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PHYSIOLOGICAL BASIS OF PHOTOSYNTHESIS AND PLANT PRODUCTIVITY

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Abstract: This article examines the biological and biochemical foundations of photosynthesis, its stages, and its role in the energy metabolism of plant cells. The light and dark phases of photosynthesis, the structure of chloroplasts, and the functions of chlorophyll pigments are analyzed based on scientific literature. In addition, the ecological role of plants as producers in the biosphere, the impact of environmental pollution on photosynthetic processes, and the significance of bioindication and environmental monitoring are discussed.

Keywords: photosynthesis, light phase, dark phase, chloroplast, chlorophyll, energy metabolism, Calvin cycle, bioindication, environmental monitoring, biosphere, producers.

Cells need energy to function. Like all living organisms, green plants obtain energy from carbohydrates and other organic substances during respiration. However, unlike most organisms, green plants synthesize organic substances themselves from inorganic substances using light energy [1]. This process is called photosynthesis. During photosynthesis, light energy is converted into chemical energy [5]. This is its uniqueness. The oxygen released is used for respiration. Photosynthesis consists of two interconnected processes: the oxidation of water to oxygen and the reduction of carbon dioxide to polysaccharides using hydrogen in water [6]. In 1905, the English plant physiologist F.F. Blackman discovered that photosynthesis can be divided into two phases: the light phase (which requires light to proceed) and the dark phase (which does not require light itself, but requires substances formed during the light phase) [3]. These substances are not stored, so despite the name, the dark phase occurs only during the day [4]. In 1779, the Dutch physician J. Ingenhuys, based on numerous experiments, showed that not only light, but also the green part of the plant is necessary for photosynthesis. In 1818, the French scientists P. Peletier and A. Cavenu isolated a green substance from leaves and called it chlorophyll [1].

The main organ of the plant where photosynthesis occurs is the leaf. Since most of the leaf is covered with a cuticle that is poorly permeable to gases, CO2 enters the tissues mainly through stomata; within the tissues, it diffuses through widely branched intercellular air passages [7]. In the upper part of the leaf, palisade parenchyma is located, the cells of which are densely packed, perpendicularly arranged, and contain many chloroplasts. It is this palisade parenchyma that is the main assimilation tissue [8]. At the same time, water, mineral ions, and assimilates are transported through a system of vessels distributed throughout the leaf [1].

The light phase takes place directly in the chloroplasts and consists of the absorption of light photons by chloroplast pigments and the conversion of this physical energy into the chemical energy of macroergic molecules [6].

The dark phase of photosynthesis takes place in the stroma of chloroplasts. High-energy compounds - ATP and reduced NADPH - pass into the stroma. Carbon dioxide, a source of carbohydrates (taken from the air and entering the plant through stomata), also comes here. In the reactions of the dark phase, carbon dioxide is reduced to glucose using the energy stored in ATP and NADPH molecules. The conversion of carbon dioxide to glucose during the dark phase of photosynthesis is called the Calvin cycle [6]. Plants are part of the biosphere, and their trophic level is producers. As a result of pollution of the biosphere, all its components are destabilized [2]. At each trophic level, heavy metals and pollutants accumulate and migrate along food chains. One of the important areas is environmental monitoring of the environment and recycling of waste based on environmentally friendly technologies. One of the important areas of monitoring is bioindication.

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