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The Study of Mechanical Properties of Biological Cells

Liu L*

Changchun University of Science and Technology, China

***Corresponding author:** Lanjiao Liu, Changchun University of Science and Technology, Changchun City, Jilin Province, China, Email: liul@cust.edu.cn

Editorial

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Editorial

Cells are the basic unit of all living organisms. They can realize various specific functions of living organisms such as energy conversion, material transportation, signal transduction, and expression of genetic information. They are the foundation for human research on the life activities of all living organisms. As a line of defense for cells to protect themselves, the cell membrane has certain mechanical properties that can ensure the balance and stability of various normal biochemical reactions inside and outside the cell during its survival, such as cell growth, movement, division, etc. When cells face changes in the environment, their surface mechanical properties will also change to a certain extent. However, the mechanism and manner in which cells respond to environmental influences are still not very clear. Therefore, in order to understand this complex mechanical behavior of cells in living organisms, it is necessary to analyze the mechanical properties of the cell surface.

In recent years, experts and scholars from many countries have conducted a large number of experimental studies on biomechanics, especially on the mechanics of single cells. Research shows that the occurrence of disease can lead to changes in the structure and mechanical properties of cells, and each disease has its own specific mechanical manifestations. In other words, any changes in the structural and mechanical properties of cells may cause abnormalities in their tissue structure, thereby triggering disease. Studying the mechanical properties of single cells will help humans understand the pathogenesis of diseases (including cancer) more clearly, and provide theoretical basis and new research methods for early screening and diagnosis of diseases. On the other hand, as humans look forward to scientific and technological progress and breakthroughs in fatal diseases, people have begun to cultivate and study cells more in vitro. For example, studying the expression and transport of protein molecules in cells. However, as the basis for research, cells need a favorable environment suitable for their survival and development, which places certain requirements on the biocompatibility of surface materials. Therefore, the study of the interaction between cells and material surfaces, and between cells and cell surfaces, will provide a theoretical basis for the development of functional materials and the study of interactions between biomolecules.

In recent decades of research, people have revealed some of the mechanisms related to cell function and pathology. At present, most research on cell mechanical properties focuses on several aspects such as cell elastic modulus, hardness and adhesion.

Cell Elastic Modulus

Most studies on cellular elastic modulus focus on comparisons between normal cells and mutant cells or cells with artificially altered structures. Li, et al. and Nikkhah, et al. showed that nonmalignant breast epithelial cells exhibited a significantly higher Young's modulus than their malignant counterparts [1,2]. Lekka, et al. used AFM to detect cancer cells, and the results showed that the elastic modulus of normal cells is larger than that of cancer cells [3]. From recent research, it is not difficult to find that the elastic modulus of normal cells is larger than that of mutant cells or cells with artificially changed structures. Therefore, the study of elastic modulus is extremely meaningful. Through studying it, people can further understand the mechanism of action of cells, as well as the diagnosis and treatment of cancer.

Cell Stiffness

Hayashi et al. used AFM to test the stiffness of human cervical cancer cells (HeLa) and human cervical cells (End1/E6E7) and found that Hela cells were softer than End1/E6E7 cells. Cancer cells all have the ability to invade and metastasize, and the ability to invade and metastasize is related to the mechanical properties of the cells. Many scientific researchers have found that cells with high stiffness are relatively difficult to deform and move. The Key Laboratory of Electronic Testing Technology of North China University used microfluidic chips to test the mechanical properties of cancer cells. The results showed that the hardness of leukemia cell lines (NB4 cells) increased significantly under the action of 0.05 μmol/L doxorubicin [4]. Cross et al. reported that healthy cells were 30% stiffer than metastatic cancer cells [5].

Cell Adhesion

Compared with the testing and analysis of cell elastic modulus and hardness, there are few experimental reports on cell adhesion. Since cell adhesion is easily affected by other external factors, such as contact materials, contact area size, external force, etc., most testing and analysis of cell adhesion focus on its trend changes. Yang et al. studied the interaction mechanism between the cell surface adhesion molecule ICAM-1 and integrin Mac-1. Studies have found that the binding degree of integrin Mac-1 to the adhesion molecule ICAM-1 is enhanced after activation. This result provides a theoretical basis for studying the activation mechanism of Mac-1 [6]. Cooper, et al. discovered that cell adhesion properties are related to the abnormal growth and metastasis of cancer cells [7]. Elter, et al. [8] research showed that the biocompatibility of substrate materials is crucial for the adhesion behavior of cells to their surfaces. Judging from the current research results, the adhesion between cells and substrate materials, cells and cells, or other molecules is very meaningful. The research results will provide a solid theoretical basis for in vitro cultivation, micro-surgery, etc.

In summary, the study of mechanical properties of biological cells plays an important role in the understanding of the complex mechanical behaviors of cells in living organisms, and is of great significance in the fields of biological cytology and biomedicine.

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