UNIT - III

AUTROPHIC NUTRITION

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Introduction:

Well friends, in our previous classes we studied about protplasm and its constituents. More specifically, we studied about compounds such as 'Water', 'Carbohydrates', 'Fats', 'Proteins', etc., and their composition. Let us try to recall what we studied about these compounds. We studied that these compounds are chemical in nature, and constitute the basic food requirements of all living organisms. You have also studied that these compounds are oxidised in the cells of a living organism, and the energy released during the process of oxidation is utilized for performing various life activities. Fine. Now, think for a while as to how living organisms meet their basic food requirements to get energy for performing various life activities. As regards the case in animals, you may say that they meet their food requirements by feeding on different types of food stuffs. Correct. But, what about plants? They do not seem to take food as animals take. Are plants existing in this world without food? If not, from where do they obtain Carbohydrates, Fats, Proteins, etc., which constitute the basic

food requirements? In simpler terms, the question before us us;

- How do plants get energy for performing various life activities?

- Let us try to find an answer to this Question in our subsequent science periods. As the previous Unit was presented, learning experiences in this Unit will also be presented through various techniques. I hope, you would enjoy undergoing such an experience.

Structured notes (Historical background)

The question that is before us is 'From where do plants get carbohydrates, fats, proteins, etc., which are the basic food required for performing various activities? Or, in other-words, 'how do plants meet their food requirement'?

This question was there in the minds of scientists even three hundred years ago. Since then, Biologists are trying to understand the way in which plants meet their food requirements. For quite a long period of time, people believed that plants obtained their food directly from the soil. In the year 1648, Van Helmant, a Belgian scientist doubted this idea. He thought of testing this idea experimentally. He took a young willow twig and planted it in a barrel containing a

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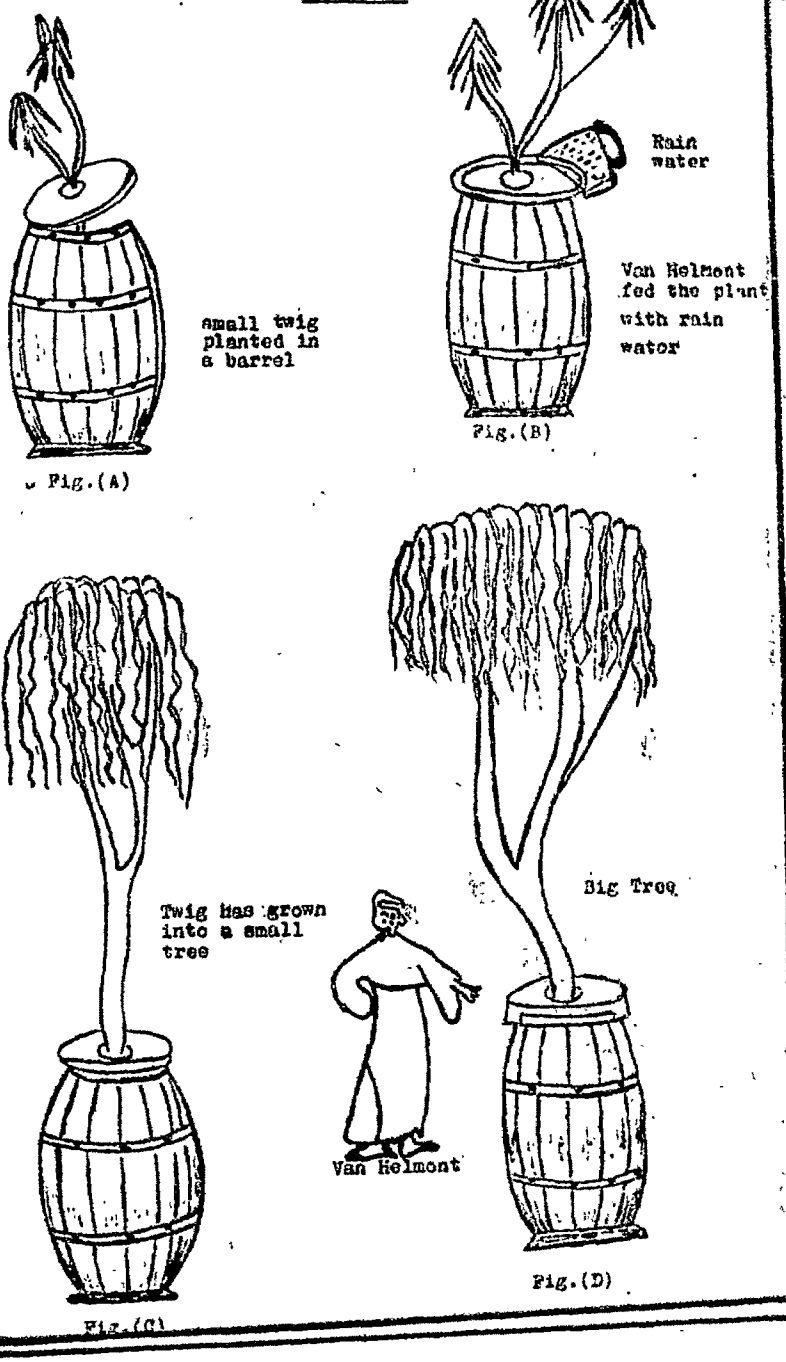
Diagram 1



weighed amount of soil (Refer to diagram 1). He fed this plant daily with only rain water. (Think, for what reasons he might not have used tap water). After five years, the twig had grown to a small tree and had gained 74.3 kgs in weight. He weighed the soil again by removing the tree from it. To his surprise he found that the soil weighed two ounces less than when he started the experiment. From this experiment, Van Helmant concluded that food of plants is derived from water. Van Helmant was partially right. We shall see further, how Van Helmant's idea that is 'food of plants is derived only from water', was disproved.

It was in the year 1772, an English scientist named Joseph Priestly, gave a clue as to how plant meet their food requirement. He was trying to find out the different gases given out during combustion, and breathing by animals. He observed, in one of his experiments, that a mouse kept under a bell-jar soon died of suffocation, because the air inside the bell-jar became impure due to rat's breathing. He did not just neglect it. He made an intelligent guess, or he hypothesised that there must be some mechanism in nature by which the spoiled air of the atmosphere is repurified. He suspected that plants were concerned in this process of repurification in some way. He started testing his hypothesis

by conducting different experiments. In one of his subsequent experiments, he placed twigs of plants under belljars containing impure air and discovered that plants really did purify the impure air. With this result, he performed another experiment. He placed two mice under two air tight belljars. In one of them he also kept a twig of plant (Refer diagram 2).

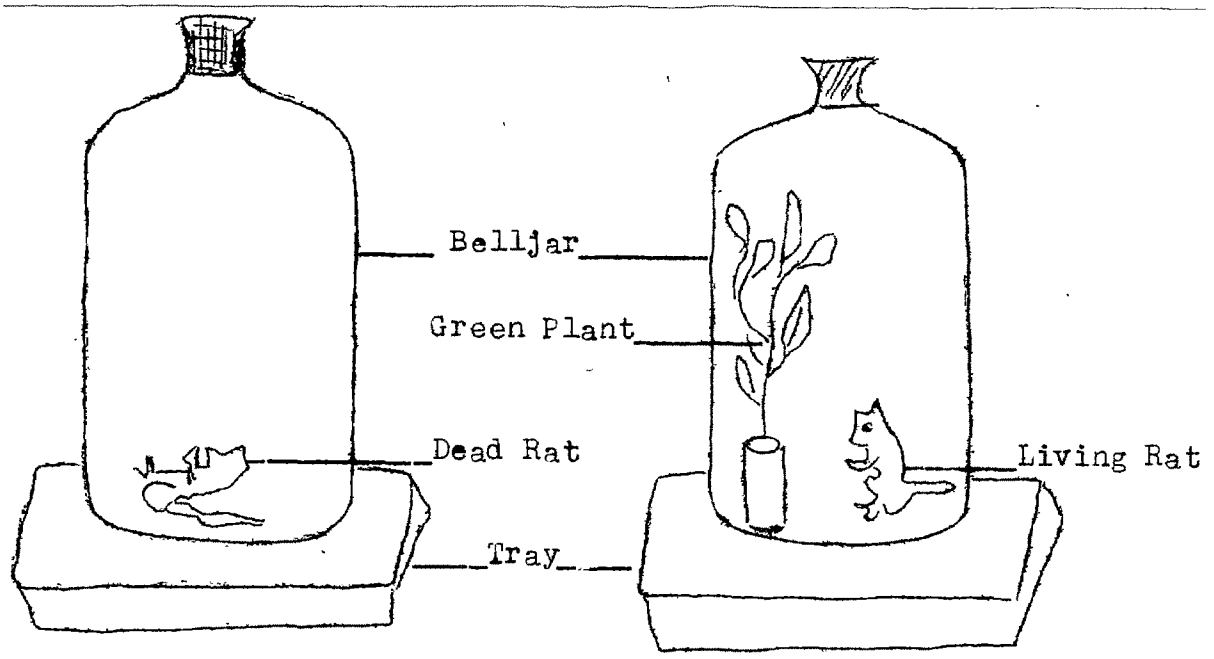


Diagram-2

Digaram - 2

Can you guess the results which Priestly must have obtained? He found that rat kept in belljar with the plant, lived happily, whereas, the rat in the other jar without plant died

of suffocation. Can you think of the reason as to why the rat in the belljar with plant lived happily, whereas the other rat died? Write down your reasons in a separate note book. You can check your reasons as to whether they are right or wrong, soon.

Even Priestly could not give full explanation as regards the way in which plants meet their food requirement. During 1730-1799, a Dutch scientist named Jan Ingenhourz, found that sunlight is necessary for the production of oxygen by the green parts of plants. This gave a clue to other biologists working in the same area. This link was further strengthened by Jean Senebier, who in 1782, discovered that green plants under certain conditions absorb carbon-dioxide from the atmosphere. Like this, a few more scientists added knowledge to the concept of 'how plants meet the requirement of their food' through a series of experiments.

As a result of this long period of experimentation, it is now understood that "green plants have the unique capacity to combine two simple substances, namely, carbon-dioxide and water into glucose, from which are derived all the other products of plants as well as animals. Even today, the exact changes that take place during the formation of glucose is not yet known to biologists. They are working

hard in their laboratories to find out these changes.

The above events tell you how scientists (biologists) have worked to find an answer to the question 'how plants meet their food requirement'. You might have also noticed how they have observed minutely, which has lead to the formation of scientific concepts. Read more about these scientists and their work from encyclopedias, and make a nice report of it for yourself. As a young biologist you can explain to others how scientists (biologists) have contributed to the world of knowledge.

Your teacher would make you understand that green plants are capable of manufacturing their own food, by asking you a series of logically sequenced questions. The letter 'T' represents the teacher, and the letter 'S' represents the student.

T. Friends, from the works of different scientists you read earlier, did you get any clue for the question 'how plants meet their food requirement'?

S. Yes.

T. Okay. In what way the works of different scientists h have given a clue to the question 'how plants meet their requirement of food?

S. The conclusion arrived at from different experiments conducted by different scientists tell us that green plants have the ability to combine two simple substances, namely, CO_2, and water into glucose, a carbohydrate, which is needed by all living organisms for energy.

T. Well, we all know that carbohydrates are an important source of energy for all living organisms. Can anybody tell me the chemical composition of carbohydrates?

S. Carbohydrates are compounds which contain carbon, hydrogen and oxygen.

T. Good. They are organic compounds and are composed of carbon, hydrogen and oxygen. We know that every living organism requires carbohydrates for their growth, development, etc. Let us take a specific example of a plant and understand how plants get carbohydrates, which is needed for their life activities. If you put a 'money plant' in water containing phosphates, nitrates, and sulphates of potassium, magnesium and calcium, it grows well. Does the water which we have supplied to the money plant contain any carbon compounds.

S. No. Water supplied to the money plant does not contain any carbon compounds.

T. Right. If you test a leaf of that money plant for starch, you will find that the leaves contain starch. You know that starch is a carbohydrate. Then from where did money plant get carbohydrate for its growth?

S. Money plant might have manufactured carbohydrates.

T. You are right. Money plant has manufactured carbohydrates. You know that the water supplied to money plant does not contain any carbon compound. Can carbohydrates be formed without carbon?

S. No. Carbon is necessary for the formation of carbohydrates.

T. Think, from where could the money plant get carbon for manufacturing starch?

S. It might have utilised the carbon of carbondioxide present in the atmosphere.

T. Good. Money plant has absorbed carbondioxide from air, and water from the medium supplied to the plant. Carbon of carbondioxide has combined with hydrogen and oxygen of water to form glucose. This glucose is later converted to starch. But,you should know that this process of manufacturing of carbohydrates is a very complex process. If you mix carbondioxide and water, you will get only carbonic acid. The combination of carbondioxide and water in plants, involves a series of reaction, which you will be studying in your higher classes. The end product of such a series of reactions is carbohydrate. The minerals which the plants absorb, help in quickening these reactions. Hence, all plants require minerals. Think of the plants that grow near your school compound, playground, etc. Nobody takes care of them. How do they grow?

S. They absorb water and mineral salts from the soil and carbondioxide from air, with the help of which they manufacture carbohydrates. This carbohydrate is utilised for growth and other activities.

T. Good. Now you know how plants meet their food requirements. How do plants differ from animals in obtaining their food?

S. Plants differ from animals by manufacturing their own food. Animals have to depend on other organisms for food.

Good, plants have the ability to manufacture their own food. We know two substances that are needed by plants for manufacturing their food. They are carbondioxide and water. Carbondioxide and water are called as the factors. Like these two factors, plants need some more factors for manufacturing their food. Let us try to understand the different factors that are needed by plants for manufacturing food. Think of the environment in which plants grow. We shall take the example of plants growing in front of our school. You know that there is plenty of sunlight, air, water,soil,etc., for these plants. But we do not know whether these things will effect the growth of plants.

T. From your daily observation and experience can you tell me whether a plant which is watered well can grow in a completely dark room?

S. No, plants cannot grow in complete darkness.

T. But the question is, why the plant does not grow in complete darkness? It has got sufficient air, water and soil. What may be the reason for plants not growing in complete darkness?

S. Eventhough the plant has got sufficient air, water, soil, etc., there is no sunlight. Hence it will not grow.

T. All right. It means sunlight is needed for the plants to grow. You know that plants can manufacture carbohydrates (food) which is needed for their growth. You also know that plants will not grow when kept in complete darkness. This may be due to nonavailability of carbohydrates to the plant to grow. Can we guess anything with regard to the effect of sunlight on the manufacture of carbohydrates by plants?

S. Yes. We can guess that during darkness, or during the absence of sunlight plants cannot manufacture carbohydrates. Hence, they will not grow and will ultimately die.

T. Good. This is only our guess. Let us put this guess in the form of a statement. 'Plants require sunlight for the manufacture of carbohydrates'. (Teacher writes the statement on the blackboard). Now how can we know whether our guess is right or wrong?

S. We have to test it.

T. Good. We shall test our guess or hypothesis by doing an experiment.

Demonstration

Aim: Teacher demonstrates the Ganong's light screen Experiment to show that light is necessary for the manufacture of starch by plants with the help of the following materials.

Materials needed

1. Well watered potted plant
2. Ganong's light screen.
3. 90% alcohol.
4. Iodine solution
5. Water in a beaker
6. Big china dish

(Your teacher would proceed in the following way to show you that plants require sunlight for the manufacture of starch).

Procedure:

A healthy and adequately watered plant will be taken and kept in darkness for 1 or 2 days. This will remove the starch present in the leaves. To one leaf, Ganong's light screen with a star like pattern cut in the black paper is fixed (Refer to the diagram 3). The so prepared plant will be kept in sunlight. After a few hours, the leaf will be tested for starch. Make your observations and discuss the results with your teacher.

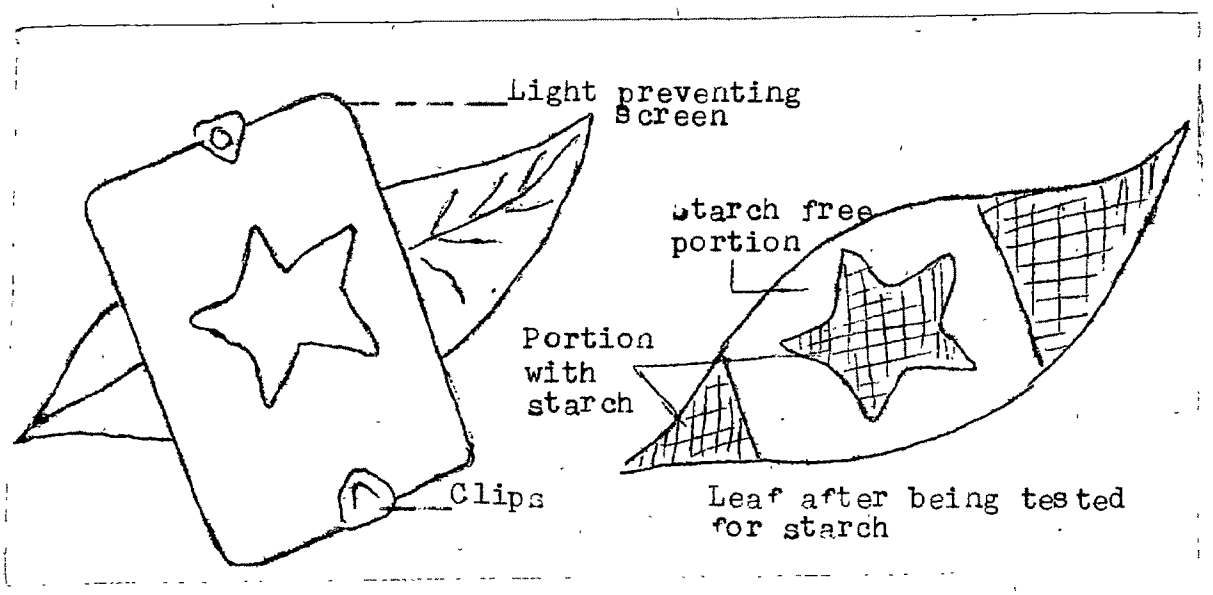


Diagram - 3

Discussion:

T. Did you observe any change in the colour of the leaf when dipped in iodine solution?

S. Some parts of the leaf turned blue, whereas the other parts did not turn blue.

T. What may be the reason for this change of colour in some parts of the leaf?

S. It is due to the presence of starch. The parts of the leaf which contained starch turned blue when it was dipped in iodine solution.

T. What may be the reason for the production of starch in the parts which were not covered by black paper?

S. The parts which were not covered with black paper were exposed to sunlight. Hence production of starch was there in those parts of the leaf.

T. Good, what can we infer from this experiment?

S. We can infer that sunlight is necessary for the manufacture of starch by plants.

T. Right. So, another factor needed by plants for the manufacture of food is sunlight. Well, think of our hypothesis that "plants require sunlight for the manufacture of carbohydrates". Can we accept that our guess is right?

S. Yes.

T. Good. As we tested our guess or hypothesis, scientists also guess certain things, and try to find out whether they are right in their guessing. Thus, they add more knowledge to the one that is already existing.

T. Well, now we know the three factors that are needed by plants for manufacturing carbohydrates. Name these three different factors that are needed by plants for manufacturing carbohydrates?

S. The three different factors that are needed by plants for manufacturing carbohydrates are carbondioxide, water and sunlight.

T. Good. Recall the example of money plant which we had taken to understand how plants meet their food requirement. While trying to understand, we made a guess that money plant might have utilised carbon of carbondioxide present in atmosphere for manufacturing carbohydrates, and hence we came to a conclusion that CO_2 is needed by plants or it is a factor. Let us try to find out whether we were right in our guess or not, by conducting an experiment. Before starting the experiment, we shall state our guess in the form of a hypothesis, namely, 'plants need carbondioxide for manufacturing carbohydrates' (Teacher writes the hypothesis on the blackboard).

Demonstration

Aim: To show the students that plants require carbondioxide for manufacturing carbohydrates. (Moll's half leaf experiment).

Material required:

1. Well watered potted plant.
2. A wide mouthed glass bottle.
3. Split cork.
4. Potassium hydroxide solution.
5. 90% alcohol.
6. Beaker of water.
7. Iodine solution
8. China dish.

(Your teacher would proceed in the following way to show you whether carbondioxide is required by plants for manufacturing carbohydrates).

Procedure:

A well watered plant will be taken and will be kept in darkness for 1 or 2 days to remove the starch in the leaves. After removing the starch, one long destarched leaf will be selected from the plant and half of the leaf will be enclosed in a wide mouthed bottle containing little potassium hydroxide solution. The leaf will be fixed with the help of a split cork. (Refer diagram 4). After all the arrangements are over, the whole apparatus will be exposed to sunlight for few hours. Afterwards, the leaf will be tested for starch. In the experiment, potassium hydroxide solution is used in order to remove carbondioxide present in the bottle.

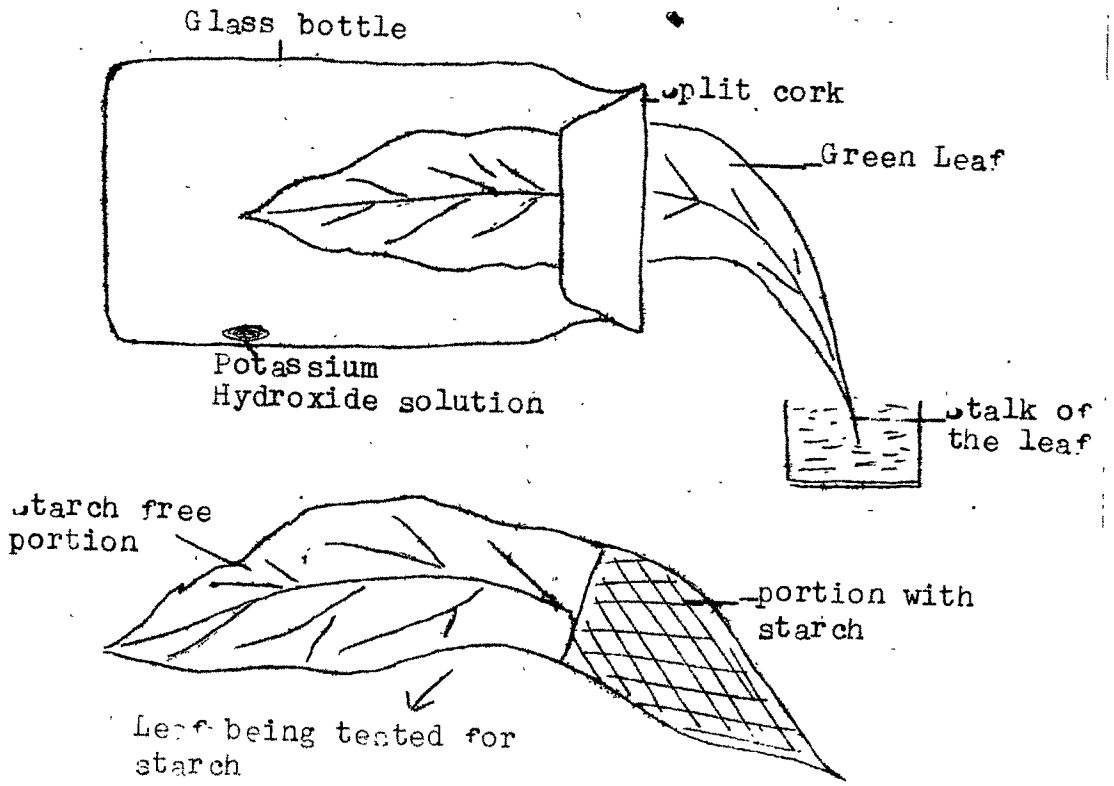


Diagram-4

Diagram - 4

Discussion:

T. In the experiment, you noticed that the part of the leaf which was inside the bottle did not turn blue when tested for starch. What may be the reason?

S. Starch was absent in that part of the leaf which was inside the bottle. Hence that portion did not turn blue when tested for starch.

T. You know that for the part of the leaf which was inside the bottle, there was sunlight, water and air. But still there was no formation of the starch. What may be the reason?

S. CO_2 was not available to that part of the leaf which was inside the bottle since it was absorbed by potassium hydroxide solution. Hence there was no formation of starch in that portion of the leaf.

T. Good. What can we infer from this experiment?

S. We can infer that plants require carbondioxide for the manufacture of starch, which is a carbohydrate .

T. Correct. Recall the hypothesis that we stated in the beginning of the experiment. Are we right in our guess that plants make use of carbon present in CO_2?

S. Yes.

T. Now, we know well that CO_2 is needed by plants for manufacturing carbohydrates or starch.

T. Now you have come to know three factors necessary for the manufacture of food,viz., carbondioxide, water and sunlight. Let us proceed further in our inquiry and find out whether there is any other factor that

T. is necessary for the manufacture of carbohydrates or starch by plants. Think of a healthy growing plant and guess what other factors that may be needed by plants for manufacturing carbohydrates.

S_1. Silence

S_2. Silence

T. O.K. Recall what you have learnt about plastids in your previous classes. You have learnt that plastids are of three kinds. Name the three types of plastids seen in plants.

S. Leucoplasts, chloroplasts and chromoplasts are the three types of plastids seen in plants.

T. Recall the function of chloroplasts. What is the function of chloroplasts?

S. Chloroplasts help the plant in the production of carbohydrate.

T. Good. What is the pigment present in chloroplasts?

S. The pigment present in chloroplasts is chlorophyll.

T. Correct. Now you think of another factor that may be needed plants for manufacturing carbohydrates.

S. Chloroplasts are necessary for the plants to manufacture carbohydrates.

T. Good. Chloroplasts contain chlorophyll. We can say that the pigment chlorophyll is necessary for the manufacture of carbohydrates by plants. Now let us try to find out whether chlorophyll is needed by plants for manufacturing carbohydrates. As we proceeded with our earlier experiments, we shall have a hypothesis for this experiment also. What hypothesis can we have for this experiment?

S. We can say that 'plants require chlorophyll for manufacturing carbohydrates'.

(Teacher writes the hypothesis on the black board)

Demonstration

Aim: To show the students that chlorophyll is necessary for the manufacture of carbohydrates.

Materials needed:

1. Croton leaf
2. Indian ink
3. Boiling water
4. 90% alcohol
5. Iodine solution

(Your teacher would proceed in the following way to to show you that chlorophyll is needed by plants for the manufacture of carbohydrates).

Procedure:

A varigated leaf leaf of a croton plant will be selected. The white and green patches on the leaf will be shown to students. The boundaries of the green patches will be marked with the help of Indian ink. Then the leaf will be killed by immersing it in boiling water and 90% alcohol. The leaf will be washed with water and kept under iodine solution. Students will be shown the colour change in the leaf (refer diagram 5).

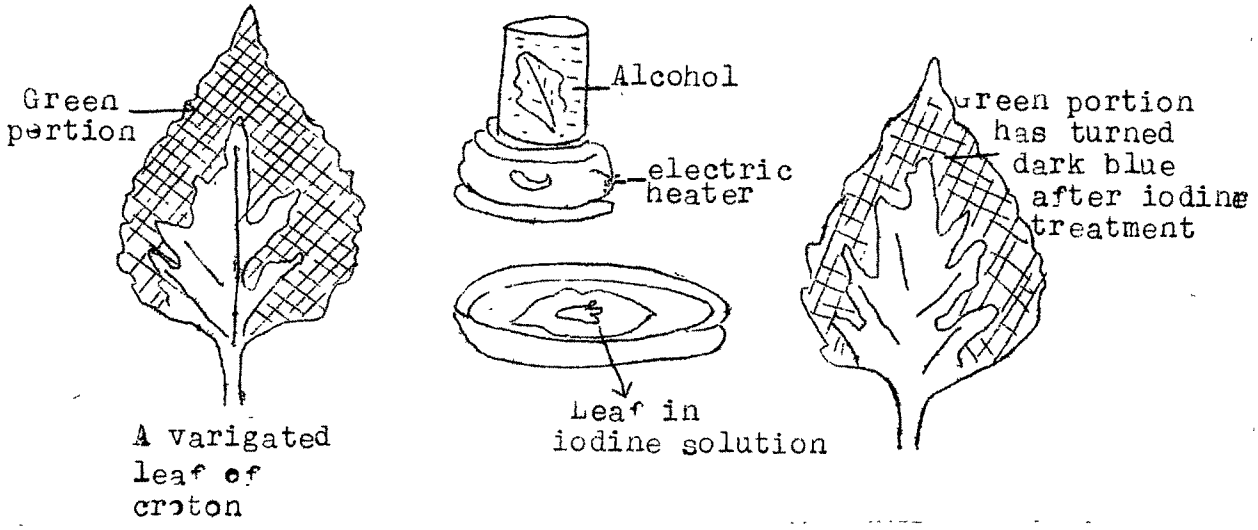


Diagram - 5

Discussion:

T. Did you notice any change in the colour of the leaf after dipping it in iodine solution.

S. Yes. In the green portions there was blue colour, whereas, in the white portions there was no blue colour.

T. All right. Why only green portions turned blue with iodine?

S. It was due to the presence of starch. In the non-green parts there was no production of starch. Hence those parts did not turn blue.

T. You know that for the entire leaf there was the availability of CO_2, water, sunlight. But still only green portions could prepare starch. What may be the reason?

S. The green portions contained chlorophyll, hence, there was production of starch, whereas, non-green portions did not contain chlorophyll, and hence there was no production of starch.

T. Good. What can we infer from this experiment?

S. We can infer that only green parts of the plant can manufacture carbohydrates.

T. Correct. Only green plants can manufacture good. What type of plastids are present in the green parts of the plant?

S. The green parts contain chloroplasts.

T. We know that chloroplasts contain the pigment chlorophyll. Hence we can say that chlorophyll is necessary for the manufacture of carbohydrates or starch by the plants.

T. So far you have understood that sunlight, carbon-dioxide, chlorophyll and water are the factors needed for the manufacture of carbohydrates by plants. Now we know that plants make use of these factors and manufacture carbohydrates. What is the end product in this process of manufacture of food by plants?

S. Carbohydrates or starch is the end product.

T. Now, let us try to study whether there is anything else other than carbohydrates that is produced during this manufacture of food by plants.

Recall what you have learnt about Joseph Priestly's experiment with rats and twig of plant kept in the belljar. You know that the rat which was kept in the belljar containing twig of a plant lived well. Recall your reasons which you had given for this. What may be the reason for the rat to die in the air tight belljar without plant?

S. It died because of suffocation.

T. Correct. But what about the other rat which lived well in the belljar containing plant twig. What may be the reason?

S. Some gas might have been produced by the plant, which might have purified the air inside the belljar.

T. Good. What can you guess about the gas that had purified the air inside the belljar?

S. It might be oxygen.

T. All right. Oxygen might have been produced by the plant, which has purified the air. What can we hypothesise from this?

S. We can hypothesise that 'plants produce oxygen during the manufacture of food'.

(Teacher writes the hypothesis on the blackboard).

Let us test this hypothesis by doing an experiment.

Demonstration

Aim: To show that oxygen is produced during the manufacture of food by plants.

Materials needed:

1. Elodia or Hydrilla plants
2. Beaker containing water
3. Glass funnel
4. Test tube
5. Glowing splinter

(Your teacher will proceed in the following way to show you that oxygen is produced during the manufacture of food by plants).

Procedure:

Fresh and green hydrilla or elodea plants will be taken in a beaker containing water. The plants will be covered with a funnel. Over the funnel a test tube filled with water is inverted. Care should be taken to see that no air bubble is inside the test tube and the mouth of the test tube is inside water in the beaker (Refer diagram 6). After the gas is collected in the test tube, it is tested.

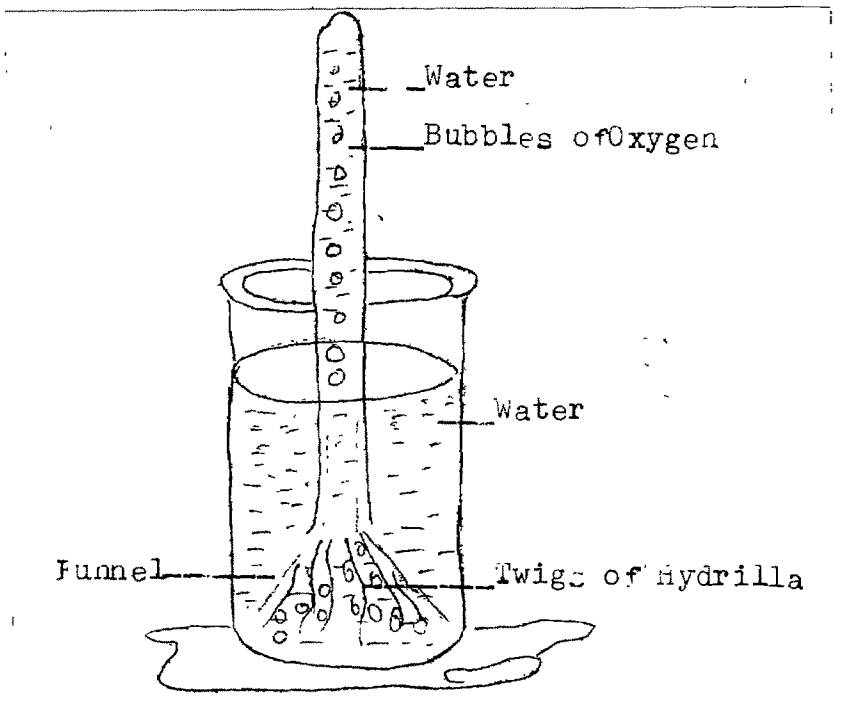


Diagram - 6

Discussion:

T. What happened to the burning splinter when it was brought near the test tube?

S. It burnt brightly. It was not put off.

T. Well. In your chemistry classes you have studied about the properties of different gases. Recall what may be the gas?

S. It is oxygen, since, it has supported the combustion.

T. Good. What can we infer from this experiment?

S. We can infer that oxygen is released during the manufacture of starch.

T. Are we right in guessing that the gas produced in Joseph's Priestelys rat and belljar experiment was oxygen?

S. Yes.

T. Well, now you know the different factors that are necessary for the manufacture of carbohydrates or starch by the plants, and you also know the end products. We shall try to express the whole process in the form of an equation.

(Teacher elecits the factors and end products from students and develops the equation)

$$CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + O_2$$

T. This process of manufacture of food by plant is called as photosynthesis. Photosynthesis is a process by which plants manufacture carbohydrates or starch with the help of simple inorganic compounds such as water and carbondioxide in the presence of chlorophyll. It is a process that provides a link between two worlds - the living and the non-living. Supplies of carbon-dioxide, water and energy from the sun are obtained from the non-living world.

T. Well, you know that chlorophyll is one of the factors needed by plants for manufacturing carbohydrates. So, in which parts of the plant can we expect the manu-facture of carbohydrates.

S. In the leaves and stems of the plants which contain chlorophyll.

T. Good. Leaves are the main organs where food is manu-factured. It can be compared to a factory, where raw materials are used and finished products are sent to different parts. In plants also the manufactured food from the leaves is distributed to other parts of the plant with the help of conducting vessels. Green plants are the 'world's food factories'. All animals and non-green plants depend on green plants for food. In what way are these statements true? As a student of Biology think about these statements and write down your views in a separate sheet of

paper. In the unit Heterotrophic nutrition you will come to know whether these statements are true or not.

Mechanism of Photosynthesis

Structured notes:

Well friends, In our previous classes we have studied the different factors needed by plants for manufacturing carbohydrates, the parts of the plant in which this process of photosynthesis takes place, etc. Each factor, namely, sunlight, carbondioxide, water, and chlorophyll, has got its own role to play in the process of photosynthesis. We are also existing in the same environment where there is water, carbondioxide, sunlight, etc. Still our body is not in a position to manufacture carbohydrates. Is it not something peculiar? Each step in the process of photosynthesis is interesting. Let us start our study of the mechanism of photosynthesis. The whole mechanism of photosynthesis can be studied under two major reactions, viz., light reactions and dark reactions. We shall study them one by one.

Light reaction:

When sunlight falls on the green tissues of the plants (leaves), the chloroplasts present in the leaves absorb the photons of the sunlight. Due to the energy absorbed,

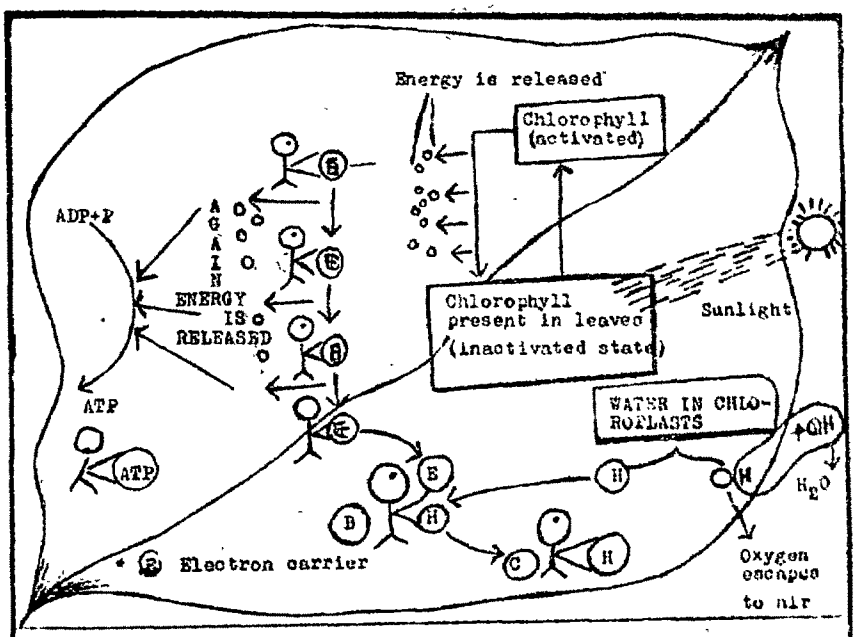


Diagram 5

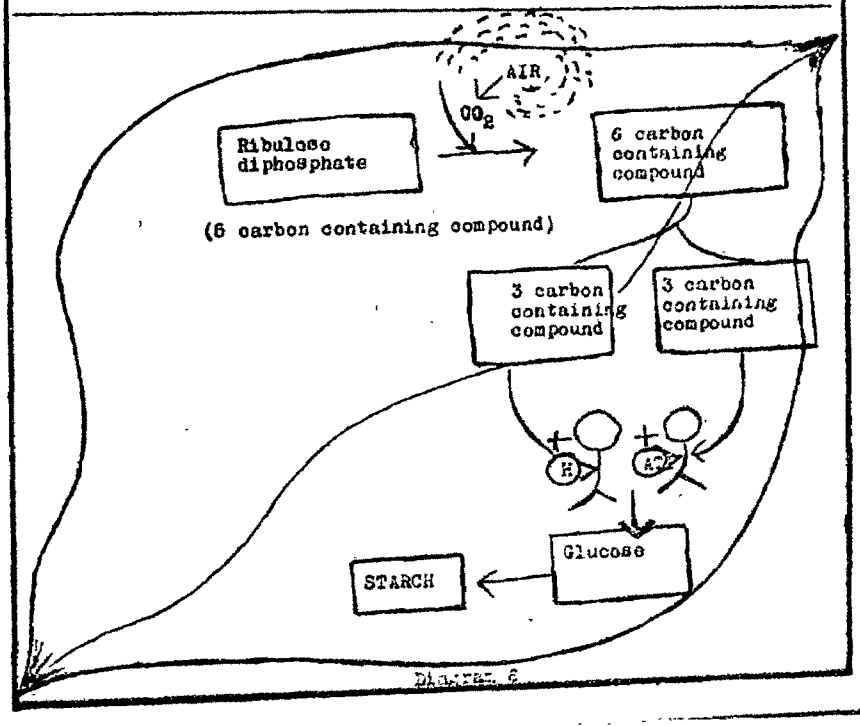


Diagram 6

chlorophyll (inactivated) present in chloroplasts becomes active (activated chlorophyll). Refer the diagram 7.

This activated chlorophyll comes back to its original state, namely, inactivated state. During this process, some amount of energy is released.

This released energy is picked up by a substance called electron carrier (Refer the diagram 7). This energy is transferred from one electron carrier to another. During this transfer, again, there is release of energy. This released energy is made use of to form ATP (high energy compound) from ADP. This is one function of sunlight. The second function of light is, when it falls on the leaves, the water present in the chloroplasts of the leaves is broken into Hydrogen and Oxygen, that is, hydrolysis of water takes place. Since this hydrolysis takes place due to sunlight, this is called as photolysis (photo = light).

Hydrogen thus obtained is accepted or picked up by another substance known as hydrogen acceptor (B) which accepts energy from electron carriers. After accepting or picking up hydrogen which is liberated from water, it gets reduced and forms a hydrogen containing compound (C) (Refer diagram 7). Oxygen is liberated to atmosphere, which is made use of for respiration by plants and animals.

In the above reactions, the main role is played by sunlight, or we can say that sunlight is made use of in the reactions. Hence these reactions as a whole is called as light reaction.

We shall summarise the steps of light reaction.

1. Chlorophyll gets activated.
2. ATP is formed from ADP
3. Water is broken into hydrogen and oxygen.
4. A hydrogen containing compound is formed.

This is followed by another set of reactions called as Dark reaction. You will understand why these reactions are called as dark reactions after going through the following reactions.

Look at the diagram (8). As the first step in dark reactions, 5-carbon containing compound called as ribulose diphosphate is formed (the formation of which you will study in your higher classes. This ribulose diphosphate which contains 5 carbon atoms, combines with CO_2 of air and forms a 6-carbon containing compound (see diagram 8), which splits into 2 compounds of 3-carbon containing compounds. At this stage, the hydrogen compound and ATP formed in the light reactions come to play. The two 3-carbon containing compounds formed by the splitting of 6-carbon containing compound combines with hydrogen compound and ATP (high energy compound)

formed during light reaction to form 6-carbon containing compound that is a sugar (fructose). In the above reactions sunlight is not made use of. Hence these reactions are called as dark reactions. Both light and dark reactions go on during day time. In one set, light is made use of, whereas in the other, light is not made use of. Now we shall summarise the steps of the dark reactions.

1. Formation of 6 carbon containing compound.
2. Combination of 3 carbon compounds with hydrogen compound and ATP to form fructose.

Now you know how food is manufactured by plants, and the role of each of the factors. Here are given few questions.

1. Looking at the diagrams 7 and 8 explain the different steps involved in the light and dark reactions in your own words.
2. Trace the path of the carbon from the atmosphere till the formation of sugar that is glucose.

Mechanism of Gaseous exchange:

Well friends, in our earlier class we tried to understand how plants manufacture starch by combining two simple inorganic substances, namely, carbon-di-oxide and water in the presence of sunlight and chlorophyll. In other words, we tried to understand the mechanism of photosynthesis. Now

we know very well that carbondioxide is one of the factors needed for photosynthesis, and how it is made use of in the manufacture of starch. In this class we shall try to understand how carbondioxide of air enters the leaf. Before that, let us try to recall what we have studied about the structure of (a) leaf in our earlier standards. (Refer diagram 9 & 10).

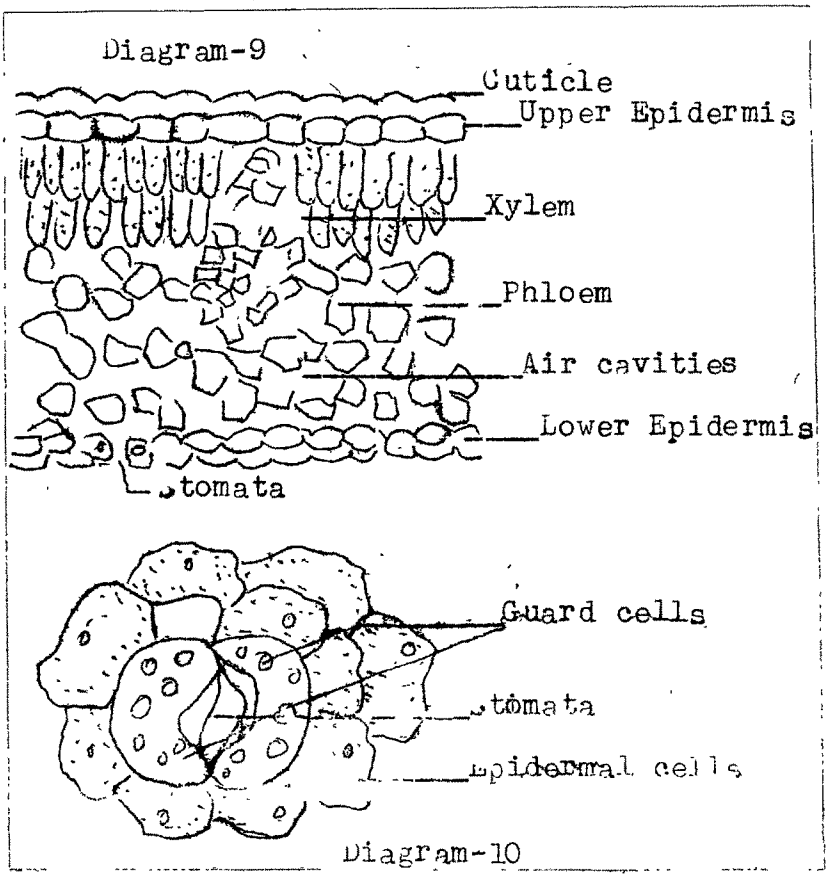


Diagram - 10

Where are the guard cells present in the leaf?

S_1 Guard cells are present in the lower surface of the leaves.

S_2 Guard cells are present in the lower Epidermis of the leaves.

T. What do you observe between two guard cells.

S_1 We observe a space between two guard cells.

T. Good. What is this space called as?

S_1 Stomata.

T. What is the function performed by these Guard cells?

S. They help in opening and closing of the stomata.

T. Look at the inner and outer walls of each guard cell. Do you find any difference?

S. Yes. The outer walls are thin and inner walls are thick.

T. You also observe that guard cells contain chloroplasts. What happens when light falls on these guard cells?

S. Food is manufactured.

T. We can say that sugar is formed. Hence, the concentration of sugar in the guard cells increases. Think, what would happen to the water surrounding the guard cells?

S_1 Silence.

S_2 Silence.

T. You may recall what you have studied about Osmosis.

S. Water will move into the guard cells.

T. Good. Due to entry of water, will any change occur in guard cell?

S. Guard cell will expand, or bulge.

T. All right. You know the difference in the thickness of the walls of the guard cells. Now, think as to which wall is more likely to expand?

S. The outer walls of the guard cells will expand.

T. Good. When the outer walls expand, what will happen to the inner walls?

S. They bend outwards enlarging the opening.

T. Good. Thus the opening of the stomata is controlled by the guard cells. You know very well that during night, photosynthesis cannot take place due to the absence of sunlight. The starch produced in the presence of sunlight is used by the plants during night. Since starch is insoluble in water, there will be no change in the concentration of water in the guard cells. Hence, the stomatal opening remains closed. Thus, gaseous exchange takes place through these stomata.

T. Well, all of you know that one of the characteristic features of all living organisms is that they respire. It is very well known to you that during respiration, oxygen is utilised and carbondioxide is thrown out

as a waste product by both plants and animals. Think, is this waste product of any use to plants?

S. Yes. Plants utilise this for the manufacture of carbohydrates.

T. Good. Plants are able to utilise carbondioxide produced during respiration for photosynthesis. Think, what may be the reason for absorbing carbondioxide from atmosphere also?

S. The carbondioxide given out during respiration may not be sufficient for the plants to manufacture food.

T. Correct. Since the amount of carbondioxide produced during respiration by plants is less, plants absorb more carbondioxide from atmosphere. They produce oxygen during photosynthesis which you know is utilised by them, as well as by animals during respiration. But you should know that oxygen released during photosynthesis by plants is more than what they actually utilise during respiration. Thus oxygen level is maintained in the atmosphere. You will understand more from the diagramatic representation of the whole process. (Refer diagram 11).

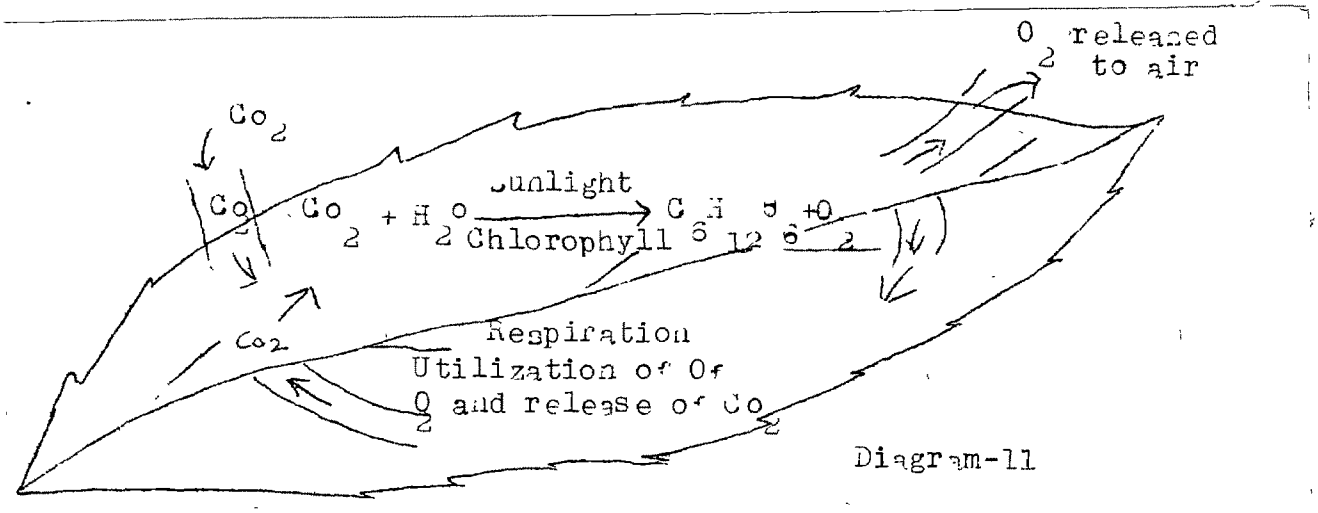


Diagram-11

T. Well, you know that carbondioxide produced during respiration in plants, is made use of by plants themselves for the manufacture of carbohydrates. They also make use of carbondioxide from atmosphere. Think of the number of plants making use of carbondioxide on this earth. You cannot just imagine. Do you have any idea as to how and from where carbondioxide comes to atmosphere?

S_1 Human beings respire and during that process carbondioxide is released to the atmosphere.

S_2 All animals give out carbondioxide during respiration.

T. Good. Can you think of any other source of carbondioxide?

S. When substances are burnt, carbondioxide is released to atmosphere.

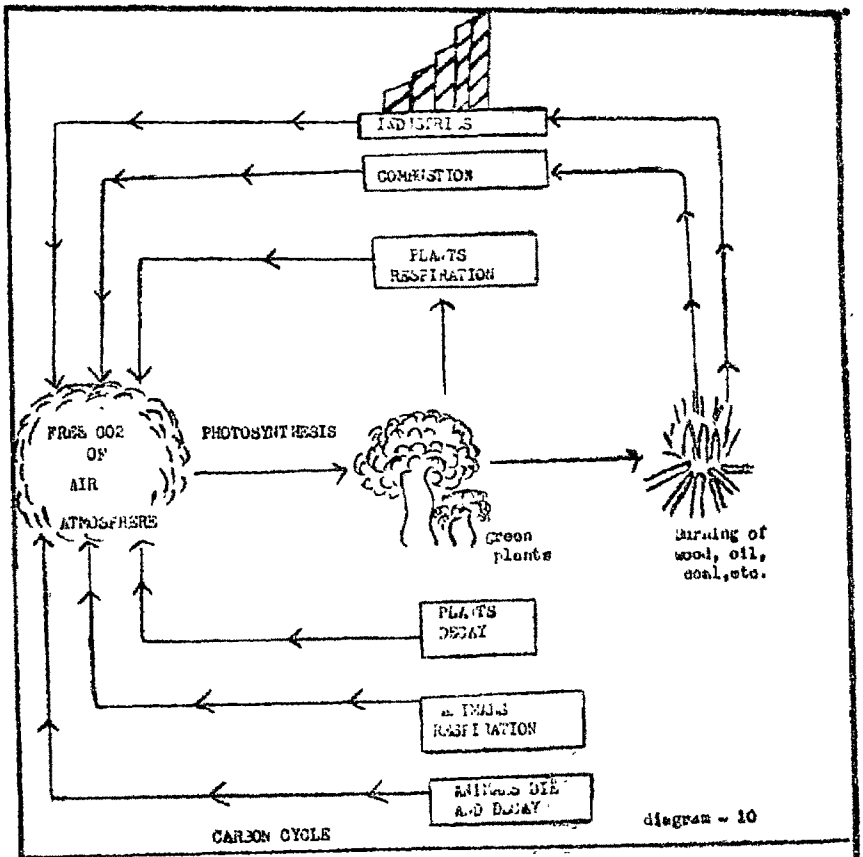
T. Right, what about decaying of dead bodies, animal excreta, etc.?

S. When dead bodies and animal excreta decay, carbondioxide is released to atmosphere.

T. O.K. Do you have any idea as to how carbondioxide is produced from decaying of dead bodies etc.?

S. Silence.

T. Certain bacteria act upon them and they release carbondioxide to atmosphere. Now you know the different sources from which carbondioxide comes to atmosphere and how plants make use of it, etc. Think what would



CARBON CYCLE

diagram - 10

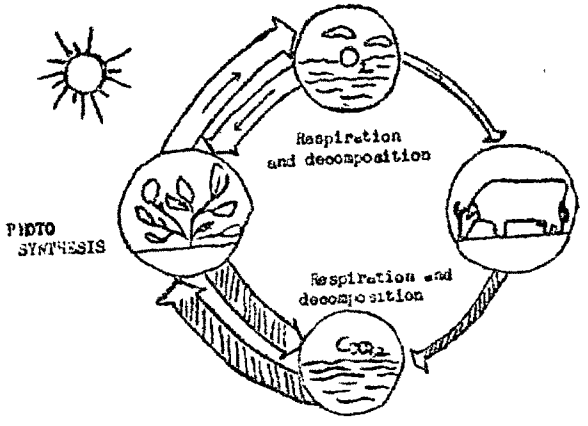


diagram - 11

have happened to animals if plants were not in a position to utilise CO_2 from atmosphere. Plants not only provide food to all animals, but also provide oxygen to animals. Plants maintain carbondioxide level in the atmosphere. Let us put the whole process of maintenance of carbondioxide level in atmosphere in the form of a cycle (Refer diagram 12).

T. Well friends, let us try to recall what we have studied so far. We have studied about the manufacture of carbohydrates (mechanism) by plants, the different factors needed by plants for this process, gaseous exchange in plants, and carbon cycle. You know that green plants have the ability to manufacture their own food, and hence they are independent for their food. The manufactured food is utilised by them for their growth and development and to perform all other life activities. This type of nutrition is called as Autotrophic Nutrition. It means plants have the ability to nourish themselves.

Now, you will do the following assignment.

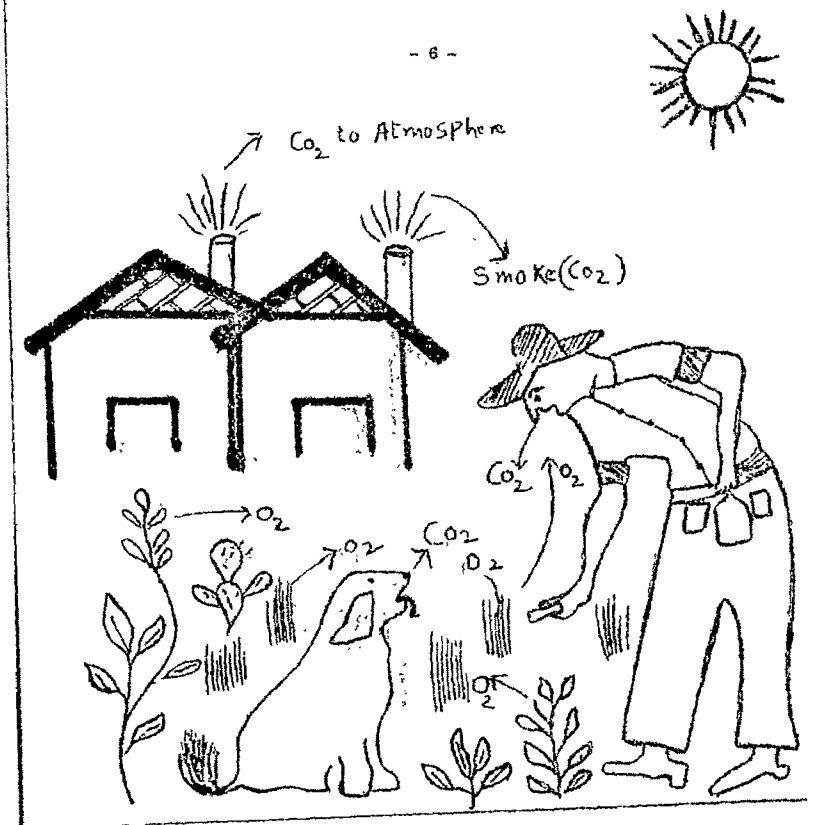
Home Assignment

So far, you have learnt many things under the unit Autotrophic Nutrition. Now, try to apply what you have learnt to the following situations.

I. Give your reasons for the following:

1. People advise that one should not sleep under a tree during night.
2. It is always good to have a small garden in front of the house.

- 6 -



How do you explain this diagram to a boy or girl of your own age who had never heard of carbon cycle that operates in the environment?

II. Here is a small activity for you to do at home. Read the procedure, and make a guess or hypothesis. Test your hypothesis and give your reasons.

Materials needed:

1. A potted green plant or any green plant growing in your garden.
2. Vaseline.

Procedure:

Water the plant well. Select one leaf and note its colour. Coat the top and bottom surface of the selected leaf with vaseline. Observe the leaf for a few days and note down the colour. Reason out if you notice any change in the colour of the leaf.

Chemosynthesis

Recall the different factors that are needed by plants for manufacturing their food. You know that chlorophyll is one of the important factor which is necessary for the manufacture of carbohydrates. Without chlorophyll, plant will not be in a position to make use of sunlight for manufacturing food. But, there are certain types of organisms in the living Kingdom, which do not possess chlorophyll but still can manufacture

their own food. For a student of biology like you it may look slightly doubtful. But, you will be clear about this doubt when you study the following. These organisms cannot utilize the free sunlight for manufacturing their food, since they do not possess chlorophyll in them. Then, think for a while as to how they manufacture their food. We shall see some examples to understand this better.

Example - I :

You are all familiar with the organisms, namely, bacteria. There are certain bacteria which possess a special kind of pigment, with the help of which they can manufacture their food. We can guess that the pigment present in them should be almost similar to that of pigment chlorophyll in green-plants and hence they can utilize sunlight and manufacture their food. These bacteria are called as photosynthetic bacteria since they utilise sunlight for manufacturing their food. We may place them under Autotrophs, since they have the ability to manufacture their own food and thus nourish themselves.

Example -II :

There are certain bacteria which are colourless and do not utilise sunlight, since they do not possess chlorophyll. Still, they can manufacture their own food. Let us take the case of Sulphur bacteria. There are many forms of sulphur bacteria which can oxidise sulphur or sulphur compounds.

The energy released during oxidation is used for manufacturing food. You may notice that the energy utilised by these bacteria is other than solar energy or sunlight. You will be more clear from the following representation

$2H_2S + O_2 \longrightarrow 2S + H_2O + 122.2$ KCal.

We shall consider another example, namely, nitrogen bacteria or nitrobacter. These bacteria oxidise nitric acid to nitrate, and the energy released is utilized for manufacturing food.

$2HNO_2 + O_2 \longrightarrow 2HNO_3 + 38$ KCal.

(nitrite) (nitrate).

Like these two types of bacteria, there are other types of bacteria, namely, Hydrogen bacteria, Iron bacteria, Carbon bacteria etc., which oxidise different chemical substance to obtain energy for manufacturing their food. However, it should not be thought that all bacteria are of this kind, that is, self-nourishing type. There are bacteria which depend upon other living and dead organisms for food. These type of bacteria do not have the capacity to manufacture food. You will study about them shortly.

The process by which certain bacteria synthesise their food by utilizing chemical energy is called as Chemosynthesis. And, such type of bacteria are called as Chemosynthetic bacteria.

Summary:

Let us summarise what we have studied about photosynthetic and chemosynthetic bacteria. We studied them as autotrophs, since both the types of bacteria have the ability to manufacture their food. Photosynthetic bacteria utilize sunlight, whereas, chemosynthetic bacteria make use of the chemical energy for manufacturing their food. Chemosynthetic bacteria are devoid of chloroplasts, and are colourless.

CONSTANCY OF THE PERCENTAGE OF NITROGEN IN AIR

Air as you know, always contains 78% of nitrogen and 21% of oxygen. From the way in which these two substances remain mixed in the air, and still maintain their separateness, we may be able to say something certain about the behaviour of these two substances with each other. What we can say about their behaviour? Sure, you would be able to say that the substances like nitrogen and oxygen do not combine. In fact, if these substances are combined with each other at ordinary temperatures then, the percentage composition of these substances in air would no longer be constant. But the substances, nitrogen and oxygen would combine at very high temperatures e.g. during lightening. When lightening takes place, you know that the temperature round the area of lightening would be very high. At these very high temperatures, nitrogen and oxygen would combine. Naturally, when chemical combination takes place, certain products would be formed. From your study of chemical reactions, you would be in a position to guess which compounds are formed in this combination. Oxides of nitrogen. This change can be represented as follows:

Nitrogen + oxygen $\xrightarrow[\text{high. temp.}]{}$ oxides of nitrogen

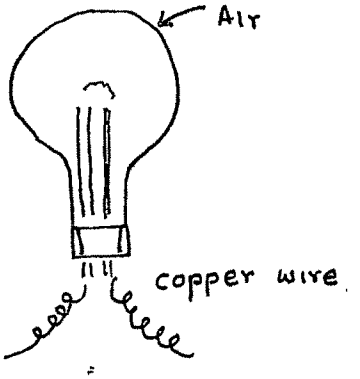
This combination takes place in nature. But you know, man is always curious to use the knowledge of developments

in science to understand nature and try to see if natural phenomena can be created through the application of this knowledge. Suppose we wish to get the oxides of nitrogen artificially, can you suggest what has to be done? A very high temperature would have to be produced. This can be done by creating electric sparks.

Combination of nitrogen and oxygen in nature (lightening)

The high temperature of lightening allows the combination of nitrogen and oxygen.

Artificial combination of nitrogen and oxygen (electric sparks)

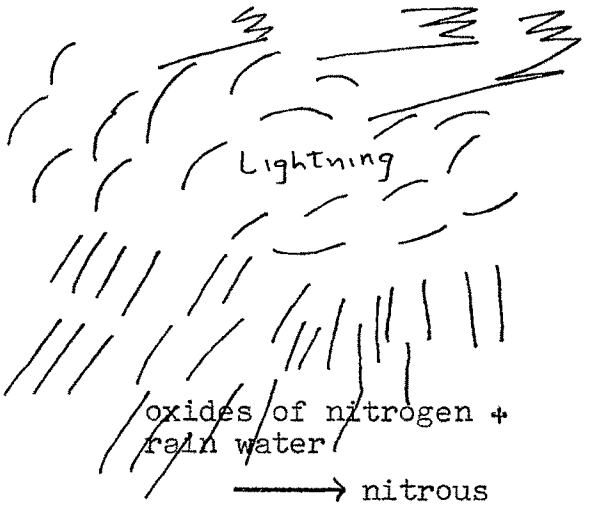


The electric sparks are obtained as follows:
A flask is fitted with a 2-holed stopper. The flask contains air. Due to the high temperature of the electric sparks high voltage would be created, nitrogen and oxygen in air would combine.

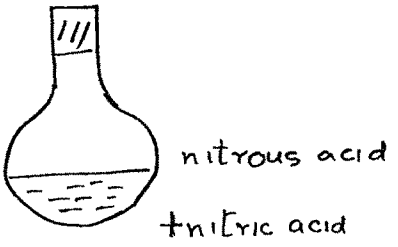
Next, what would happen to the oxides of nitrogen when it rains? Just as many substances dissolve in water, the oxides of nitrogen get converted to acids like nitrous acid and

nitric acid. In the artificial process too, the oxides of nitrogen could be easily converted into acids of nitrogen. The oxides of nitrogen must be made to dissolve in water.

Reaction between oxides of nitrogen and rain water



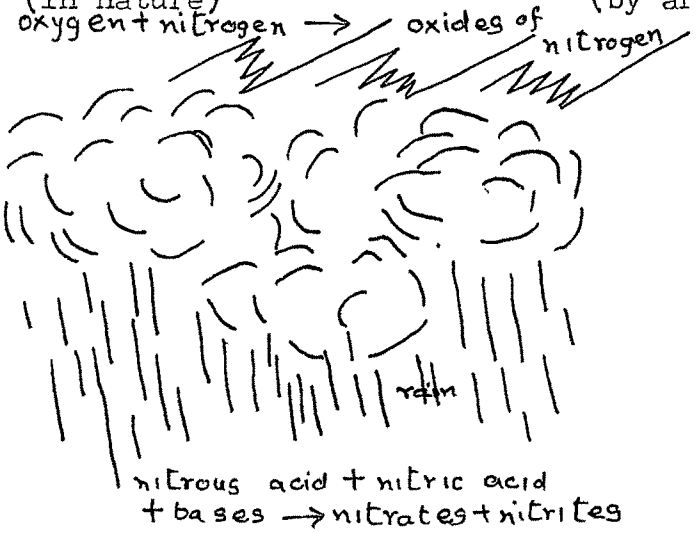
Reaction between oxides of nitrogen and water (artificial process).



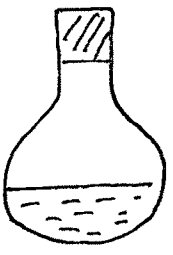
Next, arises the question as to what would happen to the acids obtained? We know that rain water would go into the soil. Along with this, the nitrous and nitric acids too would go into the soil. Soils contain certain minerals and substances like phosphorous, potassium and sulphur. When these acids reach the soil, they react with bases present in the soil. In your Unit VI (Physics and Chemistry) of this course on science you studied what happens when acids react with bases. Acids would react with bases to give salt and water. Perhaps you would guess which salts would

be obtained when acids of nitrogen react with bases. You are right; salts of nitrogen would be obtained. The salts of nitrogen are called nitrites and nitrates. This is one way by which nitrogen present in air gets converted into its salts. This process is very much chemical in nature. There is another way by which nitrogen can get converted to its salts . This is more related to what you studied in biology. The roots of plants like peas or beans contain root nodules. These nodules contain a certain type of bacteria. These bacteria have the capacity to absorb nitrogen directly from the air and convert the nitrogen into compounds of nitrogen. However, it would be interesting to know how the change is brought about by artificial means. Once the acids of nitrogen are obtained by artificial means, these acids may be made to react with bases to give salts called nitrites or nitrates. Let us ~~~ present these changes diagrammatically.

Conversion of acids of nitrogen to salts of nitrogen (in nature)

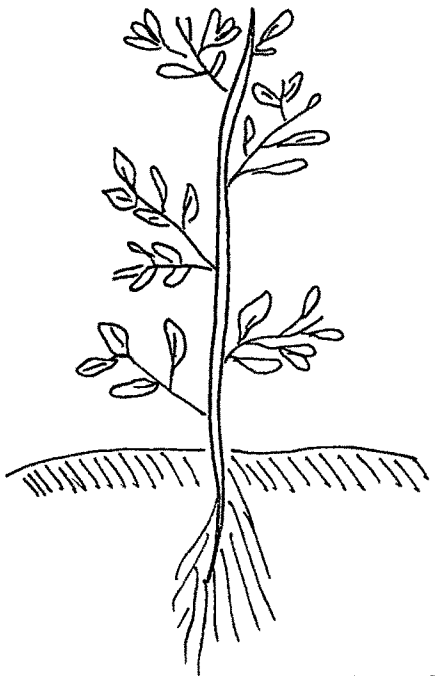


Conversion of acids of nitrogen to salts of nitrogen (by artifical means)



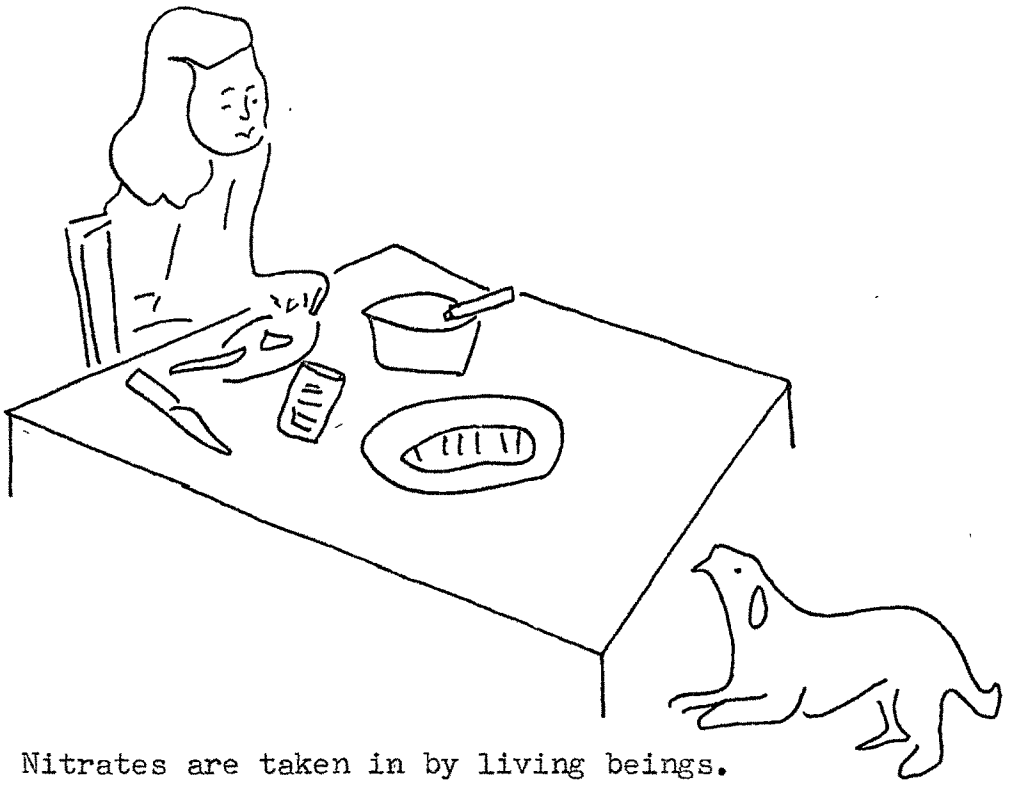
Acids of nitrogen + bases → nitrates + nitrites.

Thus both by natural means as well as by artificial means, the salts of nitrogen, namely, nitrites and nitrates are obtained. Sure, you would be curious to know as to what happens to the salts of nitrogen? The nitrates which are obtained by the natural process would be in the soil. The nitrates obtained by artificial means would be added to the soil for the growth of plants. Thus plants take up nitrates for their growth and completely absorb them.



Plants take up nitrates for their growth.

Further, you know that man and animals live on plants. When they use plants, the nitrates and other nitrogenous substances will be taken up by them.



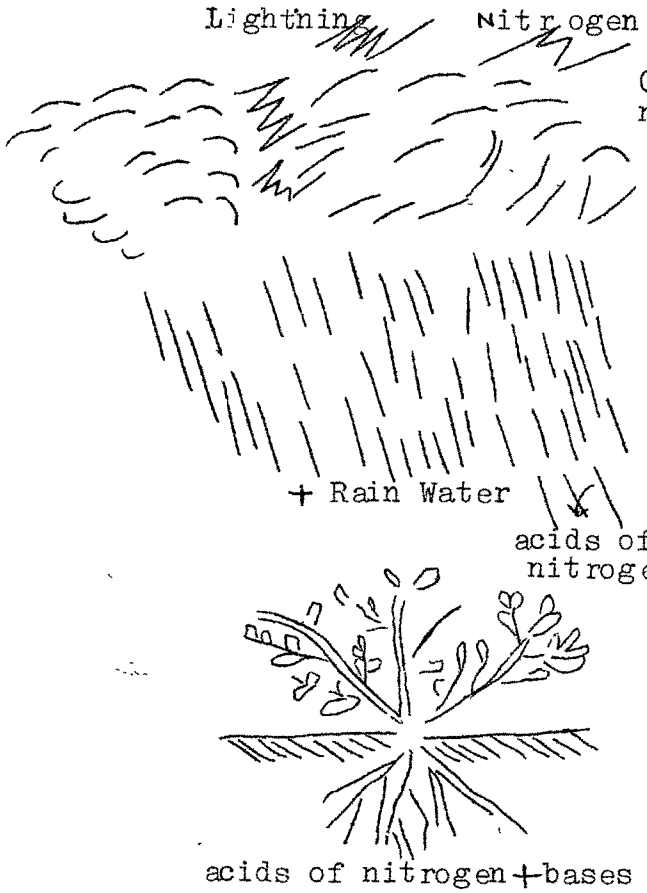
Nitrates are taken in by living beings.

In the biology class, you have studied that living beings are made up of protoplasm. Many of the compounds of protoplasm will be prepared from these nitrogenous compounds. Nitrogen occurs mainly as proteins in living organisms. Man and animals therefore, have a lot of nitrogenous compounds in their bodies. Let us represent this diagrammatically;

Then, an interesting question would arise. When all the nitrogen that is present is taken away from the air and used by man, plants and animals, one day, all the nitrogen in the air would be exhausted and no nitrogen would remain

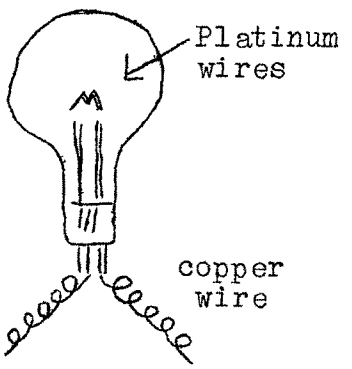
in the air. But we know this does not happen. Nitrogen does exist and added to this, air always contains approximately 78% of nitrogen. Then how is it that the supply of nitrogen is still there in air? Plants use nitrogen for their growth. Man and animals feed on plants and thereby use nitrogen. This is only half the story. You would get an answer to the question given above if you know that when plants and animals die, they decay. During decay, the nitrogenous compounds are left behind as ammonia. Some wastes of animals, like urea also contain a lot of nitrogen. Thus, the compounds containing nitrogen are recovered. Of course some nitrogen is directly returned to the air. This nitrogen again undergoes all the steps we studied earlier. The nitrogenous compounds like ammonia, would combine with the rain water, go into the soil, react with substances in the soil and form ammonium salts. These ammonium salts too, are taken up by plants for their growth. Man and animals feed on plants. They absorb the ammonium salts. When they die, they return the nitrogenous compounds to the air. In this way, the process goes on continuously. This may be represented diagrammatically as follows.

Can you see how the percentage of nitrogen in air remains constant through the cyclic process? This cyclic

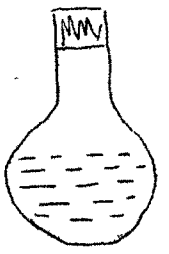


acids of nitrogen + bases

salts of nitrogen (nitrates)



Nitrogen + Oxygen → Oxides of nitrogen

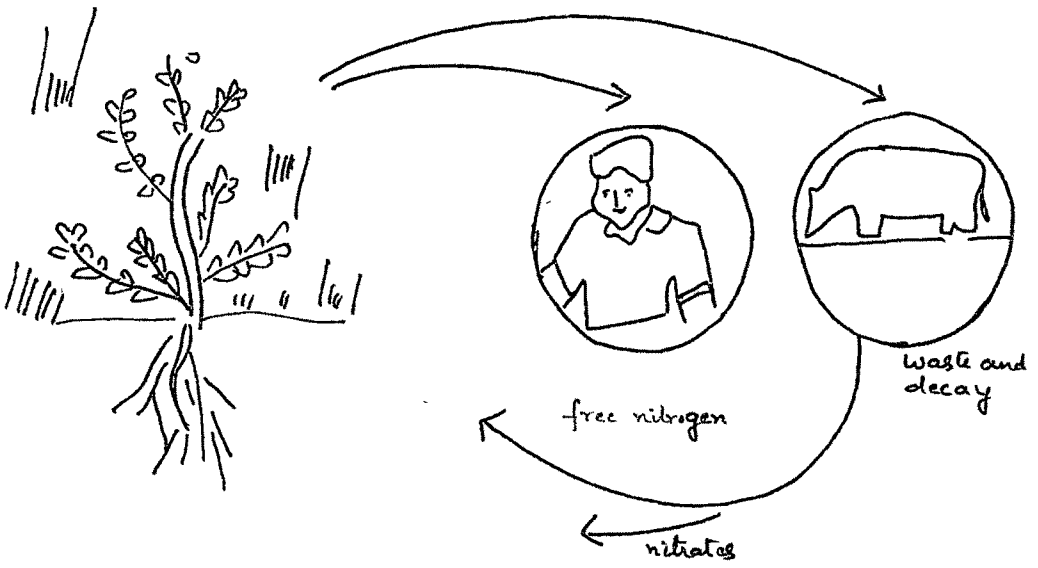


Oxides of nitrogen + water → acids of nitrogen + bases → salts of nitrogen (nitrates)

added to plants

added to plants

Man and Animals Live on Plants



The nitrogen Cycle in nature

process in nature is called the nitrogen cycle. What you stuided just now is briefly presented here:

1. Nitrogen of the air forms nitrogeneous compounds.
2. The nitrogeneous compounds are used by plants for their growth.
3. Man and animals feed on plants thereby taking in a good deal of nitrogen.
4. When they decay and also through wastes, they return nitrogen and its compounds back to the atmosphere.

This cyclic process in nature is called NITROGEN CYCLE.

UNIT TEST III

Name : _____

I. Instructions:

Here are given a few incomplete statements. Under each incomplete statement, you will find 3 or 4 alternatives with which you can complete that statement. You have to choose that alternative which is most appropriate and which completes the statement. Encircle the serial number of the alternative you have selected.

(1) Carbohydrates, fats, and proteins are the basic food requirement of: K

(a) plants only (b) animals only (c) all living organisms.

(2) In Ganong's light screen experiment, the portion of the leaf covered by the light screen did not show the presence of starch when treated with iodine because:

(a) light was not available hence starch was not formed.

(b) CO_2 was not available hence starch was not formed.

(c) Chlorophyll was absent in the leaf hence starch was not formed.

(d) all the above things were absence hence starch was not formed.

(3) In Moll's half-leaf experiment, there was no production of starch in the part of the leaf which was inside the bottle. It is because: C

(a) chlorophyll was not there in that part of the leaf.

(b) CO_2 was not available to that portion of the leaf.

(c) light was not available to that part of the leaf.

(d) there was no air inside the bottle.

(4) In the hydrilla experiment, when burning stick was introduced into the test tube containing the gas, it continued to burn. This proved that: C

(a) CO_2 is evolved during photosynthesis

(b) Hydrogen is evolved during photosynthesis.

(c) Oxygen is evolved during photosynthesis.

(d) None of the above gases are evolved during photosynthesis.

(5) It is a common experience to see green plants in fish tank. The reason for keeping green plants is: A

(a) it serves as food to fishes

(b) it evolves oxygen which is needed for fishes to live.

(c) it makes the fish tank look nice.

(6) In photosynthesis, one set of reactions are called as light reactions because: K

(a) light is made use of in the process.

(b) since it takes place only during day time.

(c) light was the name of the person who invented it.

(7) In photosynthesis, one set of reactions are called as dark reactions because: K

(a) it takes place only during night times.

(b) sunlight is not made use of in these reactions.

(c) it takes place only after light reactions.

II. <u>Fill up the Blanks</u>:

(1) The process by which green plants manufacture starch is called as _____.

8 (2) _____ and _____ are the two major types of reactions of photosynthesis. K

(3) When sunlight falls on the green leaves, _____ chlorophyll becomes _____ chlorophyll. K

III. (1) Here are given few factors. Tick ~~and~~ the factors which are not needed by plants for manufacturing food. K

(a) Oxygen
(b) Sunlight
(c) Carbon dioxide
(d) Chlorophyll
(e) Nitrogen
(f) Water

IV. Here is given the equation which represents the process of photosynthesis. There is something wrong in the equation. Correct it and write it separately:

$$CO_2 + O_2 \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_5H_{12}O_6 + H_2O$$

Correct equation

V. Here are given the steps of photosynthesis, which are mixed up. Put '_/' if it belongs to light reaction and 'x' it it belongs to dark reaction in the space provided: K

(a) Chlorophyll gets activated. ( )

(b) Formation of 6-carbon containing compound ( )

(c) Water is broken into Hydrogen and oxygen. ( )

(d) Formation of sugar by the combination of two 3-carbon compounds with ATP and high energy hydrogen compound. ( )

9 (e) Formation of ATP from ADP. ( )

(f) A high energy hydrogen containing compound is formed. ( )

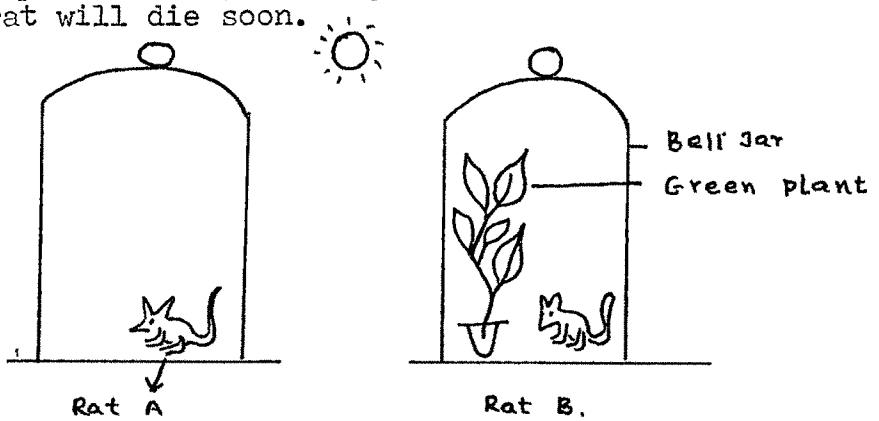
(g) Splitting of 6-carbon compounds into 2 compounds of 3-carbon atoms each. ( )

VI. Trace the path of carbon from atmosphere till the formation of carbohydrate. C

VII. Reason out:

(1) Reason out as to why a healthy plant kept in complete darkness dies within a few days. A

(2) Here are given diagrams of two rats 'A' and 'B' kept in airtight belljars. Reason out as to which rat will die soon. A



VIII. Draw a neat diagram of hydrilla experiment and write the hypothesis and procedure for the same. C