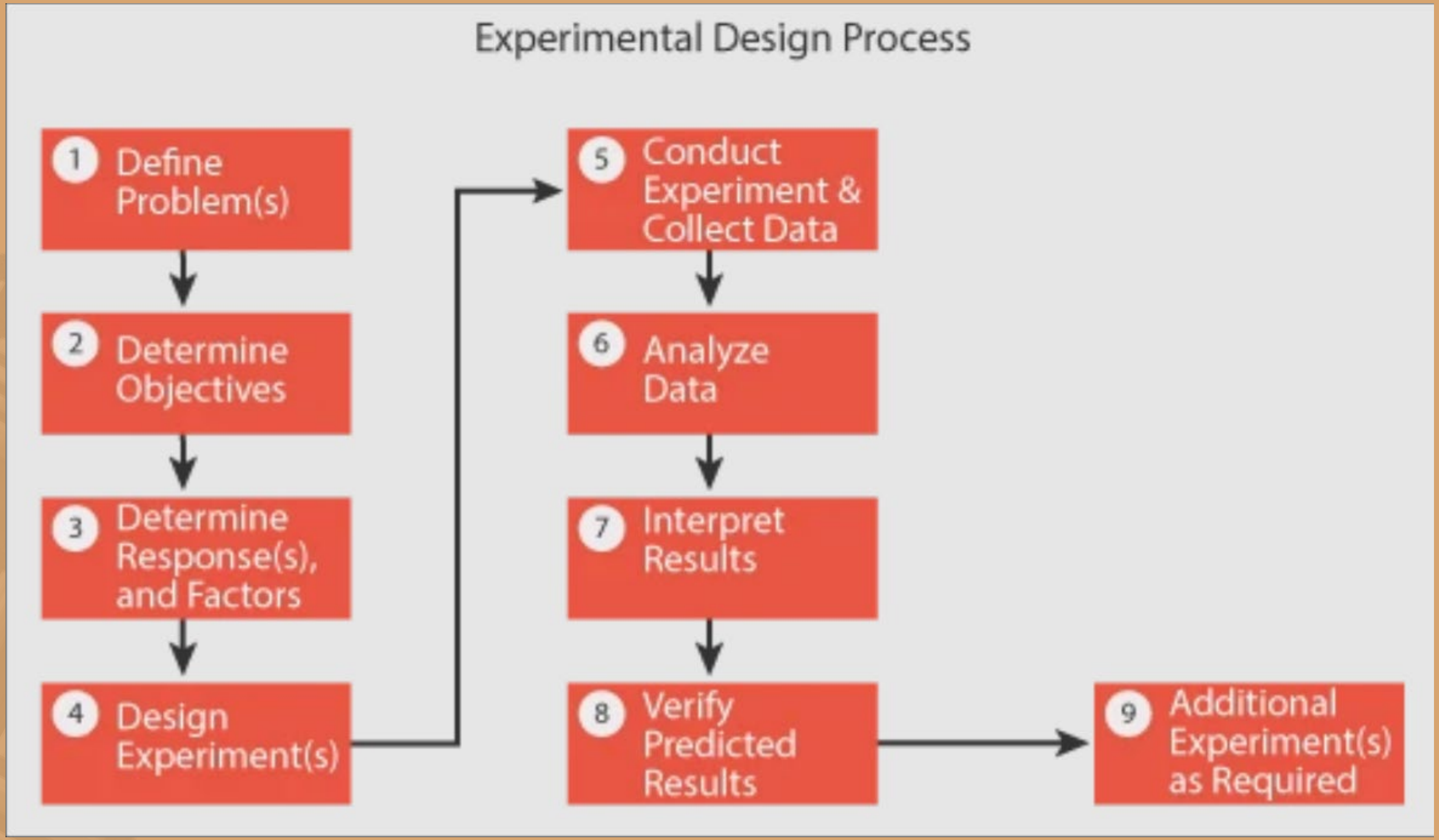
BIOLOGY L.O.11

QENA STUDENT CLUB

Experimental design



Experimental design

- It is the process of carrying out research in an objective and controlled fashion to achieve precision and draw specific conclusions regarding a hypothesis statement.
- Generally, the purpose is to establish the effect of an independent variable on a dependent variable.
- Biologists often test hypotheses by setting up an experiment.

Experimental design

- **Performing the experiment:**
- many scientists use a controlled experiment to test their hypotheses, which is an experiment that compares an experimental group and a control group and only has one variable.
- The control group provides a normal standard against which the biologist can compare the results of the experimental group.
- The experimental group is identical to the control group except for one factor, the independent variable (manipulated variable)

Experimental design

- **Testing the experiment:**
- **In some controlled experiments, the biologist who scores the results is unaware of whether a given subject is part of the experimental or control group. This factor helps eliminate experimenter bias.**
- **Experiments should be repeated because living systems are variable. Moreover, scientists must collect enough data to find meaningful results.**

Experimental design

- **Collecting and analyzing data:**
- Most experiments measure the dependent variable. This measurement provides quantitative data (the data measured in numbers)
- Biologists usually score the results of an experiment by using one of their senses. They might see or hear the results of an experiment. They also extend their senses with a microscope for tiny objects or a microphone for soft sounds.

Experimental design

- **Analyzing and comparing data:**
- After collecting data and organizing it, biologists then analyze the data. They usually display their data in tables or graphs when analyzing it.
- In analyzing data, the goal is to determine whether the data are reliable and whether they support or fail to support the predictions of the hypothesis.
- To do so, scientists may use statistics to help determine relationships between the variables involved.
- Then, they can compare their data with other data that were obtained in other similar studies.
- It is also important at this time to determine possible sources of error in the experiment just performed.

Experimental design

- **Concluding:**
- Biologists analyze their tables, graphs, and charts to conclude whether or not a hypothesis is supported.
- An experiment can only disprove a hypothesis. Having ruled out one hypothesis, a biologist will devise more tests to try to rule out any remaining hypotheses.
- Acceptance of a hypothesis is always tentative in science.
- The scientific community revises its understanding of phenomena, based on new data.

Experimental design

- **Making inference:**
- is a conclusion made based on facts and previous knowledge rather than on direct observations. Unlike a hypothesis, an inference is not directly testable.
- Scientists often draw inferences from data gathered during a field study or experiment

Experimental design

- **Applying results and building models:**
- scientists often apply their findings to solve practical problems. They also build models to represent or describe things. For example: in 1953, James Watson and Francis Crick used cardboard balls and wire bars to build physical models of atoms to understand the structure of DNA.
- Mathematical models are sets of equations that describe how different measurable items interact in a system.
- The experimenter can adjust variables to better model the real-world data.

Experimental design

- **Communicating ideas:**
- scientists working together is an essential aspect of scientific research.
- Scientists often work together in research teams or simply share research results with other scientists. This is done by publishing findings in scientific journals or presenting them at scientific meetings.
- Sharing information allows others to work independently to verify findings or to continue work on established results. For example, Roger Payne published the results of his own experiments in a journal in 1971. Then, other biologists could repeat it for verification or use it to study the mechanisms introduced by the paper.

Experimental design

- **Publishing a paper:**
- Scientists submit research papers to scientific journals for publication.
- A typical research paper has four sections.
- **The introduction:** poses the problem and hypotheses to be investigated.
- **Materials and methods:** describe how researchers proceeded with the experiment.
- **Results:** state the findings the experiment presented.

Experimental design

- **Discussion:**
- It gives the significance of the experiment and future directions the scientists will take.
- After scientists submit their papers to a scientific journal, the editors of that journal will send the paper out for peer review.
- In a peer review, scientists who are experts in the field anonymously read and critique that research paper.
- They determine if a paper provides enough information so that the experiment can be duplicated and if the author used good experimental controls and reached an accurate conclusion.
- They also check if the paper is written enough for broad understanding.
- Careful analysis of each other's research by fellow scientists is essential to making scientific progress and preventing scientific dishonesty.

Experimental design

- **Honesty and bias:**
- The scientific community depends on both honesty and good science.
- While designing new studies, experimenters must be very careful to prevent previous ideas and biases from tainting both the experimental process and the conclusions.
- Scientists must keep in mind that they are always trying to disprove their favorite ideas. They repeat experiments to verify previous findings.
- This allows for science to have a method for self-correction, and it also keeps researchers honest and credible to their peers in the field.
- The threat of a potential scandal based on misleading data or conclusions is a powerful force in science that helps keep scientists honest and fair.

Experimental design

- **Conflict of intersect:**
- **For most scientists, maintaining a good reputation for collecting and presenting valid data is more important than temporary prestige or income. So, scientists try to avoid any potential conflicts of interest.**
- **For example: a scientist who owns a biotechnology company and manufactures a drug would not be the best researcher to test that drug's safety and effectiveness critically. To avoid this potential conflict of interest, the scientist allows an unaffected party, such as a research group, to test the drug's effectiveness.**

reproducible procedures

- Reproducibility in research is a major factor that determines the uniqueness of the research study. It means obtaining consistent results using the same data and protocol as the original study.
- For example: researchers confirm the validity of a new discovery by repeating the experiments that produced the original results.
- Researchers around the world are continuously publishing their latest discovery with each paper adding to the scientific conversations.
- Published studies can motivate future research, inspire new products, and inform government policy. So, we must have confidence in the published results.
- If their conclusions are wrong, we risk time, resources, and our health in the pursuit of false leads.
- When findings are significant, they are frequently double-checked by other researchers, either by reanalyzing the data or by redoing the entire experiment.
- For example: it took repeated investigation of CERN data before the timing error was tracked down.

reproducible procedures

- There are a variety of sources for irreproducible results:
- Error could hide in their original design, extension, or analysis of the data.
- Unknown factors, such as patients' undisclosed conditions in a medical study, can produce results that are not repeatable in new test subjects.
- And sometimes, the second research group can't reproduce the original results simply because they don't know exactly what the original group did.
- Many scientists are working toward improving reproducibility in their fields. There's a push to make researchers' raw data, experimental procedures, and analytical techniques more openly available to ease replication efforts.
- Finding ways to improve the reproducibility of our results can help us get rid of those false starts more effectively, keeping us moving steadily toward exciting new discoveries.

reproducible procedures

- **Conflict of intersect:**
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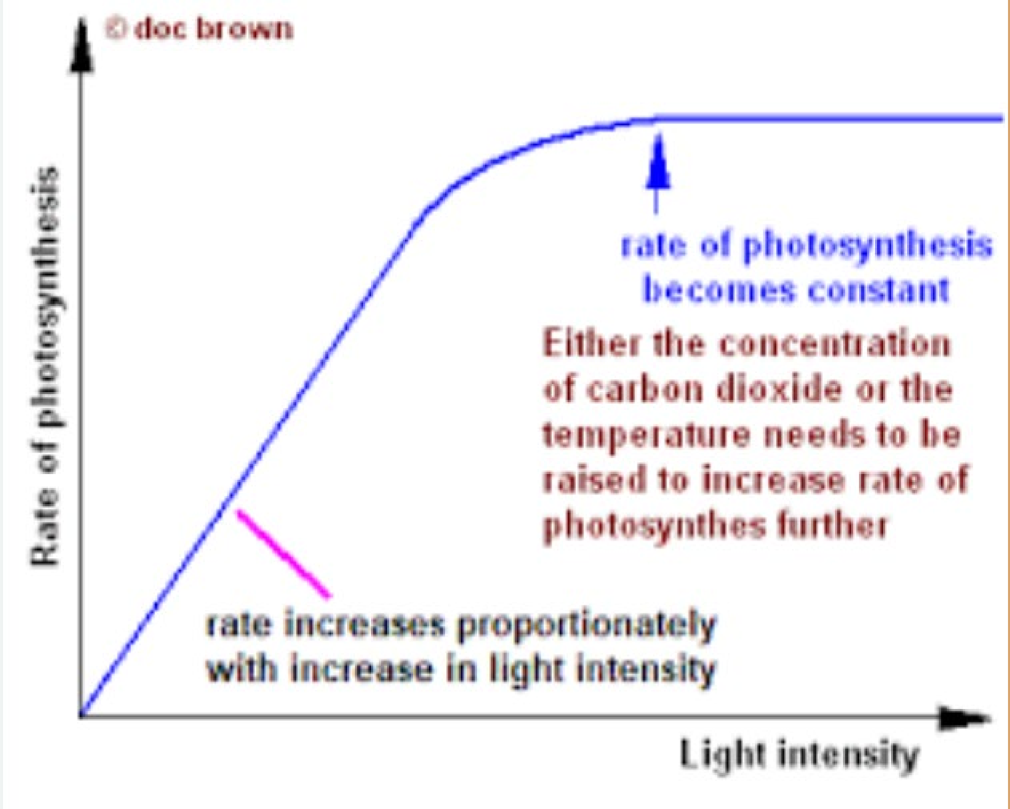
Independent variable to be manipulated

- Dependent variables: It is something that depends on other factors.
- Independent variables: the variable you manipulate, control, or vary in an experimental study to explore its effects.
- This concept talks about dependent and independent variables in the photosynthesis experiment so in this experiment, we have the intensity of the light as an independent variable (how close the light is). The quantity of released oxygen bubbles is a dependent variable (the rate of photosynthesis). The size of the pondweed, the amount of water used, and its temperature are controlled variables. The availability of light, carbon dioxide, and water affects how quickly photosynthesis occurs.

Independent variable to be manipulated

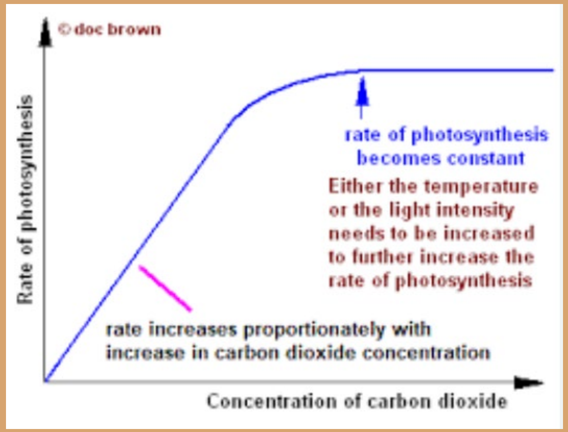
- **Light and rate of photosynthesis:**
- **When light levels decrease, the rate of the light-dependent response and consequently photosynthesis decreases. So, the relation between them is directly proportional.**
- **When more photons of light strike a leaf, The number of chlorophyll molecules that are ionized and the production of ATP and NADPH increases.**
- **However, as the light intensity rises higher than a specific limit, the chlorophyll may be damaged which ultimately the rate of photosynthesis.**

Independent variable to be manipulated



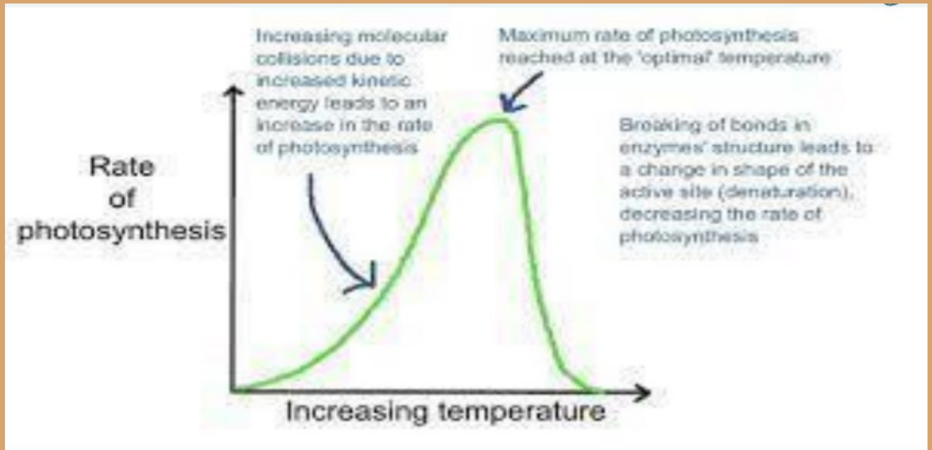
Carbon dioxide and rate of photosyynthesis

- Carbon is absorbed into carbohydrates more quickly as carbon dioxide concentration rises.



- The increase in carbon dioxide concentrations accelerates the rate of photosynthesis, which finally reaches a plateau when the maximum rate of fixation is attained. This is because carbon dioxide is typically present in the atmosphere at relatively low concentrations (approximately 0.04%).

Temperature and rate of photosyntesis

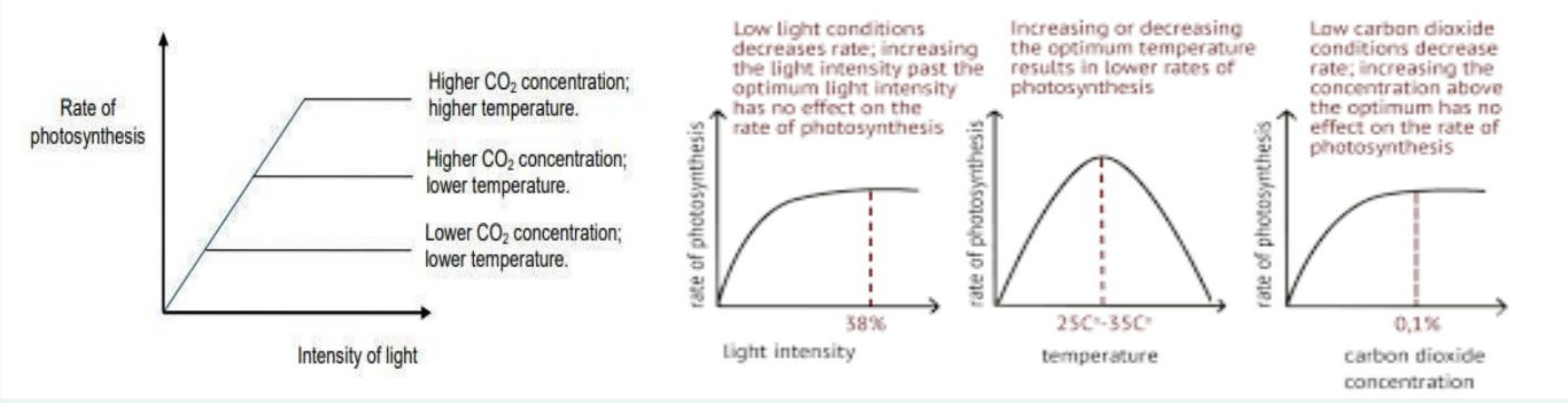


- The light-independent reactions of photosynthesis are temperature-dependent, even though the light-dependent reactions of photosynthesis are not. They are enzyme-catalyzed reactions.
- The overall rate rises as the enzymes get closer to their ideal temperatures. For every 10 °C increase in temperature, it roughly doubles.
- As enzymes are denatured above the optimal temperature, the rate starts to drop until it eventually stops.

Independent variable to be manipulated

- **Limiting factors:**
- **Blacman created the Law of Limiting Factors in 1905 while researching the variables influencing the rate of photosynthesis. "if a chemical process is affected by more than one factor, then its rate will be determined by the factor which is nearest to its minimal value"**

Independent variable to be manipulated



Light becomes a limiting factor once more with increasing carbon dioxide concentrations, allowing for higher rates before the rate plateaus once more. The largest impact on achieving a higher rate of photosynthesis will come from raising temperature if carbon dioxide and light levels are high but the temperature is low.

Cellular respiration in plants

- Cellular respiration occurs in both plants and animals and the mechanism of cellular respiration is also similar in both plants and animals but the method of obtaining energy from the cellular respiration is different in plants and animals.

Cellular respiration in plants

- The reason why cellular respiration occurs is the need for energy in both plants and animals. The only difference is that plants undergo photosynthesis and can obtain their energy through solar energy, but animals cannot undergo photosynthesis, so they are dependent on plants for obtaining energy. This is also because plants have chloroplast whereas animals do not have chloroplast and chloroplast is very necessary for the process of photosynthesis. We can conclude that the cellular respiration in plants is dependent on photosynthesis and the cellular respiration of animals are dependent on the plants.

Cellular respiration in plants

- The breakdown of glucose in both plants and animals is the most important step that provides energy, and it is known as cellular respiration.

Cellular respiration in plants

- So, in conclusion animals needs food to get glucose and oxygen to make cellular respiration while plants makes glucose and oxygen by photosynthesis to use it in the cellular respiration.

Energy release

- If the reactant molecules in each reaction have more energy than the product molecules, energy is released into the environment in the form of heat and light. **When this happens, the process is known as an exothermic reaction.**

Energy release

How do organisms release energy? **Discussed in L.O.10**

- **Cellular respiration is the process that occurs in the mitochondria of organisms (animals and plants) to break down sugar in the presence of oxygen to release energy in the form of ATP. This process releases carbon dioxide and water as waste products.**

Energy release

- The bonds between the phosphate groups of ATP can be broken by hydrolysis. When the terminal phosphate bond is broken by addition of a water molecule, a molecule of inorganic phosphate ($HOPO_3$ 2- , abbreviated P) leaves the ATP, which becomes ADP.

ATP + H_2O ADP + Pi + energy

Energy release

- Because the hydrolysis releases energy, the phosphate bonds of ATP are sometimes referred to as high-energy phosphate bonds, but the term is misleading. The phosphate bonds of ATP are not unusually strong bonds, as "high-energy" may imply; rather, the reactants (ATP and water) themselves have high energy relative to the energy of the products (ADP and Pi). The release of energy during the hydrolysis of ATP comes from the chemical change of the system to a state of lower free energy, not from the phosphate bonds themselves.

Energy release

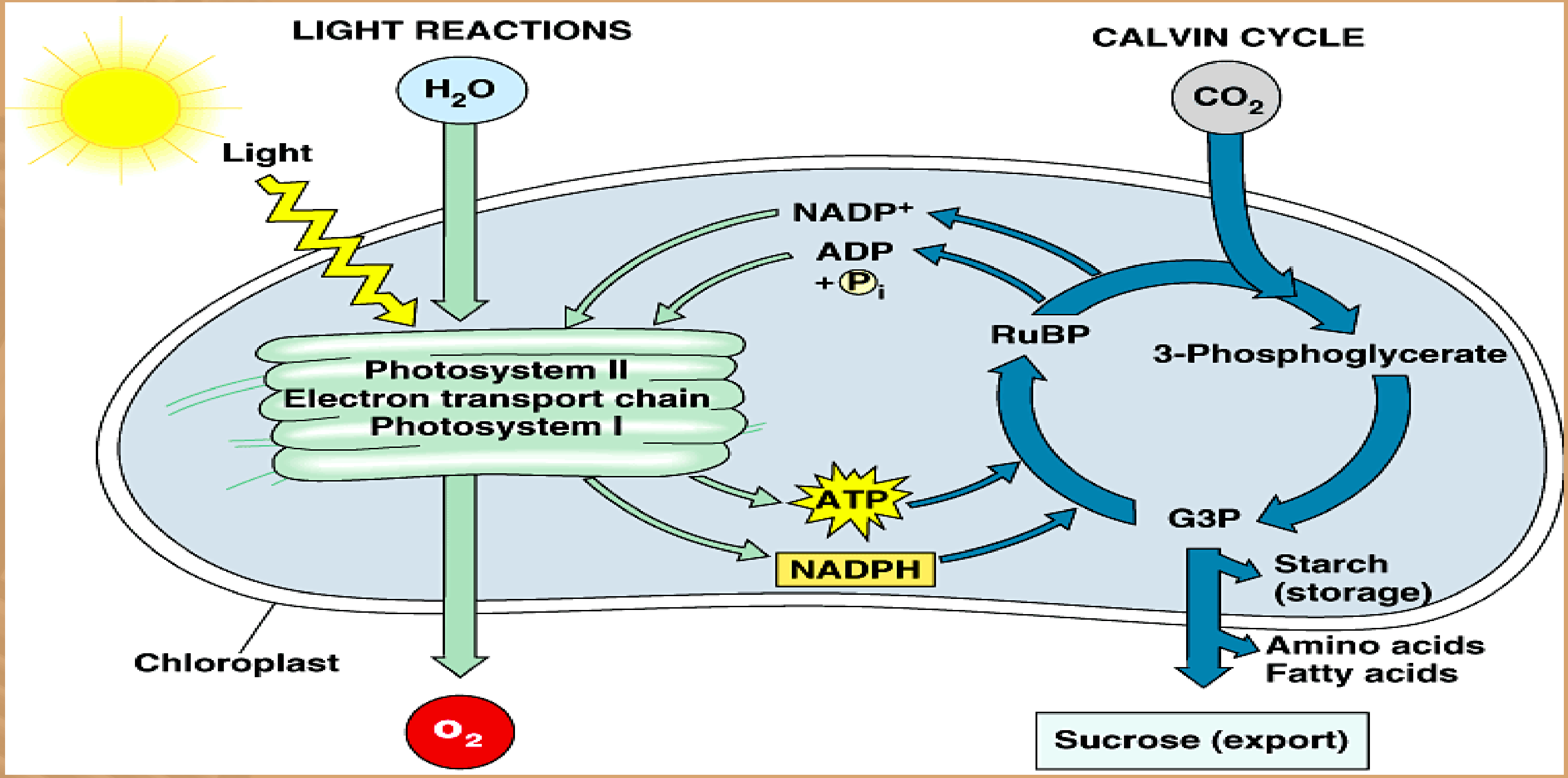
- The released energy is greater than the energy most molecules could deliver, this is because the negatively charged phosphate groups that are crowded in ATP, so they repel each other(same charges repel, similar charges attract each other), which makes this region in ATP unstable.

Capture of energy and production of carbon dioxide

Photosynthesis has two main stages:

I-Light dependent reaction

II-Dark dependent reaction (Calvin cycle)



Light-Dependent Reaction: In the light-dependent reaction of photosynthesis, which takes place in the thylakoid membranes of chloroplasts, light energy is absorbed by chlorophyll and other pigments by photosystem 1 and 11. This energy is used to split water molecules into oxygen, protons (H+ ions), and electrons. The electrons move through an electron transport chain, generating ATP (adenosine triphosphate) and NADPH (nicotinamide adenine dinucleotide phosphate), which are energy-rich molecules utilized in the subsequent stages of photosynthesis.

Dark (Light-Independent) Reaction: The dark reaction, also known as the Calvin cycle or light-independent reaction, occurs in the stroma of chloroplasts. In this stage, ATP and NADPH produced during the light-dependent reaction are used to convert carbon dioxide (CO2) into glucose through a series of enzyme-catalyzed reactions, The enzyme ruBisCo combines a five-carbon molecule of RubP with a molecule of carbon dioxide, creating a six-carbon molecule that is broken down into two three-carbon molecules (3-phosphoglycerate). This process does not directly require light but relies on the products generated in the light-dependent reaction, ATP and NADPH, which are produced during the light-dependent reaction, are used to give each 3-phosphoglycerate a hydrogen atom, creating two molecules of the simple sugar G3P. These two molecules of G3P are then used to build one molecule of glucose. This process is called reduction, because electrons are added to the sugar.

Photosynthesis

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

carbon dioxide + water ⟶ glucose + oxygen

Production of carbon dioxide

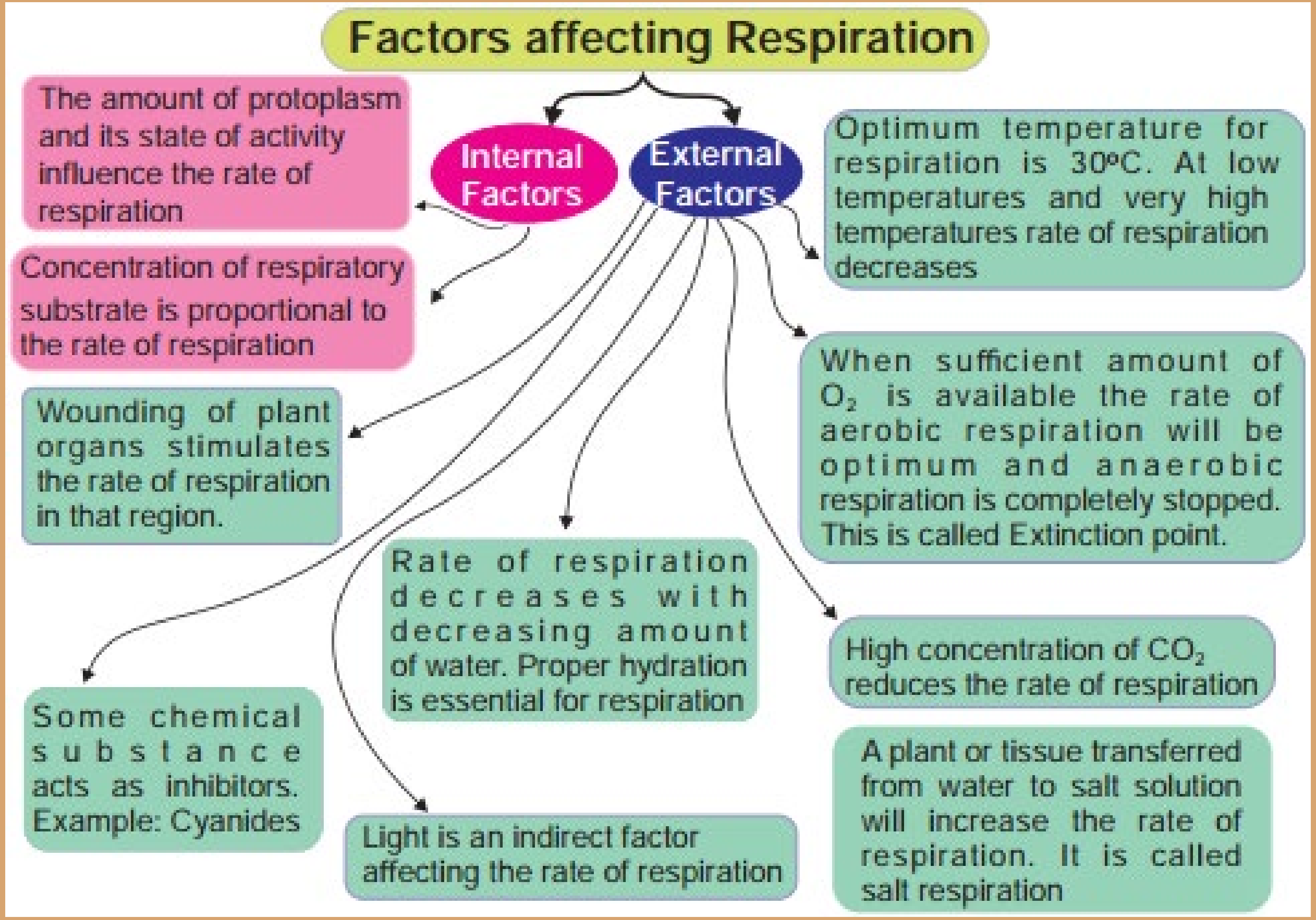
- Cellular respiration is a process that occurs in the mitochondria of all organisms that involves the breakdown of glucose to produce ATP (adenosine triphosphate), the cell's primary energy currency.
- the main steps of cellular respiration:
- **Glycolysis:** This is the first stage of cellular respiration, occurring in the cytoplasm of the cell. During glycolysis, a molecule of glucose is broken down into two molecules of pyruvate. This process also generates a small amount of ATP and NADH (nicotinamide adenine dinucleotide).
- **Pyruvate Oxidation:** In this step, each pyruvate molecule produced in glycolysis moves into the mitochondria. There, it undergoes oxidation, producing acetyl-CoA, NADH, and CO2.
- **Citric Acid Cycle (Krebs Cycle):** Acetyl-CoA enters the citric acid cycle, a series of enzymatic reactions that occur in the mitochondrial matrix. During this cycle, acetyl-CoA is gradually oxidized, producing NADH, FADH2 (flavin adenine dinucleotide), ATP, and CO2.
- **Electron Transport Chain (ETC):** The electron carriers NADH and FADH2 generated in glycolysis and the citric acid cycle donate their electrons to the electron transport chain, located in the inner mitochondrial membrane. As electrons move through the chain, energy is released and used to pump protons (H+ ions) across the membrane, creating a proton gradient.
- **ATP Synthesis:** The proton gradient established across the inner mitochondrial membrane drives the synthesis of ATP through a process called oxidative phosphorylation. Protons flow back into the mitochondrial matrix through ATP synthase, a complex enzyme, coupling the movement of protons to the production of ATP.

Glucose + Oxygen → Carbon Dioxide + Water + ATP

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + ATP$$

Factors affecting cellular respiration

- Light Intensity
- Temperature
- Oxygen Availability
- Carbon Dioxide Concentration
- Nutrient Availability
- Water Availability



Light Intensity: Light plays a crucial role in photosynthesis, but it also indirectly affects cellular respiration. During the day, when photosynthesis is active and light is abundant, plants produce sugars (glucose) through photosynthesis, which can then be used as substrates for cellular respiration. In contrast, during the night or in low-light conditions, when photosynthesis is minimal, cellular respiration becomes the primary process for energy production.

Temperature: Like in other organisms, temperature affects the rate of cellular respiration in plants. Warmer temperatures generally increase metabolic rates, including respiration, up to a certain point. However, excessively high temperatures can damage enzymes involved in respiration, leading to decreased respiration rates.

Oxygen Availability: Oxygen availability affects the type and rate of cellular respiration in plants. Adequate oxygen levels are necessary for aerobic respiration, which is the primary pathway for energy production in plants. In waterlogged or poorly aerated soils, oxygen availability may decrease, leading to decreased rates of aerobic respiration and potentially triggering anaerobic respiration.

Carbon Dioxide Concentration: Carbon dioxide (CO_2) is a substrate for cellular respiration. Higher concentrations of CO_2 can potentially increase the rate of respiration in plants, as more substrate is available. However, excessive CO_2 levels can inhibit respiration by disrupting cellular processes.

Water Availability: Water is essential for cellular metabolism, including respiration. Water stress, such as drought conditions, can decrease the rate of cellular respiration in plants. This is because water is needed for the activation of enzymes and the maintenance of cellular structure and function.

Nutrient Availability: Availability of nutrients, particularly carbohydrates and other organic compounds, influences the substrate availability for cellular respiration. Plants require a constant supply of energy-rich compounds for respiration. Deficiencies in essential nutrients can limit cellular respiration and overall plant growth and development.

Plant Age and Growth Stage: The stage of plant growth and development can affect the rate of cellular respiration. Young and actively growing plants generally have higher rates of respiration compared to mature or senescent plants. Additionally, certain plant tissues, such as actively growing roots and reproductive structures, may exhibit higher respiration rates compared to other tissues.

Temperature

- Temperature affects the physiology of living things as well as the density and state of water. It exerts an important influence on living organisms because few can survive at temperatures below 0 °C (32 °F) due to metabolic constraints. It is also rare for them to survive at temperatures exceeding 45 °C (113 °F).

Temperature

Why is temperature important in biological systems?

- **Temperature is a major determinant of reaction rates of enzymes, which regulate processes that manifest at all levels of biological organization.**

Temperature

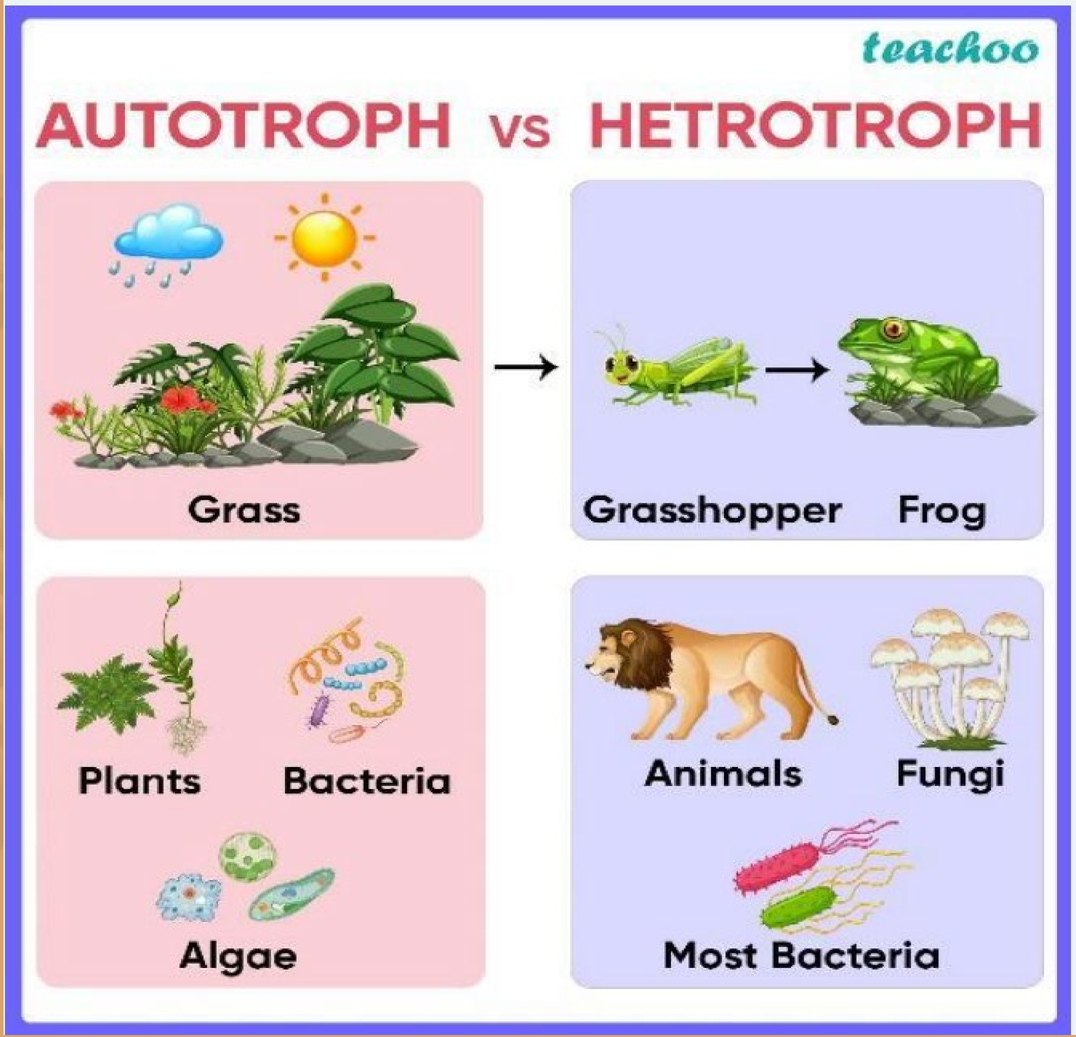
How does metabolism affect temperature?

- **It has been known since early in the 20th century that a rise in temperature is associated with an increase in metabolic rate. Each degree C rise in temperature is associated with a 10–13% increment in oxygen consumption. The elevation in temperature itself is responsible for speeding up metabolism.**

Amount of light

- **Photosynthesis:** It's the process by which green plants and some other organisms use sunlight to synthesize nutrients from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a by-product.
- **Autotroph**: It's an organism that can produce its own food using light, water, carbon dioxide, or other chemicals.
- **Heterotroph:** It's an organism that eats other plants or animals for energy and nutrients.
- **The Calvin cycle:** a series of chemical reactions occurring in the dark reactions of photosynthesis, plays a pivotal role in fixing carbon from gaseous carbon dioxide into organic compounds. This process is essential for the production of energy-rich molecules that sustain life.
- **Photosynthesis** is the primary mechanism by which light energy is converted into chemical energy, predominantly carried out by autotrophic organisms such as plants and certain prokaryotes. These organisms harness sunlight to synthesize organic compounds, serving as both energy stores and food sources for various organisms in the ecosystem.

Amount of light



Amount of light

- While sunlight is the predominant source of energy for most life forms, some prokaryotes, particularly those dwelling near deep-sea volcanic vents, have adapted to derive energy from chemicals emitted by these vents. This adaptation allows them to thrive in environments where sunlight cannot penetrate, such as the ocean depths.
- The process of extracting energy from food in living cells differs significantly from the combustion of a log. In cells, energy release occurs gradually through a series of enzyme-mediated chemical reactions. These reactions break down complex molecules, such as starch, releasing energy that is partially stored in the form of adenosine triphosphate (ATP), a versatile energy carrier molecule.
- ATP serves as a portable form of energy currency within cells, capable of delivering energy wherever it is needed for cellular processes. This molecular currency facilitates the efficient utilization and distribution of energy within the cell, enabling various metabolic activities to occur seamlessly. Thus, the intricate interplay between biochemical pathways, such as the Calvin cycle and ATP synthesis, ensures the continuous flow of energy within living systems, supporting essential biological functions and sustaining life.

Amount of light

- **ATP** provides energy for various cellular reactions, including molecule building. Photosynthesis, predominantly carried out by plants, algae, and some bacteria, converts about 1% of sunlight energy into chemical energy. This process sustains almost all life directly or indirectly. Plants serve as primary producers, converting light energy into chemical energy, which is then transferred through ecosystems. Understanding this energy flow is crucial for grasping ecological dynamics and the interconnectedness of organisms with their environments.

- **The photosynthesis has three stages :**

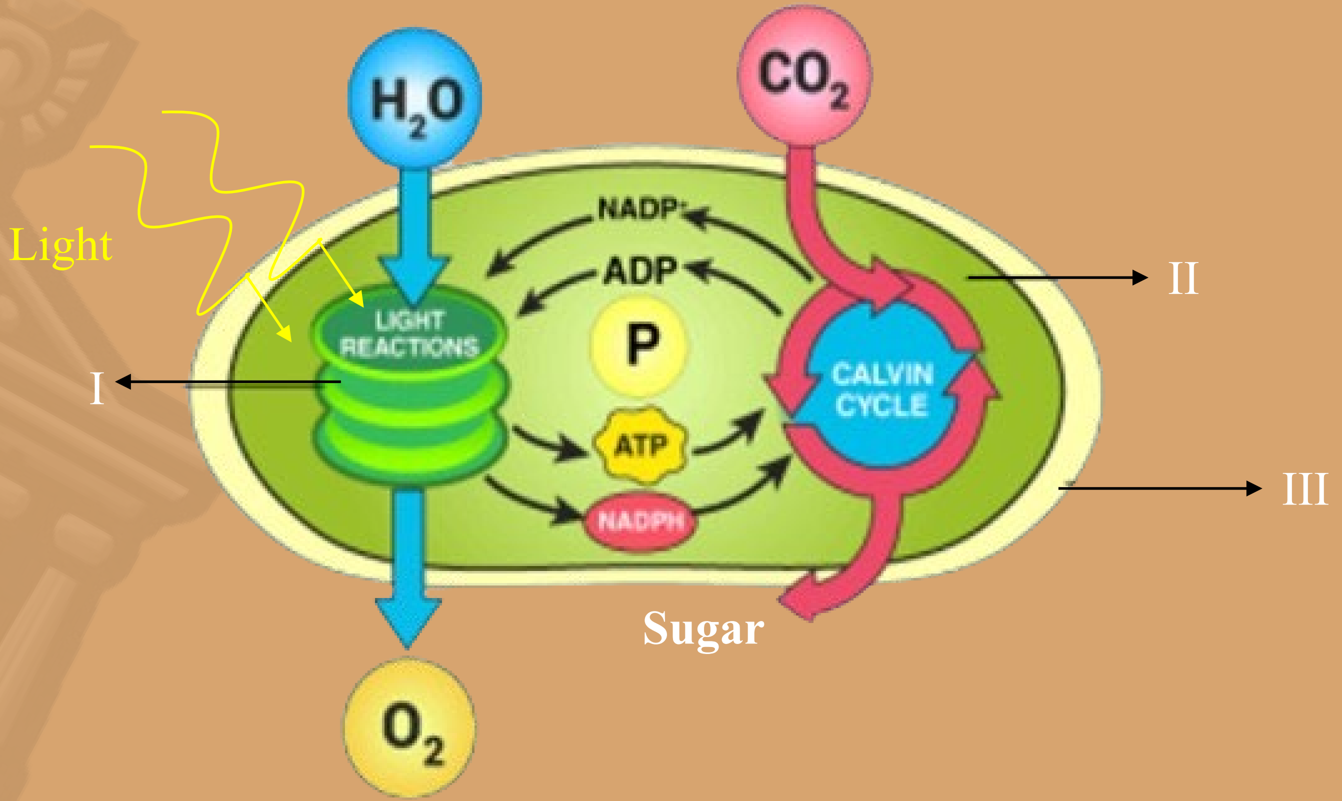
- **Stage I:** Energy is captured from sunlight.

- **Stage II:** Light energy is converted to chemical energy, which is temporarily stored in ATP and the energy carrier molecule NADPH.

- **Stage III:** The chemical energy stored in ATP and NADPH powers the formation of organic compounds, using carbon dioxide. $3CO_2 + 3H_2O \rightarrow C_3H_6O_3 + 3O_2$

Amount of light

- This equation shows that three carbon dioxide molecules, three water molecules, and light are needed to form one three-carbon organic compound and three molecules of oxygen.

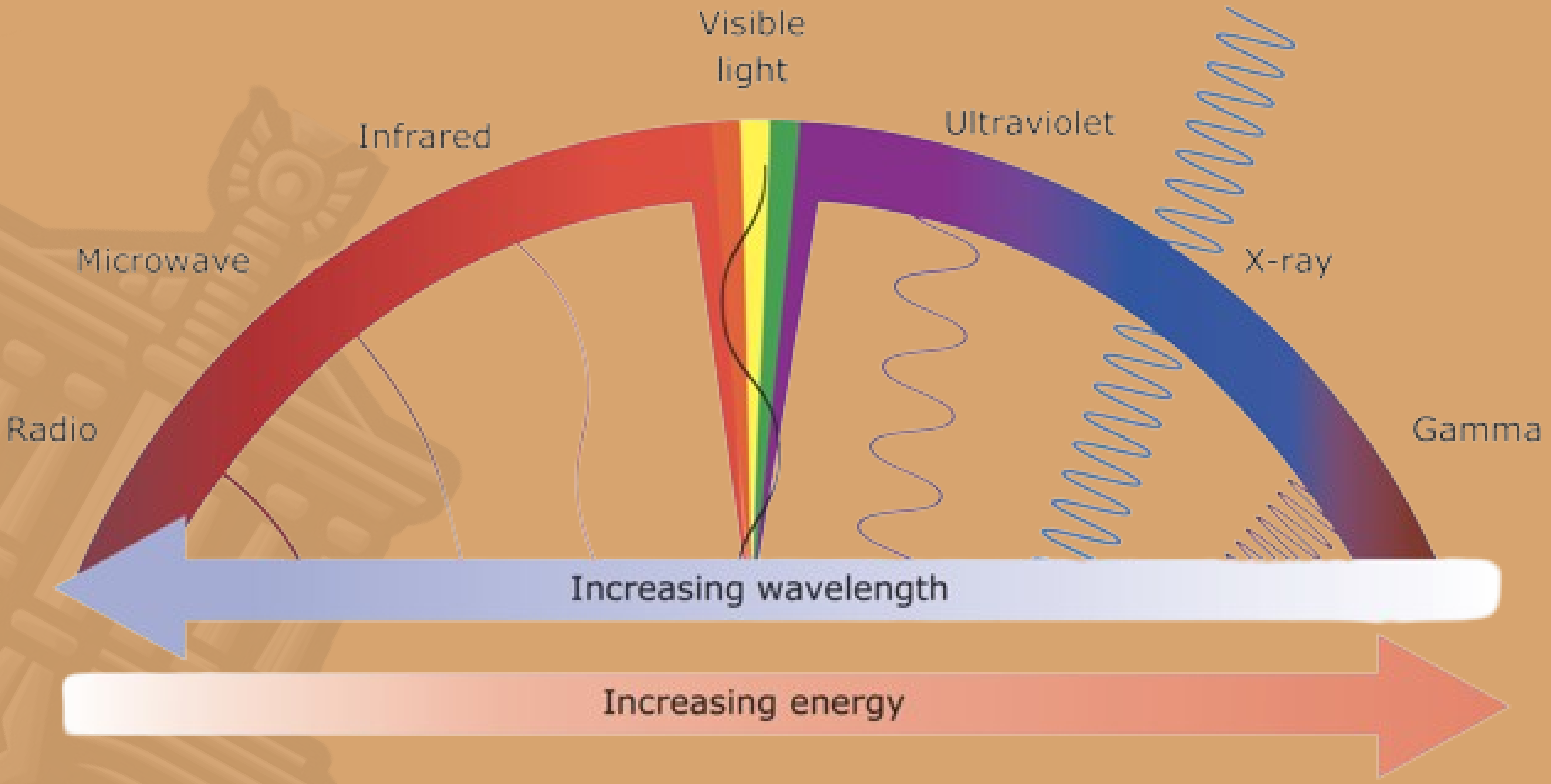


I-Thylakoid II-Stroma III-Chloroplast

Amount of light

- Plants utilize organic compounds produced during photosynthesis to sustain their life processes. Sugars synthesized during photosynthesis may be converted into starch for storage in stems or roots, later broken down to produce ATP for metabolic activities.
- All cellular components, including proteins and nucleic acids, are synthesized from sugar fragments.
- The initial and subsequent stages of photosynthesis are termed **"light reactions" or "light-dependent reactions"** as they require light absorption to proceed. Light energy is crucial for synthesizing energy-storing compounds.
- **Light:** is a form of radiant energy transmitted through space as waves, with varying wavelengths. Different types of radiation, such as light and heat, exhibit distinct wavelengths.

Electromagnetic Spectrum



Amount of light

- **Photosynthesis:** is a complex process that occurs in plants, facilitated by pigments such as chlorophyll and carotenoids. When sunlight strikes chloroplasts in plant cells, pigments absorb certain wavelengths of light, primarily blue and red, while reflecting green and yellow light, giving plants their green appearance.
- The absorbed light energy is then transferred to electrons in chlorophyll, causing them to become "excited." These excited electrons move through a series of molecules in the thylakoid membrane via electron transport chains.
- During this process, water molecules are split by enzymes within the thylakoid, releasing oxygen gas and providing replacement electrons for chlorophyll. The energy from the excited electrons is used to pump hydrogen ions into the thylakoid, creating a concentration gradient.
- Hydrogen ions then pass back out of the thylakoid through specialized carrier proteins, driving the production of ATP through a reaction that adds a phosphate group to ADP. Additionally, a second electron transport chain produces NADPH, an electron carrier that provides high-energy electrons for the synthesis of organic molecules in the Calvin cycle, the third stage of photosynthesis.

Amount of light

- **Here's another way to summarize the light-dependent reactions of photosynthesis:**
- **I-Absorption of Light Energy:** Pigment molecules within the thylakoids of chloroplasts absorb light energy.
- **II-Excitation of Electrons:** When light strikes these pigment molecules, electrons within them become excited and move through electron transport chains embedded in the thylakoid membranes.
- **III-Replacement of Electrons:** Excited electrons are replenished by electrons derived from water molecules, which are split by an enzyme. This splitting of water molecules also results in the formation of oxygen gas and the accumulation of hydrogen ions inside the thylakoids, establishing a concentration gradient.
- **IV-ATP and NADPH Production:** The energy stored in this concentration gradient is harnessed to produce ATP and NADPH, which serve as temporary carriers of chemical energy. These processes occur in the light-dependent stages of photosynthesis.

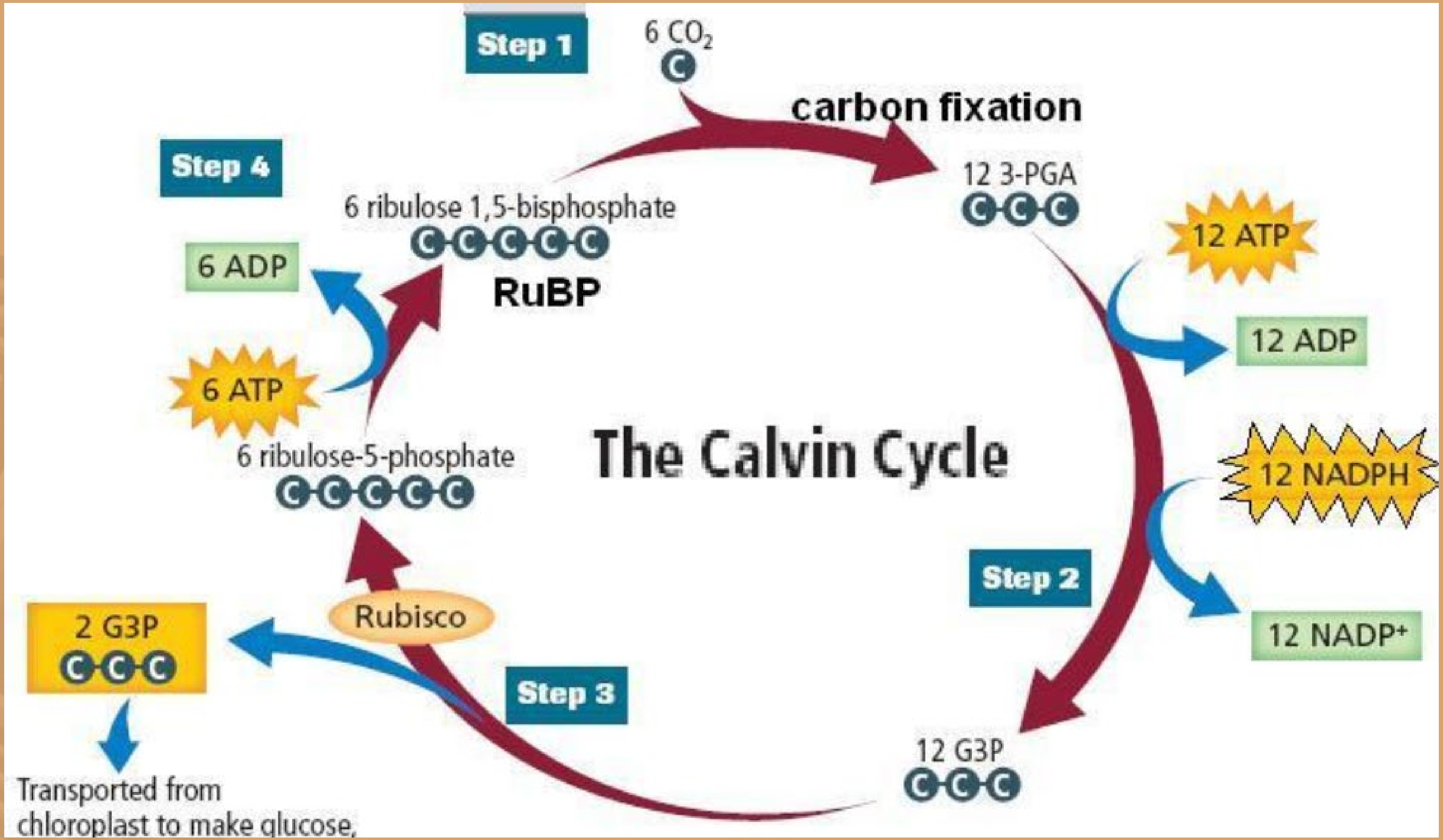
Amount of light

- **5-Carbon Dioxide Fixation:** Carbon atoms from carbon dioxide present in the atmosphere are assimilated into organic compounds, where chemical energy is stored. This process, known as carbon dioxide fixation, marks the beginning of the light-independent reactions, also referred to as "dark reactions."
- **6-Calvin Cycle:** The most prevalent pathway for carbon dioxide fixation is the Calvin cycle, which involves a series of enzyme-mediated chemical reactions. Through this cycle, carbon dioxide is converted into a three-carbon sugar molecule, facilitating the synthesis of organic compounds essential for plant growth and development.
- **The Calvin cycle:** is a series of enzyme-assisted chemical reactions that produces a three-carbon sugar.

Amount of light

- **Here are the steps of Calvin cycle:**
- **Step I:** Each molecule of carbon dioxide is added to a five-carbon compound by an enzyme.
- **Step II:** The resulting six-carbon compound splits into two three carbon compounds.
- Phosphate groups from ATP and electrons from NADPH are added to the three carbon compounds, forming three-carbon sugars
- **Step III:** One of the resulting three-carbon sugars is used to make organic compound, including starch and sucrose, in which energy is stored for later use by the organism.
- **Step IV:** The other three-carbon sugars are used to regenerate the initial five-carbon compound, thereby completing the cycle.

Amount of light



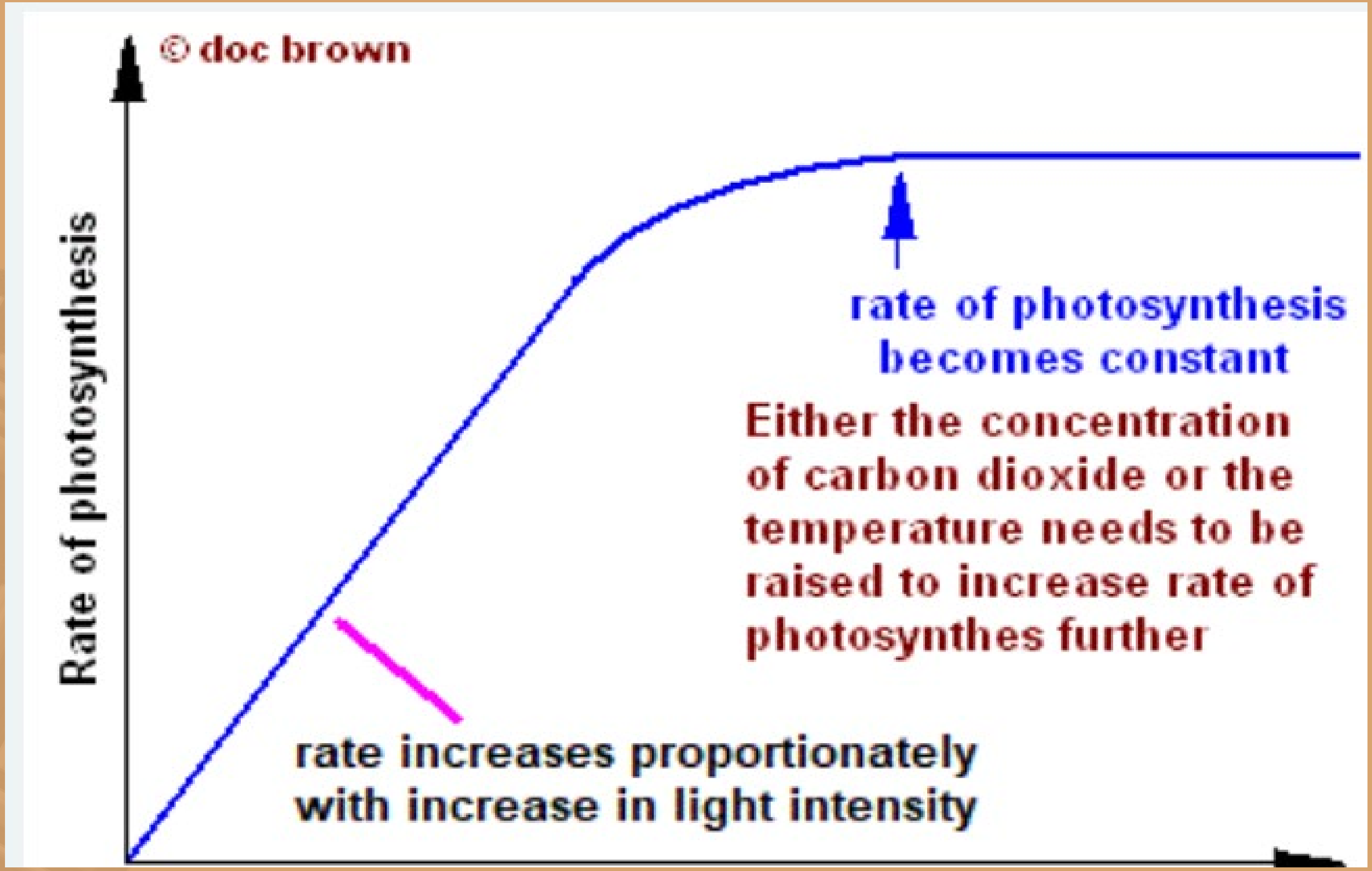
Amount of light

- The Calvin cycle is named as : (Melvin Calvin)
- An American biochemist elucidated the chemical reactions within the Calvin cycle, a cyclic process that regenerates the essential five-carbon compound needed to initiate the cycle repeatedly.
- For each three-carbon sugar synthesized in the Calvin cycle, three molecules of carbon dioxide must be assimilated.
- These resultant organic compounds serve as vital sources of energy for growth and metabolic processes within the organism.
- Photosynthesis is intricately influenced by a range of environmental factors, exerting direct impacts on its efficiency and productivity.
- The energy required for the Calvin cycle is supplied by ATP and NADPH, which are products of the preceding light-dependent stage of photosynthesis.

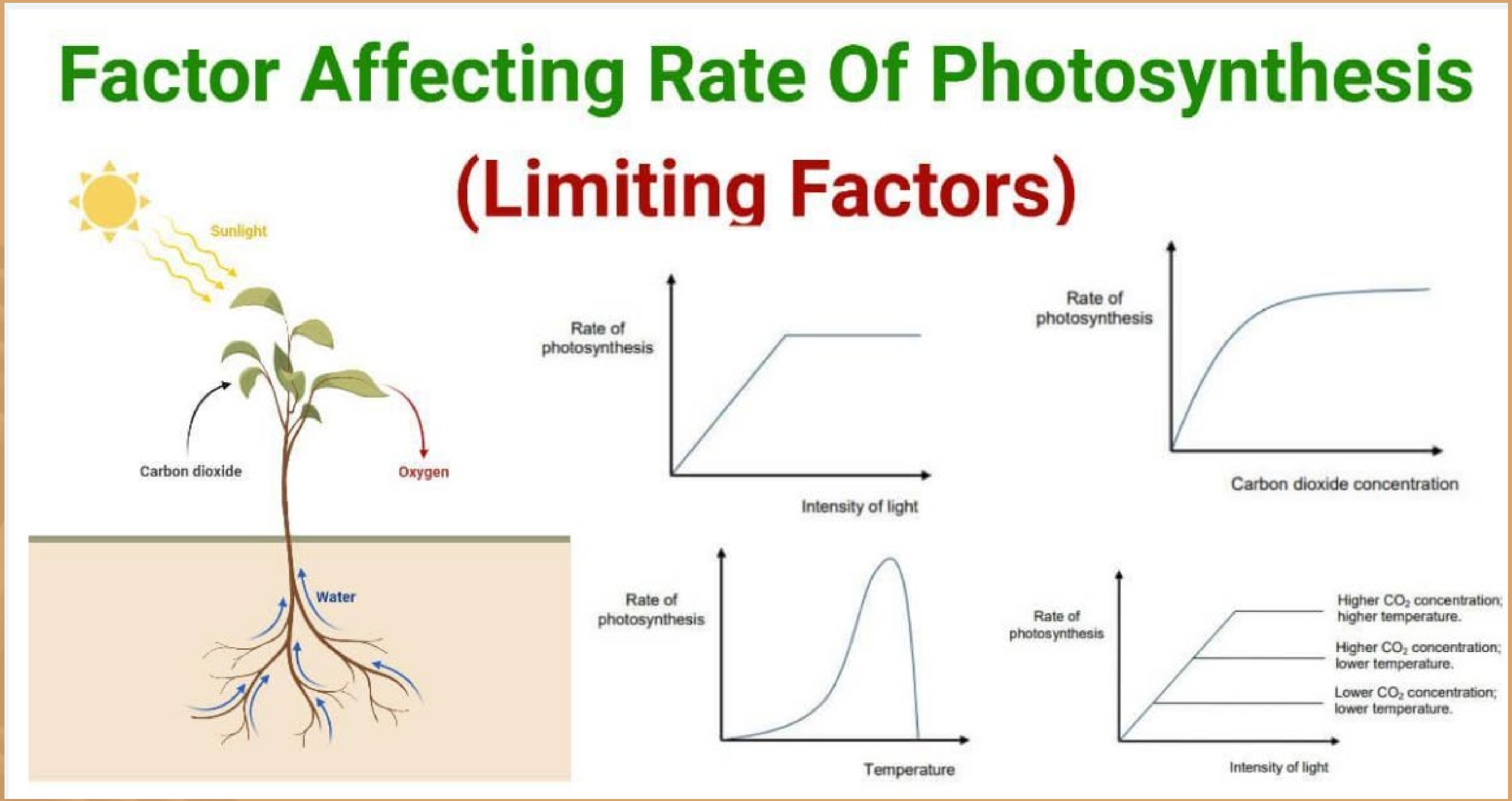
Amount of light

- **The factors of photosynthesis:**
- **I - The light :** In general, the rate of photosynthesis increases as light intensity increases until all the pigments are being used.
- At this saturation point, the rate of photosynthesis levels off because pigments cannot absorb any lighter.
- **II -The carbon dioxide concentration:** Carbon dioxide concentration affects the rate of photosynthesis in a similar manner. Once a certain concentration of carbon dioxide is present, photosynthesis cannot proceed any faster.
- **III -temperature:** Photosynthesis is most efficient within a certain range of temperatures. Like all metabolic processes, photosynthesis involves many enzyme-assisted chemical reactions. Recall that unfavorable temperatures may inactivate certain enzymes.
- **IV -Water:** Less water in the soil reduces the rate of photosynthesis.

Amount of light



Amount of light



Chemical indicators

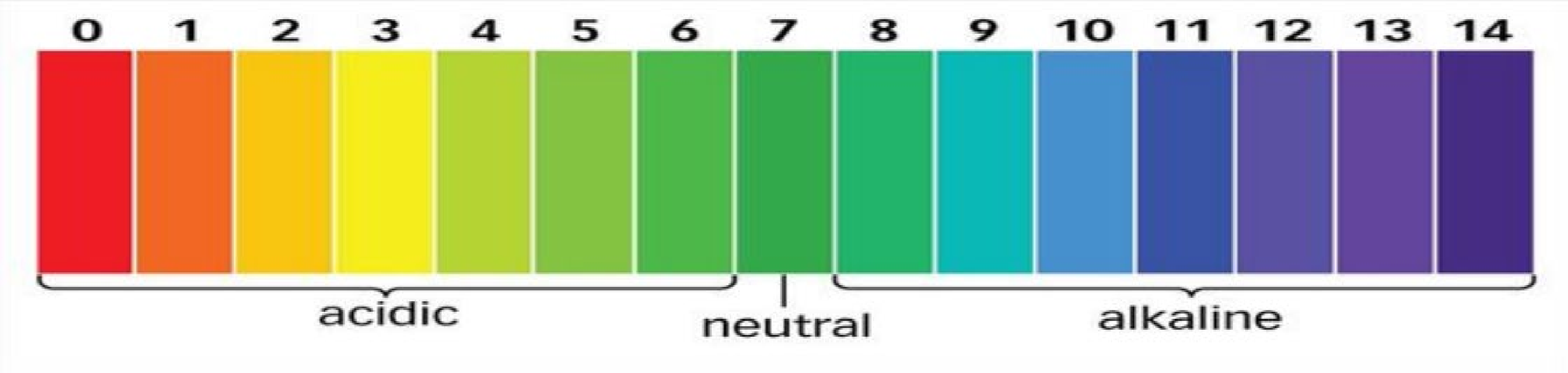
- **Chemical indicators** are essential tools for identifying the nature of substances by their reaction to acidity or alkalinity. Indicators are compounds that exhibit color changes when added to acidic or alkaline solutions. There are four main types of chemical indicators:
- **I-Universal Indicators**
- **II-Litmus Paper**
- **III-Phenolphthalein Indicator**
- **IV-Methyl Orange**

Chemical indicators

- **The universal indicator:** A universal indicator is a versatile tool for measuring the pH of a solution. It comprises a blend of multiple indicators or dyes, each exhibiting distinct color changes across the pH scale ranging from 0 to 14. The colors observed resemble those of the rainbow, offering a visual representation of pH levels.
- **When using a universal indicator:**
- A deep red color indicates a strongly acidic pH, typically falling within the pH range of 1 to 2.
- A green color signifies neutrality, corresponding to a pH of 7.
- Dark blue or purple hues suggest a strongly alkaline pH, typically within the pH range of 13 to 14.
- By observing the color changes in the indicator, one can determine the approximate pH of the solution being tested, allowing for effective pH measurement and analysis.

Chemical indicators

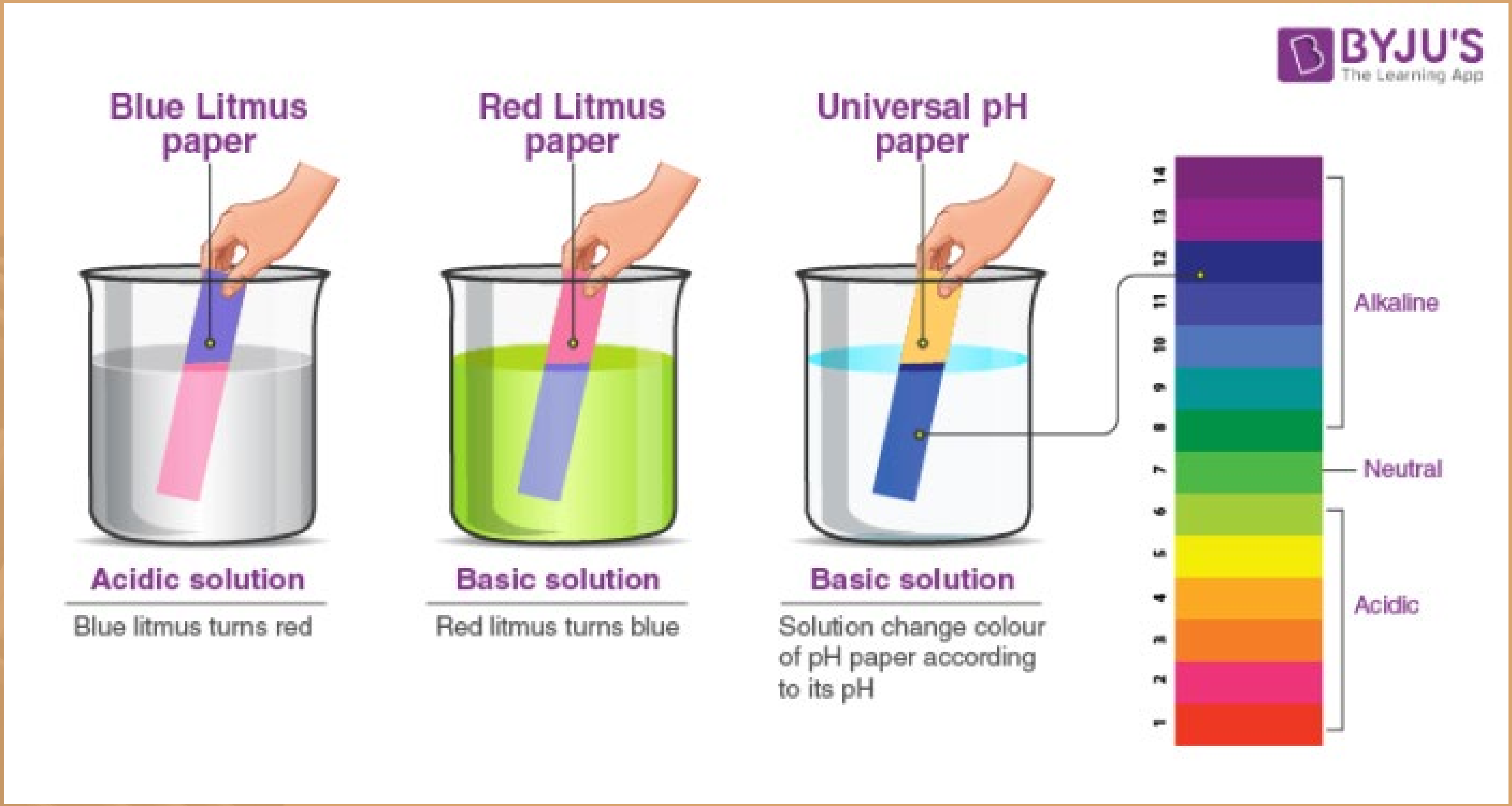
The levels of PH :



Chemical indicators

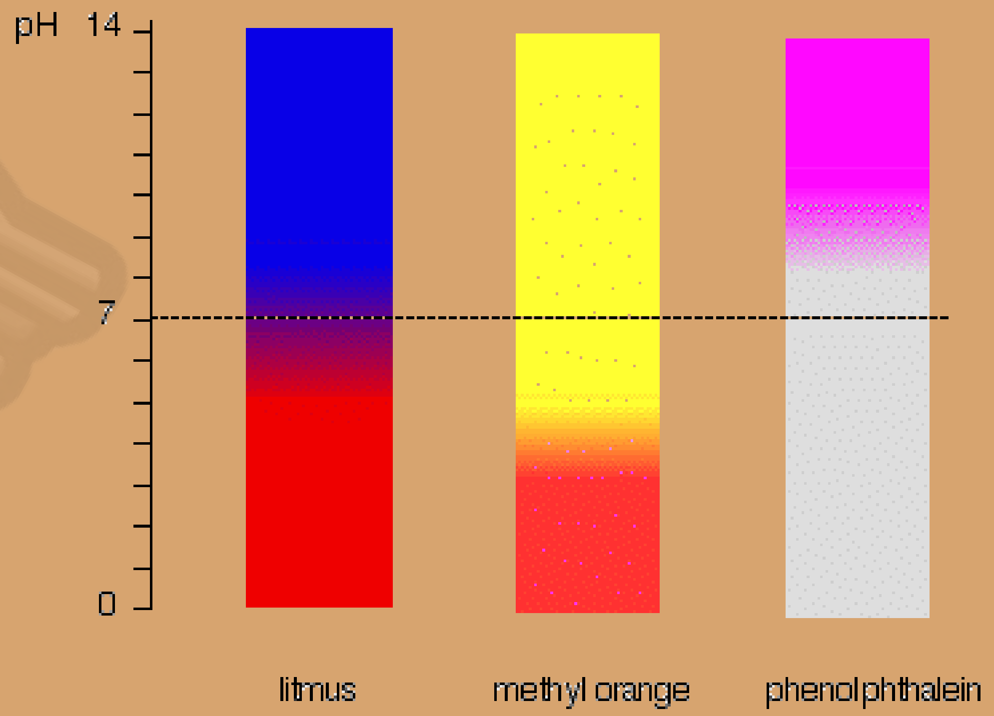
- **The Litmus paper:** Litmus paper is a type of pH indicator paper that undergoes color changes in response to the acidity or alkalinity of a solution it is dipped into. Its utility lies in measuring the acidity of a substance.
- When blue litmus paper turns red upon contact with a material, it indicates acidity. This color change signifies that hydrogen ions are present in the solution, making it acidic.
- Conversely, if red litmus paper turns blue upon exposure to a substance, it indicates alkalinity. This color shift suggests the presence of hydroxide ions in the solution, making it basic or alkaline.
- If neither the red nor the blue litmus paper changes color after dipping, the substance is considered neutral, indicating a balance between acidic and basic properties.
- **The determination of whether a substance is an acid, or a base is based on the change in the number of hydrogen ions (H+) before and after the reaction:**
- If the number of hydrogen ions decreases after the reaction, indicating a donation of hydrogen ions, the substance is classified as an acid.
- Conversely, if the number of hydrogen ions increases after the reaction, suggesting an acceptance of hydrogen ions, the substance is categorized as a base.

Chemical indicators



Chemical indicators

- **The Phenolphthalein Indicator:** It is an organic compound that we use as an acid or base indicator. Furthermore, the compound is pinkish in basic solution and colorless in acidic solution.
- it turns pink when it meets a substance of a pH of 8.2 and becomes purple at an even higher PH. Moreover, this change in color is a result of ionization.



Chemical indicators

- **Methyl Orange:** In an acidic medium, methyl orange is red, and in a basic medium, it is yellow.