On the Homology Between Human Development and Pediatrics

'He who sees things grow from their beginning will have the finest view of them' ARISTOTLE

Presidential Address to the Society for Pediatric Research^[5]

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My major concerns as pediatric investigator have followed two interdependent paths: investigation of some specific aspects of developmental biochemistry and a search for the relation between these studies in developmental biology to the discipline of clinical pediatrics. Since I have been consistently impressed by the dearth of training relative to the overall problems of human development in the medical school curriculum, my topic today concerns the importance of teaching and in investigation of human development. In addition, I would like to discuss the manner in which pediatrics is inextricably involved with this field.

In those societies where there is a great deal of disease and where overwhelming medical problems exist, it is very difficult to be a protagonist of the idea that normal human development should be a major area of concentration for the medical student and physician. In a privileged nation such as ours, the logic of such teaching is more obvious. I believe it is necessary to teach the facts and concepts of human development. Simply by examining the mortality statistics of the children from this country, we discover that congenital malformations, problems attendant to birth and prematurity, accidents, and homicides are the most prominent as causes of death of our children. All of these afflictions are related to questions of human development. Examination of the many causes of morbidity in children focuses this thesis sharply, and mental subnormality is an excellent example. One can extend the argument and indicate that the major problem in the United States today is the presence of poverty with its attendant environmental consequences: social, cultural, and maternal deprivation. These problems have a predictable adverse effect on the physical and mental growth of our children.

Many of us have declared both in writing and by speech that the pediatrician is the logical person to teach and investigate aspects of human development,

while recognizing that very few of us have been educated in the field. In fact, my concept of human development would construe pediatrics and obstetrics as the clinical and applied scientific arms of the field. I would maintain that the teaching of human development must occur early in a medical curriculum; should be a basic science equivalent to the other broad fields of biochemistry, physiology, and pathology; and that pediatrics and obstetrics are the natural specialties in which to apply much of this training.

Each of us has his personal definition of human development emanating from our specific interest. The developmental biologist construes human development to be vast and, with his prejudice, assumes that all the problems could be solved by molecular and cellular methodologies. This same individual would not consider the field of biology to be vast. The so-called child developmentalist considers human development to pertain solely to the psychosocial aspects of the individual and has utter disregard and some distaste for molecular and cellular phenomena. The psychologist and the pediatrician usually limit the term growth and development to physical anthropology, although the concept has recently been extended to include neurological behavior. All of these specialists function as members of discrete fraternities, taking little cognizance of the dependency of their particular field upon the others and of the need to inculcate the importance of biological sweep of time into our teaching and research programs.

To many physicians, human development, whether it be molecular, cellular, psychological, anthropological, or neurological, can be defined in some very broad terms embodying all of these previously mentioned fields which are really specific areas for research.

Human development has two major components. The first is the history of the organism, his phylogenesis, a study of his antecedents, so that we can obtain a more

complete understanding of how he evolved. In a practical sense, this would require the study of various animal models in order that we can learn more about the human animal.

To justify this claim, one need only survey the contributions made to our understanding of the human by studies of other species: the behavior of subhuman primates; the digestive enzymes of the sea lion; the comparative physiology of kidney, specifically the lungfish; and other examples too numerous to mention.

The second component concerns the ontogenesis of the organism comprising growth and differentiation. ARISTOTLE recognized this definition when he defined growth promoting as that which causes increase in bulk in contrast to nutritive, which today would be interpreted as differentiation. Growth should imply a longitudinal sequence of increase in amount of substance from impregnation through senescence. In molecular terms, it would imply an accumulation of molecules; in cellular terms, it would be proliferation; in psychological terms, it would be maturation. Consequently, growth is a quantitative term with time as an ordinate. Studies in development which recognized this relation were pursued by PIAGET, GREULICH, BAILEY, and SCANMAN. Others examined the vicissitudes of general physiologic parameters or changes in enzymatic activities in various organs at various times in the development of the organism. These data are all general indicators of growth.

Differentiation is equally as complex and probably less well understood. It involves primarily qualitative changes which might take place over an infinitesimally short period of time and implies that something new and different is created, whether it be a new enzyme, a new isozyme, a new cell organelle, a new movement, or a new conditioned response.

The history of these definitions extends over 2400 years, from the time of ARISTOTLE, when he wrote the *Generation of Animals* [1]. Through inductive-deductive approaches, ARISTOTLE introduced the use of comparative methods for the study of embryology, selected a theory of epigenesis, foreshadowed the modern theory of recapitulation and the doctrine of axial gradients, outlined the functions of the placenta and the intra-uterine environment, and evolved a rational approach to congenital malformations. Truly, ARISTOTLE is the father of the study of human development.

ARISTOTLE's experiences and investigations led him to expound his theory of 'Causes'. These theorems form the basis of his considerations concerning animal reproduction and development. A 'Cause' in the Aristotelean sense is the explanation of the existence of a thing. There are four 'Causes': (1) The Motive Cause—the agent which is responsible for the process by which a thing is made—the cause and effect; (2) The Material

Cause—that which indicates the matter out of which the thing is made; (3) The Formal Cause (Form)—the character of the course that the process follows; (4) The Final Cause—the objective of a formative process and the logic of its advance. ARISTOTLE felt that this Final Cause dominated every process. He believed that all of development was subservient to this cause. Many have used this philosophy to accuse ARISTOTLE of being a teleologist and cite as justification his statement, 'Nature does nothing without purpose'. To ARISTOTLE, full development of the individual was the ultimate purpose of Nature.

To illustrate these points, one can examine the human and say that the Motive Cause is the fertilization of the egg by the sperm with all the psychological aspects that led to the event. The Material Cause can be satisfied by biosynthetic processes and intrauterine physiology. The Formal Cause would be the entire process of differentiation culminating in the formation of different tissues, organs, and personality. The Final Cause would be the fully developed human who hopefully has *actualized* his biochemical, psychological, and social potential.

In stark contrast with our modern beliefs, the philosophic and social atmosphere of ancient Athens did not permit ARISTOTLE to consider seriously the major influences that environment has on the developmental process.

In 1888, ABRAHAM JACOBI [2] restated the Aristotelean thesis in very sophisticated language:

'The history of the embryo and fetus finds its legitimate termination in that of the infant and child. Thus embryology, teratology, and pedology, with pediatrics, are but chapters of the same book. The scientific consideration of any one of them is impossible without that of the others. The theories of heredity and consanguinity refer equally to all. The most important changes and diseases met within the young human being cannot be studied without the knowledge of its previous history, and the intelligent appreciation of embryology cannot be attained without the exact knowledge of its final outcome.'

Since this is the Society for Pediatric Research, I think it only reasonable to examine my statement from our insular viewpoint. What are our accomplishments as pediatricians in the area of human development and what are our failures? We state that pediatrics is the logical discipline to deal with problems of human development. Yet, we do not deal with them. We do not because we are untrained, and we are intimate with only a small segment of the panorama, generally extending from birth to 14 years of age. We do not adhere to our verbal expletives since those of us who stay within universities often tend to spend considerable time studying sporadic disease or phenomena. While doing so, we have little knowledge, give little thought and

devote little care to the relations of the specific problem to the individual and his movement through time. We do not in practice, since many of us in practice grumble and indicate that we were not trained for the realities of the outside world. At the same time, we are much more excited by a rare disease than by the development of the child. We tend to inculcate in our undergraduate and graduate students an appreciation for activities on the ward and denigrate activities within the nurseries and the outpatient departments. I believe, nevertheless, that the pediatrician has and must take a special role in the realm of teaching, investigation, and application of the principles of human development. In the arena of teaching, we could contribute the applied or clinical aspects of the basic science of human development.

In investigation, we separate into groups with deprecatory attitudes toward nonmembers of our particular establishment. We speak of one group as 'hard' science and therefore without humanism, and the other group as 'soft' science, consequently without tangibles. If we were to give this conflict a moment's thought, we would realize that the distinction between 'hard' and 'soft' science is unrealistic and that it is dependent upon methodology and the variables encountered. We speak of the hard scientist as the man who is fortunate enough to have his research evolve into a general biological law and the soft scientist as one whose research can only be generalized insofar as the group or individual with which he is dealing. We consider biochemistry or the biochemist in pediatrics the hard scientist, yet I can assure you that the physicist and biophysicist would consider him a soft scientist. Similar attitudes are held by the psychologists for the sociologists, and the sociologists for the anthropologists. It is imperative that communication between these groups be established so as to accumulate all of the knowledge necessary to understand development.

I have listed a number of debits of pediatricians, but there are considerable credits. Pediatricians could develop a cadre of the most qualified individuals to teach and to guide students in investigation of problems of human development. As the specialist who is constantly dealing with the most radically changing organism, the child, he is the person who is called upon to have knowledge of not only the molecular capabilities of the organism, but also his psychologic assets. He is the person in the medical sciences who has shown great flexibility in natural and social affairs. View our history: JACOBI, a revolutionary; GARROD, the hero of genetics; GAMBLE and DARROW, the luminaries of electrolyte metabolism; POWERS, the great clinician; BUTLER, the health organizer; LEVINE, the devotee of international health; and SPOCK, the man of political action. The pediatrician is the person who could narrow the gaps existing between all of these separate

campes, each with separate disciplines and titles, but making up the various subspecialties of human development. These thoughts, like most, are not new. They were beautifully expressed by JACOBI [3], when he stated at the time of the formation of the American Pediatric Society in 1889:

'I have tried to establish the claim of pediatrics to be considered a specialty. Not that it is one in the common acceptance of the term. It does not deal with a special organ, but with the entire organism at the very period which presents the most interesting features to the student of biology and medicine. Infancy and childhood are the links between conception and death, between fetus and the adult. The latter has attained a certain degree of invariability. His physiological labor is reproduction; that of the young is both reproduction and growth. As the history of a people is not complete without the narration of its condition when established on a solid constitutional and economic basis, so is that of man, whether healthy or diseased, not limited to one period. Indeed, the most interesting time, and the most difficult to understand, is that in which persistent development, increase, solidification, and improvement are taking place.

'I have tried to prove that pediatrics does not deal with miniature men and women, with reduced doses and the same class of diseases in smaller bodies, but that it has its own independent range and horizon...'

It has been said by most philosophers concerned with the acquisition, application, or theory of knowledge that an idea must be stated at a particular time in the development of society in order to gain adherents and protagonists. The history of science is replete with ideas and experiments that had to await the appropriate receptivity of man. One of the most striking examples is the work of GREGOR MENDEL. Now is the time for an organized study of the biology of human development.

My final statements would relate to the temper of our times. The teaching and investigation of development is dependent on applied and fundamental scientific information. Consequently, we must, as scientists, resist the constant pendular motion that has been characteristic of the Congress of the United States and our Government in regard to science. We would in a very short time be ineffectual if we would channel all our efforts into the application of science and disregard the acquisition of new knowledge. Neither can nor should exist without the other. Both require support, fiscal and emotional. It is true that we have many ills within this country which affect the development of individual children and will affect future generations of children. We cannot disregard the responsibility to our present citizens, but at the same time we cannot disregard our responsibility to the citizens of the future.

I believe it is imperative at the end of a talk before a Society such as this to have a conclusion and point as clearly as possible to the meaning of the results of the effort. I would like to leave the following recommendations with you, you in whose hands lies the future of American pediatrics.

I have attempted to indicate that as pediatric investigators and pediatric teachers, you can claim your heritage and become the teachers and investigators of the science of human development. It is irrelevant whether we function as embryologists, physiologists, molecular biologists, behaviorists, or investigators of methods of delivery of health care, as long as we remember that we are pediatricians responding to questions evolving from the developing organism, the clinical situation. Eventually, our mission is fulfilled when the answers to our queries contribute to an understanding of development.

As I leave the office of President of this Society, I feel it is appropriate to quote a passage from a book by the recently deceased, remarkable British pediatrician, Dr. SIMON YUDKIN [4]. I quote:

'It is our privilege as humans to pass on to the next generation all that our generation has learned and, ... to pass on also our own special experience. But, in addition, we can teach our children [and students] how to learn from our experiences and from their own so that they may gradually increase the range of human knowledge and be able consciously to plan a world more in accordance with their desires.'

I would like to react to the assertion of Yudkin by leaving you with an exhortation. Now is the time for those committed to the care of children to rise to the challenge by exploiting the incredible advances in the

biological sciences achieved over the past few decades. Now, we must become deeply involved in the intricacies of the biology of human development. The teaching, study, and application of this field of knowledge can satisfy the ultimate scientific desires and objectives of pediatric investigators. The pursuit of these activities will ensure an equal opportunity for every child to reach his full potential regardless of color, geography, or means, and this is, after all, the goal of pediatrics.

References and Notes

1. ARISTOTLE: Generation of animals (Harvard University Press, Cambridge, Mass. 1943).
2. JACOBI, A.: *Collectanea Jacobi*, vol. 1: Pediatrics. Address delivered before the American Pediatric Society at Washington, D. C., Sept. 20, 1889, 'The relations of pediatrics to general medicine', p. 48-49 (The Critic and Guide Company, New York 1909).
3. JACOBI, A.: *Collectanea Jacobi*, vol. 1: Pediatrics. Address delivered before the American Pediatric Society at Washington, D. C., Sept. 20, 1889, 'The relations of pediatrics to general medicine', p. 43 (The Critic and Guide Company, New York 1909).
4. YUDKIN, S.: *All our children*, chapter 2: 'How do our children grow', p. 21 (Reinhardt, London 1956).
5. Delivered at the time of the Annual Meeting of the Society, May 3, 1968, at Atlantic City, New Jersey.
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