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DEPARTMENT OF CIVIL ENGINEERING

19GET277- Biology for Engineers

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PHOTOSYNTHESIS
NITROGEN FIXATION

PHOTOSYNTHESIS

- Most life on Earth depends on photosynthesis.
- The process is carried out by plants, algae, and some types of bacteria, which capture energy from sunlight to produce oxygen (O2) and chemical energy stored in glucose (a sugar).
- Herbivores then obtain this energy by eating plants, and carnivores obtain it by eating herbivores.

PHOTOSYNTHESIS

The process

- During photosynthesis, plants take in carbon dioxide (CO_2) and water (H_2O) from the air and soil.
- Within the plant cell, the water is oxidized, meaning it loses electrons, while the carbon dioxide is reduced, meaning it gains electrons.
- This transforms the water into oxygen and the carbon dioxide into glucose.
- The plant then releases the oxygen back into the air, and stores energy within the glucose molecules.

PHOTOSYNTHESIS

Chlorophyll

- **Inside the plant cell are small organelles called chloroplasts, which store the energy of sunlight.**
- **Within the thylakoid membranes of the chloroplast is a light-absorbing pigment called chlorophyll, which is responsible for giving the plant its green color.**
- **During photosynthesis, chlorophyll absorbs energy from blue- and red-light waves, and reflects green-light waves, making the plant appear green.**

PHOTOSYNTHESIS

Light-dependent Reactions vs. Light-independent Reactions

- **While there are many steps behind the process of photosynthesis, it can be broken down into two major stages: light-dependent reactions and light-independent reactions.**
- **The light-dependent reaction takes place within the thylakoid membrane and requires a steady stream of sunlight, hence the name light-dependent reaction.**
- **The chlorophyll absorbs energy from the light waves, which is converted into chemical energy in the form of the molecules ATP and NADPH (Nicotinamide adenine dinucleotide phosphate).**

PHOTOSYNTHESIS

- The light-independent stage, also known as the Calvin cycle, takes place in the stroma, the space between the thylakoid membranes and the chloroplast membranes, and does not require light, hence the name light-independent reaction.
- During this stage, energy from the ATP and NADPH molecules is used to assemble carbohydrate molecules, like glucose, from carbon dioxide.

PHOTOSYNTHESIS

C3 and C4 Photosynthesis

- Not all forms of photosynthesis are created equal, however. There are different types of photosynthesis, including C3 photosynthesis and C4 photosynthesis.
- C3 photosynthesis is used by the majority of plants. It involves producing a three-carbon compound called 3-phosphoglyceric acid during the Calvin Cycle, which goes on to become glucose. C4 photosynthesis, on the other hand, produces a four-carbon intermediate compound, which splits into carbon dioxide and a three-carbon compound during the Calvin Cycle.
- A benefit of C4 photosynthesis is that by producing higher levels of carbon, it allows plants to thrive in environments without much light or water.

NITROGEN FIXATION

Nitrogen fixation is the essential biological process and the initial stage of the nitrogen cycle. In this process, nitrogen in the atmosphere is converted into ammonia (another form of nitrogen) by certain bacterial species like Rhizobium, Azotobacter, etc. and by other natural phenomena.

Use of Nitrogen Fixation:

- Plants are the main source of food. The nutrients obtained from plants are synthesized by plants using various elements which they obtain from the atmosphere as well as from the soil.
- This group of elements includes nitrogen as well. Plants obtain nitrogen from the soil and utilise it in the process of protein synthesis.

NITROGEN FIXATION

- Unlike carbon dioxide and oxygen, atmospheric nitrogen cannot be obtained through the stomata of leaves. Because the nitrogen gas present in the atmosphere can not be directly used by plants.

Biological Nitrogen Fixation

- Certain bacteria or prokaryotes are capable of converting atmospheric nitrogen to ammonia. This process is called biological nitrogen fixation.
- The enzyme nitrogenase converts dinitrogen to ammonia. Nitrogen-fixing bacteria may be free-living or symbiotic.
- Some of the free-living nitrogen fixers are Azotobacter, Beijernickia, Rhodospirillum, cyanobacteria, etc. Examples of symbiotic nitrogen fixers are Rhizobium (in the root nodules of legumes) and Frankia (in the root nodules of non-leguminous plants), etc.

NITROGEN FIXATION

Symbiotic Nitrogen Fixation

A species of bacteria called Rhizobium, help in nitrogen fixation. These bacteria live in the roots of leguminous plants (e.g., pea and beans plants) and using certain types of enzymes, they help in fixing nitrogen in the soil. During this biological process, they convert the non-absorbable nitrogen form into a usable form. This form of nitrogen gets dissolved in the soil, and plants absorb the modified nitrogen from the soil. This is the reason behind farmers implementing crop rotation, where leguminous plants help to replenish nitrogen content in the soil without the necessity of fertilizers.

Nitrogen fixation by bacteria is an example of the symbiotic relationship between Rhizobium and leguminous plants. While bacteria fix nitrogen in the soil, plants provide them food.

NITROGEN FIXATION

Nitrogen Fixation by Lightning:

Another process that helps in nitrogen fixation is lightning. It is a natural phenomenon where the energy of lightning breaks and converts the non-absorbable form of nitrogen into a usable form. Even though the contribution of lightning in the nitrogen fixation is small, they save plants from the deficiency of essential elements.

Thankyou