line showing the growth of bone, we see that this growing area is a centrally developing phenomenon, since it lies within the organismic area at all times. In strong contrast, however, is the pattern of growth of the whole child and the growth of bone; the former presents three cycles, whereas bone shows the termination of one at 54 months of age and then shows a second which begins at 54 months and continues to adulthood. Finally, it will be observed that bone growth is at the bottom of the organismic area until 90 months, at which time it moves rapidly upward to 120 months; from then until adulthood, it lies at the top of the area. The line presenting dental growth and eruption is conspicuously different from the line showing bone growth and from the details showing the organismic age and area. Of particular importance is the fact that within this boy the growth and eruption of the dentition are markedly retarded throughout development. This fact becomes clear when we see that at 11 years of chronologic age the dentition is 9½ years old, the organism as a whole is 14 years old, and bone is developed to the 15-year level! Observe, however, that, according to the growth of the dentition of all children in general, this boy is growing in a "normal" way, neither retarded nor accelerated. The unfolding occlusal relationships in this boy are consistent with the graphic portrayal of his growth. The bone growth in the skull and face is rapid and closely timed with the growth of bone in the wrist and elbow areas. The mandible—a bone which is peculiar in both its growth and its evolution—is slow growing relative to the other areas of the skeleton. In this case the mandibular development closely parallels the growth and eruption of the teeth. The net effect of this "within child" difference is to produce a characteristic Class II, Division 2, malocclusion which is present in the primary dentition and becomes extenuated through the mixed dentition stages when the differential growth rate is most heavily emphasized. That this growth pattern rather than other etiological factors, is responsible for the malocclusion seems apparent in this case. Furthermore, when we follow the growth and/or occlusal relations in other members of the family, we are forced to suspect, if not to conclude, that heredity is largely responsible for the way in which this child grew. We note that the father shows the same kind of skeletal pattern and malocclusion that the boy presents. The mother's facial and mandibular pattern is Class II toward Division 1, although malocclusion is Class I with marked anterior crowding above and below. The two male siblings present Class II, Division 1 malocclusion with a skeletal pattern that resembles the mother more than the father. This boy was treated orthodontically by what some call "comprehensive methods," which seems to mean non-use of extraction and deferring the treatment until all permanent teeth except the third molars are established in occlusion. The boy's age was 14 years 2 months. At this time the mandible was making a favorable adjustment to the upper face. The appliance used was the Angle-edgewise, the response was reasonably rapid with correction completed in nineteen months. Seven years later the case was reviewed and the results were to be described as excellent and stable. In summary, it appears to me that the orthodontist who treated this boy made proper use of the evidence by recognizing that the main source of the malrelation was differential growth due to heredity and by avoiding treatment until the growth pattern was more consistent with his treatment plan.

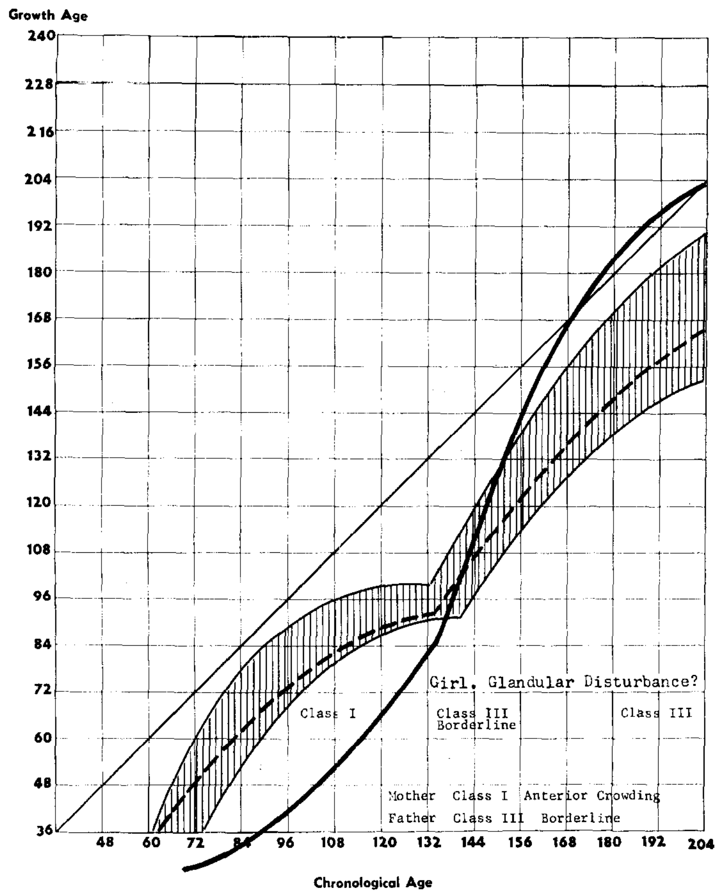

Fig. 2.

The growth pattern of a girl is shown in Fig. 2. This is a very unusual growth picture, and as yet we have been unable to provide a very satisfactory answer to the question: "Why did this girl grow this way?" Symptomatically, this first appeared to be caused by a glandular disturbance, and the girl was described medically as being hypopituitary and hypothyroid. In view of this diagnosis, pituitary and thyroid treatment was instituted at 97 months of age and continued until 123 months. The response to this treatment was unfavorable and produced no measurable change in the growth, except perhaps to slow it down and to increase the internal discrepancies. Several changes in behavior were produced; among them, several convulsive reactions to the treatment. A year after this treatment, the growth became rapid. I believe that this was not a delayed response to the therapy but, rather, that it is to be ascribed partially to the fact that the organism was relieved from heavy and disturbing interference. Further evidence indicates that this pattern of growth is hereditary and that, no matter how peculiar it may seem, it could easily be a picture of normal growth for an unusual person. The fact is that both parents are small and were late in attaining physiologic adulthood. The mother was unusually late; she did not reach the menarche until 16.5 years of age. Both parents, the mother in particular, present evidence of having devoted little energy to growth at the epiphyseal centers throughout the skeleton, and each parent has the type of skull and upper face that is associated with a short basicranial axis. The mandible of the mother is consistent with her upper face. The father's mandible, although actually small, is not consistent with the upper face, so that his face has a marked Class III appearance, although the occlusion is borderline. By way of general description, it may be said that the mother of this girl presents a skeletal pattern suggestive of chondrodystrophic dwarfism, which is primarily a phenomenon of heredity rather than of glandular disturbance, and the father looks as if his growth had been "stunted" in a somewhat similar fashion. At any rate, there is more than enough evidence in the parents to suggest that the pattern of growth in the girl is a normal expression of her genes and not a symptom of glandular disturbance. As we follow the figure, we note that the girl is subaverage throughout the developmental period, that the general pattern shows two very marked rhythms of growth, and that the internal variability is subject to considerable change as the girl matures (24 months at age 72, 10 months at age 132, and 36 months at age 204 months). The growth and eruption of the dentition follow very closely the growth of the whole child, while the growth of bone is heavily out of context with general growth, showing heavy deficiency during the first cycle and marked excess during the second growth cycle. In the early phase of development, the girl presents a Class I malocclusion with the maxillary anterior teeth being crowded. This condition remained stable until 135 months of age and then began to change so that the maxillary crowding disappeared and Class III relationships developed, although not far enough to force anterior cross-bite relationship. Here again the development of occlusion follows a hereditary pattern indicated by the occlusal relationships of the parents. The mother has a Class I malocclusion in a Class III skeletal pattern (midface deficiency), and the father has a Class III malocclusion with a Class III face (mandibular overgrowth and thrust), while the girl begins with midface deficiency, reduces this somewhat, and finally develops a Class III malocclusion that is a combination of midface deficiency and mandibular excess. This case was not treated, although it was recommended to the parents on several occasions. It was believed that the proper time to have instituted treatment was around 15 years of age when the permanent teeth, except the third molars, were stabilized in occlusion with the roots fully developed. At the present time the patient is 27 years old and the occlusal picture is heavily complicated by secondary adaptations to the developmental process as outlined.

The growth of the boy represented in Fig. 3 is again an unusual picture, since it tends to be normal or average in the statistical sense. Here we note that the growth pattern is generally linear throughout, with only a suggestion of growth rhythms. The internal variability is low, and all growing items are closely coordinated during development. Included in this pattern are the

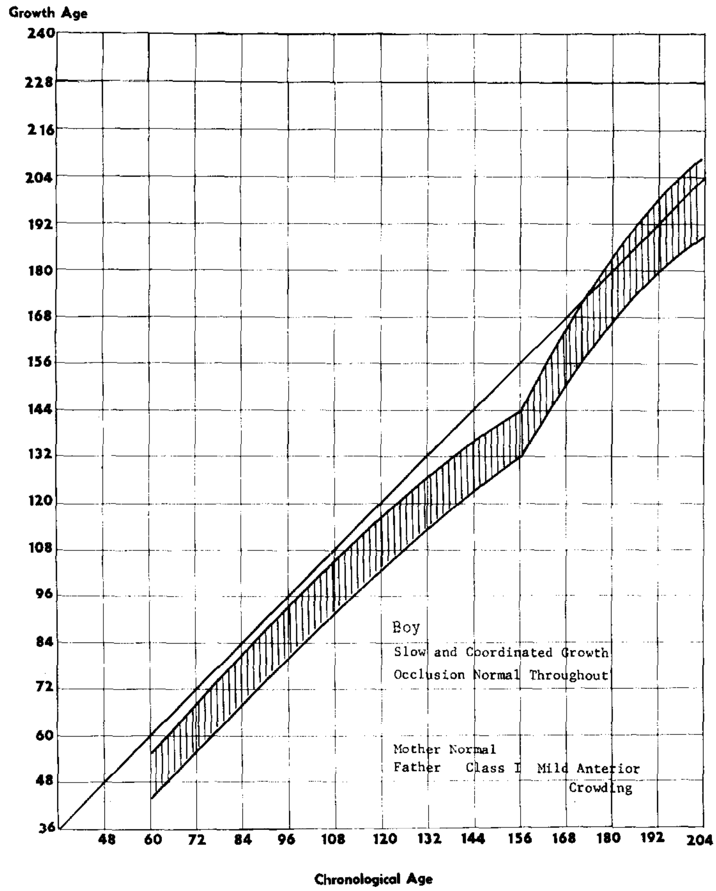

Fig. 3.

developmental lines for bone which at all times lie central to the individual and in close approximation to each other. The development of occlusion is in keeping with the rest of growth and is normal throughout. An interesting fact is that both parents show a balance between skeletal and occlusal factors, with the mother having normal relations and the father presenting a Class I malocclusion technically but an orthodontically insignificant mild anterior crowding.

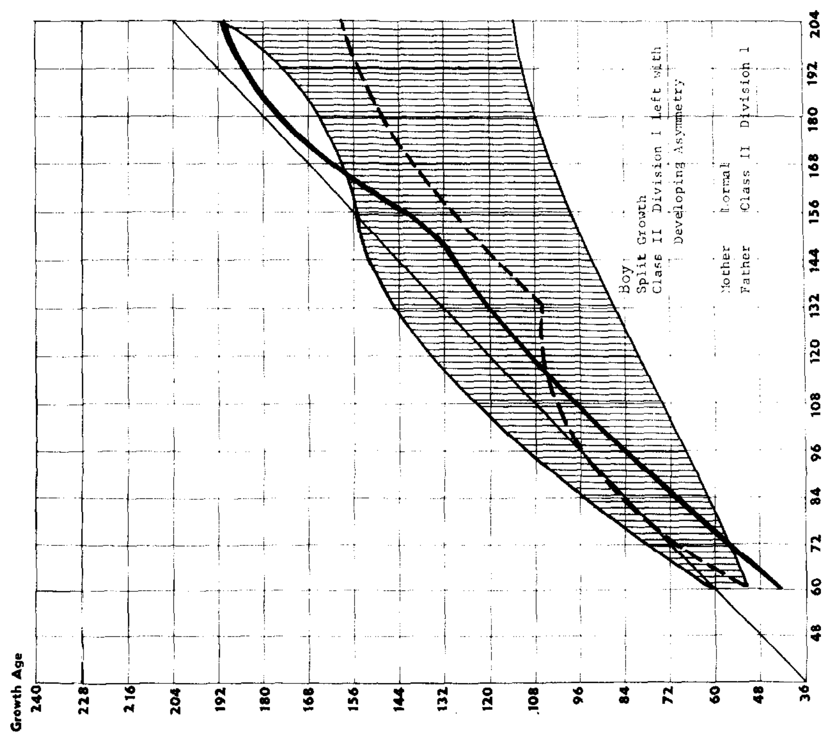
Growth Age
Chronological Age
Boy
Split Growth
Class II Division I Left with
Developing Asymmetry
Mother Normal
Father Class II Division 1

Fig. 4.

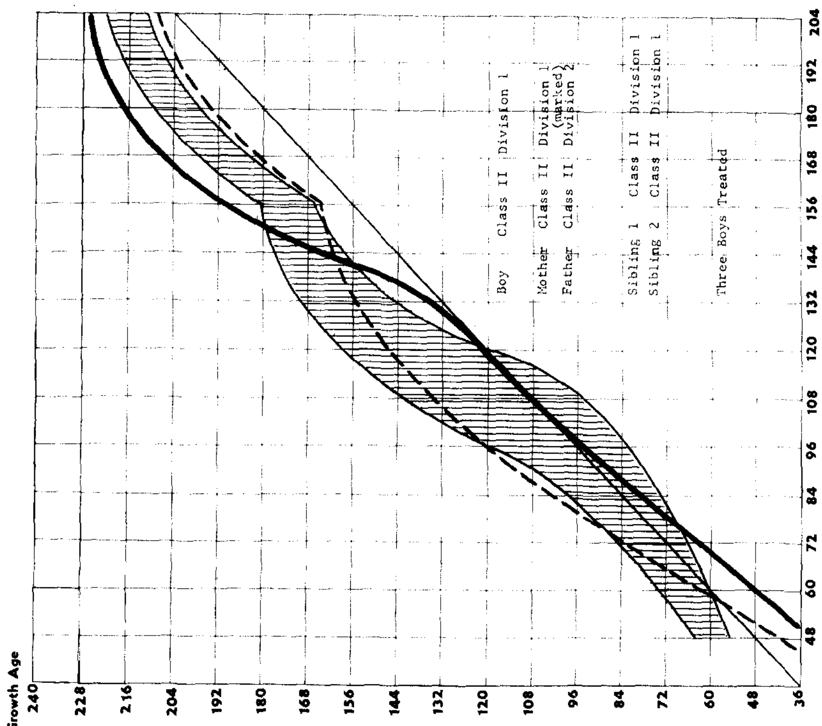
Growth Age
Chronological Age
Boy Class II Division 1
Mother Class II Division 1 (marked)
Father Class II Division 2
Sibling 1 Class II Division 1
Sibling 2 Class II Division 1
Three Boys Treated

Fig. 5.

The boy whose growth is illustrated by Fig. 4 has been labeled a "split-grower," since few of the measures used to construct the graph show much correlation with each other. The result is very marked "within variability," so that the child grows more like a population of children than he does like an individual child. This lack of balance and interrelationship during growth expresses itself in many ways. There is a high production of structural disharmonies and asymmetries; functional balances are low, often leading to diagnoses of glandular imbalances, functional dyscrasias, poor dietary adjustments, and low resistance to disease; there always seems to be something wrong, but response to specific forms of treatment tends to be limited. In the behavioral areas these children are often described as self-maladjusting and seem always in need of mental hygiene. In education, too, they create problems, and we find them needing special doses of reading, writing, arithmetic, and spelling in order to meet the standards of education. Malocclusions are usually found with these "split-growing" children, and in our population we have no split-growers who do not present malocclusions sufficiently severe to warrant correction. Especially noticeable among these children is the development of irregular and asymmetrical types of occlusion with peculiar cross-bites and types of crowding predominating and complicating the case. Most of these irregularities are based in the skeleton rather than in the teeth, with the irregularities of the teeth being secondary adaptations to the asymmetrical and nonharmonious relations of the supporting structures. The boy in Fig. 4 presents an early excess of tooth structure over bone and begins his development as a Class II, Division 1 case. By 96 months of age the permanent teeth in occlusion were $\frac{6\ 21 \mid 12\ 6}{6\ 21 \mid 12\ 6}$, with the $\frac{6 \mid 6}{6 \mid 6}$ in Class II relation, the $\underline{21 \mid 12}$ crowded, and the midline of the lower central incisor shifted to the left by about one-half the width of the lower central incisor. From 96 to 133 months of age, no additions were made in the eruption of permanent teeth. During this time the bone continued to grow and the asymmetry to the left became marked, due to a much faster rate of growth on the right half of the mandible than on the left, especially at the condyle, which both rotated and tipped the facial skeleton to the left. The next teeth to erupt were $\frac{5\ 4\ 3 \mid}{5\ 4\ 3 \mid 4\ 5}$; then 21 months later $\frac{\mid 3\ 4\ 5}{\mid 3}$ erupted and $\frac{7 \mid 7}{7 \mid 7}$ were added. The whole eruptive process was slow, and the 28 teeth were not established in occlusion until 17 years of age, a delay over average eruption of about three and one-half years. Early treatment, beginning at 8½ years of age, instituted with very poor response, so that it was discontinued at 10½ years of age with complete relapse. The case was treated again at 17½ years of age, using extraction to adjust the dentition to the irregularities of the face, with the compromise treatment giving good functional results which are still stable after ten years.

Fig. 5 shows the total growth pattern of a boy with a severe Class II, Division 1 malocclusion. Here we note a strong rhythmic pattern of growth with three periods of strong change in rate. Especially noticeable is the strong contrast in the growth lines for teeth and bone, with the teeth growing and erupting ahead of bone from 48 to 144 months of age, then with bone growth crossing tooth growth and being more rapid for the terminal period. The malocclusion is consistent with the growth picture. The early erupting teeth have an indequate amount of supporting bone with the deficiency much heavier in the maxillary area than in the mandibular area. The result is that the anterior part of the maxillary arch is thrust forward, the teeth are crowded, and the arch is markedly narrowed. The mandibular teeth are also forced forward, but not as much, giving a Class II relationship. When the $\frac{6 | 6}{6 | 6}$ come into occlusion, this condition is locked and further development either continues or gives added emphasis. Both parents of this boy present Class II malocclusions; the father's is a Division 2, while the mother's is a marked Division 1 type. In view of the parental malocclusions, it would be predicted that children born to this mating would, with high probability, have marked Class II, Division 1 malocclusions. This is verified when we note that the two sibs, both boys, also developed the same type of malocclusion. The three boys were orthodontically treated, using premolar extraction to give a better balance between teeth and the supporting bone. Treatment was initiated after $\frac{7 | 7}{7 | 7}$ were established in occlusion. For all three boys the response was both good and rapid, and after a minimum of eight years the results are stable with excellent promise that they will remain so for some time. Especially striking in these three boys is the remarkable similarity of the growth patterns, the development of occlusal relations, and the favorable response to treatment.

So far, five developmental histories have been reviewed briefly for your consideration. The total growth picture has been presented, and the general lines showing the growth of bone and the growth of teeth have been emphasized to show their relationship to each other and their positions in the growth pattern of the whole child. Four of these children needed orothodontic treatment, and three received it.

In each case the individuality of growth has been shown through the use of a multidiscipline longitudinal approach to the problem. Finally, when we see the parts of particular interest placed more relevantly to the "whole" organism, we are in a better position to understand growth and, hence, to contribute more effectively to the management, solution, and guidance of particular problems.