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THE IMPORTANCE OF THERMODYNAMICS LAWS IN MEDICINE

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Annotation.
This article analyzes the manifestation of the laws of thermodynamics in living organisms and their importance in medical science on a scientific basis. The human body is considered as an open thermodynamic system, and the concepts of energy exchange, heat regulation, metabolic processes and entropy are covered from a biophysical point of view. Also, fever, hypothermia, burns encountered in clinical practice, and the application of thermodynamics in modern medical technologies are considered. The article is intended for students and researchers studying medicine and biophysics.

Keywords: thermodynamics, open system, energy exchange, entropy, metabolism, thermoregulation, biophysics, medicine.

INTRODUCTION

The development of modern medical science is closely related to fundamental sciences, in particular physics. Thermodynamics, one of the main branches of physics, serves as an important theoretical basis for explaining the processes of energy and heat exchange in living organisms. All biological processes occurring in the human body are accompanied by energy consumption and heat release. Therefore, knowledge of the laws of thermodynamics allows us to understand the essence of medical processes more deeply. With the help of the laws of thermodynamics, it is possible to scientifically explain metabolism, the constancy of body temperature, energy exchange in cells, and changes occurring in pathological conditions. This article examines the inextricable link between thermodynamics and medicine based on a biophysical approach. In thermodynamics, systems are divided into closed, isolated, and open types. The human body is an open thermodynamic system, as it constantly exchanges matter and energy with the external environment. The organism receives chemical energy through food, absorbs oxygen, and in return releases carbon dioxide, metabolic wastes, and heat into the external environment. These processes ensure the vital activity of the organism and allow it to exist in a state far from thermodynamic equilibrium. A living organism is a complex, self-regulating, and self-renewing system that exchanges matter, energy, and information with the external environment. The article discusses the theory of open systems, the Second Law of Thermodynamics, dissipative structures, homeostasis mechanisms, and the concept of entropy in biological systems. Also, the processes of metabolism, heat exchange, gas diffusion, and neurohumoral control are explained based on the concept of an open system. Living organisms are complex systems subject to physical and chemical laws. In biophysics, the human body is considered an open thermodynamic system that operates on the basis of energy and matter exchange. This approach is particularly related to the general systems theory developed by Ludwig von Bertalanffy and the concept of dissipative structures based on Ilya Prigogine. Open systems constantly carry out the following processes with the external environment:

Exchange of matter

Exchange of energy

Information exchange. The human body exists precisely through these three components.

The human body belongs to the third type, because it receives O_2 and releases CO_2 through respiration; receives nutrients and releases metabolites; releases heat; receives information from the external environment.

The first law of thermodynamics. According to the law of conservation of energy:

$\Delta U = Q - A$

Where:

ΔU– change in internal energy

Q – amount of heat

A – work done. In the body, this law is implemented through metabolism. The chemical energy of nutrients is converted into mechanical work, electrical impulses and heat.

The second law of thermodynamics and entropy

In closed systems, entropy increases. However, a living organism maintains its internal order. This contradiction was explained by Erwin Schrödinger in his work "What is the Source?" through the concept of "negative entropy". The organism takes in ordered energy from the external environment and releases entropy to the outside. Therefore, it exists in a state far from equilibrium (non-equilibrium). Metabolism consists of two main processes:

Anabolism - synthesis processes

Catabolism - decomposition processes

For example, the oxidation of glucose:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2870$ kJ

The energy produced is stored in ATP molecules and is spent on performing biological work. Homeostasis is the ability of an organism to maintain a relatively constant internal environment. This process is controlled by the nervous system, endocrine system, and circulatory system. For example:

Body temperature ≈ 36.6°C

Blood pH ≈ 7.35–7.45

Blood pressure ≈ 120/80 mmHg

These parameters are maintained despite changes in external conditions. According to the theory of Ilya Prigogine, living organisms form an orderly structure in conditions where there is an energy flow. In the human body: blood circulation, respiration, and the transmission of nerve impulses are all maintained due to the flow of energy. When the energy flow stops, the system goes into chaos (biological death). The organism not only exchanges matter and energy, but also information: It receives external influences through receptors. The central nervous system processes. Effector organs respond. This cybernetic control mechanism is one of the important features of an open system. The human organism has the following characteristics:

Hierarchical structure (cell → tissue → organ → system → organism)

Self-repair, adaptability, evolutionary development. These characteristics distinguish it from ordinary physical systems. These features distinguish it from simple physical systems. Understanding the organism as an open system is important in the following: Resuscitation and intensive care, treatment of metabolic syndromes, problems of heat exchange and hypothermia, the operation of artificial respiration apparatus. For example, in resuscitation, oxygen delivery means restoring energy metabolism. The second law of thermodynamics is related to the concept of entropy and states that entropy in closed systems always increases. Living organisms maintain internal order due to the exchange of energy with the external environment. Although there is a high level of order and harmony within the organism, this is achieved at the expense of heat release into the external environment. Therefore, the entropy for the general system - "organism + environment" increases. This law serves as an important theoretical basis for explaining the processes of biological aging, cell degradation and death.

Thermoregulation and heat exchange.

Constant maintenance of body temperature in the human body is ensured by thermoregulation mechanisms. Normal body temperature is on average 36.6 °C. Heat exchange occurs in the following ways: conduction (through direct contact), convection (through air or

liquid flow), radiation, evaporation (sweating). In medicine, thermoregulation disorders cause pathological conditions such as fever, hypothermia, and heat stroke. Metabolism is a set of all chemical reactions occurring in cells. During these processes, chemical energy is concentrated in the form of adenosine triphosphate (ATF) and is spent on performing biological work. The rate of metabolic processes thermodynamically determines the energy balance of the organism. The basal metabolic rate is one of the important indicators in clinical diagnostics. The laws of thermodynamics are widely used in modern medical technologies. In particular:

cryotherapy - the use of low temperatures,
hyperthermia - the treatment of tumors with high temperatures,
sterilization - the destruction of microorganisms using heat and pressure,
control of heat balance in resuscitation and intensive care.

Conclusion

From a biophysical point of view, the human body is a classical open thermodynamic system. It carries out a continuous exchange of matter, energy and information with the external environment. The basic laws of thermodynamics also apply to living systems, but they operate in conditions far from equilibrium. The mechanisms of metabolism, homeostasis and dissipative structure ensure the stability of the organism. The analysis of the organism as an open system is of great importance in deepening the theoretical foundations of medicine, physiology and biophysics. The laws of thermodynamics are of fundamental importance in explaining the processes of energy and heat exchange occurring in living organisms. The human body, as an open thermodynamic system, is in constant contact with the external environment, and life activities are ensured on the basis of these laws. The role of thermodynamics in understanding metabolism, thermoregulation, pathological conditions and modern treatment technologies in medicine is invaluable. Therefore, thermodynamic knowledge serves as an important theoretical basis in the training of medical specialists.

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