

MECHANICAL AND FUNCTIONAL ASPECTS OF MEMBRANE SKELETONS

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Membrane skeletons can be characterized as cytoskeletal structures lying parallel to the bilayer part of cellular and organelle membranes. Typical examples are spectrin networks and actin-myosin cortexes. The role and mode of action of membrane skeletons are not yet fully understood. One of still unresolved tasks is to identify the macroscopic cellular parameters that most directly reflect their activities. We approach the problem of elucidating the function of membrane skeletons by theoretically analyzing mechanical models of the cellular behavior. Membranes of different physical and chemical properties are considered. In erythrocytes and some organelles membrane bilayers are smooth and simply underlaid or overlaid by membrane skeletons. It is argued that there the role of a membrane skeleton is, either, to keep the membrane composition laterally homogeneous as it is in the case of the erythrocyte, or, that it is involved in the processes of the lateral separation of integral membrane proteins as it is happening in the case of some intermediate steps of the vesicular membrane trafficking. In the second type of membranes the bilayer part is ruffled and folded, and there the membrane skeletons play a role in the determination of the cortical tension. Here we in more detail explore the mechanical behavior of a cell with such properties of its boundary. The shape of a freely suspended cell is determined by assuming that it corresponds to the minimum of the membrane energy. Then, the shape transformations are described which occur under the influence (i) of different external forces, i.e., when an originally spherical cell is aspirated into the micropipette or when such a cell is adsorbed on a flat surface, and (ii) of different internal forces on the cell boundary exerted by the cytoskeletal elements. A significant outcome of the latter case is the notion of a mechanical origin of cellular polarity.