Symmetry of STRUCTURE

an interdisciplinary Symposium

Abstracts

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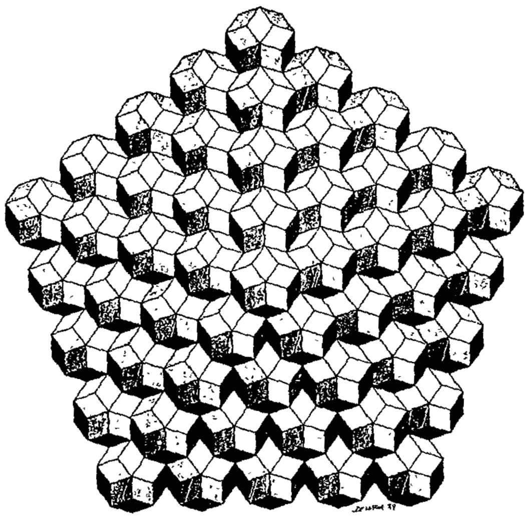

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Dissymmetrization in biological morphogenesis.

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Dissymmetrization is inevitable at all levels of life organization, in evolution and in ontogenesis. At the molecular and subcellular levels the breaking of primary order of liquid crystal organization (for example, arrangement of linear cytoskeletal structures) establishes a system of point and one-, two-dimensional singularities.

At the cellular level the topological equivalence of a cell (in particular, ovum) to a sphere does not mean that a cell possesses sphere symmetry. The cell surface and the cortical layer bear scalar and vector fields: heterogeneous polarized distribution of membrane and cytoskeletal components, biochemical gradients, directed ion currents and electric fields. All the fields disrupt the isotropic symmetry of spherical surface, as the vector field on a sphere inevitably possesses singularities.

Point singularities on spherical surface determine polarization of a cell. During integral polarization of a cell (chemotaxis or another directed movement, capping of somatic cells, ooplasmic segregation of eggs) subcellular components are displaced with respect to an immovable, stationary point in the process of continuous deformation. The existence of the stationary point also disrupts the initial spherical symmetry of a cell. Morphologically peculiar cellular site (biological pole) appears and functions as a source or sink during wave-like movement of subcellular components in the somatic cells or ooplasmic segregation wave in the eggs.

Breaking of primary symmetry in development is inevitable, it is programmed genetically and epigenetically. But cell environment asymmetry determines the localization of singular point and singular line, i.e., cellular polarization axis. In ovum, the orientation of animal-vegetal axis depends on environmental anisotropy during oogenesis i.e. contacts of the egg with cellular and extracellular structures of the ovary. Contact interrelations (cell-cell, cell-substrate), chemical and physical gradients of the environment may determine the orientation of polarization axis in the somatic cells.

Cell divisions during egg cleavage result in a certain pattern of cell contacts on blastula surface. The cell boundary pattern conforms to topological conservation principle; only five homogeneous patterns on spherical surface are possible. So during embryogenesis the cell contact pattern becomes heterogeneous: one or several cells inevitably acquire the greatest number of contacts. These cells become an initiation centre of morphogenetic cell movements during gastrulation. Following morphogenetic movements of cells and of cell sheets in embryogenesis reinforce the disruption of primary egg symmetry.