# II.4. SPACE BIOLOGY, BIOTECHNOLOGY AND MEDICINE

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**Introduction.** The program on space biology, biotechnology and medicine envisages:

— gaining principally new scientific knowledge about mechanisms of biological effects of microgravity on the population, organism, cellular and molecular levels;

— developing concepts on cell gravisensitivity and growth, development, reproduction, and resistance of organisms in microgravity.

It will promote creation of the space cell biotechnology for medicine and agriculture, express-methods for ecological monitoring of the biosphere, as well as development of new technologies for the Controlled Ecological Life-Support Systems (CELSS). These priorities of the program are based on the statement that proliferating and actively metabolising cells are the most sensitive to the influence of microgravity.

According to the conception on gravitational decompensation:

— cytoplasmic membrane is the primary site of the microgravity action;

— changes of the cytoplasmic membrane surface tension under essential lowering or absence of hydrostatic pressure can play an inductor role in modification of membrane's physical-chemical properties.

These changes modify membrane's permeability and receptors' functioning, as well as activity of membrane-bound enzymes, that, in its turn, leads to further metabolism changes resulting in physiological responses of cells and organisms to the microgravity action. A considerable attention is paid to space medicine directed to protection of human health, improvement of the quality and duration of the astronauts' life in a long-term space flight.

Space biology and medicine are the most important in the system of space sciences. Studying the biological effects of space flight factors, especially of microgravity and heavy charged space particles, the space biology obtains principally new scientific knowledge for solving fundamental problems of modern biology, namely:

— role of gravity in vital activity of organisms on Earth;

— influence of microgravity at the organism, cellular and molecular levels;

— establishment of the range of damage effects of heavy charged particles and ways of their reparation;

— working out the CELSS in long-term space flights and prediction of their functioning;

— development of the cell biotechnology in space.

During the last 25 years, complex research of bacteria, lower and higher plants, animal and plant organ, tissue and cell cultures has been performed on board the biosatellites, spaceships and orbital stations. It was conducted by the cytological, biochemical, biophysical and molecular-biological methods. Electron microscopic method was used in Ukraine for the first time in the world for evaluation of the influence of space flight factors on cells. As a result of this integrated research, the following conclusions have been made:

— lower and higher plants grow and develop in microgravity during a certain time;

— morphogenesis, division and differentiation of cells occur without essential deviations from the norm under microgravity;

— microgravity has an essential effect on cell metabolism; modifications of metabolism are reflected as rearrangements of cell ultrastructure, i. e., the cell is sensitive to gravity;

— microgravity upsets the intracellular calcium balance;

— changes in metabolism under microgravity lead to acceleration of cell differentiation and ageng;

— microgravity belongs to such alteration factors, which do not prevent the adaptive reactions at the cellular and organism levels in the range of physiological response, i. e., within the scope of

genetically determined program of ontogenesis.

The following directions of contemporary space life sciences should to be noted: 1) gravitational biology, 2) radiation biology, 3) planetary biology and prebiotic synthesis, and 4) natural and artificial ecosystems. The principal investigations of Ukrainian space biologists have been carried out in the field of gravitational biology. For this reason, a significant number of biological experiments on board the URM are intended to verify the conceptual ideas of Ukrainian scientists in this field. New methodological approaches to performance of the space and ground-based experiments with clinostats and centrifuges are considered as well.

Experiments proposed in the field of life sciences on board the URM are arranged in accordance with divisions of the Program and are presented below.

## Division 1

# BIOLOGY OF A CELL UNDER MICROGRAVITY; CYTOSKELETON ARRANGEMENT, CALCIUM HOMEOSTASIS, MECHANISMS OF GRAVISENSITIVITY OF LIVING SYSTEMS AT THE CELLULAR AND MOLECULAR LEVELS («Biolaboratory» Project)

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**Introduction.** A discovery of cell gravisensitivity, including plants, has attracted attention to elucidation of the mechanisms of biological effects of microgravity at the cellular, subcellular and molecular levels and understanding how organisms grow, develop and reproduce in the absence of gravity. The conception, which consists in that proliferating and actively metabolizing cells are the most sensitive to the influence of altered gravity, has been assumed proceeding from experimental data on the changes in cell metabolism under microgravity. Simultaneously, this conception propounds the following questions. What are the primary events underlying metabolism changes under microgravity? What are the second messengers taking part in transfer of the primary signals of microgravity? Does the gene expression undergo changes in microgravity? What peculiarities of cell metabolism regulation can be present in microgravity? Why the carbohydrate and lipid metabolism is the most sensitive to the influence of microgravity? Do the parameters of a cell cycle and proliferation activity change in microgravity? How are the changes in metabolism under microgravity integrated into physiological responses in the cells of different types connected directly with realization of their functions?

Trying to provide answers to these questions, a hypothesis of gravitational decompensation was assumed. According to this hypothesis, a change in the surface tension of the cytoplasmic membrane can play an inductor role in rearrangements of its physical-chemical properties under reduction or absence of hydrostatic pressure. The effect of such an inductor increases owing to its heterogeneity over the length of the cytoplasmic membrane. In the gravitational field, the surface tension and gravitational force are summed up, if they act in the same direction and are subtracted if their directions are opposite. In the absence of gravity, only the surface tension is present (gravitational decompensation). Under the conditions of a clinostat, the resulting action of these two forces is continuously changed in