The Gradient Theory

The gradient theory is recognized as Charles Manning Child's most significant scientific contribution. Gradients brought together Child's interest in development and his fascination with the origins of individuality and organization. The theory grew from his studies of regeneration, which were largely based on work he conducted with invertebrates, such as planaria, a flat worm, and the hydroid Tubularia. Child observed that regeneration occurred in a graded process along the axis of the organism, with the characteristics of each physiological process seemingly determined by its location along the axis. To explain these observations, Child posited the existence of physiological factors working to guide the regenerative process. He was convinced that these differences along the gradients could be explained quantitatively.

Child dedicated his career to searching for the mechanisms that governed development. By the late 1890s his research focused on development and reproduction in simple organisms. Working primarily with marine organisms, Child continued his research at various marine research stations, including Naples (1902–03), the Marine Biological Laboratory in Woods Hole, and others along the Pacific Coast. In 1895 he joined the University of Chicago where he remained until 1937.

Libbie Hyman, Child's graduate student and colleague, recognized Child's Individuality in Organisms as his most fruitful and outstanding book, wherein he advanced his ideas about gradients. It was here that Child elucidated his interest in the organization, development, and apparent unity of organisms and suggested an explanation for this unity: an anterior-posterior gradient responsible for coordinating development. To argue the existence of a gradient he described many of his experiments on regeneration in planarians illustrating a graded expression of physiological processes along the anterior-posterior axis of the organism.

He suggested polarity and symmetry were already present in the organism before developmental processes began to cause increasing differentiation and specialization. He examined the basic polar axis in organisms and described a general characteristic of polarity common across species: the apical or anterior end displayed the greatest level of metabolic activity, and the basal or posterior end displayed the lowest metabolic activity. Child studied developmental processes because he hoped his results would inform the understanding of order and organization in the individual. He presented his view as entirely mechanistic.

Child's gradient theory suggested that an externally induced metabolic gradient served as the foundation for physiological integration. He described gradients as "integrating factors" between the organism and the environment and suggested they were generated by the action of external factors on the protoplasm (or cytoplasm). External forces were seen as the cause of quantitative differences in the organism, which then led to the organized process of differentiation during development. Although he recognized that other theories had proposed quantitative differences in the organism, such as the existence of different entities, or " formative stuffs," he insisted that quantitative metabolic differences in the organism, or gradients, accounted for development. For example, he suggested that when particular substances gathered in a certain area of the organism, they did so in response to a gradient.

This physiological integration was suggested to be the result of a dominance-subordination relation within the organism. The area of the organism with the highest rate of metabolism responded most quickly to changes in the environment and dominated the areas of lower metabolism. This dominant region of the organism was relatively independent from the rest of the organism. It became the apical region or head of the organism and then determined the course of development along the major axis of the organism.

Child's experimental studies on regeneration conducted with his susceptibility assay led him to conclude that gradients determined physiological individuality and resulted from the interrelations between the organism and its external environment. By highlighting the importance of the external environment, Child drew attention to the organism's ability to alter its internal conditions in response to environmental stimuli. Although his gradient theory was criticized for its generality, Child's experimental system was not designed to extract specifics, but rather to generate evidence that was measurable in relative, quantitative terms. Child maintained that quantitative differences were sufficient to account for qualitative differences within the organism.

Sources

1. Child, Charles M. Individuality in Organisms. Chicago: University of Chicago Press, 1915.
2. Hyman, Libbie H. "Charles Manning Child 1869–1954." Biographical Memoirs of the National Academy of Sciences 30 (1955): 71–103.