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Opinion

A Reflection on Biological Development

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There is nothing contradictory in the possibility of the existence of natural phenomena that have been elusive to their complete understanding. Growth and Development (G&D) and its complexity is a good example. More and more, we can see in the literature, arguments that propose that a catalogue of genes is good to determine the traits of an organism but not enough to explain its organization. During the G&D, biological patterns, apparently stable, form in a discontinuous process of autoregulation following a model of molecular "diffusion-reaction", of molecules known as morphogens and an autodynamic maintenance through new metabolic paths, that in turn, regulate others within an intense interaction between regulatory factors and an alternative activation of genes systems. The genetic systems can specify what a cell can do, however, non-genetic phenomena are in charge to determine what actually the cell is doing. Specific patterns of proteins and RNA, are essential for embryogenesis being the elements that initiate the event's sequence guiding the morphogenic development from the embryonary and fetal structures, up to adult structures. The reductionist point of view that attempts to limit the G&D concepts to a dependence upon a genomic sequence, has been seriously questioned because it has not given a complete explanation of these processes.

A morphogen is a molecule controlling the formation of patterns during G&D in morphogenetic processes and in the location of different types of specialized cells within a given tissue. It may be specifically a signalling molecule acting directly on cells to produce a response, depending on it local concentration. Morphogens diffuse through the embryo´s structure since early stages of development, producing gradients that conduct the differentiation processes of not yet specialized stem cells, towards diverse cell lineages, forming at last all tissues and organs following the activation of various systems of genes. For instance, the genes systems involved in the segmental polarity during Drosophila´s development: wingless, hedgehog, engrailed, patch and cubitus interruptus.

The sequence in the formation of morphogenetic patterns is also crucial in the complex alternancy of processes during G&D. For instance the marine shells pigmentation studied by Meinhardt, that represent a process of high modelling resulting, apparently, from the chaotic nature of all the underlaying reactions, or on the other hand, a mechanism like the orientation of chemotactic cells in phyllotaxis. Concepts relevant to better understand the G&D.

It is clear that the genetic information is the same in all cells involved, but differentiation is completed through the action of regulatory proteins. Although the same genetic information is present there is a mechanism of aleatory fluctuations capable of initiate morphogenetic processes as long as the level of inhibitory molecules spreads out in all the involved area, and their interaction with activating molecules could be sufficient to generate an organized region with the appropriate molecular gradient that carry the activation of different systems of genes in different parts of the embryo. It is assumed that a stable activation induce the formation of pairs of somites. Each complete oscillatory cycle, in which FGF8 participates, a pair of somites is added, enabling also the sequential activation of the group of HOX genes.

The engines in the formation of morphogenetic patterns are de autocatalytic systems and the long reaching inhibition, confirming the outlined statement related to the "reaction-diffusion" process. It is assumed that the oscillations lead to the sequential activation of

specific genes, which allows an account of the formed segments, like predictive oscillatory patterns and spatial patters within the same molecular circuit. The NOTCH system is involved in these oscillations, as well as in the somite formation process. It has been also observed that there is a coupling of the oscillations and of the activation of the HOX system. There is an organizing region adequate to the actual morphogenetic pattern.

It is obviously relevant the relationship that exists between the intracellular and the intercellular molecular signalization with adjacent cells in order to obtain a coherent structure of the tissular pattern involved. To find their final location, a given ensemble of cells, for example those of the neural crest, it is necessary a precise correlation of reciprocal information with the target tissue or organ, the organism itself and with an enormous repertoire of morphogenetic patterns in a combinatory fashion.

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