

Living organism as a thermodynamic system

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Heading text

LIVING ORGANISM AS THERMODYNAMIC SYSTEM

INTRODUCTION

Thermodynamic in the biological systems: Thermodynamic studies the thermal energy and its transformation through the functions of state (Entropy, Enthalpy, Gibbs Free Energy, etc..). The living organisms are an open system that exchange with the environment matter and energy. The production of heat in most organisms is done during cellular respiration, but can be also influenced by external sources, such as sun radiation. The transport of heat in human body is done by the circulation of blood through the body, and in order to maintain the temperature constant we can lose, or even gain, heat by convection, conduction and radiation. The hypothalamus is the gland responsible for thermoregulation of body temperature.

PRODUCTION OF HEAT

The organisms can get energy and heat by external sources or internal sources. As external sources we can mention: Environmental Energy, Food (Nutrition and Radiation Absorption). The Internal sources are the basal Metabolism of all Cells that will lead to the production of ATP that is necessary for the metabolic reactions. Some animals, called heterothermic, are dependent on environmental energy to regulate their body temperature, which means that to get warm they need to lie on the sun (they are absorbing the radiation from the sun), or go to a cool rock to get colder (because, two corps at different temperatures have the tendency to achieve the thermal equilibrium) The Plants, during photosynthesis, absorb radiation and convert it into chemical Energy that is stored in carbohydrates molecules, which are synthesized from water and carbon dioxide. When animals consume these plants as food, they get energy by breaking the molecules of sugar and transforming them into ATP through cellular respiration process. This process occurs in mitochondria in four main steps: Glycolysis, Decarboxylation of pyruvate, Krebs cycle and Oxidative Phosphorilation. During cellular respiration an amount of 674000 calories is produced, part of this energy is store in ATP molecules and used to intercellular energy transfer and other part is released and used as a source of heat, responsible to maintain constant the body temperature. The Animals can also produce heat by other internal sources as the muscular tension by the muscular tremor- shivering, this is common when the body as to react to a low environment's temperature or to a loss of body's heat.

HEAT TRANSPORT

The cardiovascular system is the main responsible of heat distribution throughout the body. The blood is used as vehicle to transport heat, by convention, from the areas of high heat to areas of lower heat. This process usually occurs in the direction from body core to extremities such as the limbs and head. In heat transport it is also present, conduction and radiation processes. The heat carried by the blood is determined by the temperature of the surrounding tissue, velocity of the flow, the diameter of the blood vessel, the thickness of the fluid, and the heat transfer coefficient of the blood.

LOSS OF HEAT

In warm-blooded animal life depends on homeostasis that is the maintenance of the constant internal conditions. One of the manifestations of homeostasis is the constant body temperature. For mammals this temperature should be between 35 - 39.5 °C, changing from specie to specie. To maintain constant body temperature part of the heat produced in cells during respiration must be dissipated. Living organisms can lose heat by the loss of water through sweating and breathing (the heat of vaporization of water is 2260 KJ/Kg), but also by convection, conduction and

radiation. We have two types of sweating, imperceptible sweating and Perceptible Sweating. The imperceptible sweating is the normal condition of the body during the day. The body reacts to a high body temperature by spontaneous diffusion of water through the skin without using sweat glands. The human being loses 660 ml of water per day in standard condition. Instead in the Perceptible Sweating the human body is in an extreme condition where the water loss is of 1.5L per hour. The body is reacting to a very high environment's temperature, by the utilization of the sweat glands and this mechanism in fact enables the cooling of the organism if the temperature of the surrounding is higher than the body temperature. By radiation we can also lose, to the environment, the heat produced in our body. The convection consists of the transfer of heat by the circulation of the heated parts through a liquid or gas, so by this process, the air or water, flowing by the skin, can carry away body heat. The body conducts heat to whatever the skin is in direct contact with. Conductive heat loss occurs when the skin is in contact to either cold air or water.

THERMOREGULATION

The thermoregulation is the maintenance of body's temperature, it's a physiological mechanism that leads to the production or loss of heat. The Hypothalamus is the gland responsible for certain metabolic processes, as the homeostatic mechanism of maintenance of the body temperature, by the realizing of some hormones. The temperature sensors throughout the body respond to these hypothalamic hormones, by tremor shivering, sweating, vasoconstriction/ vasodilatation.

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Učební texty University Karlovy v Praze, Prague 2011