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OXYGENIC PHOTOSYNTHESIS

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ANNOTATION

In this paper, the types of photosynthesis phase in the flora, space localization, light-dependent phase photochemical nature of the process, light-collecting complexes-b6f or b / f complex, electron cycle and pseudo-cycle transport, The Calvin and Hatch-Slack cycles discuss the importance of photosynthesis.

Keywords: anoxic, bacteriosclerophilic, CAM (crassulaceae acid metabolism), lamellae, NADFN, caratenoids, SSK-photosystem, b6f or b / f complex, phylloquinone, pseudocycle, Calvin and Hatch-Slack-Karpilov cycle

ANNOTATSIYA

Ushbu maqolada, flora olamidagi Fotosintez bosqichining turlari, bo'shliq lokalizatsiyasi, yorug'likka bog'liq bo'lgan bosqichi jarayonning fotokimyoviy mohiyati, yorug'lik yig'uvchi komplekslar-b6f yoki b/f kompleks, elektronning sikli va psevdo sikl transporti, Kalvin va Xetch-Slack sikli, fotosintezning ahamiyati haqida fikr yuritiladi.

Kalit so'zlar: anoksigenik, bakteriosklorofil, CAM(crassulaceae kislotasi almashinuvi), lamellar, NADFN, karotinoidlar, SSK-fotosistema, b_{6f} yoki b/f kompleks, filloxinon, psevdosikl, Kalvin va Xetch-Slack-Karpilov sikli

АННОТАЦИИ

В этой статье описаны типы фаз фотосинтеза во флоре, пространственная локализация, светозависимая фаза, фотохимическая природа процесса, светособирающие комплексы-b6f или b / f комплекс, электронный цикл и псевдоцикловый транспорт, Кальвин и Хэтч - Затемные циклы обсуждают важность фотосинтеза.

Ключевые слова: аноксический, бактериосклерофильный, CAM (кассульный кислотный обмен), ламеллы, НАДФН, каратеноиды, SSK-фотосистемы, b6f или b / f комплексы, филлохинон, псевдоцикл, цикл Кальвина и Хэтча-Слака-Карпилова

INTRODUCTION

Photosynthesis is the process of formation of organic matter from carbon dioxide and water in the light with the participation of photosynthetic pigments (chlorophyll in plants, bacteriochlorophyll and bacteriorhodopsin of bacteria). In modern plant physiology, photosynthesis is more often understood as a photoautotrophic function, a combination of processes of absorption, conversion and use of the energy of light quanta in various endergonic reactions, including the conversion of carbon dioxide into organic substances,

Types of Photosynthesis

Anoxygenic carried out by purple and green bacteria, also helicobacteria. Oxygenic - Oxygenic is much more widespread. It is carried out by plants, cyanobacteria and prochlorophytes.

Stages of Photosynthesis

Photosynthesis occurs in three stages: photophysical,photochemical, chemical. At the first stage, light quanta are absorbed by pigments, their transition to an excited state and energy transfer to other molecules of the photosystem. (At the first stage, the particles of the light spectrum (light wave) are absorbed by the pigment material, their excitation and transfer of bioenergy to other elements of the photosystem).

At the second stage, there is a separation of charges in the reaction center, the transfer of electrons along the photosynthetic electron transport chain, which ends with the synthesis of ATP and NADPH. The first two stages in place are referred to as the light-dependent stage of photosynthesis.

The third stage takes place without the obligatory participation of light and includes biochemical reactions of the synthesis of organic substances using the energy accumulated at the light-dependent stage. Most often, the Calvin cycle, gluconeogenesis, the formation of sugars and starch from carbon dioxide in the air, is considered as tannins. The first processes of photosynthesis in cyanobacteria appeared in Archean era.

Spatial Localization

Photosynthesis of plants is carried out in chloroplasts: two separate membrane organelles of the cell. Chloroplasts can be in the cells of fruits, stems, but the main organ of photosynthesis, anatomically adapted to its control, is the leaf. In the leaf, the tissue of the palisade parenchyma is the richest in chloroplasts. In some succulents with degenerate leaves (for example, cacti, the main photosynthetic activity is associated with the stem. Light for photosynthesis is more fully captured due to the flat shape of the leaf, which provides a large surface-to-volume ratio. Water is delivered from the root through a developed network of vessels (vein-clist). Carbon dioxide enters in part through diffusion through the cuticle and epidermis, but most of it diffuses into the leaf through the stomata and along the leaf through the intercellular space. Plants that carry out C4 and CAM (Crassulaceae acid metabolism) photosynthesis have formed special mechanisms for the active assimilation of carbon dioxide. The inner space of the chloroplast is filled with colorless contents (stroma) and permeated with membranes (lamellae), which combine with each other to form thylakoids, which in turn are grouped into drains called granas. Inside, the thylakoid space is separated and does not communicate with the rest of the stroma, it is also assumed that the internal space of all thylakoids communicates with each other. The light stages of photosynthesis are confined to membranes; autotrophic fixation of CO2 occurs in the stroma. Chloroplasts have their own DNA, RNA, ribosomes (type 70s), protein synthesis is in progress (although this process is controlled from the nucleus). They are not synthesized again, but are formed by division of the preceding ones. All this made it possible to consider the precursors of free cyanobacteria, which entered the composition of the eukaryotic cell in the process of symbiogenesis. Cyanobacteria, thus, are, as it were, a chloroplast themselves, and in their cell the photosynthetic apparatus is not carried out into a special organelle. Their thylakoids, however, do not form stacks, but form various folded structures (the only cyanobacterium Gloeobacter violaceus lacks thylakoids at all, and the entire photosynthetic apparatus is located in cytoplasmic membrane that does not form invaginations). They and plants also have differences in the light-harvesting complex (see below) and the pigment composition,

Light (Light Dependent) Stage

During the light stage of photosynthesis, high-energy products: ATP, which serves as a source of energy in the cell, and NADPH, which is used as a reducing agent, oxygen is released as a by-product. In general, the role of light reactions of photosynthesis is that an ATP molecule and proton carrier molecules, that is, NADPH, are synthesized in the light phase.

Photochemical Essence of the Process

Chlorophyll has two excitation levels (this is associated with the presence of two maxima in its absorption spectrum): the first is associated with the transition to a higher energy level of an electron of the system of conjugated double bonds, the second with the excitation of unpaired electrons of nitrogen and magnesium of the porphyrin nucleus. With a constant electron spin, singlet first and second excited states are formed, with a changed one, the first and second triplet states. The second excited state is the most highly energetic, unstable and chlorophyll in 10-12 seconds passes from it to the first, with a loss of 100 kJ / mol of energy only in the form of heat. A molecule can pass from the first singlet and triplet states to the ground state with the release of energy in the form of light (fluorescence) or heat, with the transfer of energy to another molecule, or, since an electron at a high energy level is weakly bound to the nucleus, with the transfer of an electron to another compound. The first possibility is realized in light-harvesting complexes, the second one - in reaction centers, where chlorophyll, passing into an excited state under the influence of a quantum of light, becomes an electron donor (reducer) and transfers it to the primary acceptor. To prevent the return of an electron to the positively charged chlorophyll, the primary acceptor transfers it to the secondary. In addition, the lifetime of the compounds obtained is longer than that of the excited chlorophyll molecule. Energy stabilization and charge separation occurs. For further stabilization, the secondary electron donor restores positively charged chlorophyll, while the primary donor in the case of oxygenic photosynthesis is water. The problem that organisms conducting oxygenic photosynthesis are faced with is the difference in the redox potentials of water (for the half reaction H, 0 - O, E

0.82 V) and NADP + (E. 0.32 V). At the same time, chlorophyll in the ground state must have a potential greater than + 0.82 V in order to oxidize water, but at the same time, in an excited state, it must have a potential less than -0.32 V in order to reduce NADP +. A single chlorophyll molecule cannot meet both requirements. Therefore, two photosystems were formed, and for the complete process to be carried out, two light quanta and two chlorophylls of different types are required.

Light Harvesting Complexes

Chlorophyll has two functions: absorption and transfer of energy. More than 90% of all chlorophyll in chloroplasts is part of light-collecting complexes (SSC), which act as an antenna that transmits energy to the reaction center of photosystems I or II. In addition to chlorophyll, SSC contains carotenoids, and some algae and cyanobacteria have phycobilins, whose role is to absorb light of those wavelengths that chlorophyll absorbs relatively weakly. Energy transfer occurs in a resonant way (Förster mechanism) and takes 10^{10}-10^{12} seconds for one pair of molecules, the distance over which the transfer is carried out is about 1 nm. The transfer is accompanied by some energy losses (10% from chlorophyll to chlorophyll b, 60% from carotenoids to chlorophyll), which is why it is possible only from a pigment with a maximum absorption at a shorter wavelength to a pigment with a larger one. It is in this order that the SSC pigments are mutually localized, with the longest-wavelength chlorophylls located in the reaction centers. The reverse energy transfer is impossible. The SSC of plants is located in the membranes of thylakoids, in cyanobacteria, its main part is carried outside the membranes into the phycobilisomes attached to them - rod-shaped polypeptide-pigment complexes, in which various phycobilins are located: on the periphery of phycoerythrins (with a maximum absorption at 495-565 nm), followed by phycocyanins (550-615 nm) and allophycocyanins (610-670 nm), sequentially transferring energy to chlorophyll a (680-700 nm) of the reaction center.

Photosystem II

The photosystem is a collection of CCK, photochemical reaction center and electron carriers. Light-harvesting complex II contains 200 chlorophyll a molecules, 100 chlorophyll A molecules, 50 carotenoid molecules and 2 pheophytin molecules. The reaction center of photosystem II is a pigment-protein complex located in the thylakoid membranes and surrounded by SSC. It contains a dimer of chlorophyll ac with an absorption maximum at 680 nm (P680). Ultimately, the energy of a quantum of light from the SSC is transferred to it, as a result of which one of the electrons goes to a higher energy state, its connection with the nucleus is weakened and the excited P680 molecule becomes a strong reducing agent (E-0.7 V). P680 reduces pheophytin, then the electron is transferred to the quinones that are part of the b. composition of PSI and then to plastoquinones, which are transported in the reduced form to the b_6f complex. One plastoquinone molecule carries 2 electrons and 2 protons, which are taken from the stroma. The filling of an electronic vacancy in the P680 molecule occurs at the expense of water. PS II contains a water-oxidizing complex containing 4 manganese ions in the active center. For the formation of one oxygen molecule, two water molecules are required, giving 4 electrons. Therefore, the process is carried out in 4 steps and for its complete implementation 4 light quanta are required. The complex is located from the side inside the thylakoid space and the resulting 4 protons are thrown into it. Thus, the overall result of PS II operation is the oxidation of 2 water molecules with 4 light quanta with the formation of 4 protons in the thylakoid space and 2 reduced plastoquinones in the membrane b_6f or b/f-complex buf and creating a gradient of their concentration due to the released complex is a pump that pumps protons from the stroma into the thylakoid space in the redox reactions of the electron transport chain of energy. 2 plastoquinones give 4 proton pumping.

b_6f or b/f-complex

Subsequently, the transmembrane proton gradient (the pH of the stroma is about 8, the intrathylakoid space is 5) is used for the synthesis of ATP by the transmembrane enzyme ATP synthase.

Photosystem I

Light harvesting complex 1 contains approximately 200 molecules chlorophyll. In the reaction center of the first photosystem, there is a dimer electron is transferred to ferredoxin, which reduces NADP using the enzyme ferredoxin - NADP – reductase chlorophyll a with an absorption maximum at 700 nm (700). After excitation by a quantum of light, it restores the primary acceptor - chlorophyll a, the secondary one (vitamin K, or phylloquinone), after which protein plastocyanin reduced by b_6f "complex, B is transported to the reaction center of the first photosystem from the side of the intratilakoid space and transfers an electron to the oxidized P700.

Cyclic and pseudocyclic electron transport

In addition to the complete non-cyclic path of the electron, described above, cyclic and peudocyclic are found. The essence of the cyclic path is that ferredoxin instead of NADP restores plastoquinone, which carries the complex. As a result, a larger proton gradient and more ATP are formed, but NADPH does not arise. In the pseudocyclic pathway, ferredoxin reduces oxygen, which later turns into water and can be used in photosystem II. In this case, NADPH is also not formed.

Hem stage

In the dark stage, with the participation of ATP and NADPH, the reduction of co, de glucose (C6H120,) occurs. Although light is not required for this process, it is involved in its regulation.

C3 photosynthesis, Calvin cycle

Calvin cycle or reducing pentose phosphate cycle consists of three stages:

1. Carboxylation
2. Recovery
3. Regeneration of the CO2 acceptor

At the first stage, it is attached to ribulose-1,5-bisphosphate under the action of the enzyme ribulose-bisphosphate-carboxylase / oxygenase (Rubisco). This protein makes up the main fraction of chloroplast proteins and is arguably the most abundant enzyme in nature. As a result, it forms an intermediate unstable compound that decomposes into two molecules of 3-phosphoglyceric acid (FHA). In the second stage, FGK is restored in two stages. First, it is phosphorylated by ATP under the action of phosphoroglycerokinase, then by NADPH under the action of triose phosphate dehydrogenase, its carboxyl the group is oxidized to aldehyde and it becomes a carbohydrate (PHA). The third stage involves 5 PHA molecules, which, through the formation of 4-, 5-, 6- and 7-carbon compounds, combine into 3 5-carbon ribulose-1,5-bisphosphate, which requires 3 ATP. Finally, two PHAs are required for glucose synthesis. For the formation of one of its molecules, cycle bobots, 6 COs, 12 NADPH and 18 ATP are required.

Hatch-Slack-Karpilov cycle or C-photosynthesis

At a low concentration of co dissolved in the stroma, Rubisco catalyzes the oxidation reaction of ribulose-1,5-bisphosphate and its decomposition into 3 phosphoglyceric acid and phosphoglycolic acid, which are forcedly used in the process of photorespiration. To increase the concentration from the plant, the leaf anatomy was changed from the type. The Calvin cycle in them is localized in the cells of the sheath of the conducting bundle, while in mesophyll cells, under the action of PEGI carboxylase, phosphoenolpyruvate is carboxylated to form oxaleacetic acid, which is converted into malate or aspartate and transported to the cells of the sheath, where it is decarboxylated to form pyruvate, and mesophogylate is returned. Since photosynthesis is practically not accompanied by the loss of ribulose 1,5-bisphosphate from the Calvin cycle, therefore, it is more effective. However, it requires not 18, but 30 ATPs for the synthesis of 1 glucose molecule. This is justified in the tropics, where a hot climate requires keeping the stomata closed, which prevents the entry of carbon into the leaf, as well as with a ruderal life strategy.

CAM Photosynthesis (Crassulaceae Acid Metabolism)

In CAM photosynthesis, the assimilation of co and kla Calvin is separated not in space, as in C, but in time. At night, malate accumulates in the vacuoles of cells by a similar mechanism described above with open stomata, during the day with closed stomata there is a Calvin peak. This mechanism allows you to save water as much as possible, but is inferior in efficiency to both C and Su. It is justified with a stress tolerant life strategy.

The Importance of Photosynthesis

Photosynthesis is the main source of biological energy, photosynthetic autotrophs use it to synthesize organic substances from inorganic ones, heterotrophs exist due to the energy stored by autotrophs in the form of chemical bonds, releasing it in the processes of respiration and fermentation. The energy received by humanity when burning fossil fuels (coal, oil, natural gas, peat) is also stored in the process of photosynthesis. Photosynthesis is the main entrance of inorganic carbon into the biological cycle. All free oxygen in the atmosphere is of biogenic origin and is a byproduct of photosynthesis. The formation of an oxidizing atmosphere (oxygen catastrophe) completely changed the state of the earth's surface, made it possible for the appearance of respiration, and later, after the formation of the ozone layer, allowed life to come to land.

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