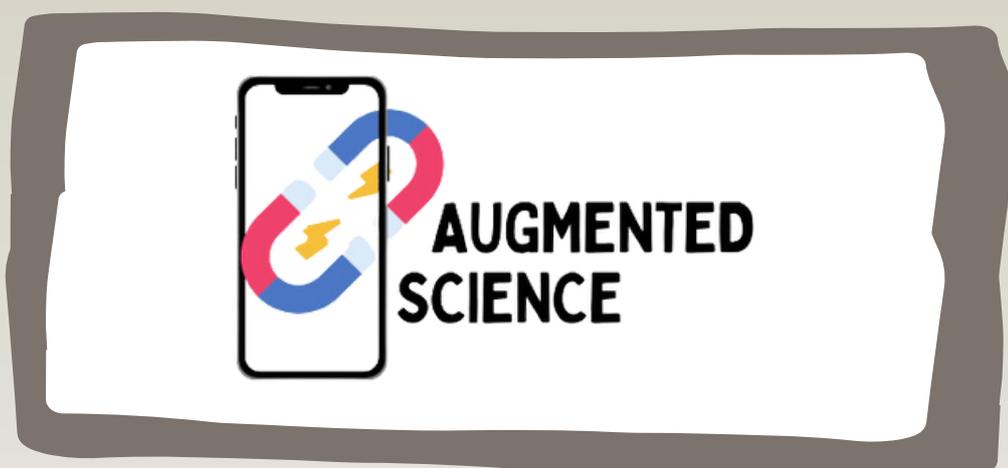


Enriching Learning with Augmented Reality Simulations for Interactive Science



Science Course Content & Scenario-Enriched Activities e- Book

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Introduction

Project Overview

Augmented Science project aims to bring the face-to-face education lab environment to students' tablets and computers and contributing to students active science learning as a response to the disadvantageous environment. In addition the project will design an AR-based learning environment that will support science teachers science learning and teaching processes and improve the students' science concept thinking. In this context, enhancing students' and science teachers' capabilities of using digital materials, learning/teaching science, conducting experiments, studying in collaboration using AR technology, which has been being integrated into science learning environments today because of positive outcomes mentioned in the education and science literature. The main motivation for Augmented Science is above mentioned possible positive contributions and developments in science teaching/learning context. Furthermore, almost all EU countries need such developments, aiming to integrate current technology into science education, because they target 21st century skills for their students and teachers. Project outputs will be adaptable, usable and they will be disseminated within EU countries' education systems. This is also another motivation for the project team to achieve project goals.

Many commissions and organizations have prepared reports on how to respond to these risky and problematic situations in educational environments. For example, in the report Global Education Innovation at Harvard and OECD Rapid Assessment of COVID-19 Education Response "Ensuring the academic learning of students" appeared as the top priority item in response to the crisis.

EU council (June 2020) report reveals that teachers and students need educational materials, virtual applications and online content to support their digital and pedagogical competencies in distance education environments.

When the realistic needs analysis results obtained from the call of the EU commission are examined

1. Generally, teachers need e-learning opportunities to provide students academic learning processes

2. Specifically, the need to integrate digital online technologies to support teachers pedagogy specific to their discipline. Considering this need, science teachers are perhaps one of the most disadvantaged branch teachers in the context of school education. Because of its nature, the science branch does not only aim for students to reach content knowledge but also aims to enable students to acquire scientific process skills such as collecting data through experimentation and observation, creating dependent independent variables, and also having components that are part of

scientific literacy and PISA literacy, such as evidence-based thinking and argument generation. Augmented Science project aims to:

- Bring the face-to-face education lab environment to students' tablets and computers and contribute to students' active science learning.
- Design an AR-based learning environment that will support science teachers' science learning and teaching processes and improve the students' science concept thinking.
- Present scenario-based simulations using AR Based E-Activities over highly abstract, difficult to understand, and/or dangerous activities in a science course to facilitate science teaching to students.
- Promote scenario based experiments and improve embodied interaction in technologically-enriched learning materials by means of Web Based Active Learning System.

About the Scenario-Enriched Activities e-Book

This Scenario-Enriched Activities e-Book includes a variety of Augmented Reality based activities under 12 Science Course Units for Science teachers and students.

These scenario-enriched course content and AR-based activities were specially designed for the target group of the Augmented Science project (science teachers and secondary school students) . Science course content, units and activities were determined after a serious Needs Analysis study with experts, science teachers, educational technologists and academicians.

Each unit has its own AR based activity. Teachers or students can easily scan the specially designed target images in the e-book using their mobile phones or tablets. Then they will be able to reach the AR-based activity, specific to the science course content. The e-book is also printable.

These high quality AR-based activities were designed and developed in order to enhance learning, interaction, challenge and curiosity. These activities will contribute to Science teaching/learning process in schools. Thanks to augmented reality, students will be able to concretize abstract concepts. It will be easier for them to understand the topics and identify the relationships between concepts. A more fun and interactive learning environment will motivate them.

Thanks to this e-book, learning materials and AR-based activities that can be used by science teachers in digital environments has been developed, and the continuity of students' learning will be ensured. The e-book can easily be used both in face to face and distance education settings.

UNIT 1:

Magnetic Field and Current

In this activity we will learn the basics of electricity and magnets and put them together to understand the working principle of an electric motor.

Learning Outcomes:

- Recognises the magnet and discovers that it has poles.
- Gives examples of the use of magnets in daily life.
- Discovers the relationship between magnetic field and current.

Introduction

What is the relationship between magnetic field and current?

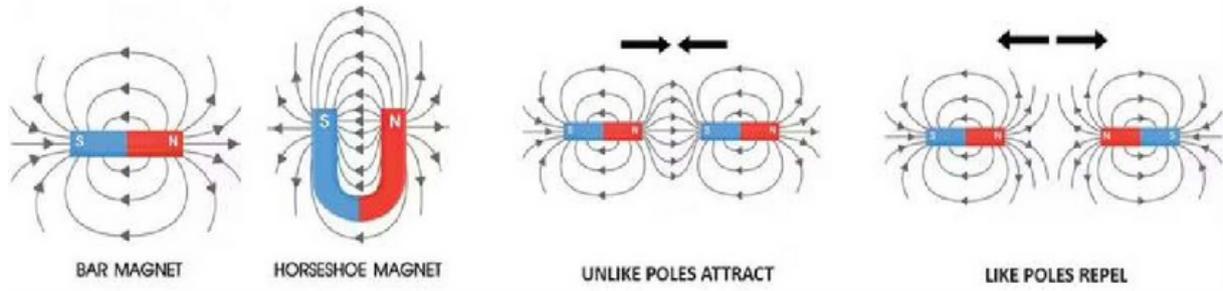
The invisible force field that forms around magnets and can affect electrically charged particles is known as the magnetic field. This field, which explains the attractive or repulsive effects of magnets, is one of the fundamental concepts in electricity and magnetism.

Let's take a closer look at these:

Magnet: Materials that create a magnetic field around them and attract magnetic substances such as iron, nickel and cobalt are called **magnets**. A magnet has two poles called north and south. While the same poles of two magnets brought closer to each other repel each other, different poles attract each other.

Magnetic Field There is an invisible field around the magnet, but its effect can be felt. This field is called "magnetic field". The magnetic field shows how far the power of the magnet extends. This field is stronger near the magnet and weaker the farther away it is. If you place a sheet of paper on a magnet and pour iron powders on the paper, you can observe the magnetic field lines in the plane of the paper.

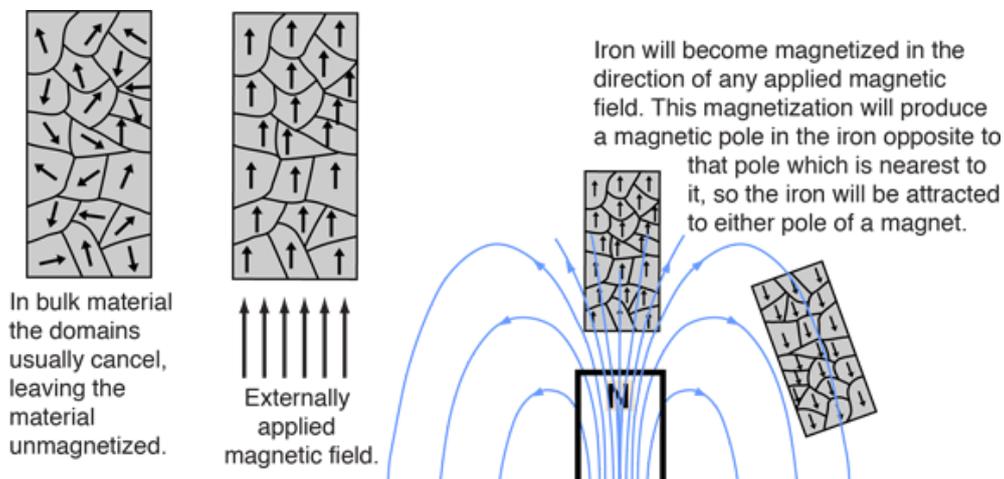




What happens if we take a magnet and cut it into two pieces?

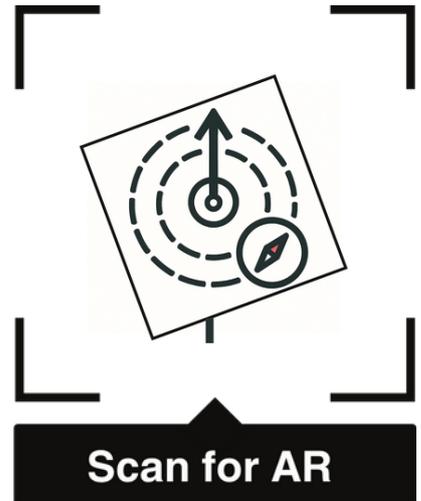
If you cut a magnet in half, each part will still have a north and south pole. The atoms inside the magnet act like little magnets and are all aligned in the same direction. This alignment causes one side of the magnet to have a north pole and the other side to have a south pole. This is a fundamental property of magnets. So the magnetic lines of force inside the magnet always come out of the north pole and go towards the south pole.

Therefore, we can say that a magnet consists of a combination of many small magnetic regions at the atomic level, based on the fact that each part we obtain by dividing a magnet shows magnet properties. We can also use this to explain the interaction of magnets with magnetic materials.



As can be seen from the image, magnetic materials that do not exhibit spontaneous magnet properties also have small magnetic regions at the atomic level within themselves. However, since the magnetic fields that make up these materials dampen each other, they do not show magnetic properties as they are found in nature. However, it is still possible to turn them into magnets with an external influence. The simplest way is to rub these materials against a magnet. You have observed that when you rub a magnet against an iron, the iron becomes a magnet and attracts magnetic materials such as paper clips and needles. In this way, we give the iron a magnet property, albeit temporarily.

Another way to magnetise magnetic materials that do not show magnet properties is to pass current through them. This is actually a situation that scientists have discovered by coincidence. Danish physicist Hans Christian Oersted, while continuing his studies on the electric circuit, accidentally noticed that the needle of a compass near the circuit deviated when electric current passed through the circuit. As a result of his studies, Oersted observed that when the current passes through a conductive wire, it creates a magnetic field around the wire and two current-carrying wires attract or repel each other according to the direction of the current. Oersted's findings influenced the work of scientists such as Michael Faraday and Joseph Henry on electromagnetism. Thus, it was understood that there is a relationship between electricity and magnetism.



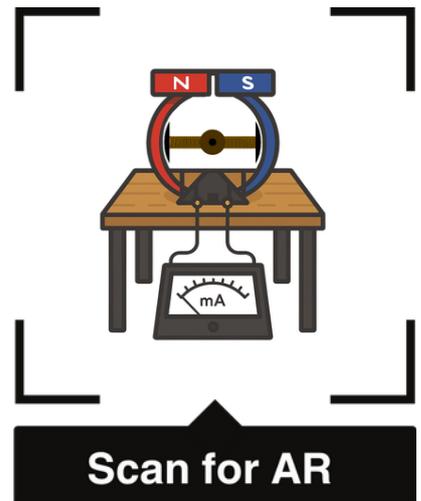
The magnetisation feature you see here is actually the basis of the working principle of electric motors and generators. Let's do a learning activity to understand this better.

LEARNING ACTIVITY:

In this activity you will explore how magnets play a role in the operation of electric motors using a simple electric motor model. Scan the QR code to get started.

Write down and explain your observations (What did you observe? Why do you think this happened?)

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What conclusions did you draw as a result of your observations? What do you think is the relationship between magnetic field and current?

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UNIT 2:

Kinetic & Potential Energy

In this activity we will learn about kinetic and potential energy and explore the factors that affect them.

Learning Outcomes:

- Classify energy as kinetic and potential energy by associating energy with the concept of work.
- It is stated that potential energy depends on mass and height, kinetic energy depends on mass and speed.
- Infer that energy is conserved based on the transformation of kinetic and potential energy types.

Introduction

Before understanding either form of energy, it's vital to understand what energy really is. In the simplest terms, energy is the ability to do work, which is when a force is applied to an object and it moves.

Potential energy is one of the main types of energy in the universe. It's fairly straightforward, although slightly difficult to grasp intuitively: It is a form of energy that has the potential to do work but is not actively doing work or applying any force on any other objects. Potential energy

of an object is found in its position, not its motion. It is the energy of position.

Potential Energy can be quantified as mass times gravity times height.

$$\text{Gravitational P.E.} = mgh$$

m = mass of object (kg)

g = gravitational acceleration, on Earth = 9.8 m/s^2

h = height of object from sea level (defined as 0 m)

m is the mass in kilograms, g is the acceleration due to gravity (9.8 m/s^2 at the surface of the earth) and h is the height in meters. Potential energy is usually measured in units of Joules (J); one Joule is equal to $1 \text{ kg m}^2 / \text{s}^2$. When objects are displaced from positions of equilibrium, they gain energy that was stored in the objects before being knocked out of equilibrium by elastic rebound, gravity, or chemical reactions. This is best demonstrated in an object like an archer's bow, which stores the energy that is created from pulling back the bowstring. The potential energy stored in the pullback is responsible for the energy that occurs upon release, which is known as kinetic energy.



Understanding kinetic energy is intuitively easier because it's more obvious that moving things have energy.

Kinetic energy is created when potential energy is released, spurred into motion by gravity or elastic forces, among other catalysts. Kinetic energy is the energy of motion. When stored potential energy (energy of position) is transformed into motion, it becomes kinetic energy.

$$KE = \frac{1}{2}mv^2$$

m = mass of object (kg)
 v = velocity (speed) of object (m/s)

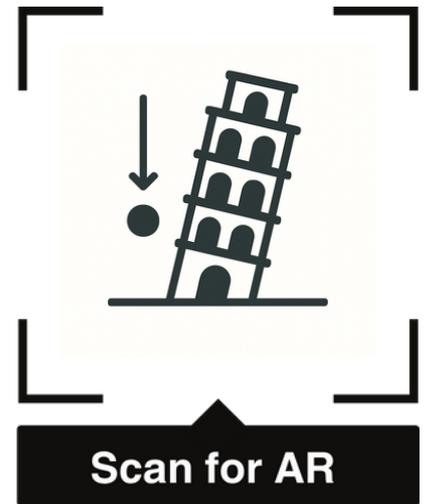
Kinetic energy can be quantified as one half of the mass times the velocity squared. In SI units, the mass should be in kilograms (kg), and the velocity in meters per second (m/s). Kinetic energy has the same units as potential energy ($\text{kg m}^2 / \text{s}^2$), and is measured using the unit Joule (J).

So why is there no gravitational acceleration in the kinetic energy formula? Doesn't gravity affect the motion of the object? Please take a moment and think about it. It actually seems quite logical, doesn't it? But it is not exactly true. Yes, gravity can be the cause of the motion of a free-falling object. But gravity may not be the cause of the motion in all cases. Consider, for example, a spaceship suspended in the vacuum of space in zero gravity. At rest, we can say that its kinetic energy is zero. But when it starts its engines and starts moving, it will have kinetic energy due to its speed. If we had added gravitational acceleration as a multiplier to the formula, we would have made the mistake of ignoring the kinetic energy of the spaceship since it is moving in zero gravity. So we can state that gravity is not directly related to kinetic energy; it is just one of the possible components that are effective in the emergence of the velocity factor.

You already know that energy is conserved and transferred within and between systems, not created or destroyed. Therefore, in a system where friction is neglected, the entire change in potential energy will be converted into kinetic energy.

Now that we have learned the basics of kinetic and potential energy, we can solve a few problems using what we have learned.

LEARNING ACTIVITY: When you scan the QR code on the side, you can repeat the free fall activity designed in an augmented reality environment in different environments, with objects of different masses and by releasing them from different heights. Please answer the following questions using the simulation.
(When designing your experiment, make sure that you only change one variable at a time. Otherwise, it may not be possible to determine which variable caused the change in the measurements.)



a) Calculate the potential energy of an object with a mass of 15 kg at a height of 100 m, its kinetic energy at the moment of impact and how fast it will hit the surface.

POTENTIAL ENERGY:

KINETIC ENERGY:

VELOCITY:

b) Calculate the potential energy of an object with a mass of 45 kg at a height of 100 m, its kinetic energy at the moment of impact and the speed at which it will hit the surface.

POTENTIAL ENERGY:

KINETIC ENERGY:

VELOCITY:

c) Calculate the potential energy of an object with a mass of 15 kg at a height of 150 m, its kinetic energy at the moment of impact and the speed at which it will hit the surface.

POTENTIAL ENERGY:

KINETIC ENERGY:

VELOCITY:

What do you learn about kinetic and potential energy when you compare the data obtained in cases 'a' and 'b'?

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What do you learn about kinetic and potential energy when you compare the data obtained in cases 'a' and 'c'?

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What would the results have been if you had carried out these experiments on the Moon instead of on Earth? Discuss with your peers.

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UNIT 3:

Relationship Between Weight and Mass

In this activity, we will focus on the difference between the concepts of mass and weight, which are often used interchangeably in everyday life.

Learning Outcomes:

- Compares the concepts of mass and weight.
- Names the force of gravity acting on the mass as weight.

Introduction

In everyday life, you may have witnessed many times that the concepts of mass and weight are used interchangeably. However, in science books, it is stated that these are related but different things. So what exactly is the difference between mass and weight? Let's take a closer look at the concepts of mass and weight:

What is mass?

Mass is the unchanging amount of matter in an object; it is determined depending on the number and type of atoms contained in objects. It is measured with an equal-arm balance. Its unit is gram or kilogram. For example, the mass of 1 carbon atom is 1.9945×10^{-23} grams. Therefore, if you weigh a pure substance consisting of 10^{23} carbon atoms, you will see that it comes to 1.9945 g. Then we can say that the mass of an object is equal to the sum of the masses of the atoms that make up that object.

If the mass of an object is to be changed, the number and/or type of particles that make up that object must be changed. For example, when you add more water to the water in a glass, you increase the mass because you change the amount of particles in the glass. Likewise, when you drink some of the water in the glass, you decrease its mass because the amount of particles in the glass decreases. However, as long as the amount of particles remains constant, the mass of the object will not change.

What is weight?

Weight is the magnitude of the force acting on the mass. It is measured with a dynamometer and its unit is "Newton." As can be understood from the definition, we define weight in relation to mass. We cannot talk about weight without mass. When the mass of an object increases, its weight also increases. When its mass decreases, its weight also decreases. However, mass and weight are still not the same thing because it is possible to change the weight without changing the mass.

Let's carry out a learning activity to better understand the difference:

LEARNING ACTIVITY:

Imagine that you take two identical objects and place them on the scales of an equal-arm balance. Since they are identical, the balance will remain balanced. If you took this balance and the weights to the Moon, Mars or any other planet, do you think the balance would be out of balance? Discuss with your peers.



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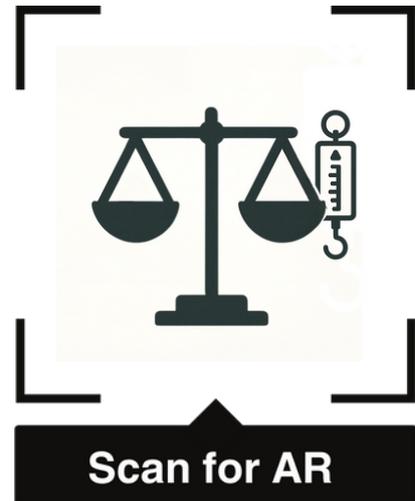
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By scanning the QR code on the side, you can travel to different planets in an augmented reality environment and make observations about the mass and weight of objects. Write down your observations.



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Describe the relationship between the concepts of mass and weight based on your observations.

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Imagine a weightlifter trying to lift an 80 kg weight. Do you think the weightlifter would lift the barbell more easily if he/she did this experiment on Earth or on the Moon? Explain your opinion with justifications.

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UNIT 4:

ABSORPTION OF LIGHT

In this activity we will focus on the reflection and absorption of light. We will discover how the amount of absorption of light depends on what is happening.

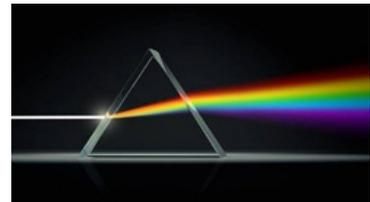
Learning Outcomes:

- Concludes that white light is a combination of all light colours.
- Discover that light can be absorbed by matter as a result of its interaction with matter.

Introduction

The rainbow that appears on a rainy day when the clouds disperse and the sun begins to shine is a fascinating natural phenomenon that attracts the attention of many people. The rainbow, which is the subject of many stories and legends with its beautiful appearance, has led to the emergence of many puzzles and question marks for curious minds. For example, what is the relationship between rainbows and rain? Why is the order of colors in the rainbow the same every time? Let's take a look at Newton's work on optics to find answers to these questions.

Sir Isaac Newton was the first scientist to correctly explain the nature of light. Until the 1660s, it was believed that white light was a color on its own. In 1666, Newton conducted a prism experiment in a dark room and showed that, contrary to popular belief, white light is actually a mixture of all colors. In this experiment, Newton was actually aiming to explain how rainbows are formed. With a simple setup in which sunlight passed through a prism, white light refracted at different angles created an artificial rainbow with red, orange, yellow, green, blue and purple colors on the reflected surface. So what was going on to create all the known colors when white light passed through the prism? Newton could not answer this question because the structure of light was not yet understood at the time. About 135 years after Newton's experiment, in 1801, scientist Thomas Young proved that light is a wave. Young proved that as light passes through a prism, it is refracted at different angles according to its wavelength and thus separated into its colors.



So far we have understood that when white light is refracted, other colors of light are formed. It is also possible to say the opposite. That is, the combination of light colors creates white light. But there is still one more question we need to answer: Why is the order of colors in the rainbow always the same? Let's do a little experiment to find the answer to this question.

LEARNING ACTIVITY:

On a hot summer day, you may have felt warmer when you wore dark-colored clothes. Wearing light-colored clothes in hot weather can make you feel less affected by the heat. But how? In this activity, we will examine the temperature increase of identical materials of different colors under light.

Perform the experiment in an augmented reality environment.

OBSERVATION 1: When you measure the temperature of different coloured T-shirts under sunlight (white light), record the temperature data in the table below. (The T-shirts are made of the same type of fabric).

	Black T-shirt	White T-shirt	Red T-shirt	Green T-shirt	Blue T-shirt
White Light	.... °C	.... °C	.... °C	.... °C	.... °C

What do you think is the reason for this difference in temperature values?

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OBSERVATION 2: Repeat the experiment this time using different coloured lights.

	Black T-shirt	White T-shirt	Red T-shirt	Green T-shirt	Blue T-shirt
Red Light	....°C	.... °C	.... °C	.... °C	....°C
Green Light	.... °C	.... °C	.... °C	.... °C	....°C
Blue Light	....°C	.... °C	.... °C	.... °C	....°C



When we look at a red T-shirt in sunlight, we see it as red because it reflects only the red colours of the white light falling on it.

Remember that sunlight (i.e. white light) is a combination of all the colours of light.

So where have all the other colours of light in sunlight disappeared except red? How do you think this could be related to the heating of the T-shirt in sunlight? Discuss with your peers.

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Do you think that dark coloured objects always heat up more when they are exposed to sunlight? Is colour the only factor affecting the absorption of light? Discuss with your peers.

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UNIT 5:

Cell Theory

In this activity you will explore different types of cells and the similarities and differences between them.

Learning Outcomes:

- Compare animal and plant cells in terms of their basic parts and functions.
- Specifies the names and functions of cell organelles.

Introduction

The cell is the smallest unit of life. Every human, animal, or plant around you is referred to as an organism. Cells are the fundamental building blocks of all these organisms.

In multicellular organisms, certain types of cells come together to form tissues like muscle tissue, connective tissue, and nerve tissue, working together to perform specific functions.

Some of these tissues combine to create organs such as the stomach, heart, or brain.

Furthermore, certain organs work together to form organ systems like the digestive system, circulatory system, or nervous system. Through the coordination of these systems, organisms are formed.

Now, let's take a little journey with you on how the cell was discovered.

What is Cell Theory?

For centuries, the origins of life and the nature of living organisms have been subjects of great curiosity for humanity. This curiosity has driven people to ask questions about the beginning of life and how it emerged. Until the 1600s, researchers could only gather information about the types of living organisms they could observe and were unaware of the existence of microscopic life forms. Where did the disease-causing microbes and molds come from? How did they reproduce? What were the components of each of their parts? If there were smaller components, what did they look like? These questions remained unanswered until the invention of the microscope.

With the invention of the microscope, a whole new world previously hidden from view was suddenly revealed, and insights into this microscopic realm began to enter our lives at an astonishing rate. In 1674, the Dutch scientist Antonie van Leeuwenhoek examined a sample of sticky fluid from his teeth using a microscope he had built himself. He discovered tiny structures he referred to as "animalcules," meaning "little animals." Leeuwenhoek is celebrated as the "Father of Microbiology" for uncovering this previously invisible world of living organisms.

Around the same time, English scientist Robert Hooke examined thin slices of cork under the microscope and noticed a series of small, box-like structures. He named these structures "cells" due to their resemblance to the small rooms or cells in a monastery. Hooke's discovery marked the first time that cells were observed and described. This observation laid the groundwork for the first doctrine of Cell Theory:

"Cells are the smallest building blocks of living things."

In 1831, approximately 200 years after the initial discovery of the cell, Robert Brown identified the cell nucleus. By 1838, zoologist Theodore Schwann and botanist Mathias Schleiden, through their examinations of plants and animals, discovered similarities between the cells of both organisms. Their experiments revealed that these cells shared the same nuclear structure. This led to the formulation of the second doctrine of Cell Theory:

"All living organisms are composed of one or more cells."

As a result of all these experiments and research, scientists began to wonder: If animals arise from other animals and plants arise from other plants, then what are bacteria made of? At that time, the prevailing view on microorganism reproduction was still influenced by Aristotle's idea of "spontaneous generation." However, in 1858, Rudolf Virchow examined the division of bacteria and described this process as "binary fission." His research led him to conclude that all cells arise from pre-existing cells, thus challenging the notion of spontaneous generation and further refining Cell Theory.

Years before Virchow, Lazzaro Spallanzani had disproved the theory of spontaneous generation by demonstrating that microbes came from the air and could be killed through boiling. Despite his findings, he struggled to find support for his ideas at that time. Nearly a century later, Louis Pasteur conducted experiments that supported Spallanzani's work, ultimately disproving the theory of spontaneous generation and solidifying the concept that microorganisms arise from other microorganisms. Thus, the third doctrine of Cell Theory was established:

"Cells arise from pre-existing cells."

Each subsequent scientific study has taken our understanding of the cell one step further. For example, Schultze noted that physical and chemical effects in animal and plant cells are similar. However, differences between the two types of cells were also observed, with Cohn being the first to discover the presence of a cellulosic membrane. In animal cells, this membrane allows for more flexible movement and interaction with the external environment, while in plant cells, the cellulosic membrane permits only internal movement.

In 1853, Huxley introduced the concept of the cell membrane, emphasizing its significance both chemically and morphologically, as it lies beneath the cell wall. Huxley also highlighted

that living organisms do not arise spontaneously but through a process involving the fusion of sperm and egg, suggesting that a new organism is produced through this combination rather than by asexual reproduction alone.

By the late 19th century, the development of staining techniques for cells under the microscope allowed for a clearer observation of the cytoplasm. This led to the discovery of various specialized structures known as organelles. Initially, the endoplasmic reticulum was identified, followed by the discovery of mitochondria and the Golgi apparatus, revealing that the cytoplasm is not empty but composed of living structures. Subsequent discoveries included observations of how cells divide, the mechanisms of division, chromatin structure, and the stages of mitosis and metaphase. These advancements significantly enhanced our understanding of cellular processes and structures.

Now that we've learned about the basics of Cell Theory, let's dive into the different parts of a cell. By getting to know the various organelles and what they do, we can better understand how a cell works and keeps everything running smoothly.

LEARNING ACTIVITY:

In this activity you will explore the similarities and differences between cell types of different organisms.

An organelle is a small structure within a cell that has a specific job to do. Just like organs in our body have their own special functions, organelles have their own unique tasks inside the cell.

This is why they are called organelles—because they work like the organs of a cell.

The shape and structure of a cell can differ depending on the type of tissue it is attached to. You may have noticed that the image of an animal cell and the image of a nerve cell in your textbooks are not very similar. This is because the cell has specialized functions according to the tissue to which it is attached. Therefore, keep in mind that the number and shape of organelles may differ depending on the cell type.

The development of cells provides us with various clues about the level of development of the organism to which that cell belongs. For example, some cells had a nucleus while others did not. This difference is very important for the classification of cells. Cells are divided into two types according to whether they have nuclei or not: Cells with a nucleus are called prokaryotes and cells with a nucleus are called "eukaryotes". This difference in level of development also affects the organelles. However, eukaryotic and prokaryotic cells can also differ in terms of organelle structure. For example, an organelle in a eukaryotic animal cell may not be present in a eukaryotic plant cell (or vice versa). However, there are also organelles that are common



to all cell types, regardless of the cell type. It can be stated that these organelles are essential for the cell to maintain its vitality.

Discovering this is an important step in our understanding of how life on earth began at the most basic level, and how today's advanced complex organisms evolved from single-celled organisms.

During the activity you will observe that some organelles are found in all cell types, while others are found only in some cells.

What were the differences you noticed during your observations?

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What structures do you observe as common to all cell types?

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UNIT 6:

Seed Germination

In this activity we will observe how various environmental variables affect seed germination.

Learning Outcomes:

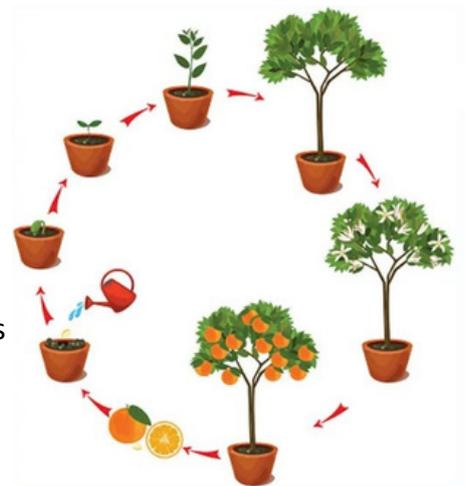
- Design an experiment involving dependent, independent and controlled variables related to factors affecting seed germination.
- Explores how the scientific method works by conducting experiments.

Introduction

Plants reproduce in two basic ways: sexual and asexual reproduction. In sexual reproduction, flowers serve as reproductive organs and these plants reproduce through seeds. In flowering plants, seeds are formed as a result of the fertilization process.

The life cycle of flowering plants consists of the following stages: pollination, fertilization, zygote and embryo formation, seed and fruit formation, germination of the seed and formation of the young plant. This whole cycle takes place on a set timetable. As you know, plants bloom at certain times and bear fruit at certain times. This is because certain conditions are necessary for the transition from one stage to the next in the life cycle. If the conditions for germination are not met, the seeds remain dormant. Today, with the development of agricultural technologies, it is possible to simulate these environmental conditions and produce fruits and vegetables out of season. However, for this, all environmental parameters must be ideal.

So let's take a closer look at what conditions must be met for a seed to germinate:

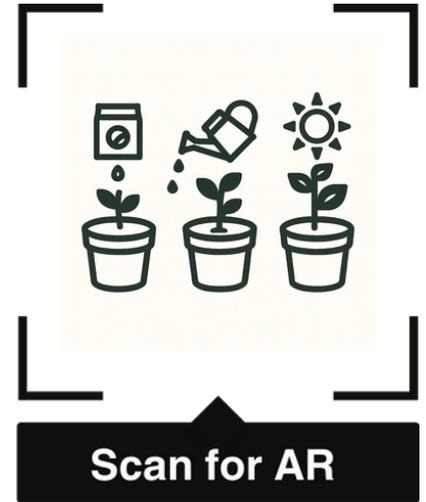


LEARNING ACTIVITY:

Before starting the activity, please state your initial thoughts:

*What do you think are the factors that affect seed germination?
How do you think these factors affect seed germination?*

.....



Observations: At this stage, you are expected to observe the result by changing the environment variables in the augmented reality environment and record your observations.

NOTE: During the activity you should only measure the effect of one variable at a time. All other variables should be kept under control. Otherwise, it will not be clear which variable caused the observation result. For example, if both the temperature and the amount of irrigation are changed at the same time, it will not be known whether the result is due to the difference in the amount of irrigation or the temperature difference).

Dependent Variable (Variable whose effect is measured)	Control Variables (Variables whose effect is kept under control)	Independent Variable (Observation)
Irrigation Amount	Temperature Seed Type Light Amount	
Temperature	Irrigation Amount Seed Type Light Amount	
Seed Type	Irrigation Amount Temperature Light Amount	
Light Amount	Irrigation Amount Temperature Seed Type	

Do the observation results match your initial thoughts?

.....

After the activity, discuss and evaluate your observations with your peers.

Do your observations coincide with the observations of your peers?

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Are there plants for which light is effective in germination? Have a discussion with your peers.

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UNIT 7:

Human Body Systems

In this activity we will explore the systems in human body and their interrelationships.

Learning Outcomes:

- Explains the functions of the systems in our body and the importance of all systems working as a whole.
- Explains the structures and organs that make up the systems in our body.

Introduction

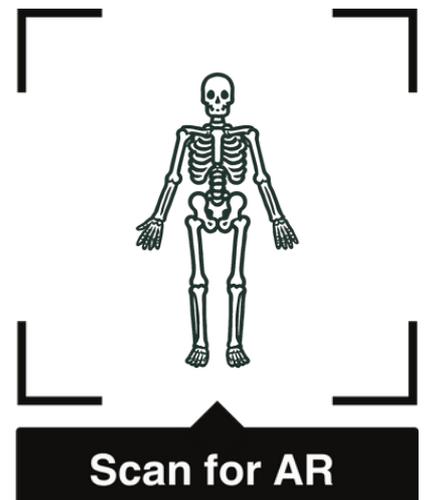
Our body is made up of various systems that involve a complex and perfect organization; these systems perform various functions such as blood circulation, respiration, digestion, etc. that enable us to sustain our lives, and each of them works in harmony with the other systems to ensure the holistic health of the body (internal balance, homeostasis). For example, the circulatory system carries oxygen and nutrients to the organs through the heart and blood vessels, and the digestive system distributes nutrients from digested food. At the same time, the respiratory system regulates the intra-body gas exchange with oxygen uptake and carbon dioxide excretion, a process coordinated by the nervous system. The harmony between these systems makes it possible for the body to adapt to both internal and external factors. This cooperation between systems is critical for maintaining a healthy life. In this context, in this unit, we will learn about the systems in our body and the functions of the organs and structures that make up them.

MUSCULATURE SYSTEM

Humans perform their movements with the support and movement system. The support and movement system consists of bones, joints and muscles. Our skeleton is formed when bones, cartilage and joints come together.

Musculature system;

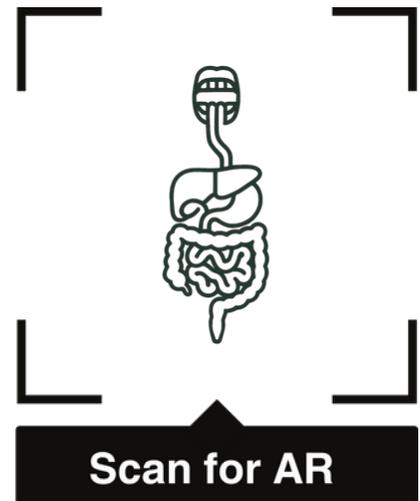
- provides the movement of our body together with muscles.
- shapes our body and keeps it upright.
- provides an attachment surface for muscles and internal organs
- and
- protects internal organs.
- produces blood cells such as red blood cells and white blood cells.
- stores some of the minerals we need (calcium, phosphorus, magnesium, etc.).



Scan the QR code on the left to learn more about the Musculature system.

DIGESTIVE SYSTEM Digestion is the process by which food is broken down, processed and converted into nutrients in the body, starting in the mouth. This process is critical for the body to convert food into energy and obtain essential nutrients. Digestion involves both mechanical and chemical processes. The organs and structures involved in digestion constitute the digestive system. The organs of the digestive system consist of the mouth, pharynx, esophagus, stomach, small intestine, large Intestine and anus.

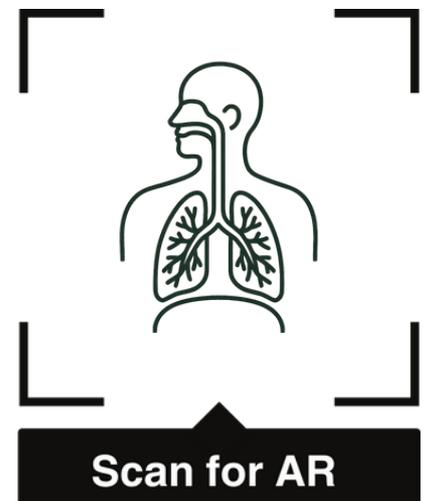
The liver and pancreas are organs that help the digestive system: The liver sends bile secretion to the small intestine through a duct, which enables the physical digestion of fats in the small intestine. The pancreas sends pancreatic juice to the small intestine for the chemical digestion of carbohydrates, proteins and fats. Scan the QR code on the left to learn more about the digestive system.



RESPIRATORY SYSTEM

Respiration is a biological process in which organisms chemically break down nutrients using oxygen to produce energy, and in the process produce waste products such as carbon dioxide and water. In this respect, the respiratory system plays a vital role in the body's energy production and gas exchange. The main task of the respiratory system can be summarized as taking in oxygen from the air and expelling carbon dioxide accumulated in the body. The transportation of oxygen and carbon dioxide within the body is carried out through the blood circulation.

The organs that make up the respiratory system are the nose, pharynx, larynx, trachea and lungs. Air is taken in through the nose or mouth and passed into the lungs through the trachea. The alveoli in the lungs allow oxygen to pass into the blood and carbon dioxide to escape from the blood into the air. Oxygenated blood is transported through the heart to various parts of the body, while carbon dioxide is brought back to the lungs and expelled through respiration. Thus, the respiratory system meets the body's need for oxygen and removes waste gases, ensuring the proper functioning of metabolism.



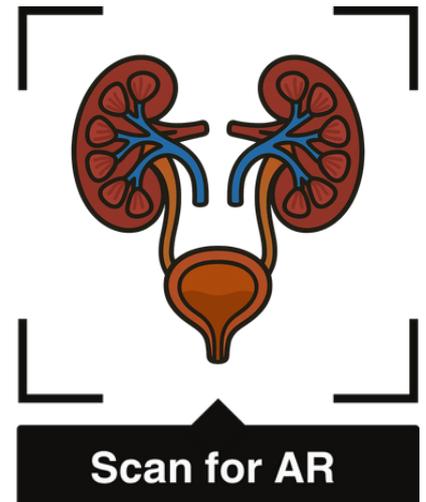
Scan the QR code on the left to get to know the respiratory system better.

EXCRETORY SYSTEM

As a result of the metabolic activities that take place in the body, during the energy production of cells and other biochemical processes, various waste products are produced. These waste products include substances such as carbon dioxide, urea, uric acid and creatinine and need to be systematically removed as they can be harmful to the body. This is where the excretory system comes into play. The excretory system is the system that cleans the body of the waste products produced as a result of vital activities in the cells and the excessive amount of unused residual substances taken into the body.

The organs that make up the excretory system are the kidneys, urinary tube (ureter), bladder (bladder) and urinary canal (urethra).

Scan the QR code on the side to get to know the excretory system better.

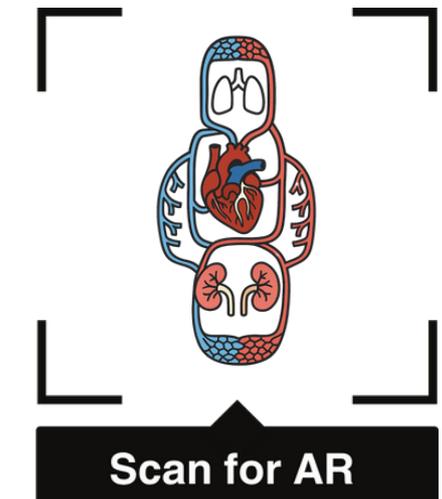


CIRCULATORY SYSTEM

The circulatory system is the system that ensures the transportation of nutrients and oxygen in cells and the removal of carbon dioxide and waste materials formed in cells. In addition, the circulatory system regulates body temperature and delivers hormones to target organs. It fights infections by transporting immune cells and supports the healing of wounds. With all these functions, the circulatory system plays a vital role in maintaining overall health and quality of life.

The circulatory system fulfills basic vital functions by forming a network that carries blood to every part of the body. The main structures and organs that make up this network are: Heart, Blood vessels (arteries, veins, capillaries), blood.

Scan the QR code on the side to get to know the digestive system better.



LEARNING ACTIVITY

Learning Stations:

So far, you have learned the theoretical information in the unit of systems in our body. You have discovered the organs and structures that make up the systems. In this activity, you will use this knowledge to build systems from scratch using the station technique.

One system will be handled in each station created. At the beginning, the groups are distributed to the stations so that each group is assigned to a station. The groups transfer what they know about the system at the station they are assigned to the poster at the station in writing, drawing or any other way they want. After a while, with the sound of the bell, the groups leave their work where they left off and move on to the next station. At this new station, students examine what the previous groups have done and continue their work where they left off. This cycle will continue until all groups have visited all stations. At the end of the activity, the posters will be displayed and you will be asked to evaluate them.

UNIT 8: Photosynthesis

In this activity you will explore how photosynthesis takes place and the factors that affect the rate of photosynthesis.

Learning Outcomes:

- Recognises the importance of photosynthesis in nutrient production in plants.
- Makes inferences about the factors affecting the rate of photosynthesis.

Introduction

You have learned that green plants have the ability to produce their own supply of sugar through the process of photosynthesis. Photosynthesis is a complex chemical process in which green plants produce sugar and oxygen for themselves. The equation for photosynthesis is as follows:



The plant uses the sugar it produces through photosynthesis to grow and produce more leaves, stems, and roots—the biomass of the plant. The process of photosynthesis, however, does not happen all the time, and when it happens depends on a number of environmental factors. For example, plants need a supply of water, carbon dioxide, and light energy for photosynthesis to work. Plants must get these resources from the surrounding environment. The process of photosynthesis can also slow down or speed up depending on environmental conditions. In this lab investigation, you will explore how different environmental conditions affect how quickly photosynthesis takes place within a plant. You will then develop a conceptual model that explains why.

Overview of Photosynthesis : Main Structures and Summary of Photosynthesis

Photosynthesis is a multi-step process that requires sunlight, carbon dioxide, and water as substrates. It produces oxygen and glyceraldehyde-3-phosphate (G3P or GA3P), simple carbohydrate molecules that are high in energy and can subsequently be converted into glucose, sucrose, or other sugar molecules. These sugar molecules contain covalent bonds that store energy. Organisms break down these molecules to release energy for use in cellular work.

The energy from sunlight drives the reaction of carbon dioxide and water molecules to produce sugar and oxygen, as seen in the chemical equation for photosynthesis. Though the equation looks simple, it is carried out through many complex steps. Before learning the details of how photoautotrophs convert light energy into chemical energy, it is important to become familiar with the structures involved.

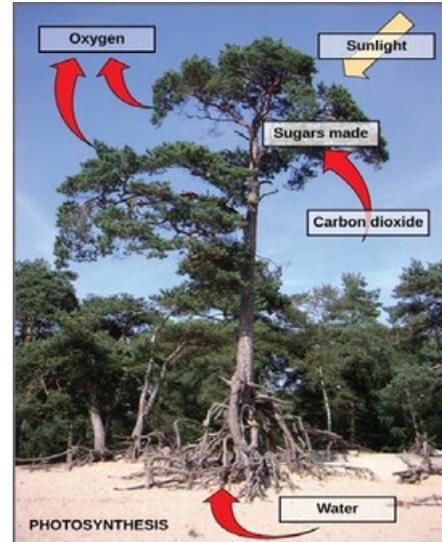


Figure 1: Photosynthesis: Photosynthesis uses solar energy, carbon dioxide, and water to produce energy-storing carbohydrates. Oxygen is generated as a waste product of photosynthesis.

Photosynthesis and the Leaf

In plants, photosynthesis generally takes place in leaves, which consist of several layers of cells. The process of photosynthesis occurs in a middle layer called the mesophyll. The gas exchange of carbon dioxide and oxygen occurs through small, regulated openings called stomata (singular: stoma), which also play a role in the plant's regulation of water balance. The stomata are typically located on the underside of the leaf, which minimizes water loss. Each stoma is flanked by guard cells that regulate the opening and closing of the stomata by swelling or shrinking in response to osmotic changes.

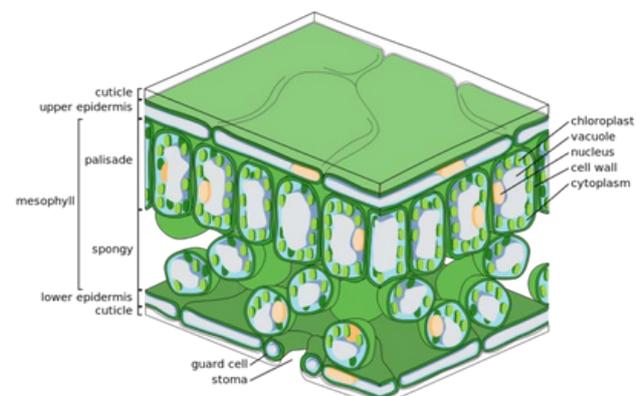
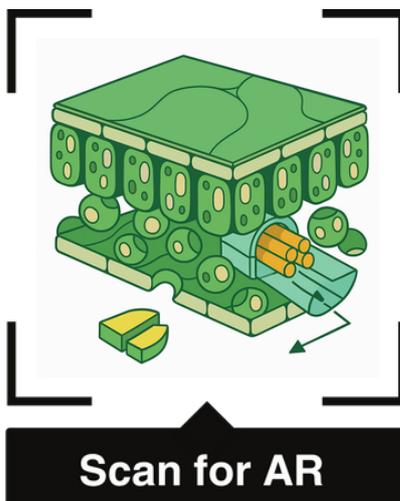


Figure 2: Structure of a leaf (cross-section)

Photosynthesis takes place in the mesophyll. The palisade layer contains most of the chloroplast and principal region in which photosynthesis is carried out. The airy spongy layer is the region of storage and gas exchange. The stomata regulate carbon dioxide and water balance.

Let's Explore Together

Research Question: How do temperature and light intensity affect the rate of photosynthesis in plants?

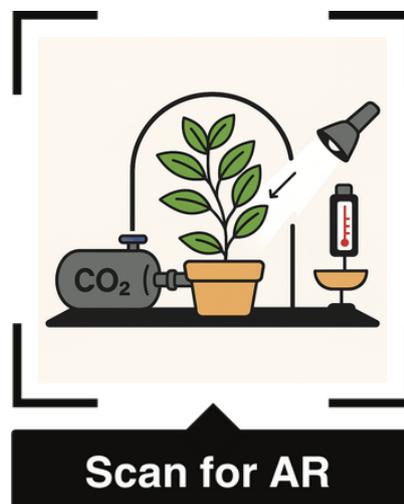
Your Task: Design a series of experiments to determine how temperature and light intensity affect the rate of photosynthesis in spinach. Then develop a conceptual model that explains why these environmental factors affect the rate of photosynthesis in the way that they do.

Getting Started

The first step in developing your model is to design and carry out a series of experiments to determine how temperature and light intensity affect the rate of photosynthesis. You will therefore need a way to calculate a rate of photosynthesis. A photosynthesis rate can be calculated by measuring how much CO₂ a plant consumes or how much O₂ a plant produces over time using the following equation:

$$\text{Photosynthesis rate} = (\text{change in CO}_2 \text{ or O}_2 \text{ level}) / \text{time}$$

Observation:



There is a plant inside a sealed flask with a CO₂ gas sensor or O₂ gas sensor. Observe the change in photosynthesis rate by changing the temperature and light color variables in an AR environment.

The next step is to think about how you will collect the data and how you will analyze it. To determine how you will collect your data, think about the following questions:

- *What will serve as a control (or comparison) condition?*
- *What will serve as the treatment condition(s)? (Hint: To investigate the effect of temperature on photosynthesis rate, you will need to determine how to vary the temperature inside the flask. To investigate the effect of light intensity on photosynthesis rate, you can use lightbulbs with different wattages.)*
- *How will you make sure that your data are of high quality (i.e., how will you reduce error)?*
- *How will you keep track of the data you collect and how will you organize the data?*

To determine how you will analyze your data, think about the following questions:

- *How will you determine if there is a difference between the treatment and the control conditions?*
- *What type of calculations will you need to make?*
- *What type of graph could you create to help make sense of your data?*

Once you have carried out your series of experiments, your group will need to develop a conceptual model. Your model needs to explain why these two environmental factors affect the rate of photosynthesis in the way that they do. The model should also explain what is happening at the submicroscopic level during the process of photosynthesis.

Augmented Sessions

Once your group has finished collecting and analyzing your data, prepare an argumentation report that you can use to share your initial argument.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the report.

You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations? Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to discuss with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question! (Why Do Temperature and Light Intensity Affect the Rate of Photosynthesis in Plants?)

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document.

UNIT 9:

Interactions between Molecules

In this activity you will explore weak intermolecular bonds and strong intramolecular interactions.

Learning Outcomes:

- Expresses the difference between weak and strong interactions.
- Explains the boiling event at the molecular level by associating it with weak and strong interactions.

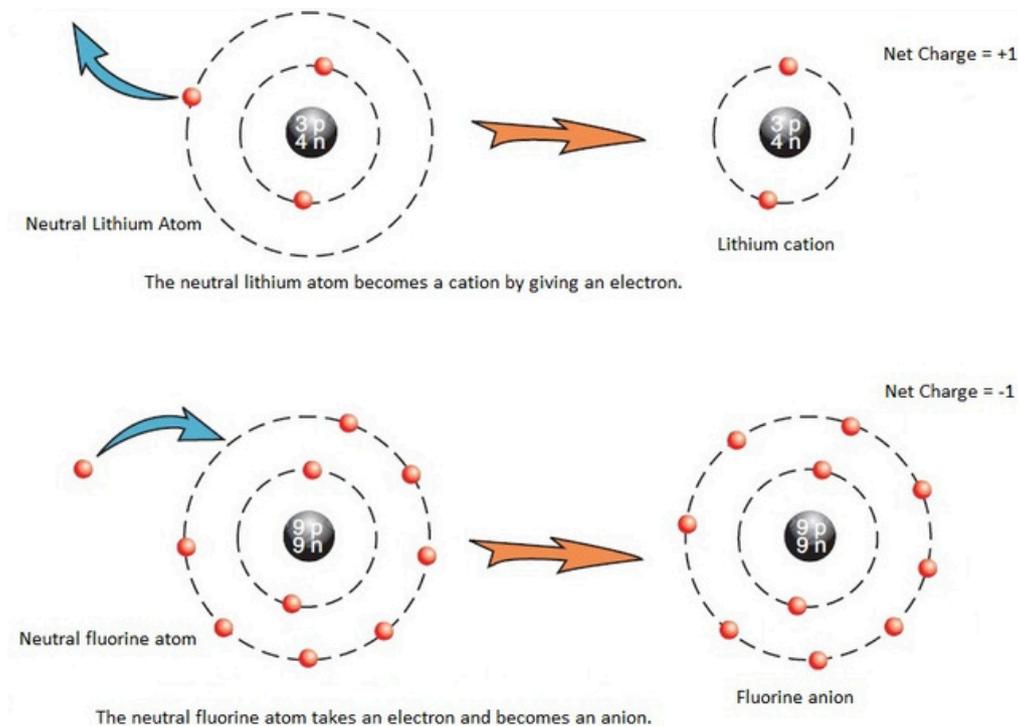
Introduction

We know that all matter in the universe is made of atoms. However, atoms are very rarely found alone in nature. Atoms interact with other atoms to form elements and compounds. How this interaction takes place depends on the number and arrangement of electrons atoms have.

To understand this, let's take a closer look at the atom.

In fact, when you try to observe an atom, the only shape you will see in the first place is the nucleus. The nucleus is located at the center of the atom and contains the "+" charged particles called "protons" and the uncharged "neutrons" that hold these protons together like glue (because, as you know, like charges repel each other and opposite charges attract each other). The particle that determines the type of an atom is the proton. So you can think of the number of protons as the atom's identity card. In addition to these, there is a third type of particle outside the nucleus, which is inconspicuous at first glance, but which is the protagonist of chemical bonding, which we will discuss in a moment: Electrons. We say inconspicuous at first glance because electrons are much smaller particles than protons and neutrons, and they move very fast, far away from the nucleus. However, these "-" charged particles do not move completely randomly. In science books you have seen various models of the atom (the Bohr model of the atom), which are likened to the solar system. Although this is not a completely accurate representation, it is still used in many sources because it makes it easier to understand the movement of electrons and the role they play in the bond structure. According to this notation, electrons move in specific orbits around the nucleus, or in more technical terms, in energy levels consisting of several layers of probability states for their position. These layers have different electron capacities. The layer closest to the nucleus can hold up to two electrons. The second and third energy levels can hold up to eight electrons. When a layer at one energy level is full, the next electron arrives and settles in the layer at the next higher energy level. Therefore, all the layers before the outermost layer of the atom are completely full of electrons. For this reason, electrons in the outermost orbital (valence orbital) are taken into account when talking about chemical bonds. In some elements, the electron capacity in the valence orbital is not completely filled. This causes that atom to be in an unstable state. Atoms always tend to fully fill the electron capacity in all orbits and become stable. To do this, they can share electrons with other elements, give electrons to them or accept electrons from them. As a result, the balance of positively and negatively charged particles in the atom will change. If the number of "+" charged protons and "-" charged electrons in an atom is equal, it is called a "neutral atom". However, if an atom does not contain an equal number of protons and electrons, it is called an "ion".

Since the number of electrons in such atoms is not equal to the number of protons, each ion has a net charge. They are called "negative ions" if the number of electrons is greater than the number of protons, and "positive ions" if the number of protons is greater than the number of electrons.

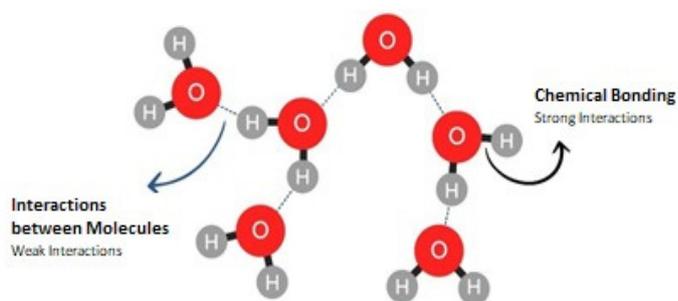


For example, lithium has a single electron in its outermost layer. It takes less energy for lithium to give up that one electron than to accept seven more electrons to fill its outer layer. If lithium loses an electron, it now has three protons and only two electrons, leaving it with a total charge of +1 and the name lithium cation. The lithium ion we are talking about here is a positive ion.

The tendency of atoms to stabilize and the interactions between the charged ions they transform into form the basis of chemical bonds. We can classify these interactions between chemical species as "strong interactions" and "weak interactions".

Through these interactions, atoms take the elemental and compound forms they are found in nature. Strong interactions are the forces that hold the atoms that make up molecules together, i.e. chemical bonds. Weak interactions are the forces that arise between positively and negatively charged molecules.

Interactions between Chemicals



STRONG INTERACTIONS CHEMICAL BONDS

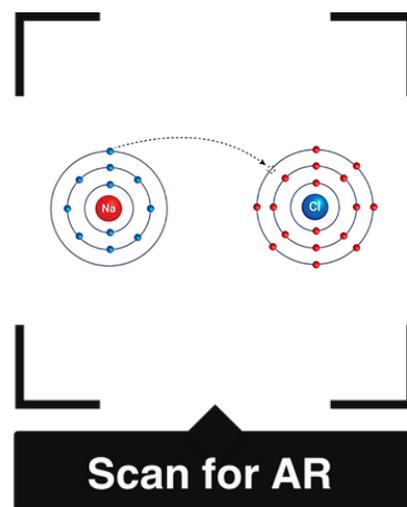
Atoms can form chemical bonds by giving, receiving or sharing electrons. In this section we will take a closer look at ionic bonding and covalent bonding.

1. Ionic Bonding:

Ionic bonding is based on the exchange of electrons between two chemical species. The result is an anion, an ion with a minus charge, and a cation, an ion with a plus charge. The chemical bond formed due to the electrical attraction between the positive and negative charges is called an ionic bond..

The neutral sodium atom has 11 electrons and 11 protons. The outermost valence orbital shell has 1 electron. It can become stable by giving up this 1 valence electron. The neutral chlorine atom has 17 electrons and 17 protons. The outermost valence orbital has 7 electrons. Chlorine can become stable by taking 1 electron. During the formation of the sodium chloride molecule, sodium atoms give 1 electron to form the plus charged sodium ion (Na^+) and chlorine atoms give 1 electron to form the minus charged chlorine ion (Cl^-). Due to the electrical attraction between the oppositely charged ions, an ionic bond is formed between them.

There is a marked difference between the electronegativities of the atoms forming the ionic bond, that is, their capacity to attract electrons participating in the chemical bond. For this reason, ionic bonds are usually formed between metal atoms with low electronegativity and nonmetal atoms with high electronegativity.



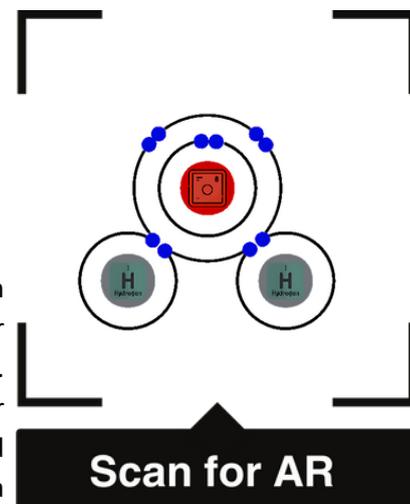
2. Covalent Bond

When there is no significant difference between the electronegativities of two atoms, they can try to reach a stable state by sharing electrons. The chemical bond formed between atoms with close electronegativities and in which electrons are shared is called a covalent bond.

A covalent bond between two atoms of the same type is called an apolar covalent bond. For example, in the hydrogen (H_2) molecule, two hydrogen atoms share their electrons and try to make their electron arrangement similar to helium, a noble gas.

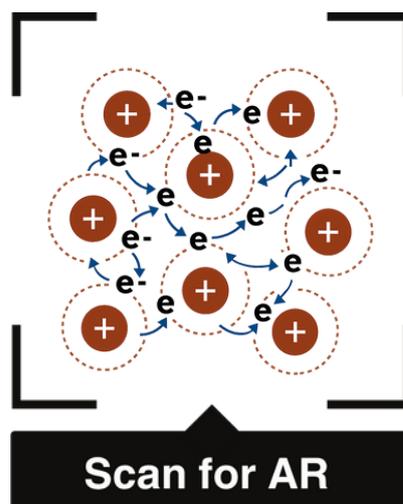
Since the electronegativities of the atoms are the same in an apolar covalent bond, the electrons involved in the bond formation are equally attracted by the atoms. Therefore, the distribution of electrical charges in the molecule is balanced.

A covalent bond between two atoms with a small difference in electronegativity is called a polar covalent bond. For example, in the water molecule, the electronegativity of oxygen is greater than that of hydrogen. Since the bonding electrons shared by hydrogen and oxygen in the water molecule are more attracted by oxygen, oxygen atoms are partially charged with a negative charge and hydrogen atoms are partially charged with a positive charge. Therefore, the water molecule is a polar molecule.



3. Metallic Bond

A metallic bond is a type of bond formed between metal atoms. Due to the low electronegativity of metals, these atoms weakly attract the electrons involved in bond formation. When metal atoms come together, the valence electrons in the highest-energy electron shell are separated from the atoms and move freely in the valence orbitals of neighbouring metal atoms. These free-moving valence electrons form a sea of electrons and, as a result, a metallic bond is formed due to the electrostatic attraction forces between the positively charged metal ions and these free electrons. Properties of metals such as high melting and boiling temperatures, bright colours, malleability, good conductivity of heat and electricity are due to the freely mobile valence electrons.



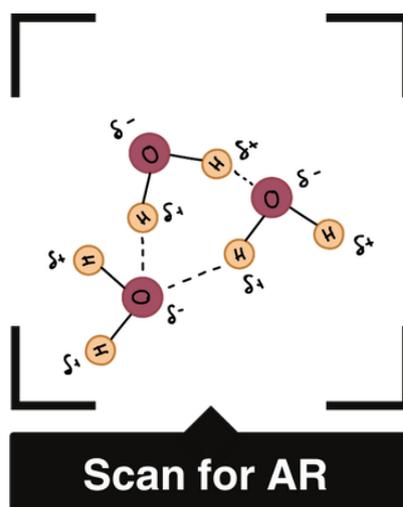
WEAK INTERACTIONS

Weak interactions are interactions between positively and negatively charged molecules. Weak interactions do not involve a bond. Although they are a type of interaction that is not as difficult to break as chemical bonds, we can clearly notice the effect of weak interactions in our environment. We can basically categorize weak interactions under two headings: hydrogen bonding and Van der Waals forces.

1. Hydrogen Bonding

Hydrogen bonding is the strongest type of weak intermolecular interaction. It occurs between molecules formed by hydrogen and elements such as oxygen, nitrogen and fluorine, which are willing to take electrons to stabilize (electronegativity).

When hydrogen forms a covalent bond with an element of high electronegativity, the electrons involved in the bond formation are more attracted to the atoms of the element of high electronegativity. Therefore, the negative charge density is higher on the atom with high electronegativity than on hydrogen. As a result, the atom with high electronegativity is partially charged with a negative charge ($\delta\delta^-$), while hydrogen is partially charged with a positive charge ($\delta\delta^+$). This causes the molecule to be polar. An electrostatic force of attraction arises between the partially plus charged ($\delta\delta^+$) hydrogen atom in the polar molecule and the partially minus charged ($\delta\delta^-$) atom in the neighboring molecule. This interaction is called hydrogen bonding.



Hydrogen bonds play many roles in sustaining life. For example, hydrogen bonds hold two DNA strands together. Hydrogen bonding is at the heart of many interesting and unique properties of water. For example, its high boiling point, its expansion when it freezes, its high heat capacity - that is, the amount of heat required to raise its temperature by 1 oC - are all due to its ability to form hydrogen bonds.

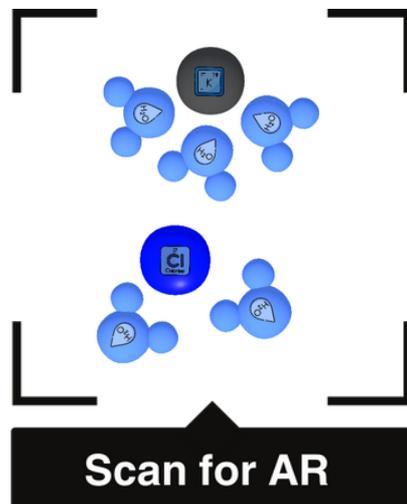
Without hydrogen bonds, water would be a gas instead of a liquid at room temperature. Hydrogen bonding also causes the surface tension of water to be high.

2. Van der Waals Forces

Van der Waals forces make molecules stick together and stay together. These forces are particularly involved in phase changes of substances such as gases and liquids and in the interactions of molecular surfaces. In short, Van der Waals forces are the general name for the attraction and repulsion interactions between molecules and play an important role in understanding the structure and behavior of substances.

There are different types of van der Waals forces:

- Between a polar molecule and another polar molecule (dipole- dipole interactions),
- Between a polar molecule and an apolar, i.e. non-polar molecule (Dipole-Induced Dipole Interactions),
- Between partially negatively and partially positively charged molecules (London forces),



LET'S CONSTRUCT WHAT WE HAVE LEARNED:

In this activity, we will discuss the boiling event that we frequently encounter in daily life at the molecular level and discuss the effect of strong and weak interactions on boiling.

Boiling is the rapid transition from liquid to gaseous state when the vapour pressure of a liquid is equal to atmospheric pressure. Since this event occurs not only on the surface of the liquid, as in evaporation, but all over the liquid, bubbles are observed to form in the liquid during boiling. However, the temperature at which liquids begin to boil under constant pressure, i.e. the boiling point, varies according to the type of liquid. In other words, boiling point is a distinctive feature for liquids. But why? What changes when the type of liquid changes so that the boiling point changes?

To understand this, we need to look closely at liquid molecules.

The boiling point depends on the strength of intermolecular interactions. The stronger the force of attraction between molecules, the higher the boiling point. Therefore, when the type of liquid changes, the boiling point changes because the intermolecular attraction force of the liquid also changes. So what do you think the force of attraction between molecules depends on?

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Answer the following questions according to the table below.

	Type of Weak Interaction (Intermolecular)	Number of Bonds Between Molecules	Boiling Point*
Water (H ₂ O)	Hydrogen Bonding	2	100 °C
Ethyl Alcohol (C ₂ H ₅ OH)	Hydrogen Bonding	1	78.37°C
Methyl Alcohol (CH ₃ OH)	Hydrogen Bonding	1	64.7°C

*Under normal conditions (sea level, 1 atm pressure)

When we compare ethyl alcohol and water, it is seen that there are hydrogen bonds between the molecules of both compounds. What do you think is the reason why the boiling points of ethyl alcohol and water are different?

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What do you think is the reason why the boiling points of ethyl alcohol and methyl alcohol are different?

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A student analysed the table above and made the following argument:

“The type of weak interaction between methyl alcohol molecules and ethyl alcohol molecules is the same. Both chemicals have hydrogen bonds between molecules. The number of bonds between methyl alcohol molecules and the number of bonds between ethyl alcohol molecules is the same. However, the boiling points of these two chemicals are different. This is because the number of intramolecular bonds forming these chemicals is different.

In both ethyl alcohol and methyl alcohol, the atoms in the molecule are connected to each other by covalent bonds. However, when the formulas of the compounds are examined, it is seen that the number of atoms forming the molecule is different. This shows that the number of bonds in the molecule is different. Since the number of bonds (thus the amount of strong interaction) is high in molecules with a high number of atoms, the boiling point is high.”

This argument is known to be false. Determine why this argument is wrong.

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Since this argument is known to be false, what do you think is the reason for the difference between the boiling points of ethyl alcohol and methyl alcohol?

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UNIT 10:

Acids and Bases

In this activity, you will learn about acids and bases and the concept of pH, which we encounter in many places in our daily lives.

Learning Outcomes:

- Expresses the general properties of acids and bases
- Gives examples of acids and bases from daily life.
- Makes inferences about the acidity and alkalinity of substances by using pH values.

Introduction

An interesting discovery: Hydrothermal vents

Hydrothermal vents were discovered by chance in 1977 by a group of scientists from the United States during a seafloor survey off the Galápagos Islands in the Pacific Ocean. Their main objective was to study the joints of tectonic plates on the seafloor. But during the dive, they unexpectedly discovered streams of warm, mineral-rich water emerging from the seafloor at a depth of 2,500 meters.

Ocean water, heated by magma seeping through crevices in the ocean floor, carries metal ions and other minerals from the magma to the ocean floor. The accumulation of these minerals over time forms hydrothermal vents. With the effect of hot water rising from the magma, the temperature can reach 350-400°C inside the chimney and 100°C at the mouth of the chimney. Generally, black or white colored smoke is observed from the chimneys. While black smoke contains high amounts of sulfur minerals, white smoke contains light colored minerals such as barium, calcium and silicon. This makes the ambient conditions very challenging for life, both in terms of temperature and acidity.

However, contrary to expectations, many species have been observed that have adapted to these harsh conditions. Some of them are even known to be endemic, meaning that they can only survive in the region where hydrothermal vents are located on Earth. It may seem strange that we would choose to live in such a harsh place when there are so many other places on Earth where conditions are more favorable. But who knows: maybe our living conditions are similarly challenging for those creatures. For example, if any of you are interested in flowers, you will know that some flowers do not grow in all soils, they need their own special soil. As in the case of hydrothermal vents, in our flower growing example, acidity-basicity is an important parameter for vital activities. So let's take a closer look at acids and bases, which are vital for life:

What are Acids and Bases?

The concepts of acids, bases and pH are very important in our understanding of chemical substances. Acids and bases have been defined in different ways throughout history. Acids are usually known for their sour taste, while bases are known for their bitter taste. Also, acids turn litmus paper red, while bases turn it blue. However, since tasting every chemical can be dangerous, it is necessary to use safer and more detailed methods of analysis to determine whether a substance is acidic or basic. If you look at science books, you will see that there are different definitions of acid and base. One of the most common is the Arrhenius acid-base definition developed by the Swedish scientist Svante Arrhenius.

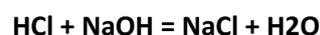
According to this definition, substances that give off hydrogen ions (H⁺) when dissociated are acids and substances that give off hydroxyl ions (OH⁻) are bases. Although this definition is still used, it may be insufficient in some cases. Because according to this definition, for a substance to be acidic, it must have hydrogen in its structure, and for it to be basic, it must have a hydroxyl group. However, there are substances that do not contain OH⁻ in their structure but still exhibit basic properties. One of the best examples is NH₃. The compound NH₃ (ammonia) has basic properties even though it does not contain OH⁻ ions. Another definition of acids and bases is the Brønsted-Lowry Definition. This definition is based on an acid-base reaction theory created independently by Johannes Nicolaus Brønsted and Thomas Martin Lowry. According to this theory, substances that give (H⁺) ions when they dissociate are acids and those that can receive them are bases. Acids give hydrogen ions (H⁺) and turn into their own base. Bases, on the other hand, take hydrogen ions (H⁺) and turn into their own acid.

Although water is actually neutral, it is known that it can show acidic or basic properties depending on whether the substance it interacts with is acid or base. When water interacts with acid, it shows base; when it interacts with base, it shows acidic properties. Because of this property, water is defined as an amphoteric substance. While Arrhenius definition is insufficient to explain these amphoteric substances, Brønsted-Lowry definition can explain these substances.

The Place of Acids and Bases in Our Lives

When we think of acids and bases, many people think of the dangerous chemicals they learned about in science class, stored in locked cabinets in the laboratory. Especially acids may evoke danger for many people. However, acids and bases are found in many places in our daily lives. Examples of acids in our daily lives are citric acid, which is found in oranges, lemons, vinegar and many foodstuffs. As you can see, they all fit Arrhenius' definition of acid. Base rise is mostly found in cleaning products. Soaps, bleach, toothpaste, washing soda (sodium bicarbonate) are base materials that we frequently use in daily life.

Another reflection of acids and bases in our daily lives is salts. Salts are formed when acids and bases combine and neutralize each other. Therefore, in laboratories, if you get splashed with acid during an experiment, it is recommended that you wash it off first with plenty of water and then with plenty of soap.



For example, we use toothpaste, which is a base, to prevent the acids in the food we eat from damaging our teeth. But in toothpaste we do not use the very strong bases used in laboratories, which have an irritating effect. Therefore, it is not enough to classify substances as acids and bases.

Analytical methods are needed to determine the strength of acids and bases. At this point, we come across the concept of "pH" or "power of hydrogen". Let's take a closer look at the concept of pH.

The concept of pH

The pH concept is a measure of the acidity or basicity of a substance. The pH scale gives us clear information to determine whether a substance is acidic or basic. According to this scale, if the pH value is less than 7, the substance is acidic; if it is greater than 7, it is basic; and if it is 7, it is neutral.

The pH value of a substance directly depends on the ratio of hydrogen ion [H⁺] and hydroxyl ion [OH⁻] concentrations. If the concentration of H⁺ is higher than the concentration of OH⁻, our substance is acidic; that is, the pH value is lower than 7. If the concentration of OH⁻ is higher than the concentration of H⁺, our substance is basic; that is, the pH value is greater than 7. If equal amounts of OH⁻ and H⁺ ions are present, the substance is neutral with a pH of 7.

For example, pure water (pH=7) is an example of a neutral substance. As the pH value approaches 0, the substance becomes more acidic and as it approaches 14, it becomes more basic.

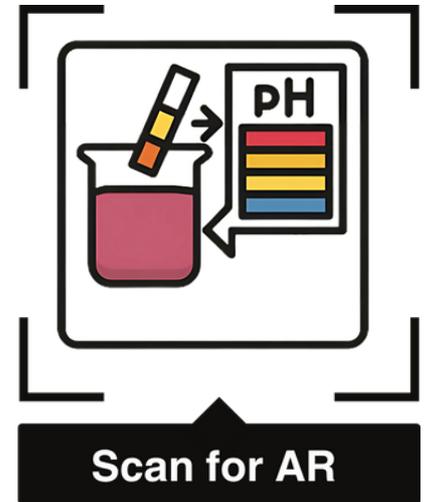
CAUTION: Strong bases with high pH can be as dangerous as strong acids. For this reason, it is very important to know the pH of the chemical to be used.

LEARNING ACTIVITY:

In this activity, you are asked to decide whether the chemicals in the augmented reality environment are acids or bases, and then rank them according to their pH degrees from weak to strong. You can use the "pH indicator chart" to decide the pH degree.

Why do you think different indicators are needed when determining pH?

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How did you choose the indicator during the activity?

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Briefly explain the concept and importance of pH in the light of what you have learned in this unit.

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UNIT 11:

Vapor Pressure

In this activity you will learn about vapor pressure and the factors affecting vapor pressure.

Learning Outcomes:

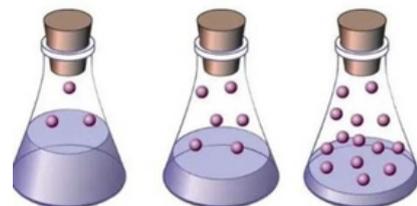
- Defines vapour pressure.
- Explains what the vapour pressure changes depending on what.

Introduction

Steam engines played a critical role in the industrial revolution in the 18th century, radically transforming industrial and economic development. First developed by Thomas Newcomen in 1712, the steam engine was used to pump water from mines. This machine had a design in which low-pressure steam provided the piston motion. Later, in 1765, James Watt's innovations optimized energy use by increasing the efficiency of steam engines. Thanks to these machines, industrial production accelerated, labor costs fell and transportation networks expanded. These developments played a fundamental role in the formation of modern industrial society, laying the foundations of today's technological and economic structure. Today, the power of steam is still utilized in thermal and geothermal power plants and in various fields of industry and manufacturing. So let's take a closer look at evaporation and vapor pressure.

Evaporation and Vapor Pressure

When the molecules on the surface of a liquid have enough energy, they are freed from the attraction of other liquid molecules and turn into gas. As you know, evaporation occurs at any temperature. The pressure created by these molecules that become gaseous as a result of vaporization in a closed container or system is called "vapor pressure".

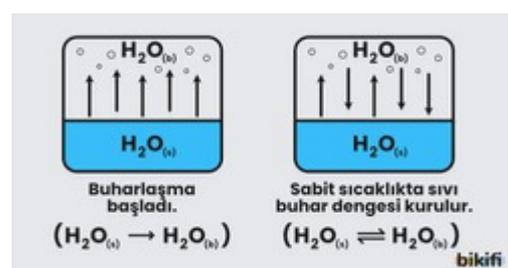


Let's design an experimental setup to better understand vapor pressure.

LEARNING ACTIVITY:

Imagine that you have a closed container and you empty all the air out of the container and fill it with some water. Imagine that you heat the liquid in the container a little and keep it at a constant temperature.

The liquid in the closed container, which is not full, will evaporate over time, filling the empty volume of the container with its own vapor. After a while, the container will become saturated with gaseous liquid molecules. Some of the gas molecules that lose their energy in this process will condense and return to the liquid state. At the beginning, the rate of evaporation is higher than the rate of condensation, but over time the rates of these two



will equalize and an equilibrium situation will occur. The vapor pressure at the moment when the evaporation-condensation equilibrium occurs at constant temperature is called "equilibrium vapor pressure". In equilibrium, there is no change in the liquid level and the number of vapor particles in the container.

What do you think are the factors affecting the equilibrium vapor pressure?

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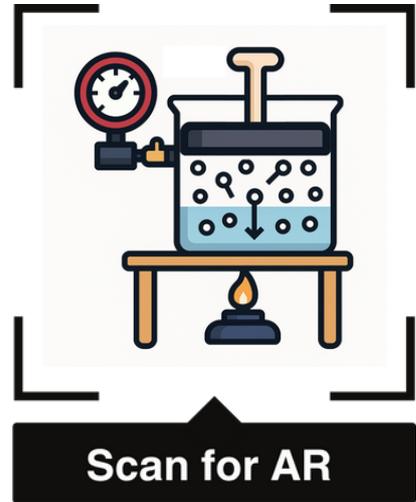
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Scan for AR

Scan the QR code on the side to test the variables whose effect on the vapor pressure you want to measure.

Dependent Variable (Variable whose effect is measured)	Independent Variable (Observation)	Relationship of the variable with vapor pressure
Atmospheric pressure		
Liquid type		
Impurity		
Temperature		

At 25 °C, examine the vapor pressure of water, alcohol and salt water. Which of these liquids would you expect to boil first? Explain your opinion.

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Evaluate the validity of the following claim based on the data you obtained as a result of the activity.

"Boiling and vapor pressure are closely related. Boiling occurs at the temperature at which the vapor pressure of a liquid becomes equal to the atmospheric pressure of its environment. Therefore, the vapor pressure of a liquid varies depending on the atmospheric pressure."

I think this claim is true/false. Because

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UNIT 12

Physical and Chemical Change

In this activity, you will discuss physical and chemical change at the microscopic level.

Learning Outcomes:

- Defines physical and chemical change.
- Explains the differences between physical and chemical change by observing various events.

Introduction

Physical and chemical change are two fundamental concepts that we use to make sense of events in our environment and that profoundly affect our interactions with the world. Physical and chemical changes are involved in the processing of many raw materials into products. Therefore, observing how physical and chemical changes occur in everyday life plays a major role in understanding the behavior and interactions of substances and shaping the products that will be formed by managing the way these processes occur. This understanding helps us to live a more comfortable, more conscious and sustainable life.

Let's take a closer look at physical and chemical changes:

Physical Change

Changes that occur only in the external appearance of matter without changing its internal structure are called physical changes. In other words, when a substance undergoes physical change, **the identity of that substance does not change**. The substance is still the same substance. New substances (new molecules or particles) are not formed as a result of physical changes; only the properties of the substance such as color, shape, size and distance between particles change. In some physical changes, a substance can change back to its original state. State changes, dissolution (such as dissolution of sugar or salt in water), glass breaking, paper tearing, wood turning into sawdust are examples of physical changes.



Chemical Change

Changes in the internal structure of matter are called chemical changes. **The identity of the substance changes as a result of chemical change**. Therefore, the substance undergoing chemical change cannot be recycled. The new substance has its own unique properties. During this transformation, events such as color change, gas release, heat or light emission are observed. Events such as combustion, decay, rusting, fermentation can be given as examples of chemical change.



But what exactly happens during physical and chemical change? What exactly is meant by change in the internal structure of matter? Let's consider this with an example.

LEARNING ACTIVITY:

Those of you with a sweet tooth know that sugar is melted into caramel. When heated, the sugar first becomes liquid, then changes color, darkens and turns into caramel.

Let's heat sugar in an augmented reality environment and observe how its particles behave when heated.

How do the particles of melting sugar behave when heated?

What happens if we continue to heat the melting sugar?

Write down your observations.

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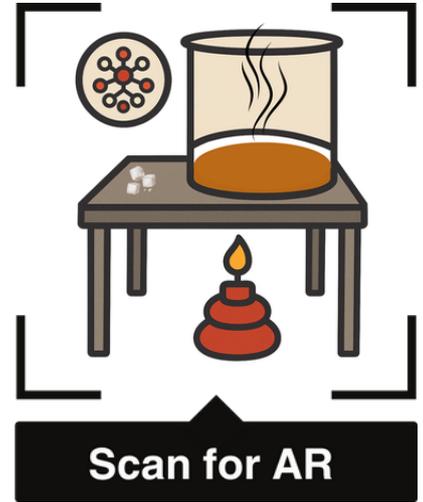
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Do you think melting sugar and then turning it into caramel is a physical change or a chemical change? Write your predictions.

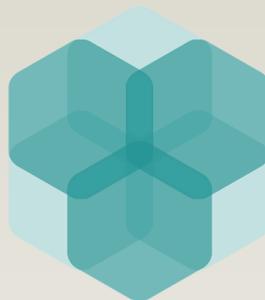
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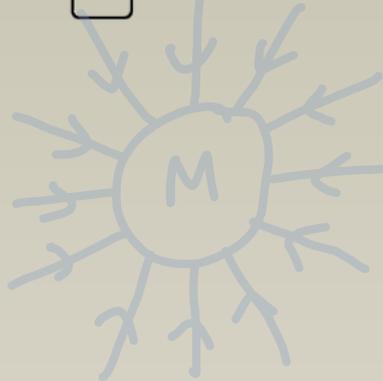
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Consortium



innovation hive





$$\Delta\varphi = \frac{-W}{m} = \frac{-1}{m} \int_{r_1}^{r_2} F \cdot dr$$

$$g = \frac{F}{m}$$

$$g = -\frac{GM}{|r|^2} \hat{r} - (|w|^2 |r| \sin\phi) \hat{a}$$

ϕ zenith angle relative

$$U = \frac{-W_{or}}{m} = -\frac{1}{m} \int_{\infty}^r F \cdot dr = -\int_{\infty}^r g \cdot dr$$

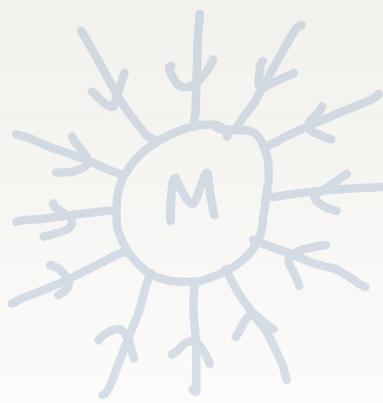
$$\Phi_{\Omega} = \int_S \Omega \cdot dA \quad g = -\nabla U$$

Point mass
 $M = Gm$

$$g = \frac{Gm}{|r|^2} \hat{r}$$

$$V = \sqrt{\frac{2Gm}{r}}$$

$$\Phi_G = \int_S g \cdot dA$$



$$\Delta\varphi = \frac{-W}{m} = \frac{-1}{m} \int_{r_1}^{r_2} F \cdot dr$$

$$g = -\frac{GM}{|r|^2} \hat{r} - (|w|^2 |r| \sin\phi) \hat{a}$$

ϕ zenith angle relative

