Sonja Kuster 09/12/2023
Woody plant physiology
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UNIT GUIDE 2023-24

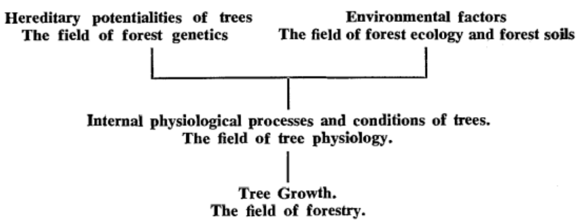
LO 3. Understand the main physiological processes that woody plants carry out and the main environmental factors which influence growth

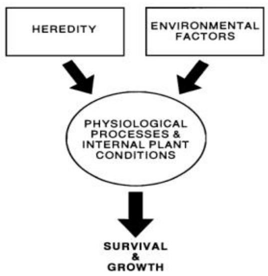
3.1. Describe the principles of the physiological processes of woody plants
3.2. Identify a minimum of three environmental factors which influence growth
3.3. Describe how the factors named in 3.2 influence growth
3.4. Identify what fuels the physiological processes
3.5. Define the terms potential energy and kinetic energy
3.6. Define the terms dynamic and static mass

3.1. Describe the principles of the physiological processes of woody plants

The twofold purpose of tree physiology in forestry is to first explain the nature of the fundamental physiological processes in the tree that regulate growth and then to demonstrate how both heredity and environment have an impact on these processes either individually or collectively.

Plant physiology can assist foresters to grow better trees by showing them how trees grow. The principal role of plant physiology in forestry is to assist foresters to understand why trees behave as they do under environmental conditions and to predict how they will behave under other conditions. Knowledge of tree physiology is essential to this understanding because environmental factors can affect the growth of trees only by affecting their internal physiological processes and conditions.





Klebs' concept developed by the German plant physiologist Klebs.
Heredity and environmental factors combine to influence physiological processes and internal plant conditions, and hence, plant survival and growth.
The diagram emphasizes factors that should be kept in mind when considering tree growth. The first is that a tree's growth is governed by two interacting groups of factors: its genetic potentialities and its environment, and the second is that genes and the environment can affect a tree's growth by influencing its internal physiological processes and conditions.

Important Physiological Processes
Photosynthesis: The synthesis of carbohydrates from carbon dioxide and water provides the basic food materials for all other processes.
Nitrogen metabolism: The incorporation of inorganic nitrogen into organic compounds makes possible the synthesis of proteins and protoplasm itself.
Fat metabolism: Synthesis of fats and related compounds.
Respiration: The oxidation of food in living cells releases the energy used in assimilation, mineral absorption, and other energy-using processes.
Assimilation: The conversion of food into new protoplasm, cell walls, and other substances. A basic process in growth.
Accumulation: The storage of food in seeds and the woody structure of trees.

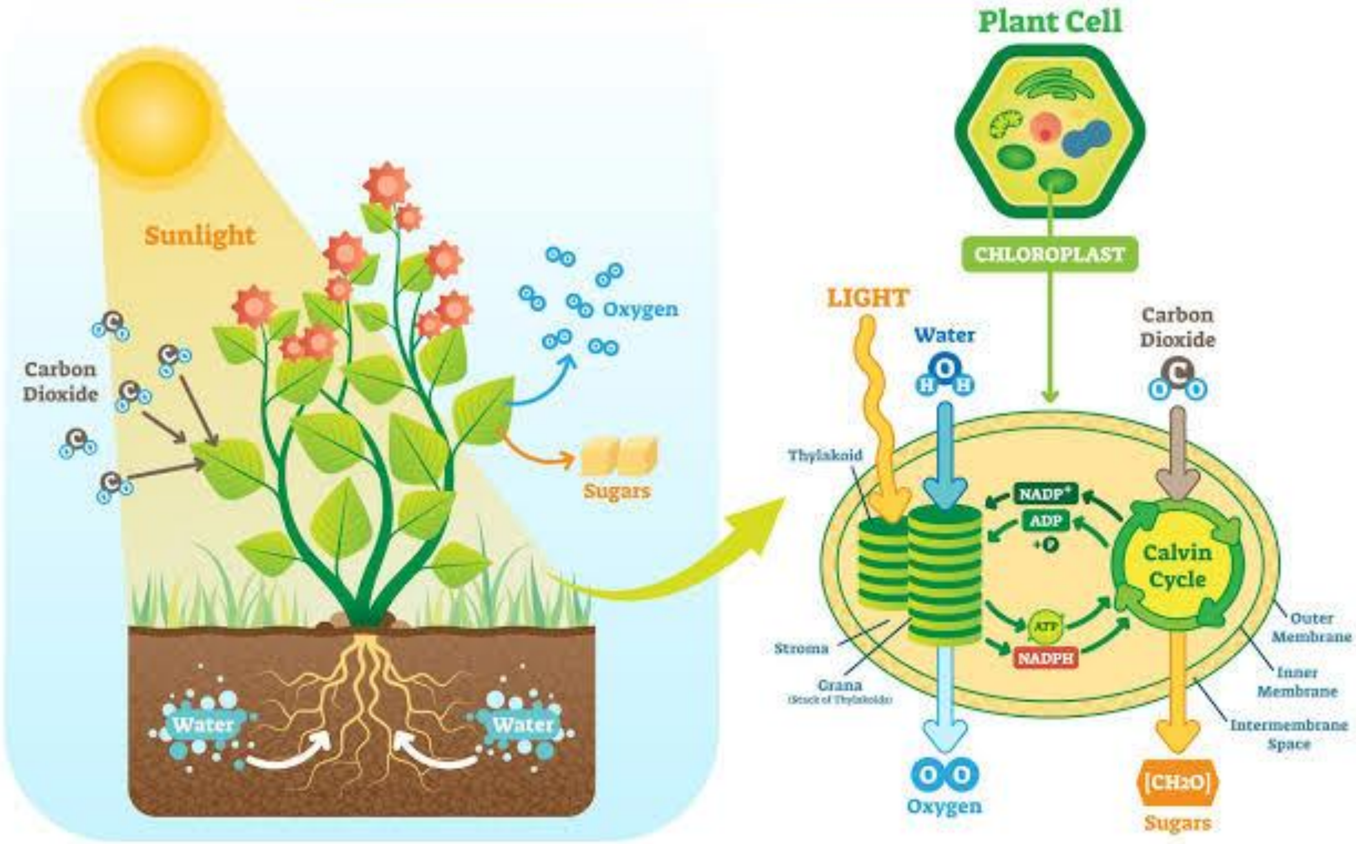
Digestion: Conversion by enzyme action of complex or insoluble forms of food such as starch into simpler, soluble forms which can be translocated and used in respiration and other processes.
Absorption: The intake of water and minerals from the soil, and oxygen and carbon dioxide from the air.
Translocation: The movement of water, minerals, foods, and hormones from place to place in trees.
Transpiration**:** The loss of water from trees in the form of vapor.
Growth: Permanent increase in size which results from the interaction of the various processes just listed.
Reproduction: Production of cones or flowers and finally of seeds. This also results from the interaction of several physiological processes.

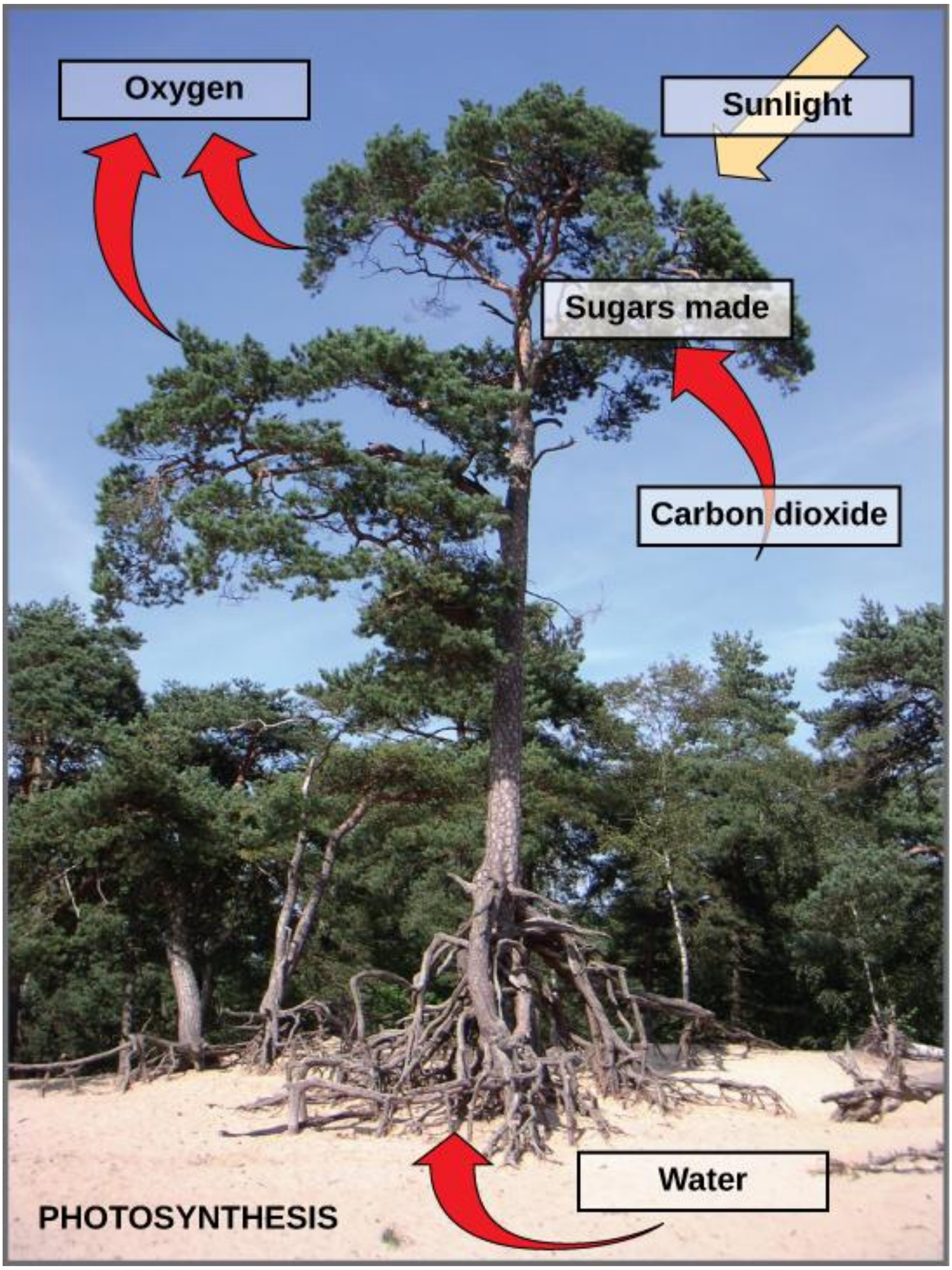
Important Physiological Conditions
Kinds and amounts of carbohydrates present and their interconversion, for example starch to sugar and the reverse.
Kinds and amounts of nitrogen compounds and the ratio of carbohydrates to nitrogen.
Kinds and amounts of other constituents, such as organic acids.
Protoplasmic characteristics: Cold and drought resistance probably are at least partly dependent on special characteristics of protoplasm.
Permeability of cell membranes: Related to uptake of minerals, translocation, and cold resistance.
Osmotic pressure of cell sap: Increased osmotic pressure often associated with exposure to drought and cold.
Turgidity of cells: Loss of turgidity causes cessation of growth and affects rates of various physiological processes.

Photosynthesis:
Photosynthesis is the process by which plants use sunlight, water, and carbon dioxide to create oxygen and energy in the form of sugar.
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.
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 colour. During photosynthesis, chlorophyll absorbs energy from blue- and red-light waves, and reflects green-light waves, making the plant appear green.
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. 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.

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 most 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.

PHOTOSYNTHESIS





Photosynthesis uses solar energy, carbon dioxide, and water to produce energy-storing carbohydrates.
Oxygen is generated as a waste product of photosynthesis.

Nitrogen metabolism:
Plants require more nitrogen since it is essential to their structure and metabolism. Nitrogen makes up over 80% of the earth's atmosphere, soaking the entire plant world, but most plants cannot use it in its most basic form. They must rely on the soil for its supply, from which they obtain nitrogen in inorganic form, either as ammonium compounds or as nitrate. Only a few bacterial systems can directly utilise ambient nitrogen.

Nitrogen Cycle:
Although nitrogen constitutes around 78% of air by volume, it is not normally utilised by plants in its free condition. Nitrogen, on the other hand, is only found in 1-3 percent of the plant's dry matter. Nonetheless, it is vital to plant life because it is a component of proteins, chlorophyll, and protoplasm. Furthermore, it is required for growth, particularly of the leaves. Excess nitrogen promotes robust growth of vegetative organs, particularly the leaves, but inhibits reproduction activity.

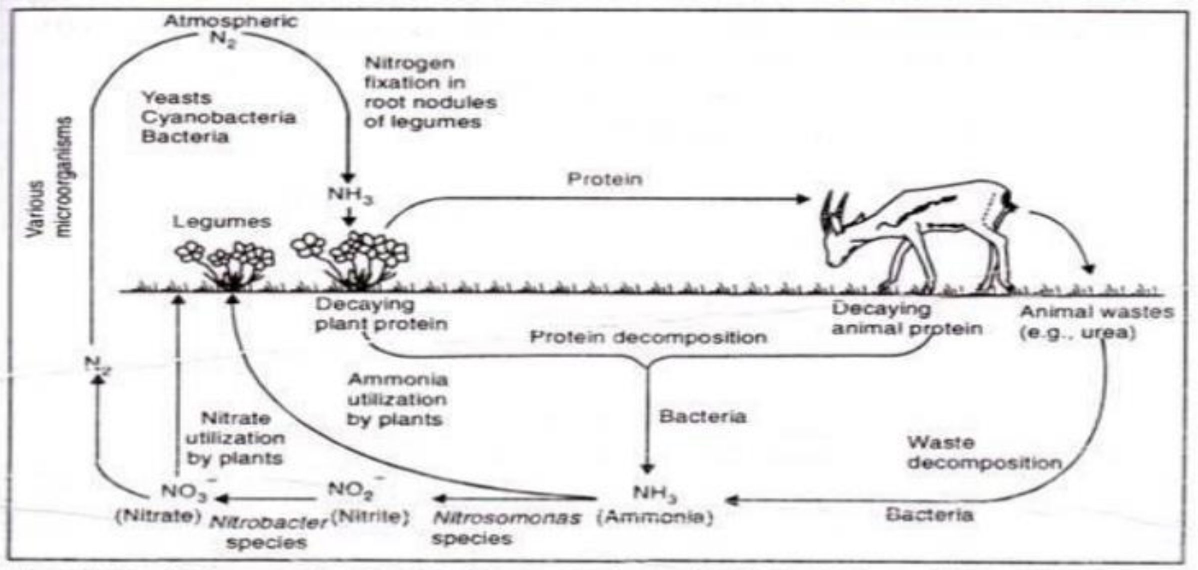


Fig. 5.8. The Nitrogen cycle (after I.E. Alcamo, Fundamentals of Microbiology, 1994). The amount of nitrogen in the atmosphere is maintained by a balance between the processes that withdraw nitrogen from it (nitrogen fixation) and those which add nitrogen to it (denitrification).

The nitrogen cycle is one of the most essential biological necessities for the survival of life. During this process, atmospheric nitrogen is fixed into organic combinations in living organisms, such as amino acids, proteins, nucleic acids, and so on, via inorganic forms such as NH4 + (ammonia). Inorganic nitrogen is released when live organisms die and decompose.

Ammonification: Ammonia (NH3) is created when the dead bodies of plants and animals are broken down by microorganisms.

Nitrification: Ammonia is quickly transformed into nitrites (NO2) and eventually nitrates (NO3) in this process. Nitrosomonas and Nitrobacter are the bacteria that convert ammonia to nitrite and nitrite to nitrate, respectively. Nitrate is now accessible to the plant.

Denitrification is the process by which nitrate (NO3) is converted into N2 gas by the bacteria Pseudomonas. Through the process of biological nitrogen fixation, this nitrogen gas can be fixed again in the form of NH4 +.

The soil contains different amounts of nitrogen. The primary source of nitrogen for the plant, however, is the soil. Both inorganic and organic nitrogen compounds can be found in plants. The main types of inorganic compounds are ammonia and its constituents, potassium and calcium nitrates and nitrites, while proteins are the main types of organic compounds. Normally, specific nitrifying bacteria present in the soil convert the ammonium compounds present in the soil into nitrate before making them available to the green plants for utilisation. The name for this procedure is nitrification.

<u>Nitrogen Fixation</u>

Physical nitrogen fixation:

Physical nitrogen fixation refers to the conversion of atmospheric nitrogen into useable form by lightning and rainfall. During thunder and lightning, gaseous nitrogen is oxidised to nitrogen peroxide, which then reacts with rainwater to produce nitrous and nitric acid. Calcium nitrate and potassium nitrate are formed in the soil with calcium and potassium, and are absorbed by plants.

<u>Biological Nitrogen Fixation of Plants</u>

Both free-living and symbiotic microorganisms participate in biological nitrogen fixing. Cyanobacteria, Azotobacter, and Clostridium are the free-living nitrogen-fixing bacteria.

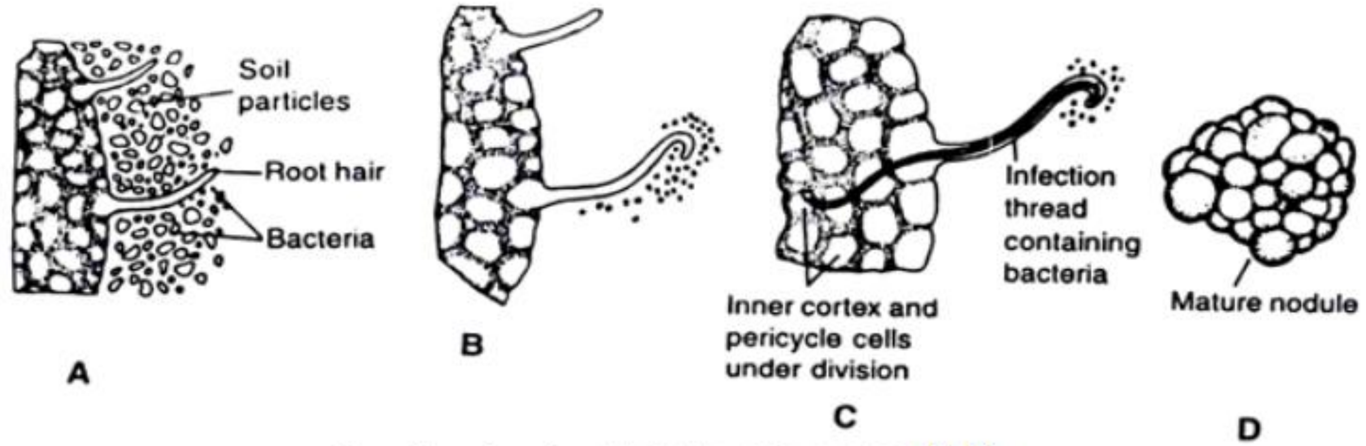
<u>Symbiotic N2 Fixation</u>

The nitrogen fixers will occasionally make the ammonium compounds (NH4) available to the plants. Rhizobium (R. leguminosarum) is the most well-known symbiotic bacteria for nitrogen fixation. This bacterium thrives in soil and causes plants of the Leguminosae family, including gramme, pea, groundnut, beans, and others, to develop root nodules. Leghaemoglobin is a pigment found in the little outgrowths on roots known as root nodules. The red colour of human blood, haemoglobin, and this pigment are closely related. The nodule serves as a place where N2 is fixed. It

has all the essential metabolic elements, including leghaemoglobin and nitrogenase. A Mo-Fe protein called nitrogenase catalyses the transformation of atmospheric N2 into NH3. Since this enzyme is particularly sensitive to oxygen, nodules include an oxygen scavenger called leghaemoglobin.
Rhizobia grow, colonise, and cling to the epidermal and root-hair cells of legume plants.
The root-hair coils, allowing germs to enter, spread an infection through the root, and reach the cortex.
Here, nodule formation is started by bacteria.
The germs are subsequently released into the cells by the infection thread. This causes unique nitrogen-fixing cells to differentiate. The nodule creates a direct link with the host to exchange nutrients in this way.
The enzyme nitrogenase, found in the nodule, transforms atmospheric nitrogen into ammonia, the first stable byproduct of nitrogen fixation.

Formation of root nodules in leguminous plant

A leguminous plant's root hair becomes twisted or misshapen when it comes into touch with the bacterium Rhizobium. The cause of curling is a unique chemical compound released by bacteria (Rhizobium).
Rhizobia (bacteria) infiltrate the root tissue at the location where the root hair curls and multiply there. Some bacteria grow to become bacteroid, which are membrane-bound structures. Some bacteria do not undergo transformation because the bacteroid are unable to divide; as a result, the infection might spread. The infected tissue is separated from the rest of the plant by an infection thread made of plasma membrane that develops from the infected cell of the plant and grows inward. The diseased tissue has an increase in cell division, and more bacteria penetrate the developing tissues.



Formation of root nodule in leguminous plant. (A-D)

A combination of cytokinin produced by invading bacteria and auxin produced by plant cells is thought to encourage cell division and extension, which leads to molecule creation.
The nodule so produced oversees direct vascular connection with the host for nutrition exchange. N2 fixation, on the other hand, is controlled by plant nod genes and a bacterial nod, nif, and fix gene cluster.

Nitrogen metabolism

Nitrogen metabolism includes both anabolic and catabolic processes.
The anabolic processes are: a) Nitrogen fixation b) Amino acid synthesis c) Protein synthesis
The catabolic processes are: d) Proteolysis and amino acid destruction e) De-nitrification f) Nitrification.

Nitrogen fixation is of two types: non-biological nitrogen fixation and biological nitrogen fixation.
Nitrogen is converted to ammonia in the fertiliser business at extremely high temperatures and pressures using an iron catalyst. Nitrogen can also be repaired by electrical discharges that occur during lightning strikes. In this process, atmospheric nitrogen reacts with oxygen to form nitrogen oxides, which are then hydrated by water vapour and transported to earth as nitrites and nitrates by rain.

Biological Nitrogen Fixation

A group of genes known as the nitrogen fixation (nif) genes control the process by which some bacterial species gain the ability to decrease nitrogen to ammonia. 'Nitrogen-fixing' organisms are what these species are known as. These creatures can either be non-symbiotic microbes that can exist on their own or specific bacteria that coexist with higher plants. A few species of heterotrophic bacteria, including aerobic (Azotobacter sp.) and anaerobic (Clostridium sp.), photosynthetic bacteria (Rhodospirillum sp.), and several blue-green algae (Cyanophyta) are included in the first group. To build a significant nitrogen-fixing cooperative, the symbiotic system combines bacteria from the genus Rhizobium with numerous plants from the family Leguminosae, including peas, beans, clovers, soybeans, etc.
The growth of nodules on the plant roots is a crucial component of the symbiotic fixation.

Amino acid synthesis
Amino-acids are supposed to be initial products of nitrogen assimilation. Synthesis of amino-acids takes place by two main methods. They are as follows: I. Reductive amination, and II. Transamination.

Reductive amination
Here, ammonia reacts with α-ketoglutaric acid, which results in the formation of glutamic acid. Enzyme responsible for this reaction is glutamate dehydrogenase.

Transamination
The amino (-NH2) group from one amino acid is transferred to the keto group of the keto acid during this procedure. The principal source from which the other seventeen amino acids are transaminated is glutamic acid. The transaminase enzyme oversees this reaction. The two most significant amides in plants are glutamine and asparagine. Glutamic acid and aspartic acid, two amino acids, are used to create them. The acid's hydroxyl (-OH) component is swapped out for another (-NH2) radicle during this procedure. It is possible that glutamine synthetase or asparagine synthetase are the enzymes in charge of this process. Amides are a structural component of most proteins and contain more nitrogen than amino acids.

Protein Synthesis in Plants
One or more polypeptide chains make up proteins. These chains are made up of hundreds of amino acids each. Since the quantity of amino acids differs significantly between proteins, so does their molecular weight.
The carboxyl (-COOH) group of one amino acid and the amino (-NH,) group of the following amino acid form a peptide bond, which links the amino acids and amides in the polypeptide chain. In the structural and functional organization of the cell, proteins play a crucial role. Structural proteins make up a variety of cellular sections as well as some extracellular components, such as cuticle and fibres. Almost all the metabolic, biosynthetic, bioenergetic, growth-regulating, sensory, and reproductive functions of the cell are regulated by functional (enzymatic and hormonal) proteins. The cell itself produces all the proteins needed by the cell for its various functions intracellularly.

The catabolic processes are:
Proteolysis and amino acid destruction
Proteins are broken down into smaller polypeptides or amino acids via a process called proteolysis. Proteolysis can also be caused by intra-molecular digestion; however, it is commonly catalysed by cellular enzymes called proteases. Proteolytic processing of a polypeptide chain after its synthesis may be required for the generation of an active protein. For instance, digestive enzymes break down proteins in meals to give amino acids for the organism. Additionally, it helps prevent the buildup of undesirable or aberrant proteins in cells and regulates several physiological and cellular processes. The N-terminal methionine, the signal sequence, the cleavage of polyproteins, and the cleavage of precursor proteins are all examples of proteolytic processing.

Amino acid degradation
The amino acids first go through deamination before being transformed into metabolic intermediates. Deamination's major objective is to utilise or convert the residual carbon skeleton (to glucose) after excreting excess nitrogen (as urea). This deamination is a two-stage process. The first phase is often a transamination, which is catalysed by an aminotransferase and involves the transfer of the amino group from the amino acid to -ketoglutarate, producing a new -keto acid that contains both the amino acid and glutamate. Aspartate and -keto-glutarate could then be created by the amino group of glutamate transferring to oxaloacetate. One of the following seven metabolic intermediates

results from the breakdown of amino acids: pyruvate, acetyl-CoA, acetoacetate, a-ketoglutarate, succinyl-CoA, fumarate, and oxaloacetate.

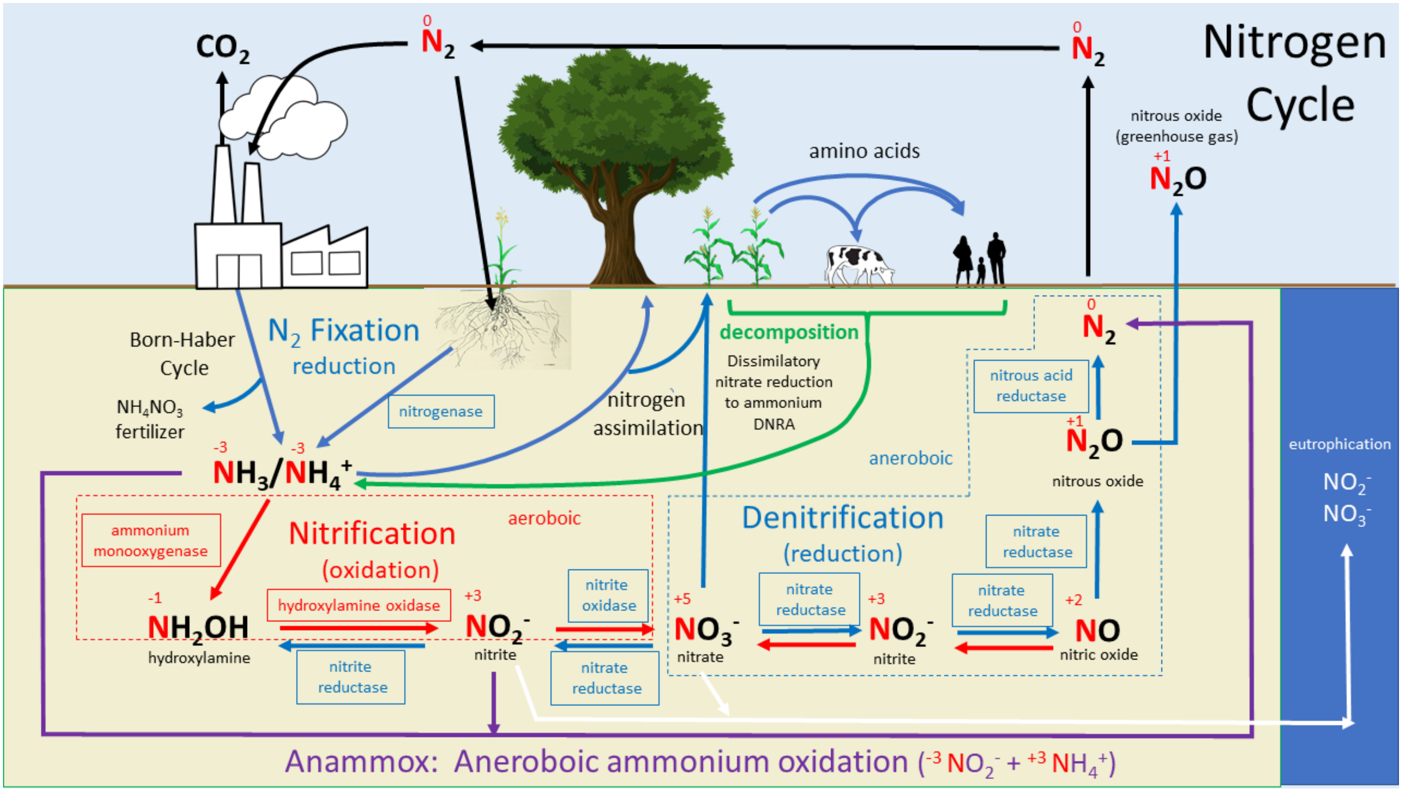
De-nitrification

It is a process in which soil bacteria such as Pseudomonas dentifrices convert the nitrate ion (NO3) to nitrogen dioxide (NO2), di-nitrogen oxide (N2O), nitrogen monoxide (NO), or nitrogen (N2).
As a result, nitrogen is released into the atmosphere. Plants also lose modest amounts of nitrogen to the atmosphere as gaseous ammonia, N2O, NO2, and NO, especially when nitrogen is abundant.

Nitrification

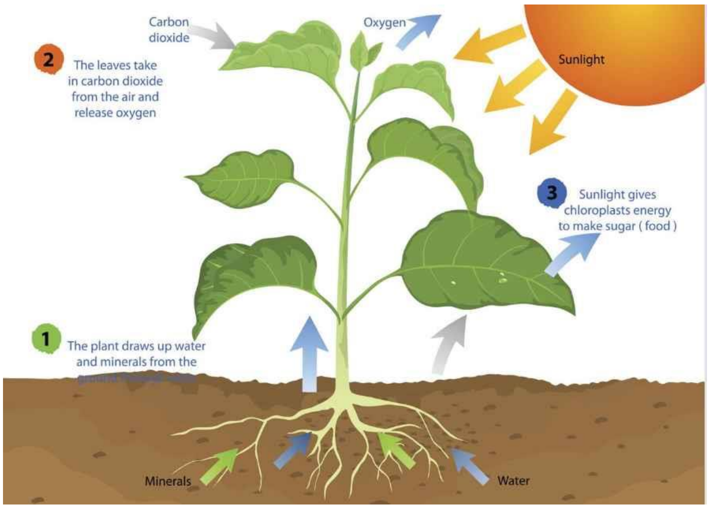
Nitrosomonas, Nitrococcus, and Nitrospira bacteria in oceans and soils convert ammonia to nitrites, which are then converted to nitrates. In their metabolism, these bacteria largely utilise the energy of dead organic matter. Several bacteria, including Penicillium (a fungus), Nitrobacter, and others, convert nitrites to nitrates. Weathering of nitrate-containing rocks also makes certain nitrates accessible.

https://www.cbsetuts.com/nitrogen-cycle/



Respiration

Respiration is the process by which food, or substrate, is oxidised in living cells to release energy. The released energy is stored as chemical energy by the substrate's molecules. Respiration produces energy and metabolic intermediates, which give cell components their carbon skeletons. The maintenance and growth of tissues, the movement of organic and inorganic materials, and the assimilation of mineral nutrients all depend on these products. There is proof that respiration and the development of woody plants are strongly correlated. Every living cell in a tree, including the roots and leaves, is capable of respiration. It can happen at any time of day or night because it does not require light. The process of respiration involves the combining of oxygen and the energy that was stored as glucose during photosynthesis to create usable energy. As a byproduct, carbon dioxide and water are emitted. A tree's ability to respire and, hence, its ability to convert glucose into energy can both be negatively impacted by compaction and waterlogging of the roots, which can hinder the roots' ability to take in oxygen.

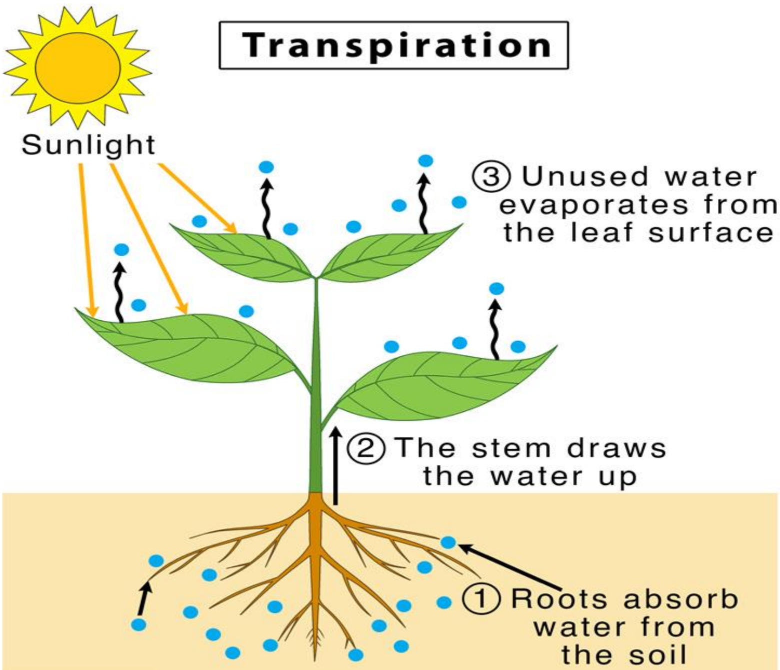


Osmosis

Osmosis is the method by which water and minerals are transferred from the soil into the roots. Osmosis is the process by which water moves across a semi-permeable membrane from an area where water molecules are concentrated in a high concentration to an area where they are concentrated in a low concentration, resulting in an equal concentration of water molecules on both sides. Water molecules migrate into a tree's roots from the surrounding soil, where the concentration of water is higher, because the minerals and carbohydrates in the roots lower the concentration of water. To maximise the amount of water absorbed, the roots develop many extended hairs and thin walls. Water will, on the other hand, flow out of the roots and into the soil if the concentration of water molecules in the surrounding soil is lower than in the root cells. This process, known as reverse osmosis, can harm a tree by causing it to lose water. This can happen if there are a lot of minerals in the soil, which can happen by overusing fertilisers or salting roads during the winter.

Transpiration

The flow of nutrients and water around a tree is called transpiration. In the end, this mechanism causes water to evaporate from the leaves through stomata, which essentially draws up all the water molecules in the tree's water system behind it. Water and nutrients are drawn up through the roots (osmosis), through the trunk, into the leaves, and out of the stomata by means of this pulling force. Water and nutrients are continuously moving through a tree's system during the growing season. The network of tiny vessels in the tree guarantees a steady supply of nutrients and water, which is necessary for the tree's survival and growth. The tree will eventually perish from a lack of nutrients and water if the procedure is unable to supply water to any part of the tree, such as a broken branch.



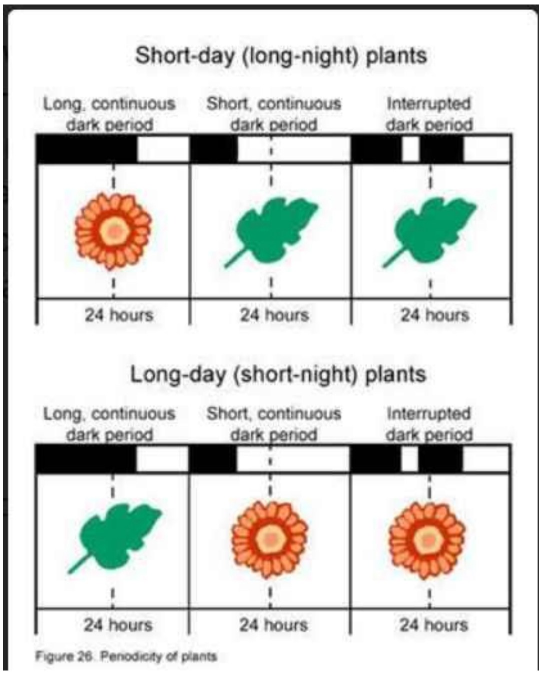
3.2. Identify a minimum of three environmental factors which influence growth

Environmental factors that affect plant growth include light, temperature, water, humidity, and nutrition.

3.3. Describe how the factors named in 3.2 influence growth

Light
Three principal characteristics of light affect plant growth: **quantity, quality,** and **duration.**
The intensity, or concentration, of sunlight is referred to as its light quantity. The seasons have an impact on it. Summertime has the most light, while wintertime has the least. Up to a certain extent, a plant's ability to produce food through photosynthesis increases with the amount of sunshine it receives.
The term "light quality" describes the wavelength or colour of light. The full spectrum of wavelengths found in sunlight can be divided into bands of red, orange, yellow, green, blue, indigo, and violet with a prism. The light that plants absorb and use most to grow is blue and red light. The main factor causing vegetative (leaf) growth is blue light. When blue and red lights are mixed, flowering is encouraged. We see green in plants because they reflect green light instead of absorbing it.
Selecting the right light source is crucial for controlling plant growth. Fluorescent light, or cold white light, has a strong blue wavelength. It works great for beginning seedlings and promotes leafy development. Although incandescent light has a high red or orange colour temperature, it usually generates too much heat to be useful for plants as a light source. Fluorescent grow lights use a combination of red and blue wavelengths to mimic sunlight; nevertheless, they are not much better than standard fluorescent lights and can be expensive.

The duration of a plant's exposure to light is known as its photoperiod. For many plants, the photoperiod regulates flowering (Figure 1). Scientists once believed that flowering and other responses in plants were caused by the duration of the light period. As a result, they label plants as either long-day or short-day, depending on the circumstances in which they flower. We now understand that the duration of continuous darkness, rather than the duration of the light cycle, is crucial for the growth of flowers.



Plant Periodicity, Figure 1 Plants that are short-day (long-night) types need a lot of continuous darkness to blossom. For plants that are long-day (short-night) plants to flower, they need a brief duration of unbroken darkness. Keep in mind that the uninterrupted dark phase is the one that affects blossoming. Its influence on blossoming will be negated if a lengthy period of darkness is broken up by even a brief interval of light.

Plants are divided into three groups based on how they react to the length of light or darkness: short-day (long-night), long-day (short-night), and day-neutral. Only when the day lasts fewer than roughly 12 hours do short-day plants begin to flower. This group includes many plants with spring and fall flowers, like Christmas cactus, poinsettia, and chrysanthemum.
Long-day plants, on the other hand, only blossom when the day lasts longer than twelve hours. This group includes most summer-flowering plants (such as rudbeckia, California poppy, and aster) and numerous vegetables (beetroot, radish, lettuce, spinach, and potato).

Day-neutral plants produce flowers at any time of day. Tomato, corn, cucumber, and certain strawberry cultivars are a few examples. Certain plants are identical, meaning they can react to different combinations of day lengths. For example, petunias flower at any time of the day, but on longer days, they flower earlier and more heavily.

Temperature

Most plant functions, such as photosynthesis, transpiration, respiration, germination, and blooming, are influenced by temperature. The processes of photosynthesis, transpiration, and respiration all increase with temperature—up to a point. Temperature influences the transition from vegetative (leafy) to reproductive (flowering) growth when paired with the duration of the day. Temperature has the potential to either accelerate or slow down this transformation, depending on the circumstances and the particular plant.

According to a 2018 German study, trees are growing more quickly than they did more than a century ago. On the other hand, although growth rates had increased by 77%, in certain species, the density of the wood created had decreased by 12%. As a result, even though higher growth rates may benefit reforestation efforts, the resulting trees may not be strong enough to survive storms and other extreme weather, which are becoming more frequent and severe worldwide because of climate change.

Water and humidity

Ninety percent of growing plants are made of water. Water has numerous functions in plants:

It is:

- A primary component in photosynthesis and respiration
- Responsible for turgor pressure in cells (Like air in an inflated balloon, water is responsible for the fullness and firmness of plant tissue. Turgor is needed to maintain cell shape and ensure cell growth.)
- A solvent for minerals and carbohydrates moving through the plant
- Responsible for cooling leaves as it evaporates from leaf tissue during transpiration
- A regulator of stomatal opening and closing, thus controlling transpiration and, to some degree, photosynthesis
- The source of pressure to move roots through the soil
- The medium in which most biochemical reactions take place

The ratio of water vapour in the air to the total amount of water the air could retain at the pressure and temperature it is at right now is known as relative humidity. More water vapour can be held in warm air than in cold air. The following formula can be used to express relative humidity (RH):

RH = water in air ÷ water air could hold (at constant temperature and pressure)

Relative humidity is given as a percent. For example, if a pound of air at 75°F could hold 4 grams of water vapor, and there are only 3 grams of water in the air, then the relative humidity (RH) is:

3 ÷ 4 = 0.75 = 75%

From a region with high relative humidity to one with low relative humidity, water vapour travels. Water travels more quickly the wider the humidity differential is. This is significant since a plant's transpiration rate is directly impacted by the flow rate of water. In the air gaps between leaf cells, the relative humidity is almost 100%. When a stoma opens, a bubble of high humidity occurs around the stoma when water vapour from inside the leaf bursts into the surrounding atmosphere (Figure 2). The bubble lessens the differential in relative humidity between the air spaces inside the leaf and the air next to it by soaking this tiny patch of air. Transpiration thus slows down.

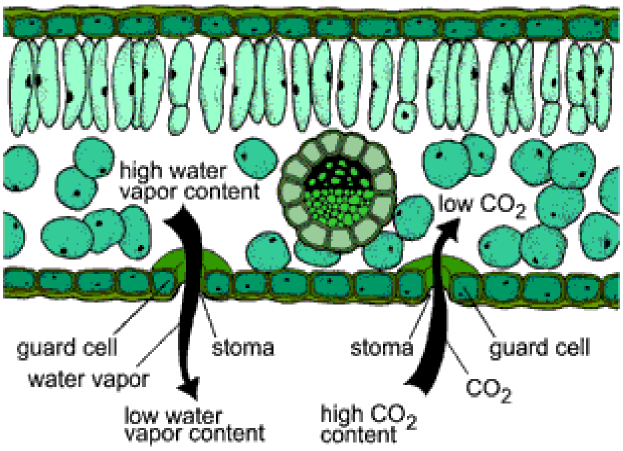


Figure 2. Stomata open to allow carbon dioxide (CO2) to enter a leaf and water vapor to leave.

Transpiration rises, though, if wind drives the humidity bubble away. Thus, hot, dry, windy days are typically when transpiration is at its highest. On the other hand, in colder climates with high humidity and no wind, transpiration is typically slow. Plants wilt quickly in the summer because of the hot, dry conditions that typically prevail during this season. Turgor pressure is lost and leaves become limp if there is not a steady supply of water for the roots to absorb and transfer to the leaves.

3.4. Identify what fuels the physiological processes

Six key requirements for trees:
1. Sugars supplied by photosynthesis. Air and water are chemically recombined to form glucose, which stores energy captured from the sun. Oxygen is a byproduct.
2. Water is required for most metabolic activities and serves as a vehicle to carry materials through a tree. A large tree may move as much as 50-100 gallons of water on a hot summer day.
3. Nutrients. It is not how much of a particular nutrient exists in the environment; it is a matter of how available the nutrient is to the tree. For example, the atmosphere is largely composed on nitrogen, but trees can only use nitrogen in forms that have been altered by soil bacteria and other organisms. The major chemical elements used by plants are: carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulphur, calcium, iron, and magnesium.
4. Hormones and enzymes. These chemicals are critical in the controlling the timing and activity of physiological processes. They are usually produced in the roots or leaves. We do not often think of plants having "hormone" deficiencies, but hormones are critical to the survival of any organism, including trees.
5. Mycorrhizae. Pronounced *"my-core-HI-zee",* this is a group of beneficial fungi associated with most tree roots. It represents an ecologically symbiotic relationship where the fungi receive food from the tree and the trees receive greatly enhanced nutrient and water absorption. Mycorrhizae will also protect tree roots from other invading fungi. There tends to be very specific species relationships between fungus and tree.
6. Environmental factors. A tree needs an appropriate mix of precipitation, temperature, sunlight, and soils to thrive. These factors need to occur at the right time. Each tree species has a different set of environmental requirements. Changing climate will lead to changing environmental factors, which can lead to changes in forest ecosystems.

The energy source for a plant's physiological functions is sunlight since it is necessary for photosynthesis, which creates glucose, which is used by the entire plant to power cell division and growth. Water is necessary for the nutrients to travel up via the xylem from the soil and to keep the plant's cells turgid and functional. Phloem carries the sugars produced by photosynthesis from the leaves to the locations where they are needed, from the source to the sink. The phloem can move in both directions throughout its course. The leaves are the source during the growing season because they produce and transfer glucose from photosynthesis to other sections of the plant, which serve as sinks for the storage or utilisation of the material. As the plant draws on the sinks during dormancy, the leaves turn into the sink as they use the stored energy to expand when growth resumes in the spring. Phloem absorbs winter-stored sugar from the roots as springtime brings longer days and warmer temperatures that kickstart development. The internal circadian rhythm of plants aids in controlling when distinct growth stages occur, preventing energy from being spent when the plant may be harmed by inclement weather. With the help of photoperiodism, a plant can determine when to start its reproductive cycle and bloom for a specific duration of the day. Like how springtime brings with it an increase in light and temperature, autumn brings with it the beginning of hibernation. Chlorophyll production will stop during abscission, and the plant will re-absorb it to break down nutrients for utilisation in other parts of the plant. The leaf will drop once a protective seal has been created by the separating layer. During a dormant period, when light and temperature are at their lowest, most physiological processes are suspended, and surplus energy is not lost because the tree can no longer photosynthesise using its leaves. Hormones play a key role in a plant's physiological functions by directing growth in specific directions. Auxins, for instance, are engaged in phototropism, where development is focused on the light source. Gibberellins are a hormone that breaks dormancy by causing buds to burst and seeds to germinate in the spring. Gibberellins are built up during cold weather.

3.5. Define the terms potential energy and kinetic energy

Scientists studying the environment recognise that the sun is the primary energy source for most of the life on Earth. Plants absorb light and transform it into chemical potential energy through a process called photosynthesis. The potential energy is then stored by plants as biomass, or biological matter that powers almost all animals on the planet.
The potential energy from the sun is only released into kinetic energy for growth and movement once an animal eats the plant.
The chemical mechanism by which green plants turn sunlight into sugar is called photosynthesis. This mechanism essentially converts light energy into chemical potential energy, which is subsequently stored by the plant in the bonds between sugar molecules.
The process of photosynthesis, which takes place every time light from the sun reaches a plant's leaves, is explained in the phases that follow:
A molecule of chlorophyll absorbs light within the chloroplast, a unique organelle found within plant cells. The plant's green hue is also a result of the chlorophyll component.
The sun's light energy is converted through a series of chemical reactions into the chemical bonds that hold together unique molecules that carry energy—the most prevalent of which are termed ATP. At this phase, the solar energy is being stored as chemical potential energy in the ATP molecules.
The plant converts carbon dioxide into glucose by using the chemical energy that ATP stores. Subsequently, the plant converts the glucose into even bigger energy-storing cellulose and starch molecules. The plant stores energy in the bonds it forms as it assembles molecules into ever-longer chains, which it will eventually release. As the plant gets bigger, it builds cell walls using the biggest molecules.

Equation photosynthesis reaction: $\text{Sunlight} + 6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$

This equation states that sunlight, combined with six molecules of water (H2O) and six molecules of carbon dioxide (CO2), produces one molecule of sugar (C6H12O6) and six molecules of oxygen gas (O2).

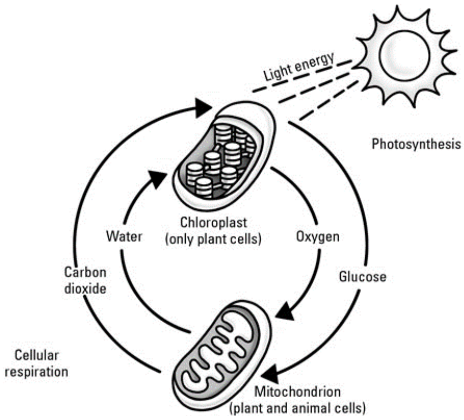
By this mechanism, green plants absorb solar energy, use part of it for growth and function, and store part of it in their plant structure so that other species can use it when they consume the plants. The plants also release oxygen into the atmosphere at the same time.

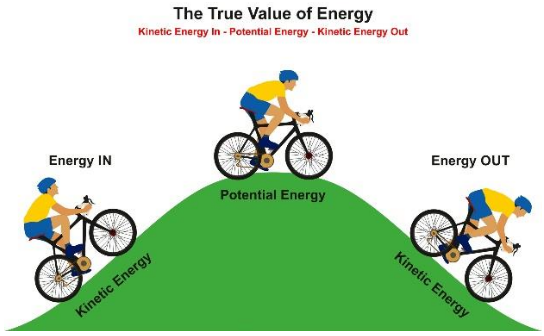
The initial phase of energy transfer in an ecosystem is photosynthesis. Plants store energy that is necessary for you and every other animal to survive. However, not all living things consume energy. Plants also require energy to grow. The process of respiration, which releases stored energy for usage, takes place in the mitochondria of each cell in both plants and animals.

Respiration is photosynthesis in reverse: $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + \text{energy}$

A complex chain of chemical events makes up respiration. The chemical potential energy of glucose's bonds is transferred to the chemical potential bonds of an ATP molecule during the first stage of glucose oxidation. The ATP molecule can then be moved around the cell to fulfil different functions by using its stored energy. Water and carbon dioxide gas are released during this process.
Your breathing is powered by the oxygen you inhale and takes place inside your cells. Your exhaled breath is the product of a fully executed cycle of cellular respiration.

Only plants can photosynthesize, yet to release the chemical potential energy that was first obtained through photosynthesis, both plants and animals need to breathe.
The relationship between respiration and photosynthesis is shown in the figure. As you can see, for plants and animals to live, these two life-sustaining processes are necessary.

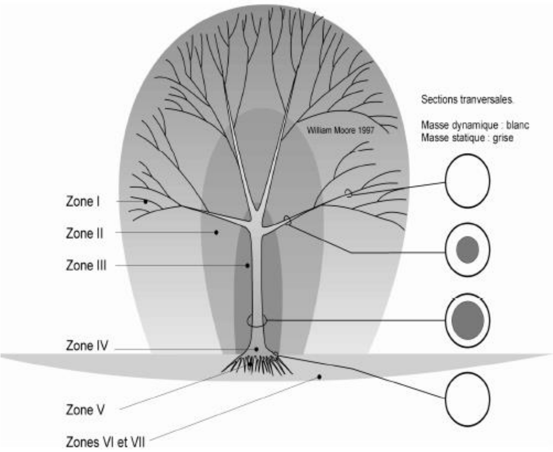




<u>3.6. Define the terms dynamic and static mass</u>

Trees can have up to seven zones within them. Depending on the stage of tree development, zones I, II, and III may represent the aerial organs. Three zones (V, VI, and VII) always represent the subterranean organs, and the root collar, the transition area (zone IV) between the aerial and subterranean zones, is always present.

These seven zones can be distinguished by:
Tree function: dynamic mass/static mass relation.
Anatomy: diameter of branching.
Architecture: capture and transmission of wind force.
Relationships with living beings.
The relationship between dynamic and static masses serves as the primary foundation for the tree zone model (the core skin hypothesis). This says that a dead hearth is covered in a living skin to produce a tree. A tree is a living (sapwood) tree that is reviving a dead (true heartwood) tree.
Most of the cells in the sapwood, which makes up the dynamic mass, are alive. In contrast, the static mass is made up of many kinds of dead cells found in protective wood. It is possible to designate distinct tree zones using this ratio of dynamic to static mass.
Typically, branches widen as they move from the crown's outer to inner regions, changing the relationship between DM and MS in the process. In the case of older trees, the trunk and shafts exhibit a 1:0 ratio, whereas the surrounding twigs have a 1:0 ratio. Typically, the actual heartwood stops close to the root collar.
The woody roots produce discoloured and false heartwood instead of real heartwood. The accumulation of traumatic and natural openings in an ageing root system raises the likelihood of infection. As a result, Zones V and VI create a static mass. To avoid presenting static mass, most of the pieces in Zone VII are temporary and constantly under refurbishment.



STATIC MASS DISTRIBUTION IN AN ADULT TREE WITH HEARTWOOD.

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