ANF STEAM Curriculum

This curriculum is created by Speros Perakis, Alison Collard de Beaufort, Nathan Hyde, and Emily Minch for the Angels-Net Foundation afterschool teachers and volunteers.

It is part of the "Enhancing Angels-Net Foundation's STEAM Program and Visibility" Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science.

To view the full project: https://wp.wpi.edu/southafrica/projects/2020-projects/anf/

Introduction

These slides are to be used by the volunteer or ANF staff member when conducting the STEAM activities during the ANF after-school program. These slides should be shown to the students prior to completing the activities. Volunteers are welcome to make a copy, revise, and/or add to the slides if they so wish to. This document is a companion to the "ANF STEAM Curriculum Instructor's Guidebook" and should be used simultaneously.

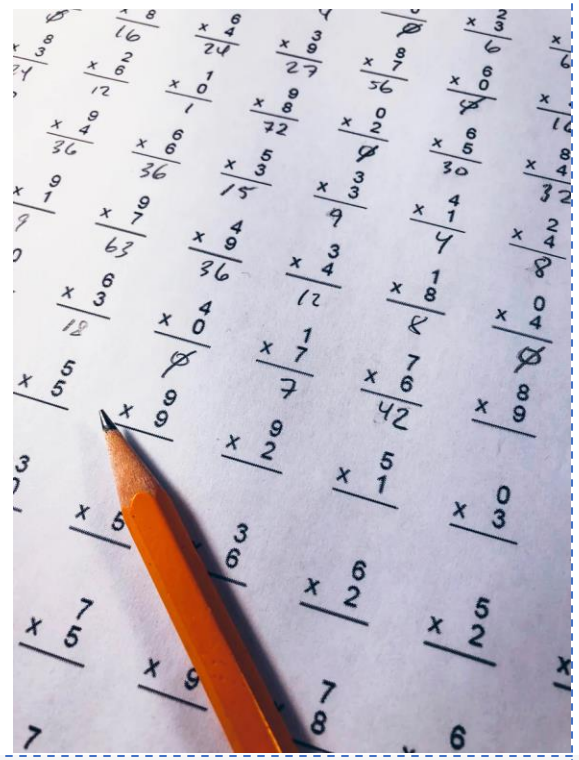
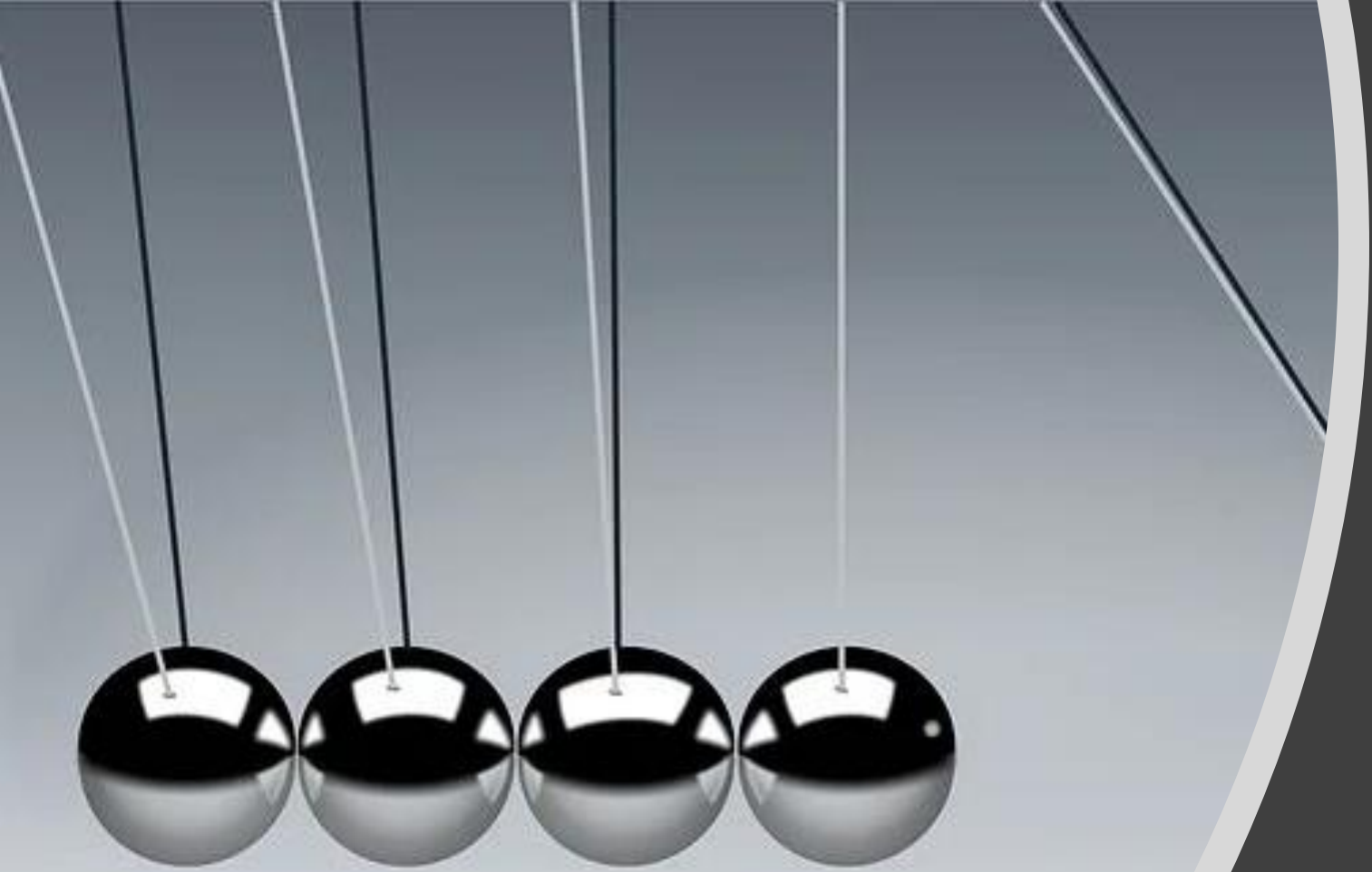


Table Contents



Physics

Physics Table of Contents

Lego Car

Intro Question

Have you ever built a Lego set before?

Steps to Follow as You Are Building

- Follow instructions
- Organization
- Plan Ahead

Following Instructions

- In the scientific world it is important to follow instructions in detail so that you can repeat the same procedure as before.
- If instructions are not followed than the result will be different, and in this case the car may not work.

Organization

- When building Legos...
  - It is important to keep the pieces organized.
  - Make sure you have a flat large surface to work on so that you don’t lose pieces.
  - Keep the pieces separate from other Legos you may have to prevent the mixing of kits.

Plan Ahead

- It also useful to plan ahead when building Legos
  - Knowing where the next pieces are going might help you understand how to construct it
  - Knowing what the Lego set should look like ahead of time might also help you make sure you are building it correctly

Lego Car Ramp

Kinematics

VELOCITY

ACCELERATION

LAW OF CONSERVATION OF ENERGY

Velocity

- Velocity is the speed at which an object travels in a certain direction.
- Average velocity is defined by this equation

$$V_{avg} = \frac{d}{t}$$

Acceleration

- Acceleration is the change in velocity.
- Average acceleration is defined by this equation

$$a = \frac{\Delta v}{t}$$

- Gravity is a common source of acceleration and its standard value is 9.81 m/s^2.
- Gravity is always pulling objects closer to the surface.

Law of Conservation of Energy

- The Law of Conservation of Energy states that no energy can be created or destroyed but may be changed from one form to another.

Potential vs Kinetic Energy

- In this activity, the types of energy involved are potential and kinetic energy.
- As the car starts at the top of the ramp it has all potential energy and no kinetic energy.
- As it slides down the ramp the potential energy then converts to kinetic energy.

Let's Get Rolling!

Bonus Material

Adding a t-shirt on the ramp, explore the concept of friction.

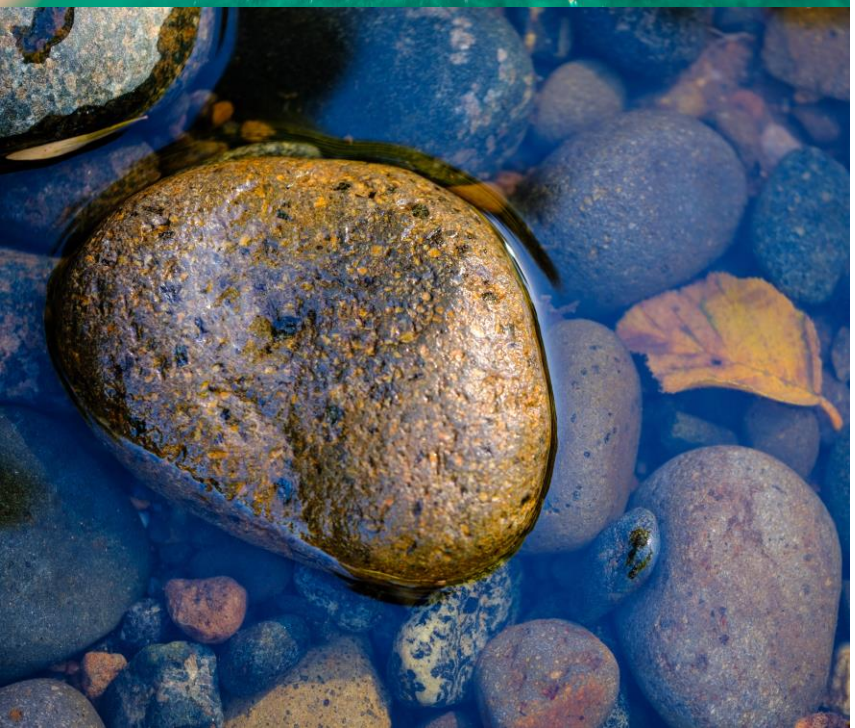
Friction

- Friction is the resistance of motion from one object moving relative to another.

BUOYANCY TESTS

INTRO QUESTION

Have you heard of the Salt Sea?



WHAT IS BUOYANCY?

- The ability or tendency to float in water, air or another fluid.
- But why do some objects float while others sink?

MASS & WEIGHT

Mass

- Mass is a measure of the quantity of matter contained in an object.
- It is a property of matter and does not change.

Weight

- *Everyday definition:* a measure of how heavy a person or object is
- *Scientific definition:* the force exerted on an object due to the acceleration of gravity

$$W = mg$$

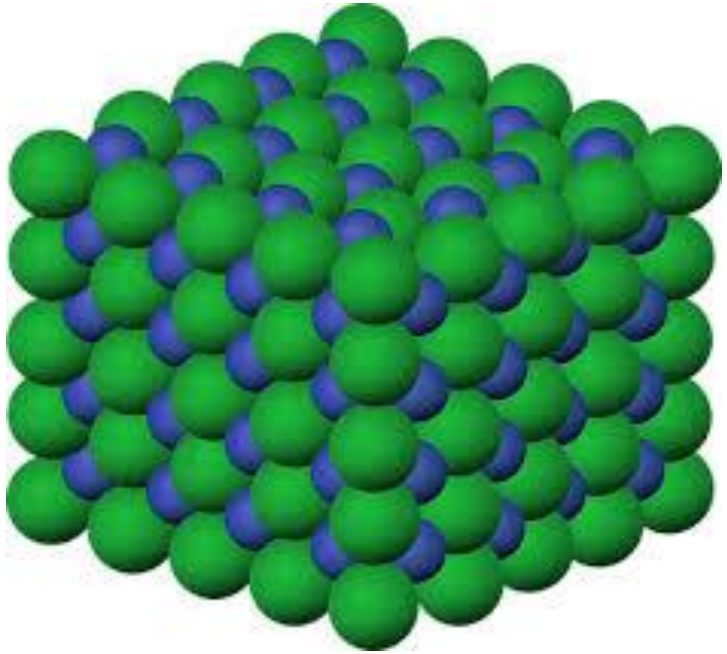
Weight of object = mass of object x acceleration of gravity

Mass vs Weight

- The same mass can have a different weight depending on the acceleration.
  - For example, a person has the same mass on the Earth and on Mars, yet weighs only about one-third as much on Mars.

DENSITY

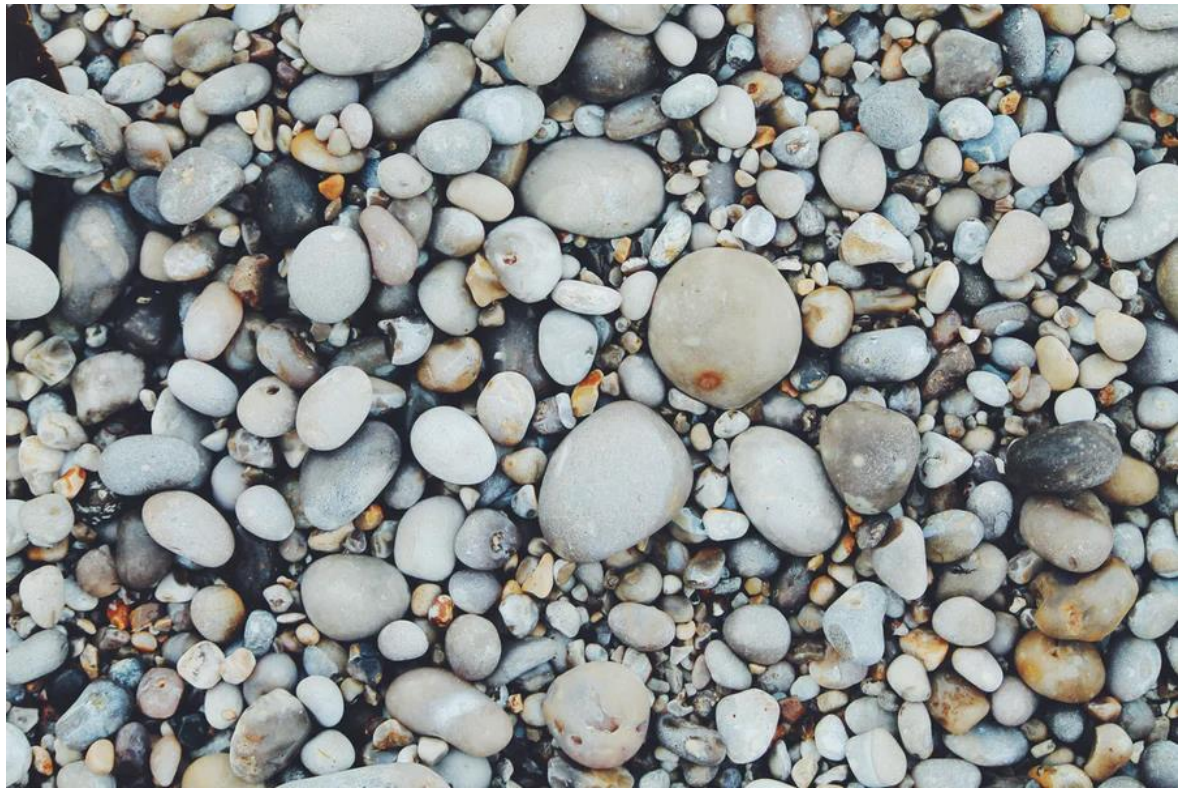
- **Density** is how tightly packed the mass is in an object
    - It is the number of kilograms that each meter cubed of the material weighs.



DENSITY VS WEIGHT

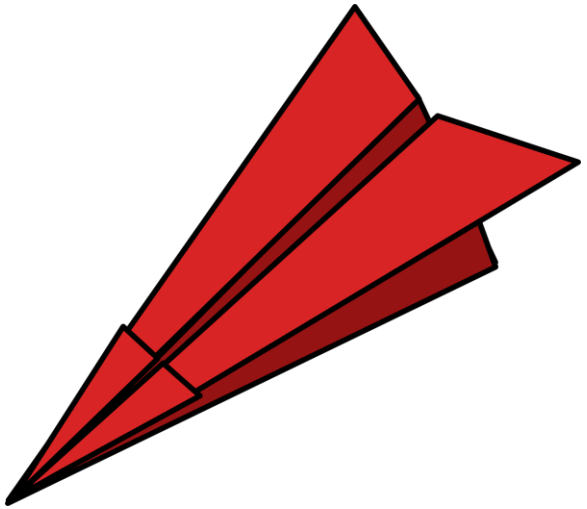
	Density	Weight
Definition	A measure of the amount of matter available in a unit volume.	The amount of matter in an object.
Unit	Kilogram/cubic meter	Newton
Effect of Gravity	No relation to gravity	Directly affected by gravity

- The ***key difference*** between density and weight is that weight is a measure of the amount of *matter* in an object, whereas density measures the amount of matter in a unit *volume*.



ACTIVITY 1 – PLASTIC CUP

ACTIVITY 2 - EGGS



Paper Airplanes!

Welcome!

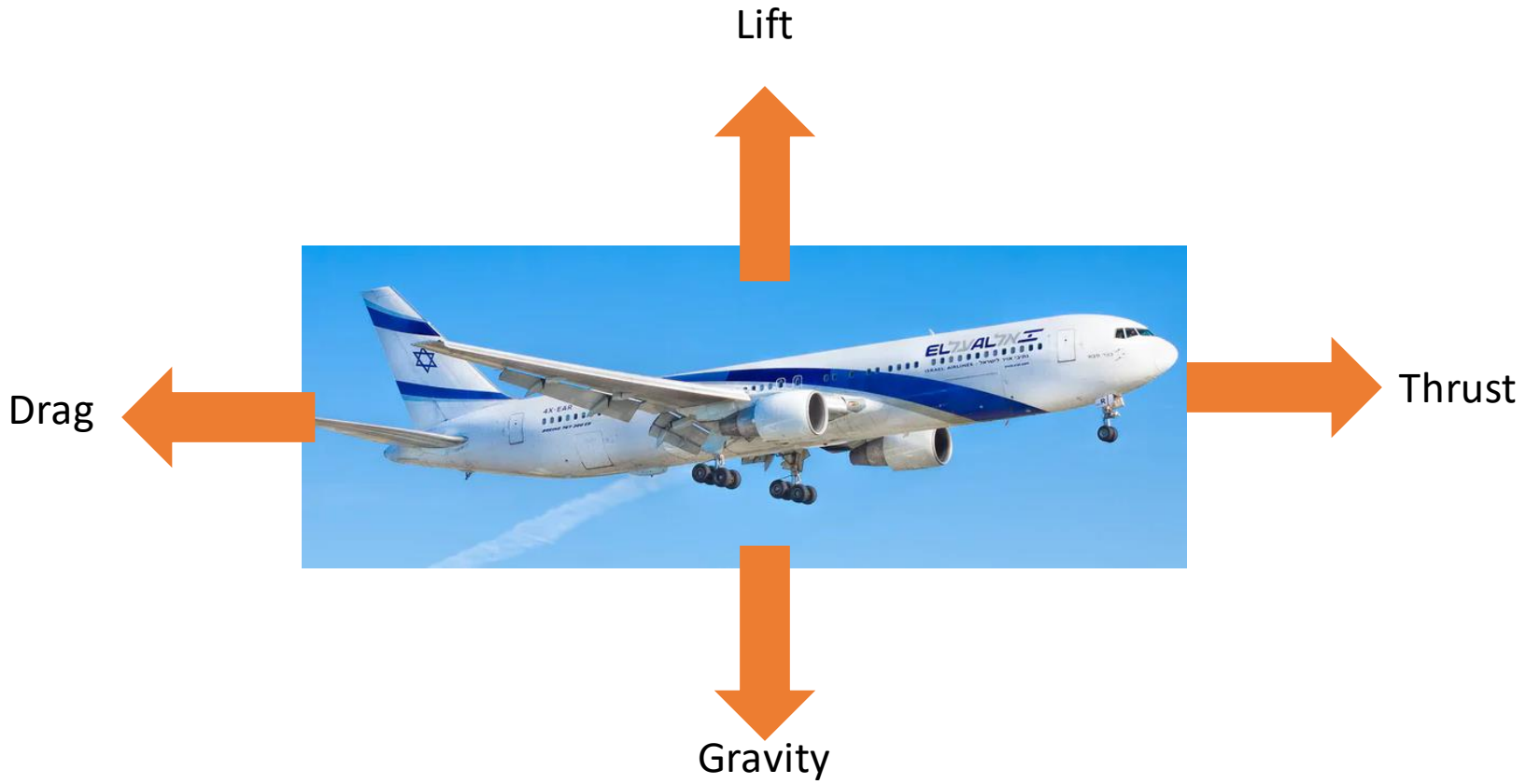
Intro Questions:

1. Have you ever built a paper airplane?
2. What do you think makes airplanes fly?

Aerodynamics

Forces:

- Gravity
- Drag
- Thrust
- Lift

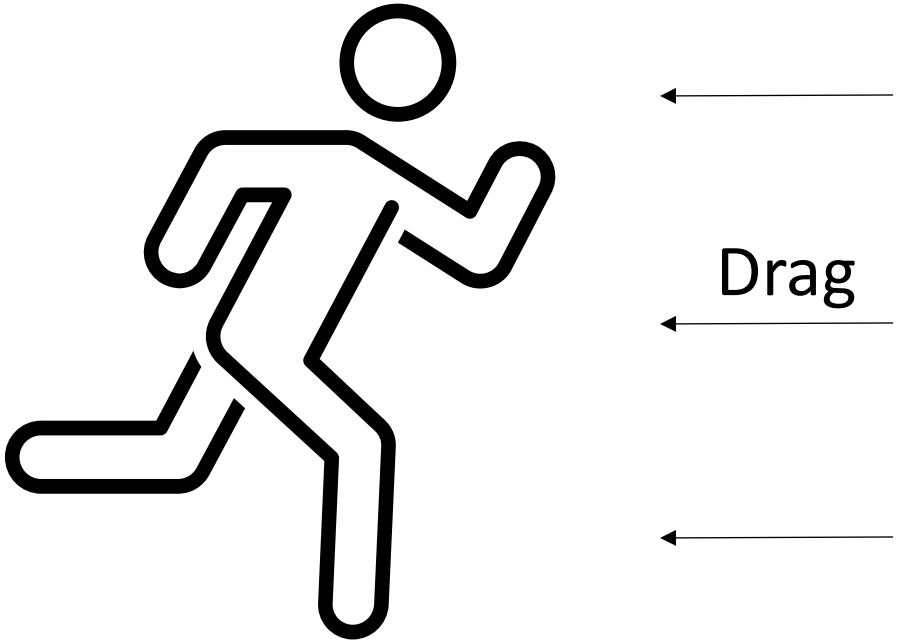


Gravity

- Gravity will act on the paper airplane by pulling it down.
- In order to combat this, the paper airplane must be as light as possible
  - When you add more weight to the paper airplane the gravity will pull it down faster.

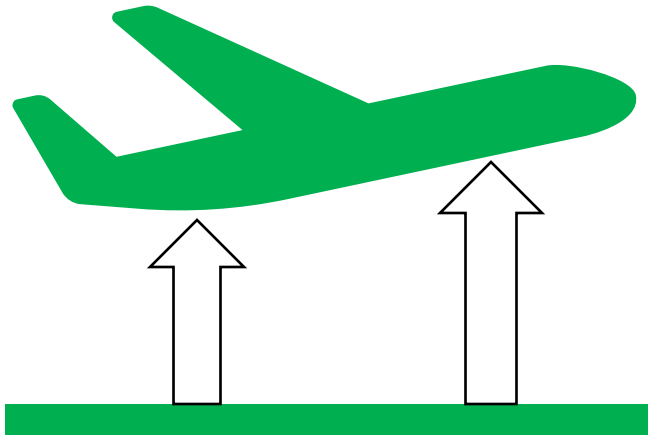
Drag

- Drag is the air resistance that prevents forward motion.
- Try This:
  - Position your hand as if you are reaching out for a handshake and then wave left and right.
  - Then turn your hand horizontal and wave left and right.



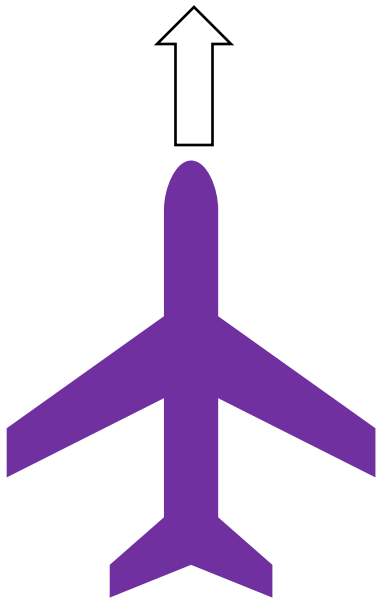
Lift

- Lift is the force that opposes gravitational pull downward and is arguably the most important part of keeping a plane in air.
- Occurs when the air is pushing up harder than the air pushing down.
- Wings harness this force:
  - Curved
  - Large



Thrust

- Thrust is the forward motion generated by a force
  - Throwing Arm
  - Airplane Engines
- Increasing the thrust of the paper airplane will increase its forward motion.



Build Time!

Recyclable Race

Introduction

Have you learned about Newton's Laws of Motion before?

Have you learned about friction before?

If you said yes to either question, can you explain what they mean?

Newton's 1st Law of Motion

- A body at rest will remain at rest, and a body in motion will remain in motion unless acted upon by an external force
- A car will remain at rest until acted upon by the force of an engine.
- A car will remain in motion until acted upon by the force of the brakes and eventually friction.
- How does this law relate to the recyclable racecar and balloon?

Newton's 2nd Law of Motion

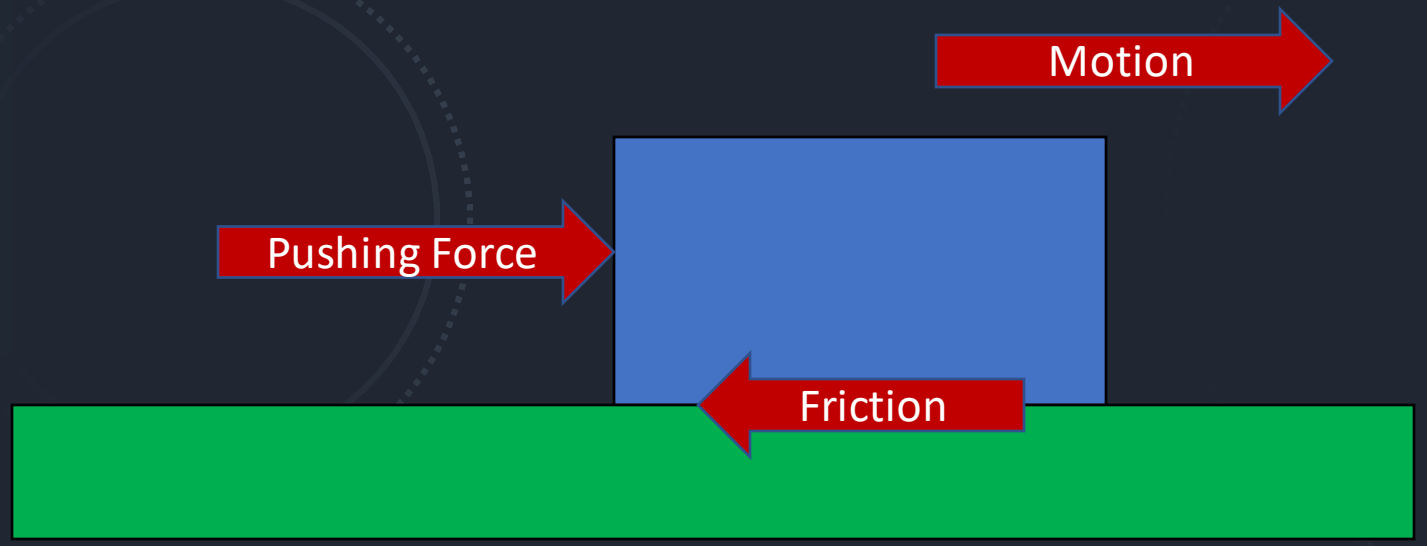
- The force acting on an object is equal to the mass of that object times its acceleration.
- In other words, less force is required to move a lighter object.
- More force is required to move a heavier object.

Newton's 3rd Law of Motion

- For every action, there is an equal and opposite reaction.
- When you swim you apply a force in the direction behind as you are paddling.
- The water provides an equal and opposite force that pushes you forward.
- What part of the recyclable cars relates to this?

Friction

- Friction is the resistance to motion of one object moving relative to another.
- Opposes the motion of an object.



On Your Mark
Get Set
GO!!!

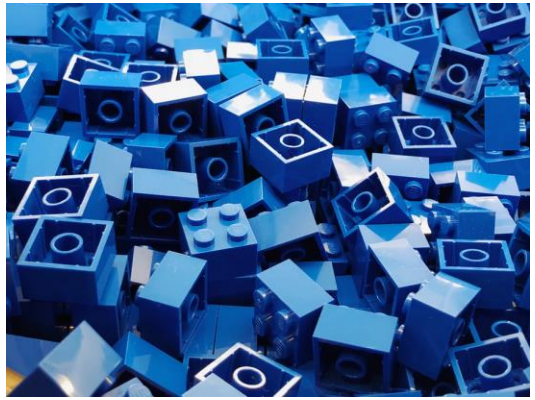
Math

Math Table of Contents

Fractions with LEGOs

Which LEGO is half the size of this LEGO?

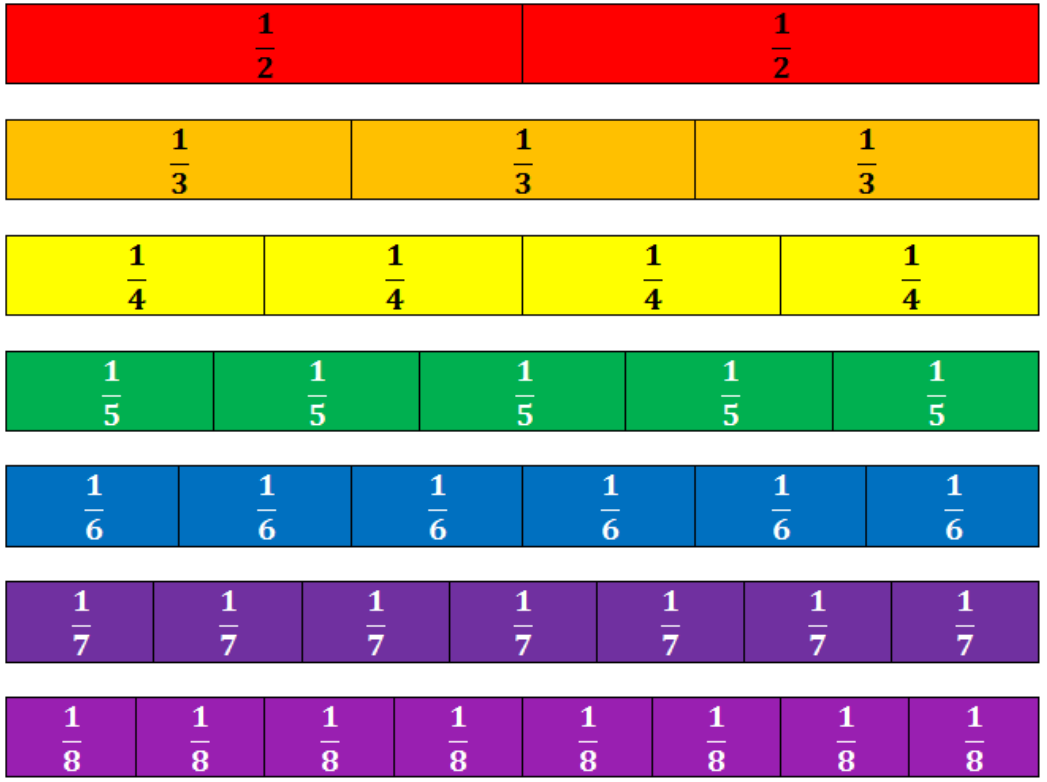
a.)



b.)

c.)

Fractions



- Fractions numbers that are not a whole number.
- Examples: ½, ¼ , 4/3

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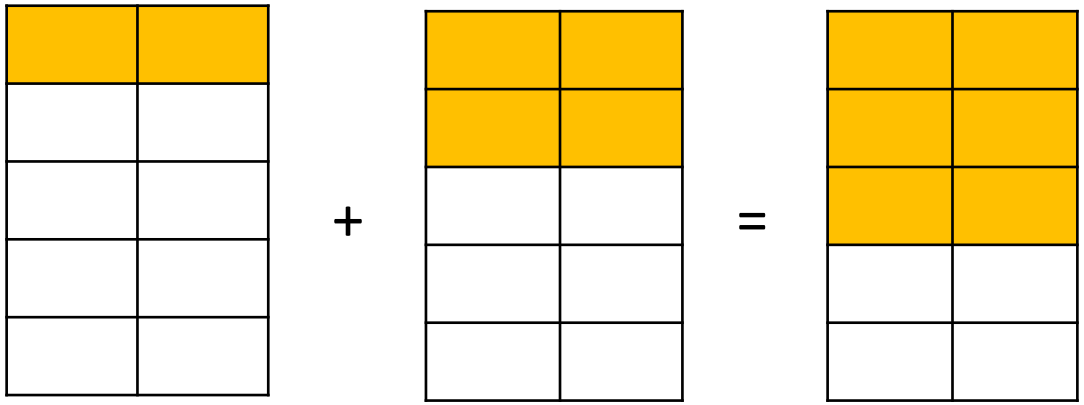
Adding & Subtracting Fractions with Same Bottom Number

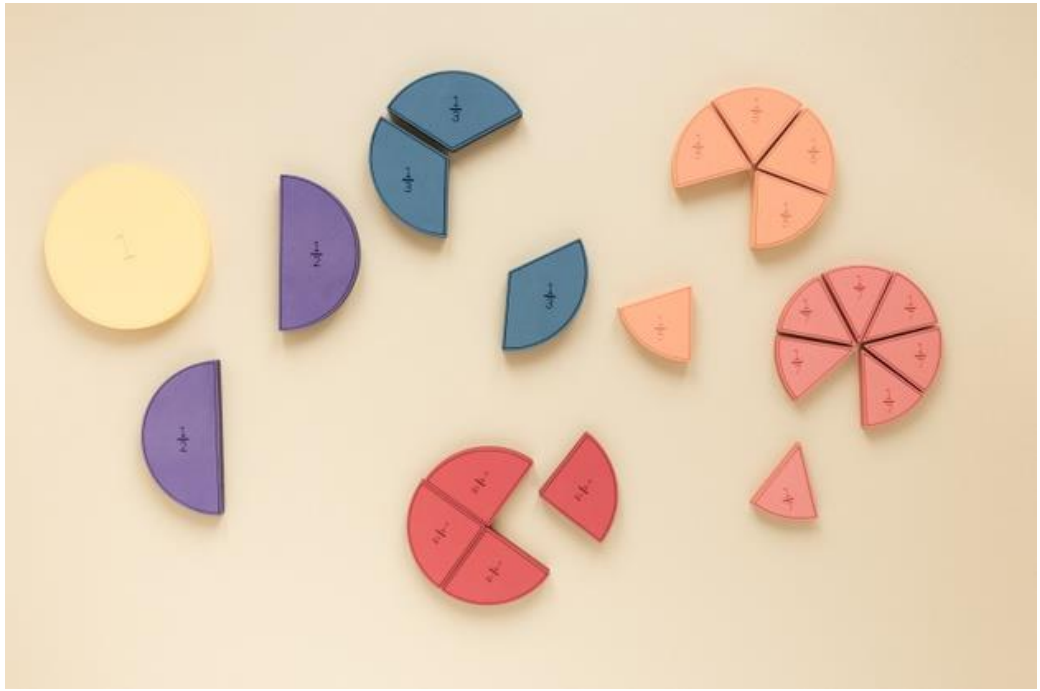


2/10 + 4/10 = 6/10

- Keep the bottom number the same
- Add or subtract the top numbers

Adding & Subtracting Fractions with Different Denominators

- Multiple the opposite fraction by the number in the other fraction's denominator.
- Add or subtract the fractions like normal

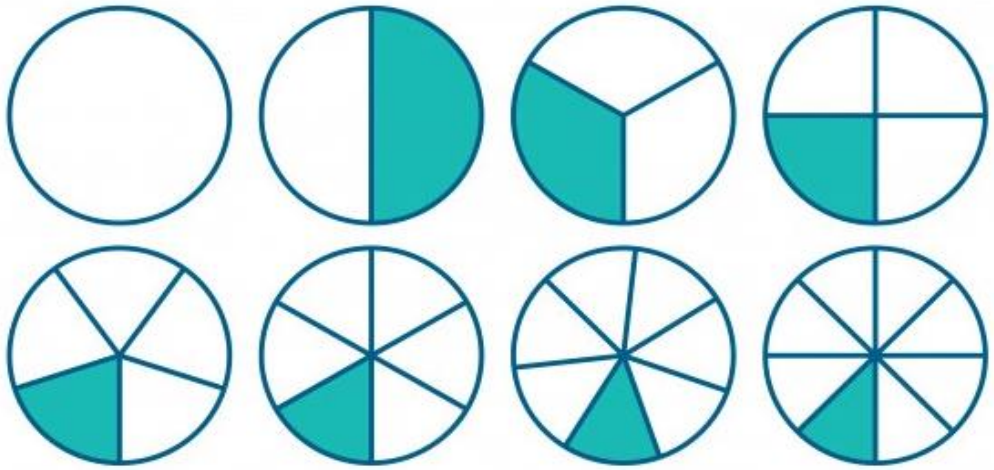


$$\frac{3}{3} \times \frac{7}{9} - \frac{2}{3} \times \frac{9}{9}$$

Multiplying Fractions

- Multiply the numerators and denominators by each other

$$\frac{2}{5} \times \frac{3}{7} = \frac{2 \times 3}{5 \times 7} =$$



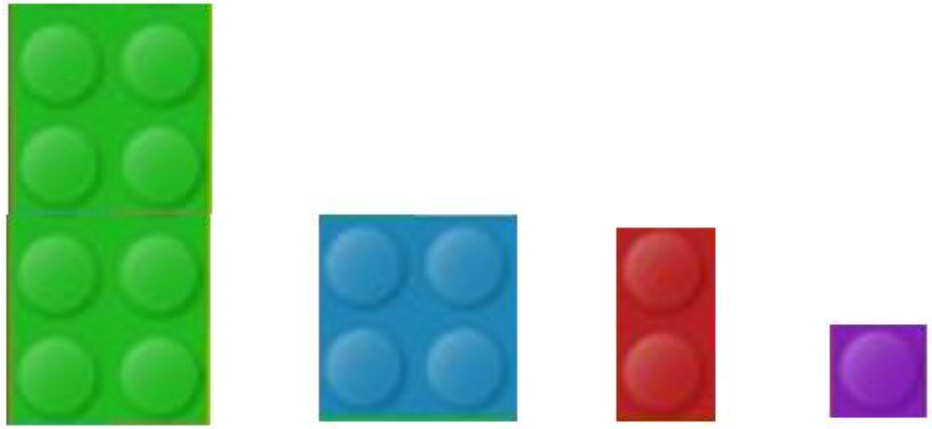
Dividing Fractions

- Flip the second fraction
- Multiply the fractions together

$$\frac{3}{4} \div \frac{1}{8}$$

$$\frac{3}{4} \times \frac{8}{1}$$

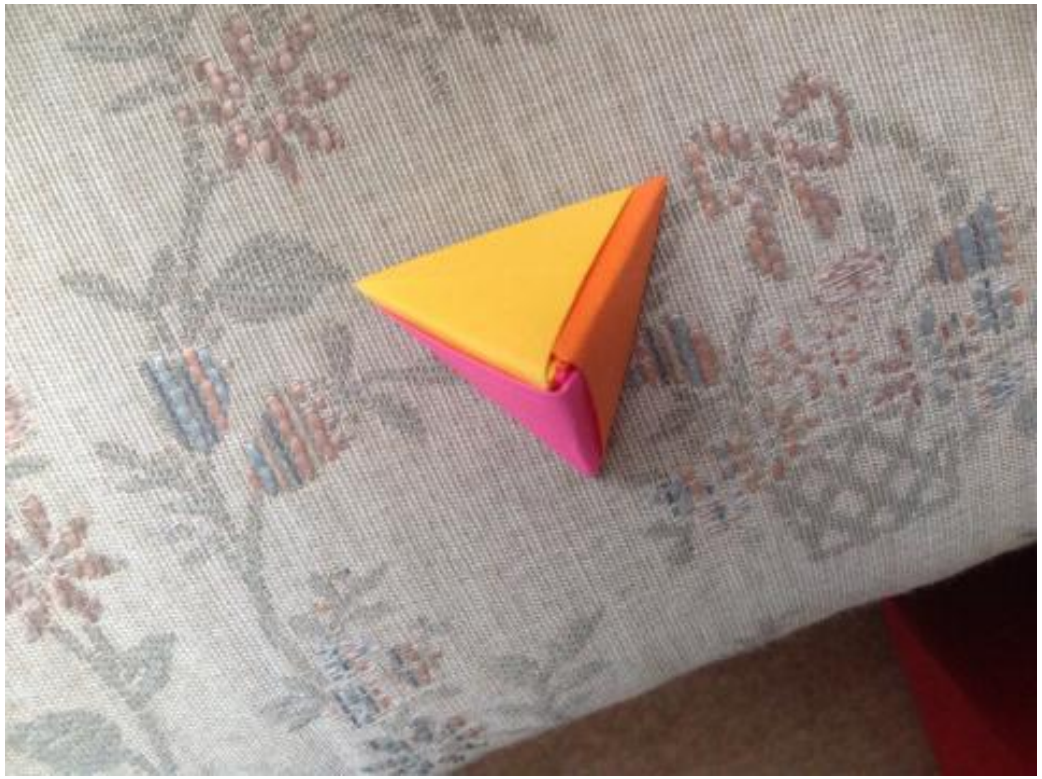
Activity



Answers:

1. 1/1, 2x4 LEGO
2. 6/8, 2x2 & 1x2 LEGOs
3. 3/8, 2x1 & 1x1 LEGOs
4. 9/8, 2x4 & 1x1 LEGOs
5. 1/4 ,2x1LEGO
6. 1/8, 1x1 LEGO
7. 7/8, 2x2 & 2x1 & 1x1 LEGOs
8. 0
9. 1/4 ,2x1LEGO
10. 1/4 ,2x1LEGO
11. 1/8, 1x1 LEGO
12. 1/8, 1x1 LEGO
13. 2/1, 2 of the 2x4 LEGOs
14. 1/2 ,2x2 LEGO
15. 8/4, 2 of the 2x4 LEGOs
16. 1/2 ,2x2 LEGO

Origami Pyramid



Introduction

- Have you ever done origami before?
- Have you ever learned about surface area before?
- Have you ever combined the two?

How Does Origami Relate to Math?

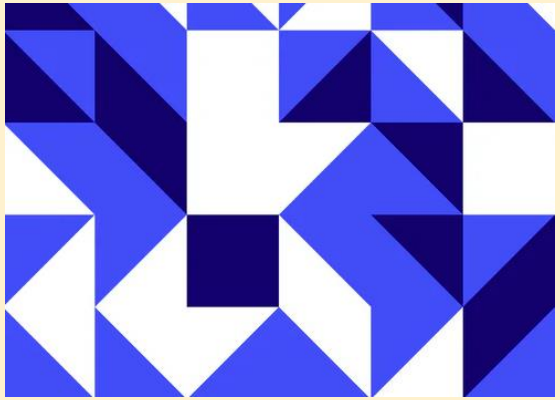
Patterns

Surface Area

Area of Simple Shapes

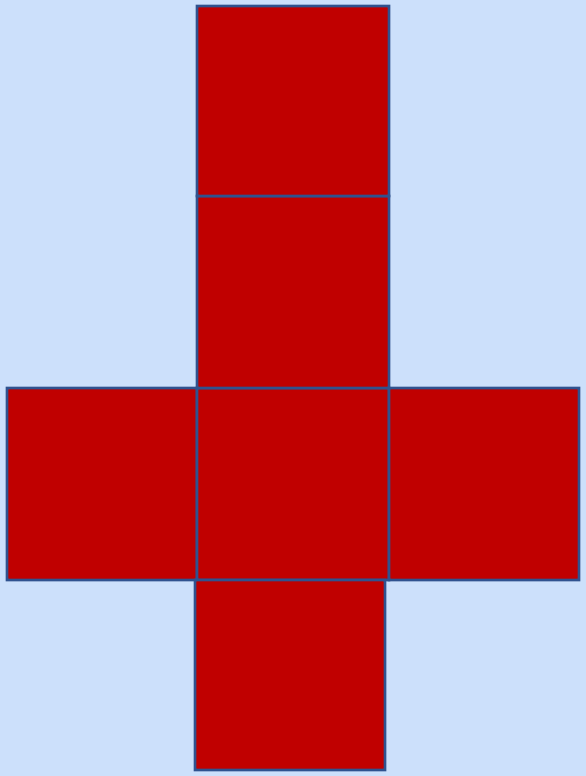
Patterns

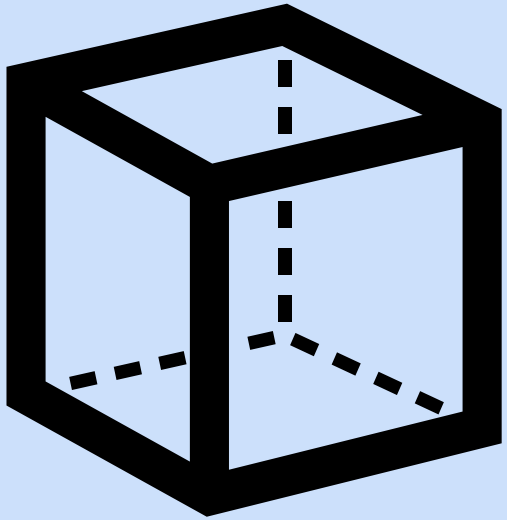
$$1^2 = 1 = 1$$
$$2^2 = 4 = 1 + 3$$
$$3^2 = 9 = 1 + 3 + 5$$
$$4^2 = 16 = 1 + 3 + 5 + 7$$
$$5^2 = 25 = 1 + 3 + 5 + 7 + 9$$
$$6^2 = 36 = 1 + 3 + 5 + 7 + 9 + 11$$



- Patterns occur all throughout math.
  - Can be used to predict the next value or answer
  - Number patterns/sequences

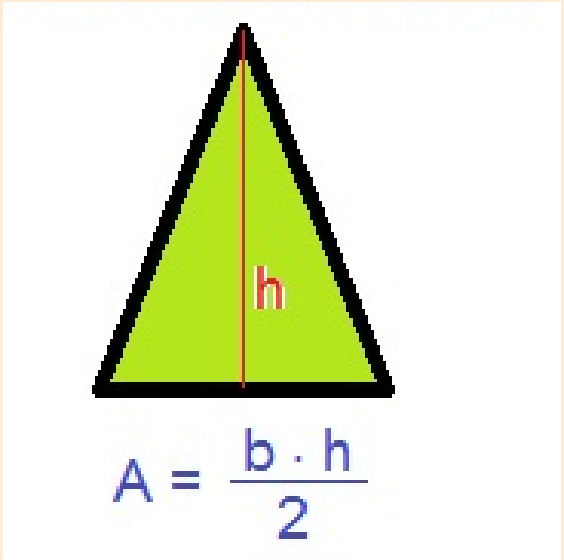
Surface Area

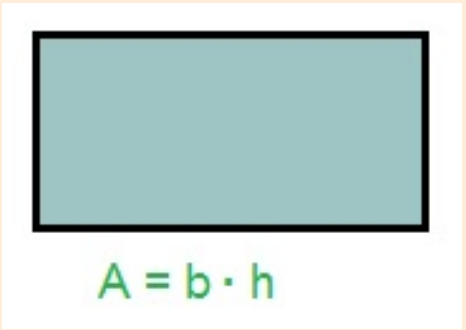


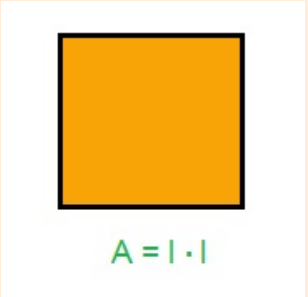


- Surface area is the area of the entire surface of a 3D object.
  - Sometimes it is difficult to calculate.
- Using patterns makes it easier to calculate it

Area of Simple Shapes





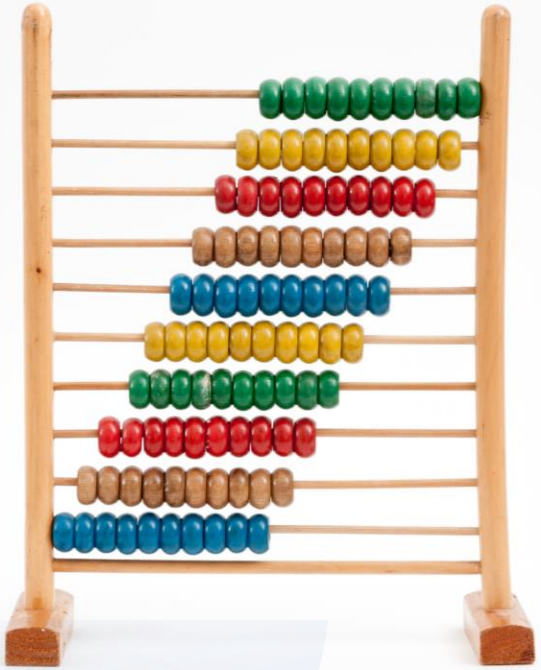


- Square
  - A = b*h
- Triangle
  - A = ½*b*h
- Rectangle
  - A = b*h

Origami Time!

Follow the instructions on your worksheet to make an origami pyramid!

Math with Skittles



Introduction

- Who likes Skittles?
- Who knows what Probability, Percent, or Variables are?

Probability

- Probability uses numbers to determine how likely something is to happen.
- When you flip a count there is a ½ chance that it will be heads or tails.

Percent

- A percent is a fraction expressed out of 100.
- For example:
  - ½ = 0.5
  - 0.5 x 100 = 50
  - ½ = 50%

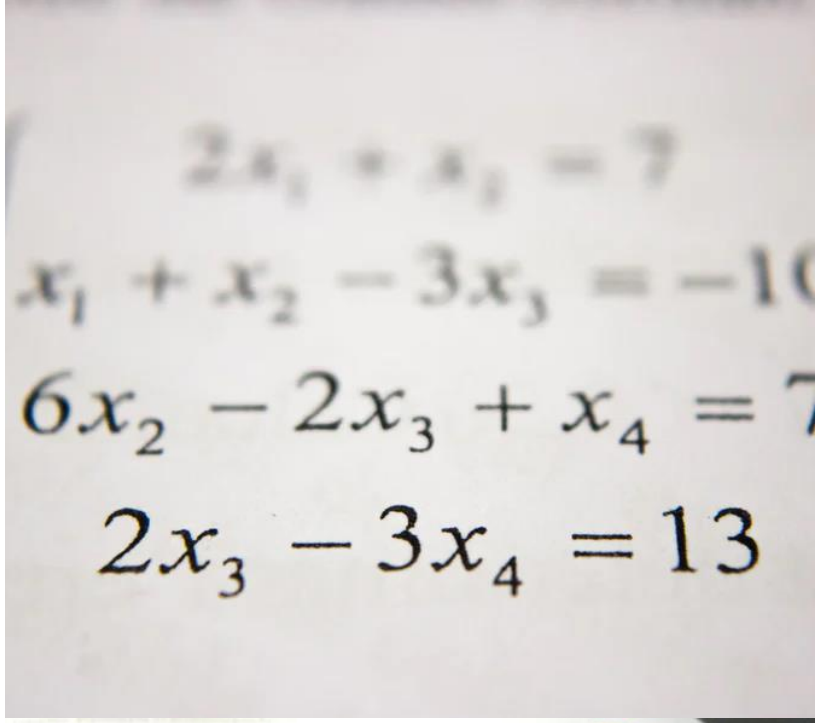
Math Signs

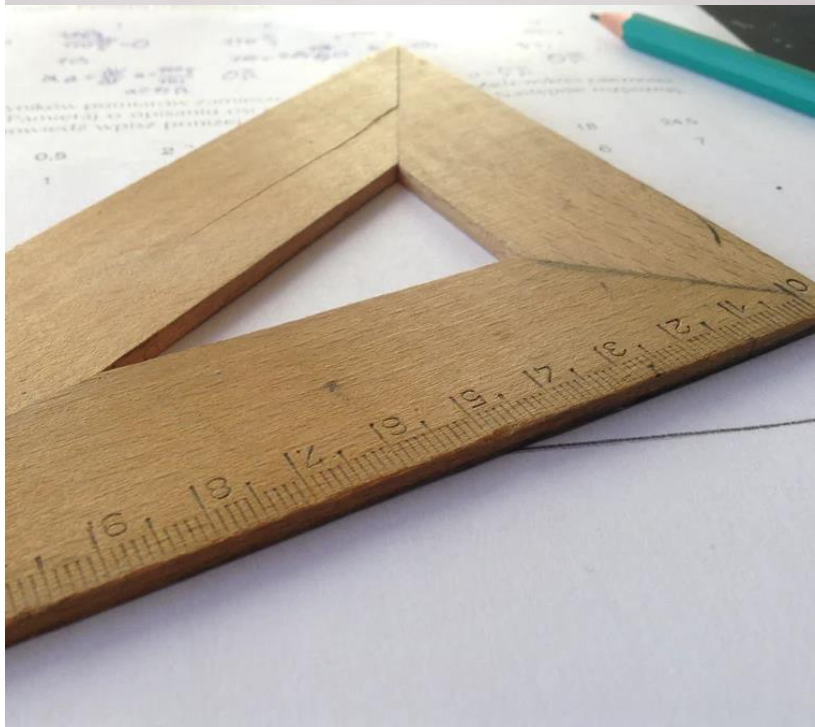
< > =

- Greater than: <
  - 3 < 6
- Less than: >
  - 4 > 2
- Equal: =
  - ½ = 50%

Variables

- Variable is a symbol you use to represent a number
- We normally use letters to represent variables in math.
- X=10





Activity

Biology

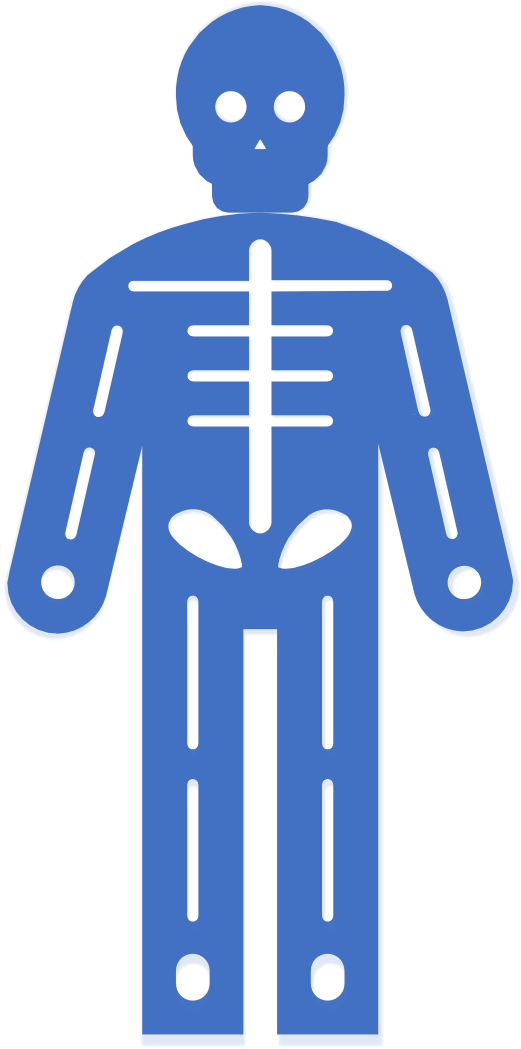
Biology Table of Contents

The Anatomy of a High-Five

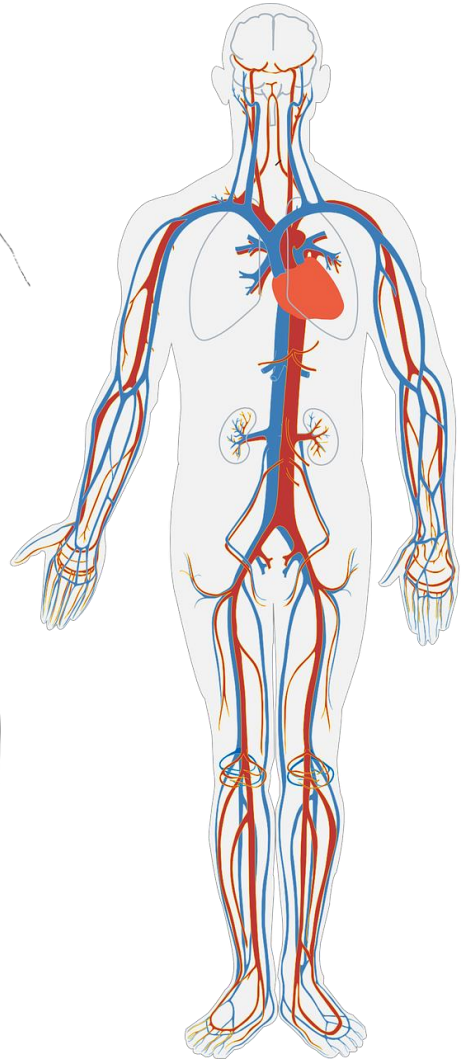
Have you ever seen an X-Ray?

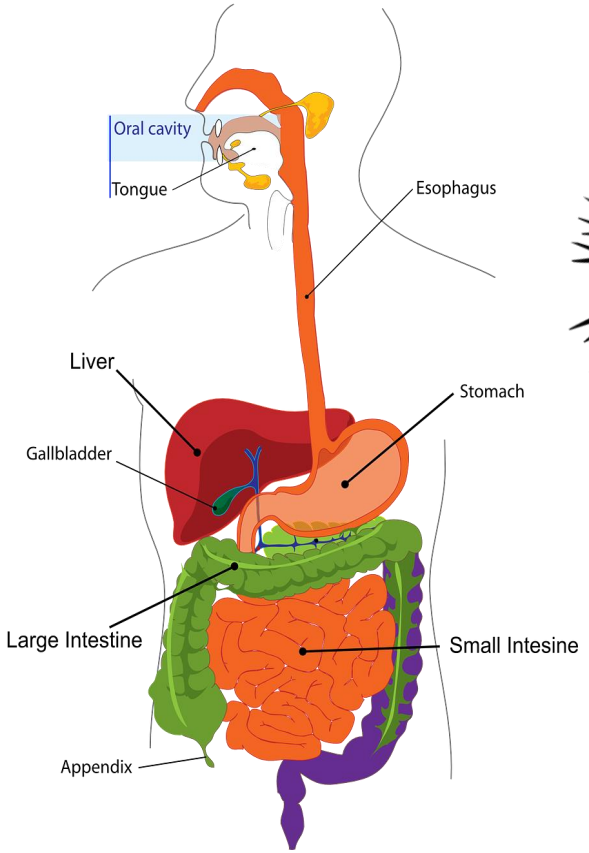
Anatomy

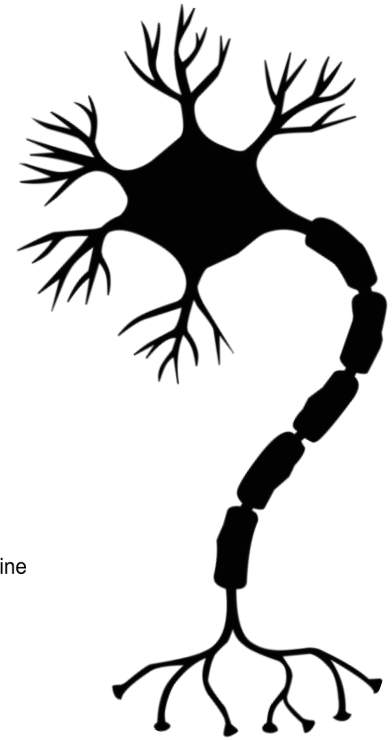
- Anatomy is the study of the structure of living things
- There are multiple levels of study for the human body:
  - The smallest are the cells!
  - Cells make up tissues
  - Tissues make up Organs
  - Organs make up the Organ System

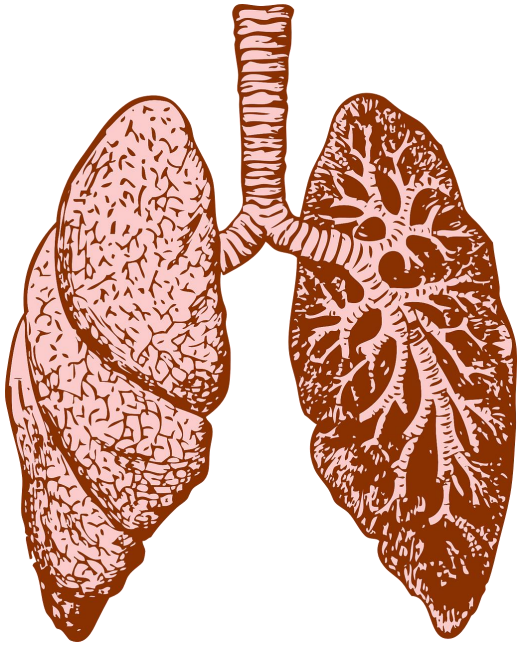


Let's name each system!









Anatomy

Every part of our body is made up of Tendons, Arteries, and Nerves

Nerves

- Humans have over 100 Billion nerve cells in our body, as our Nervous System!
- Nerves transfer information from one area of our body to the next.

Tendons

- A tendon is a tough tissue that connects a muscle to a bone

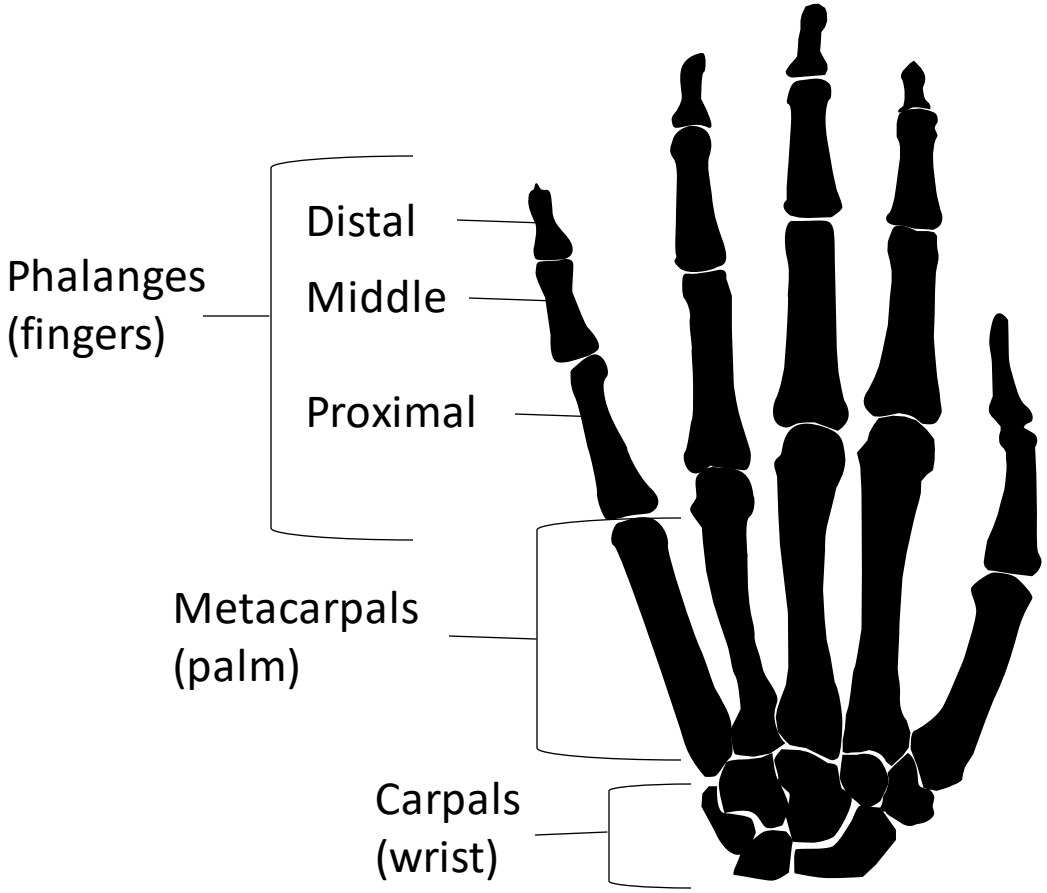
Arteries

- Our arteries carry blood from our heart to the rest of our body

Anatomy of a Hand

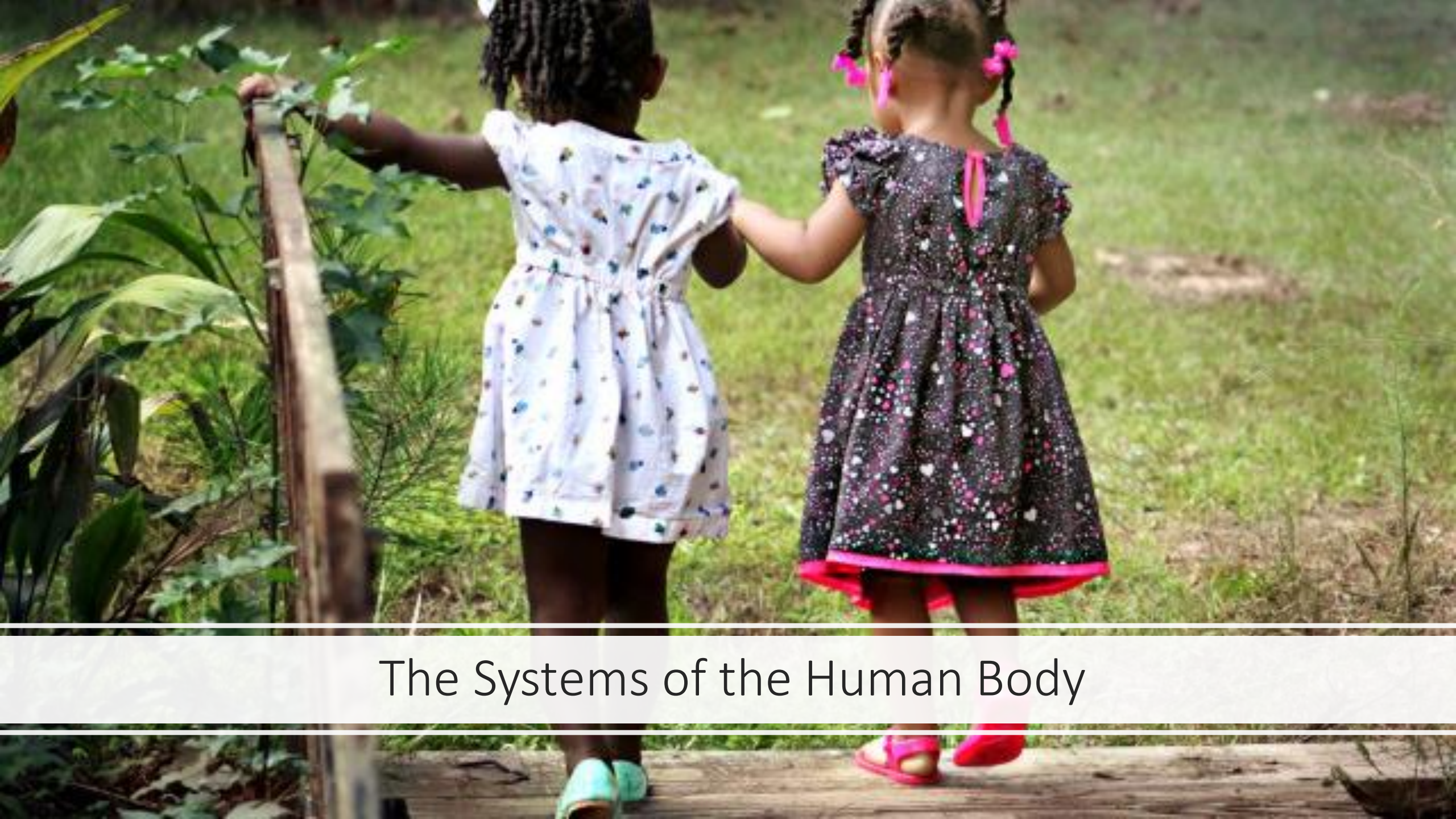
Fun Facts about Bones

- Bones are rigid organs that make up your skeletal system
- We have 270 bones when we are born, but only 206 as adults!



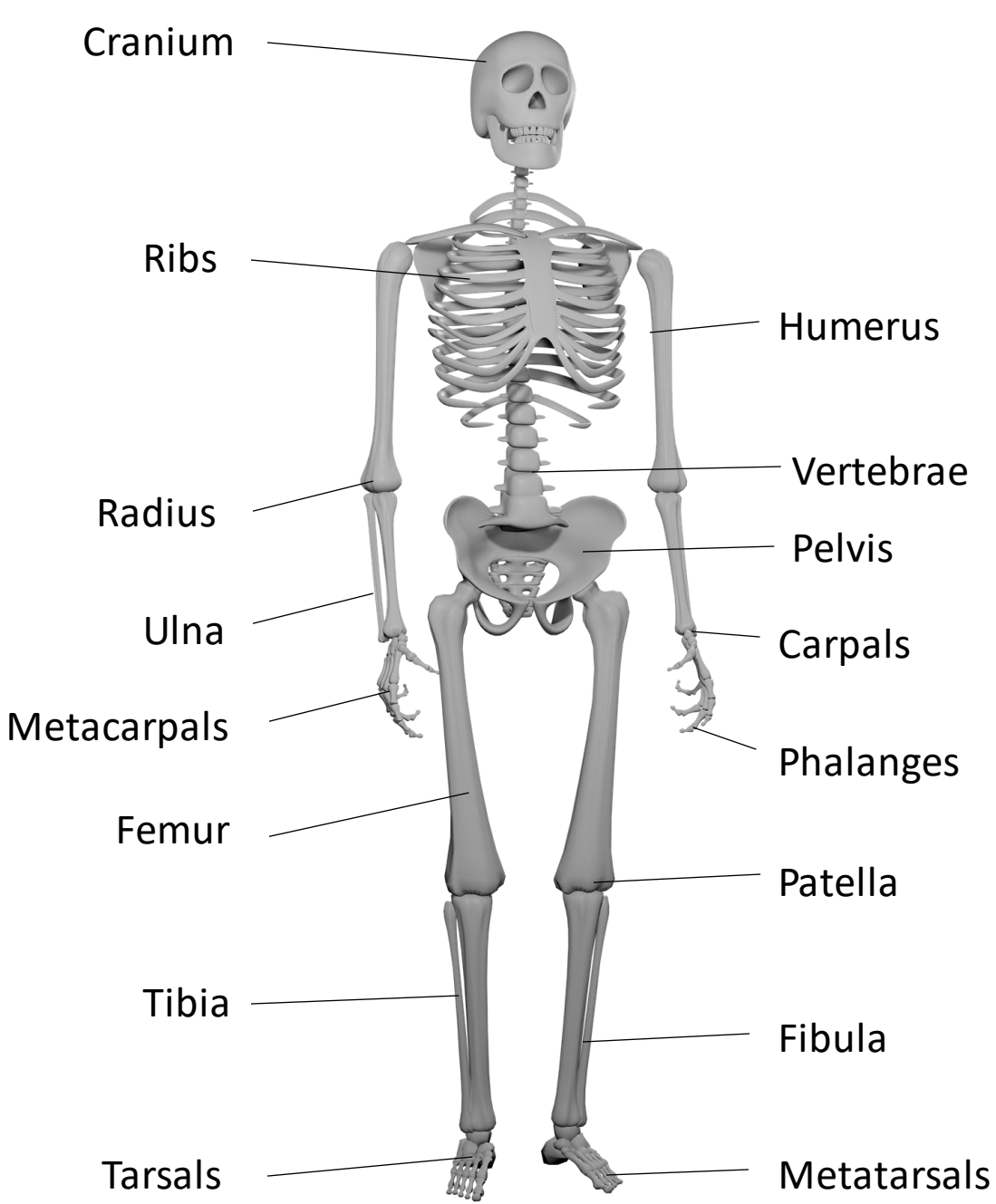
Let's go over the bones in a hand!
Can you feel each of them in your hand?

Activity Time!

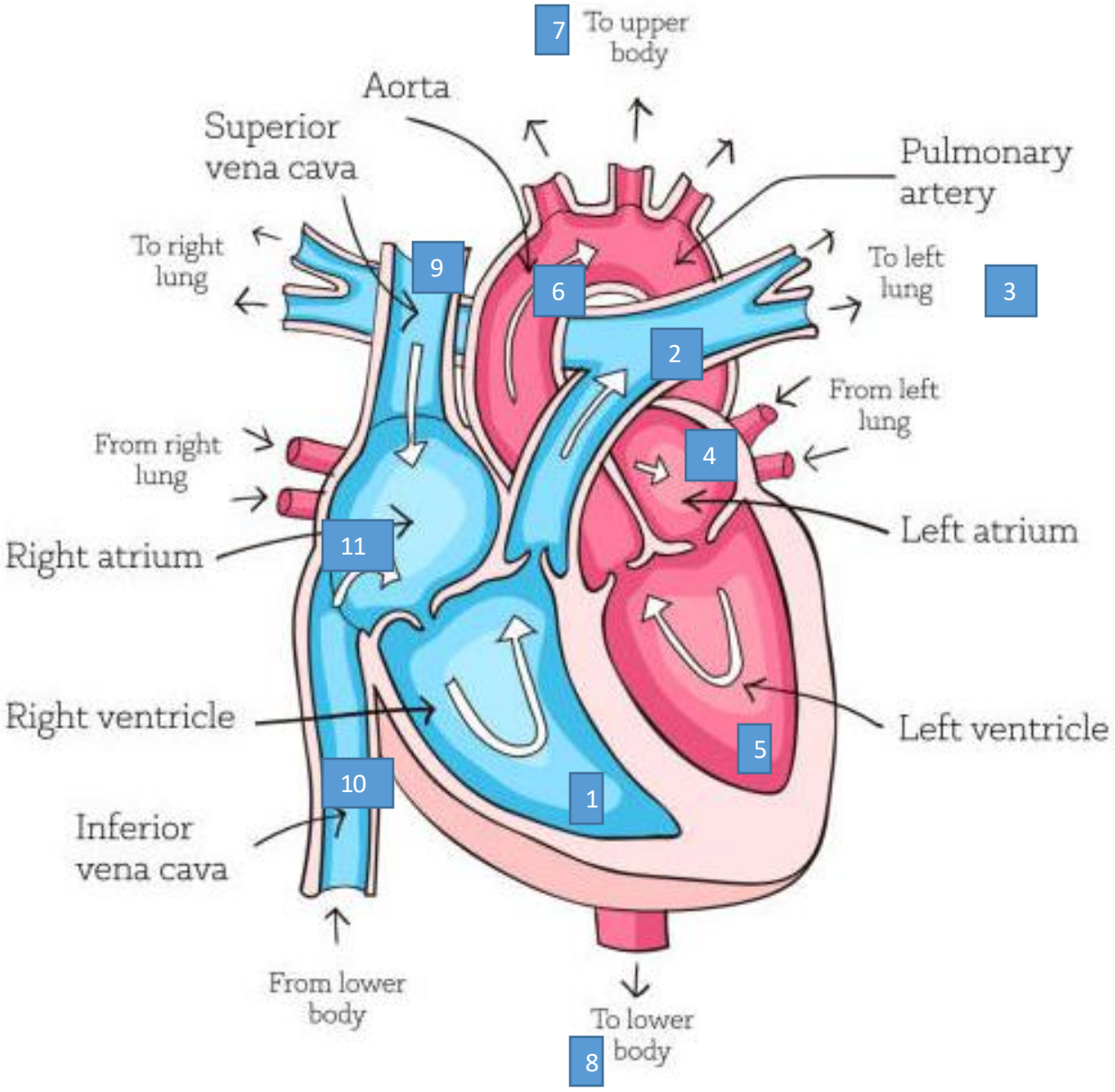


The Systems of the Human Body

Have you ever broken a bone or gotten sick?

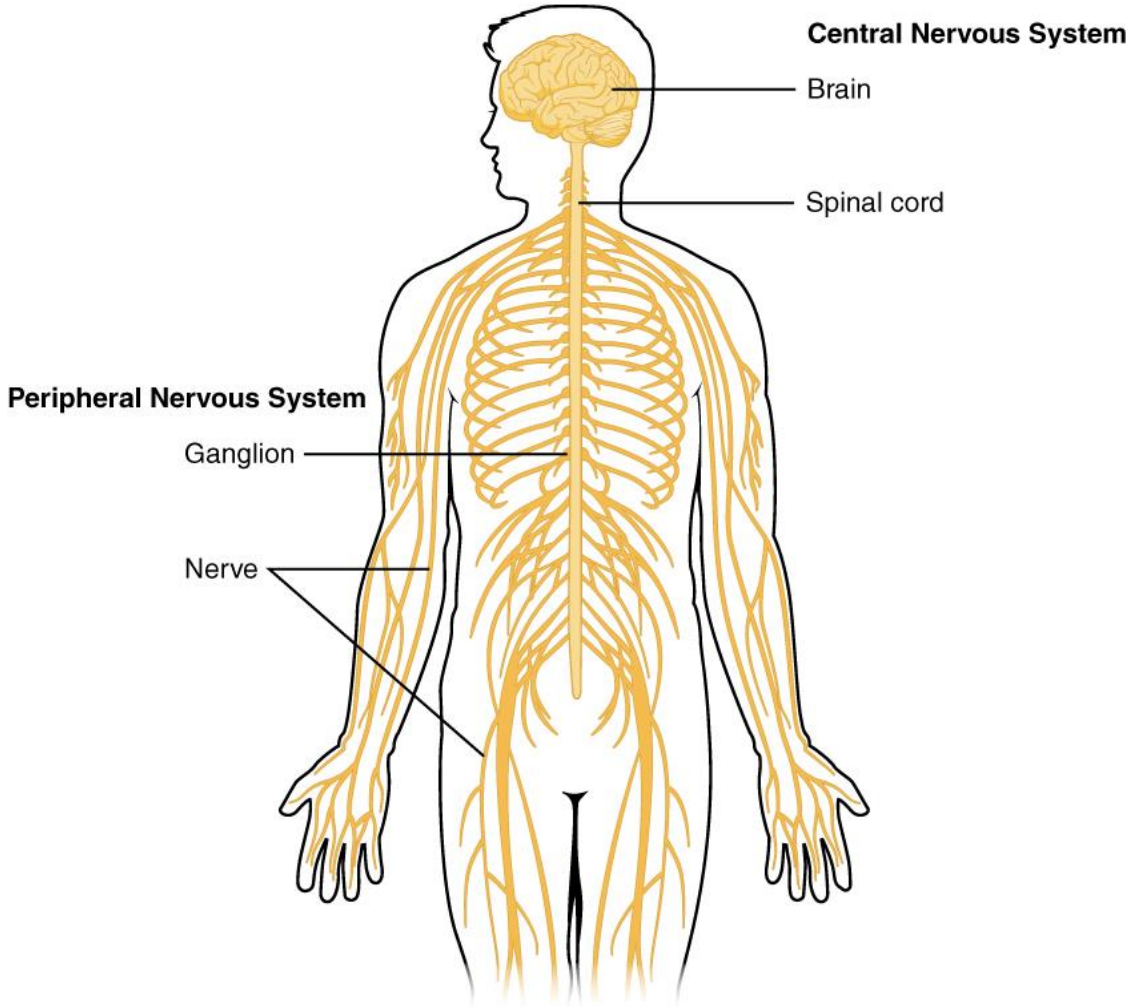


Skeletal System

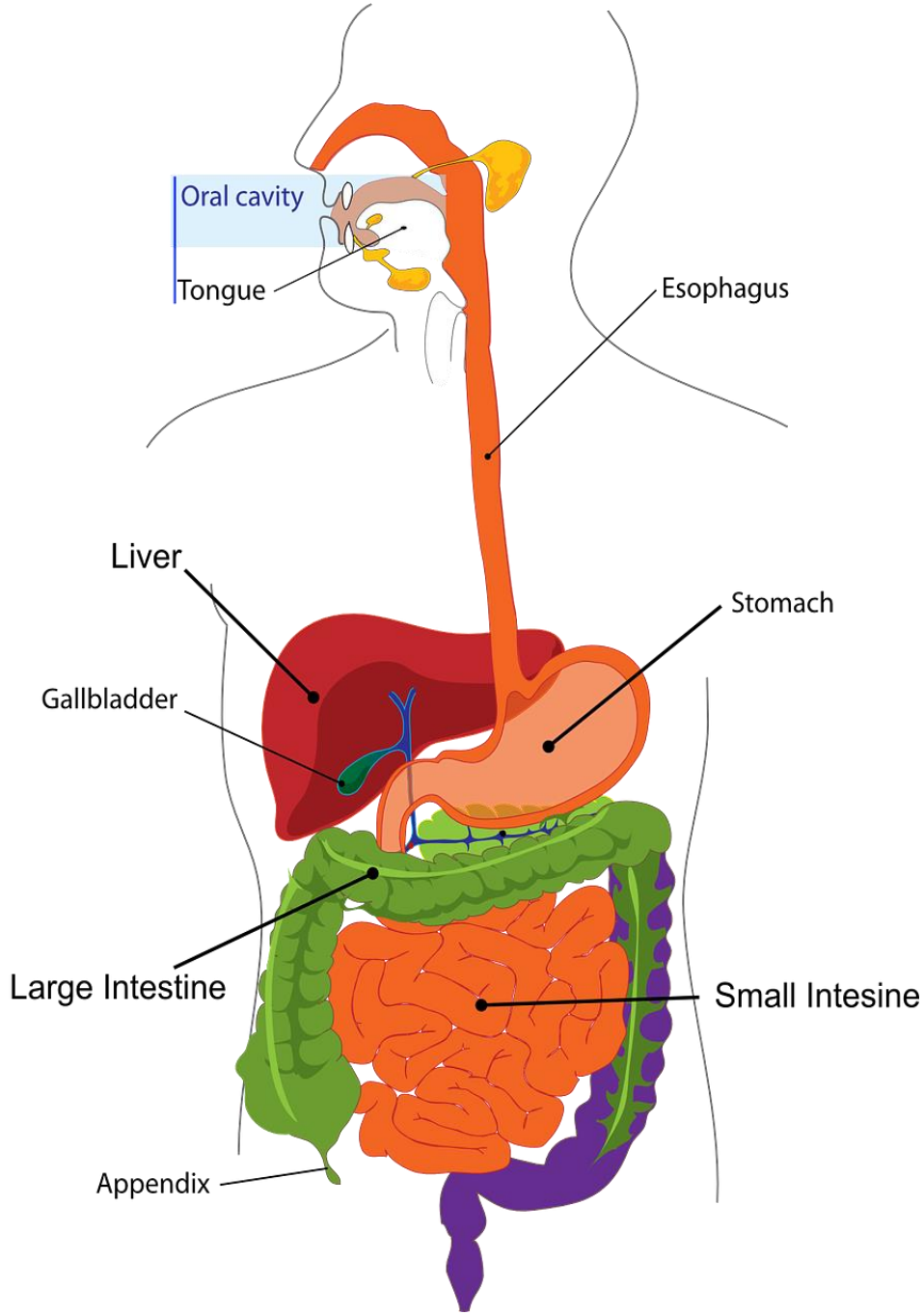


THE HUMAN HEART

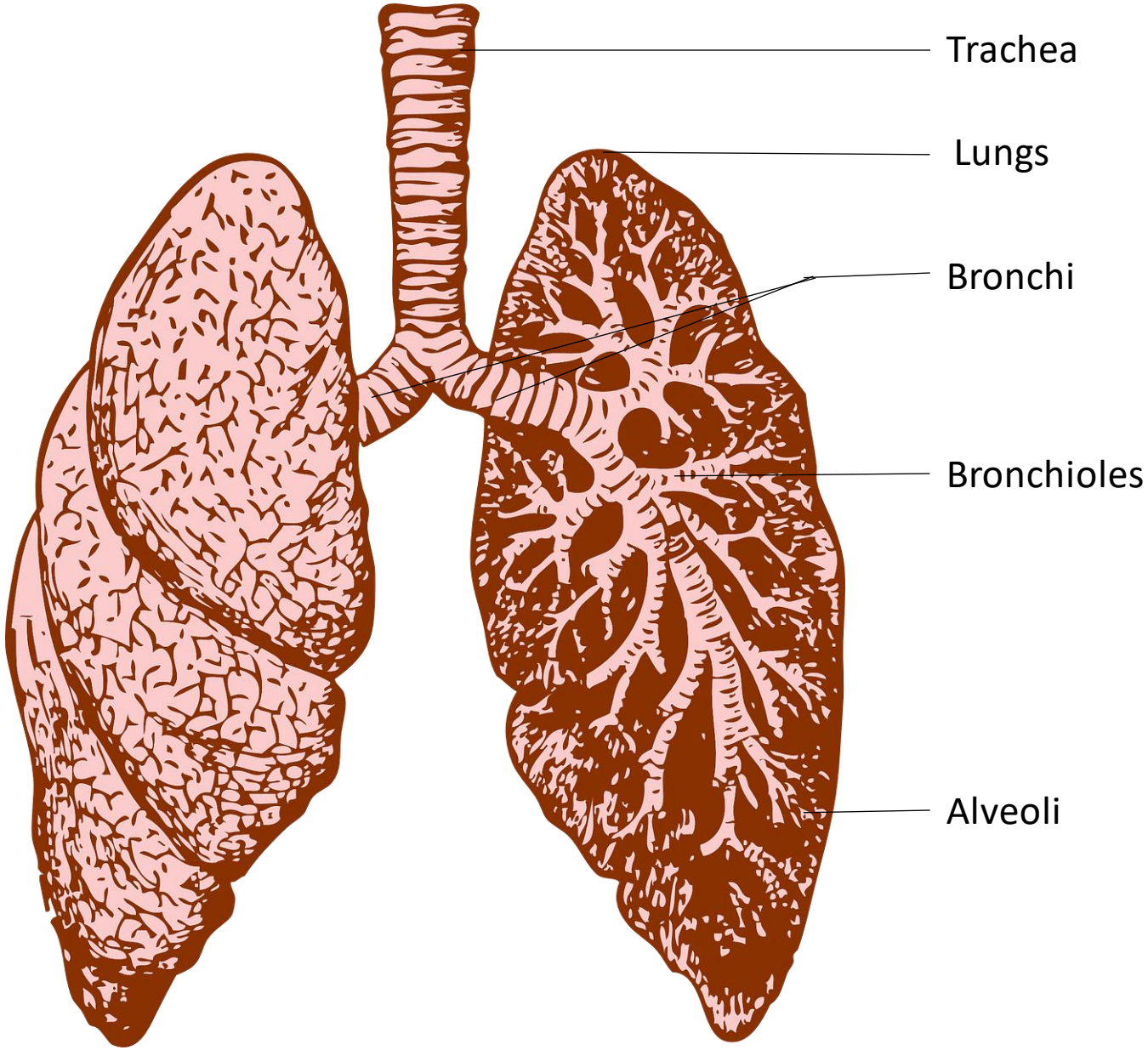
Circulatory System



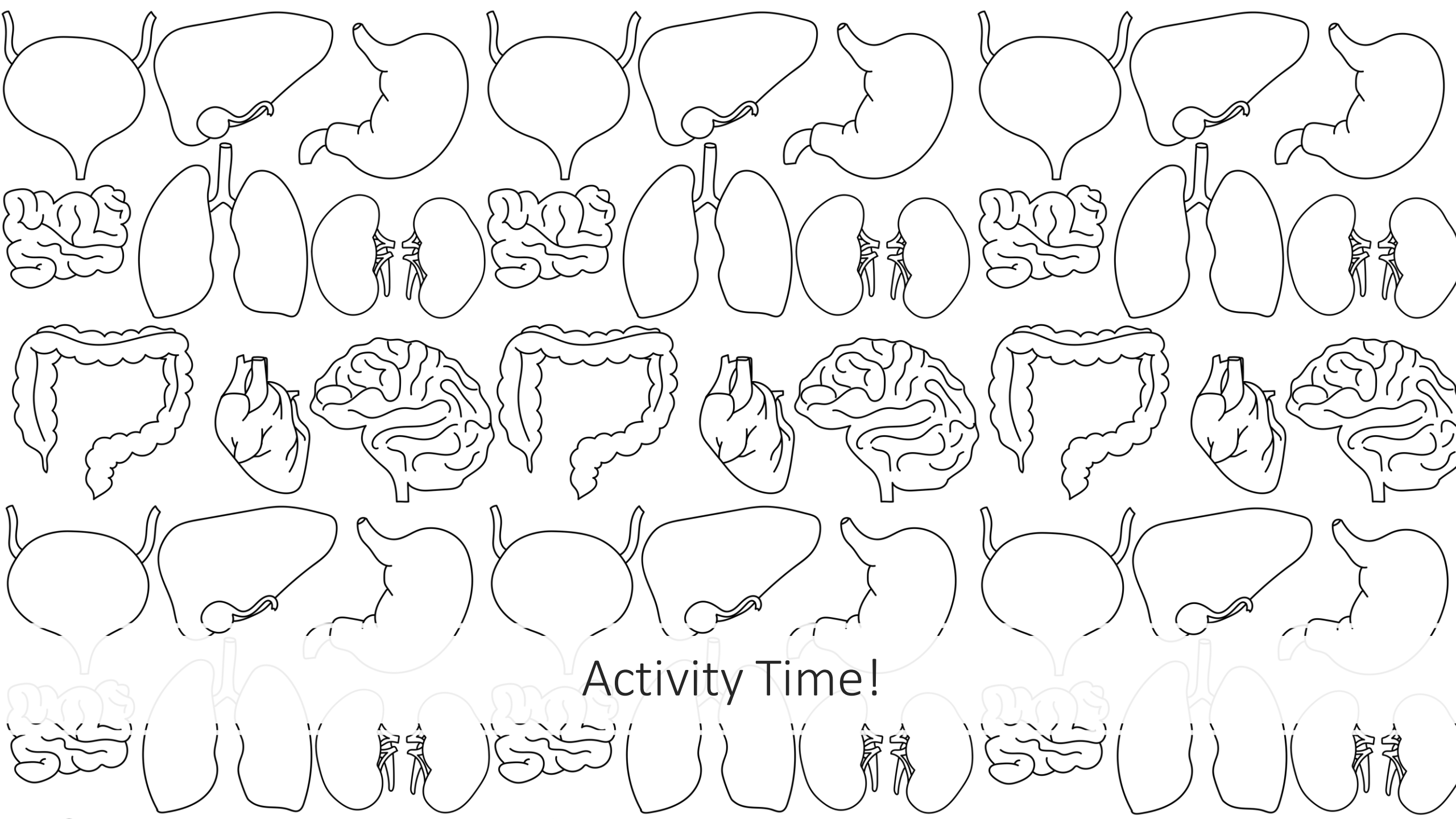
Nervous System



Digestive System



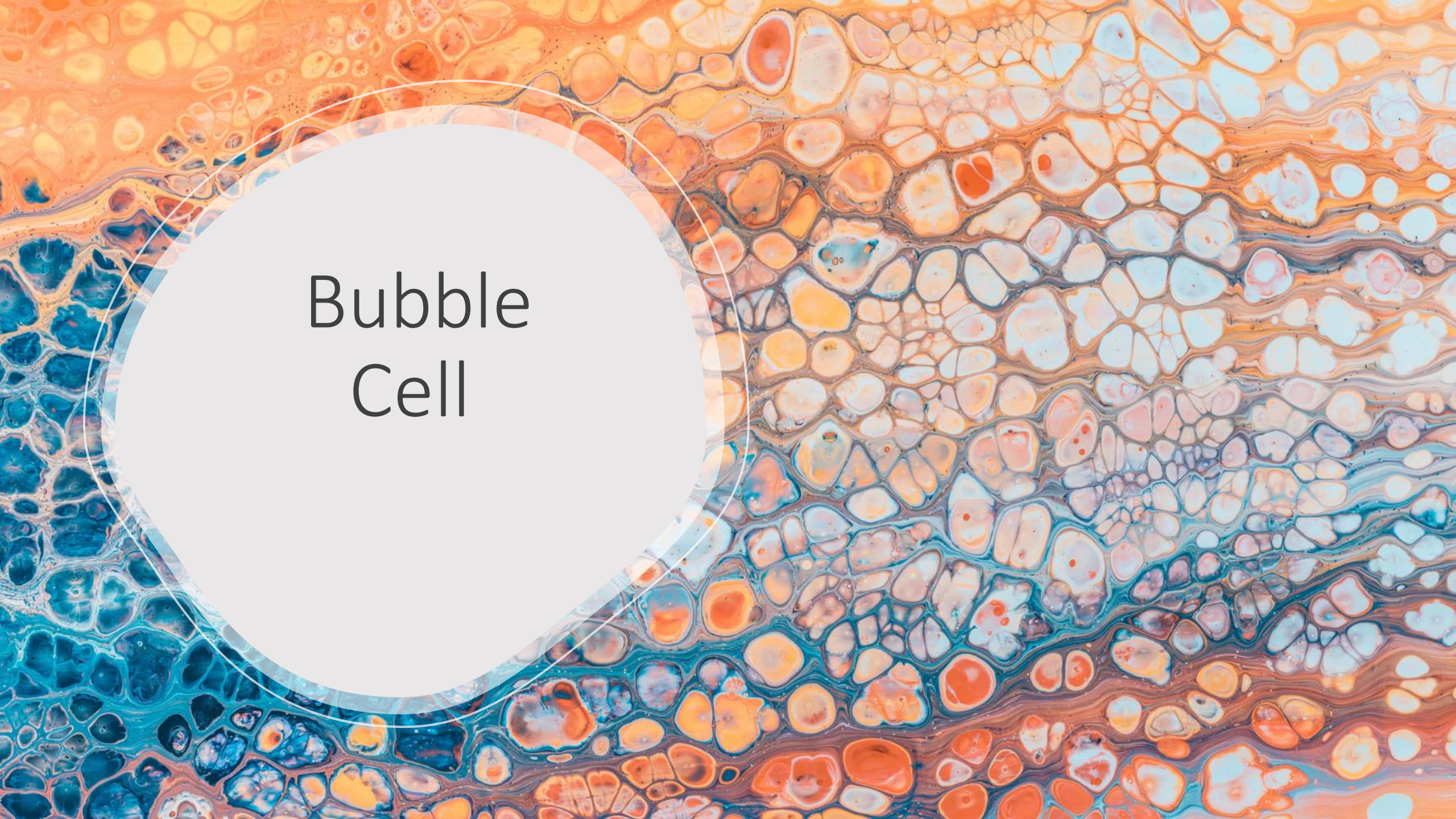
Respiratory System

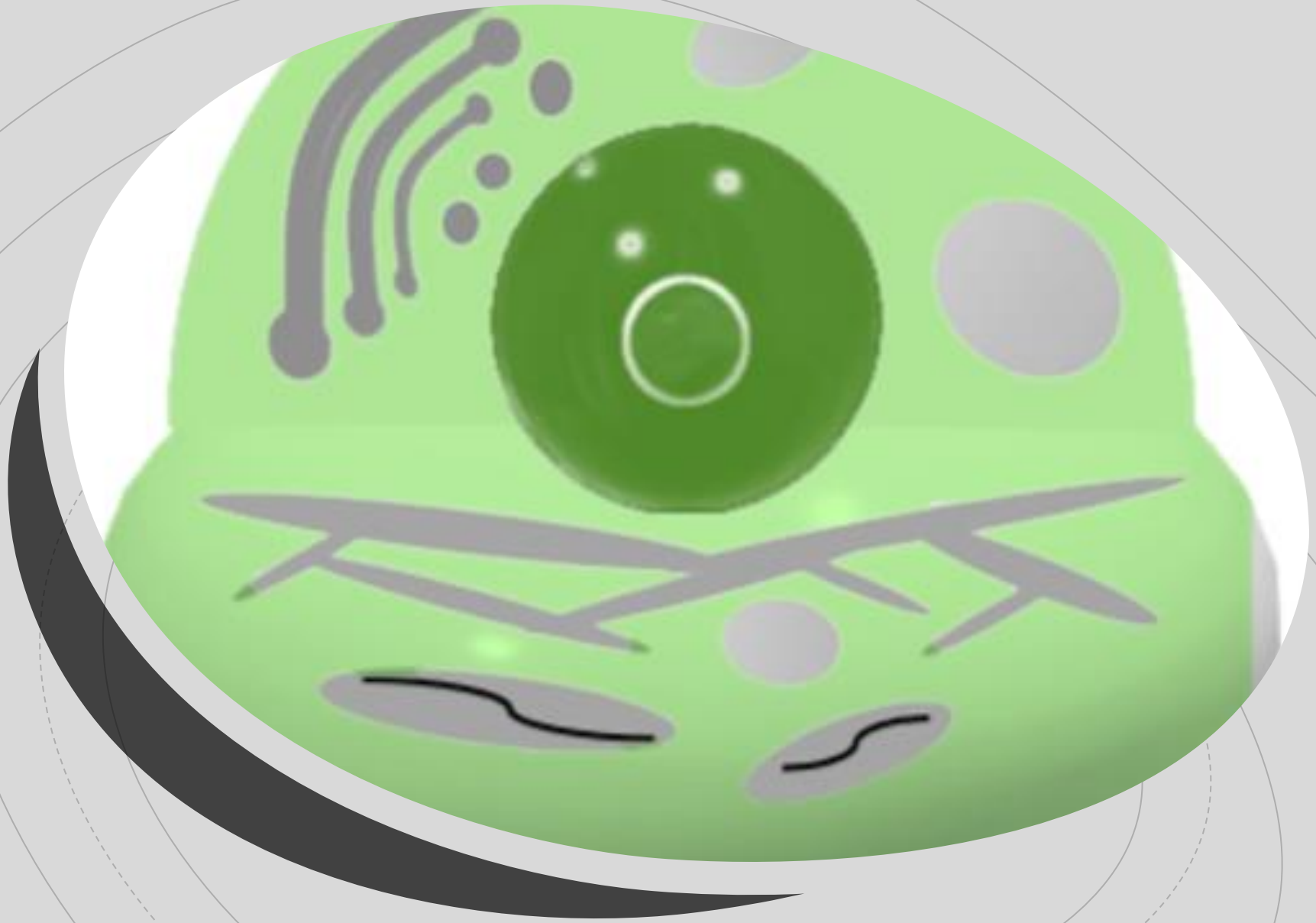


Activity Time!

Bonus: The Bone Dance!

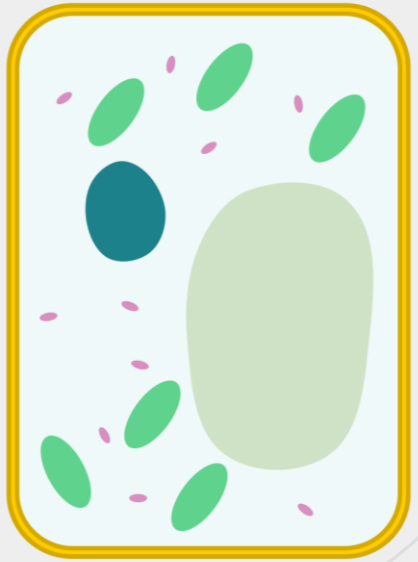
YouTube video link: https://youtu.be/CMV8y2b4whI

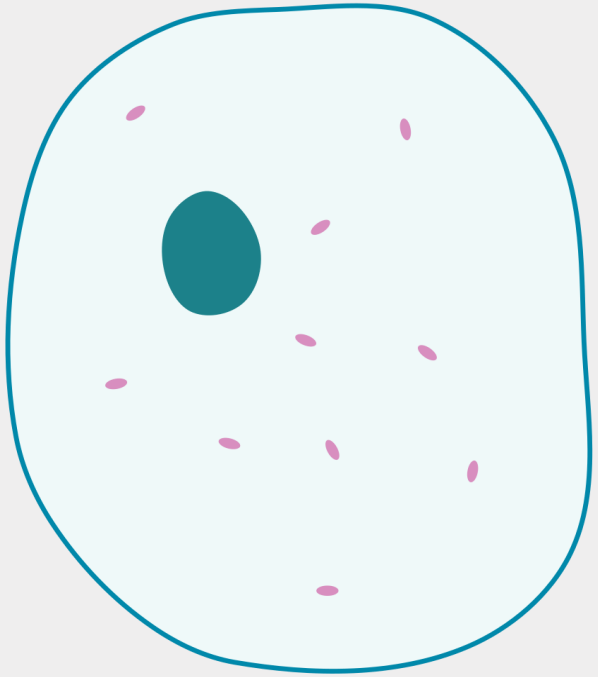

Bubble
Cell



Who knows what a cell is?

Cells

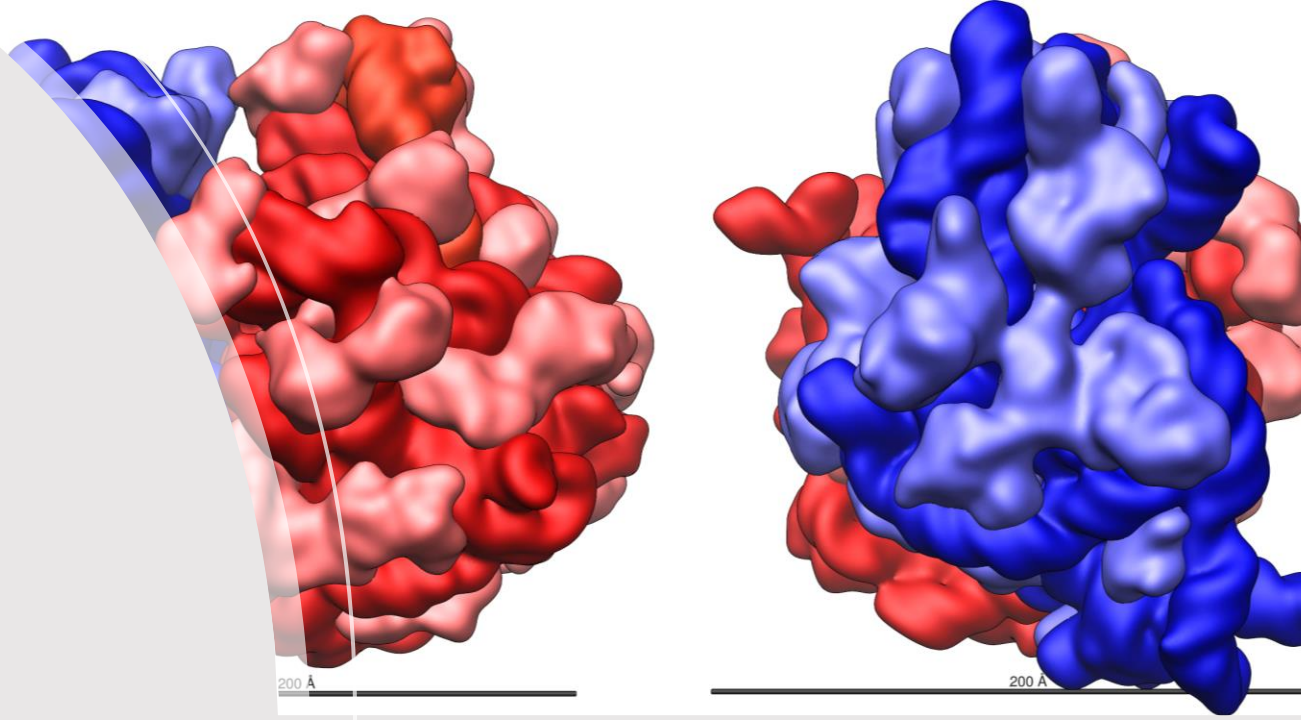


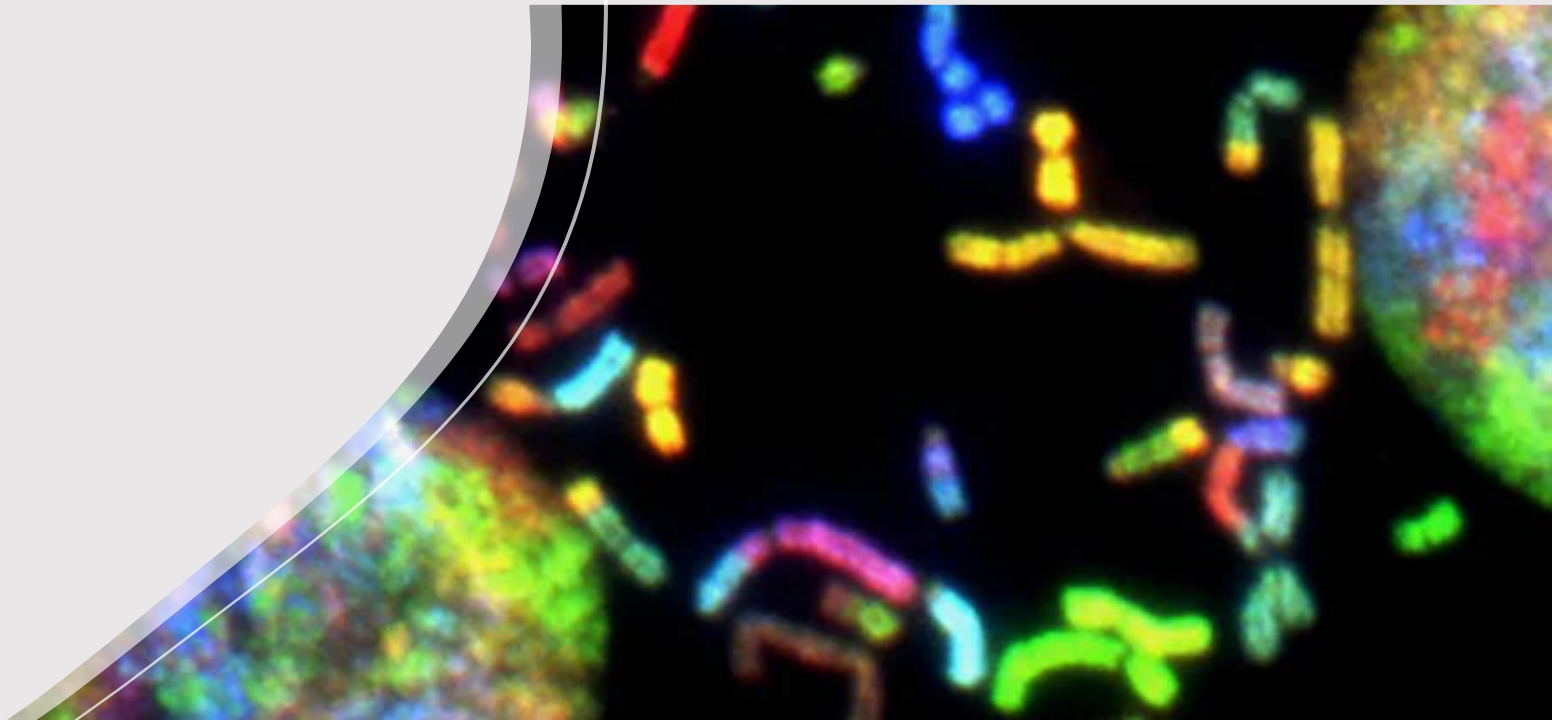


- Cells are the most basic units of life
- All living things are made from cells

Parts of a Cell

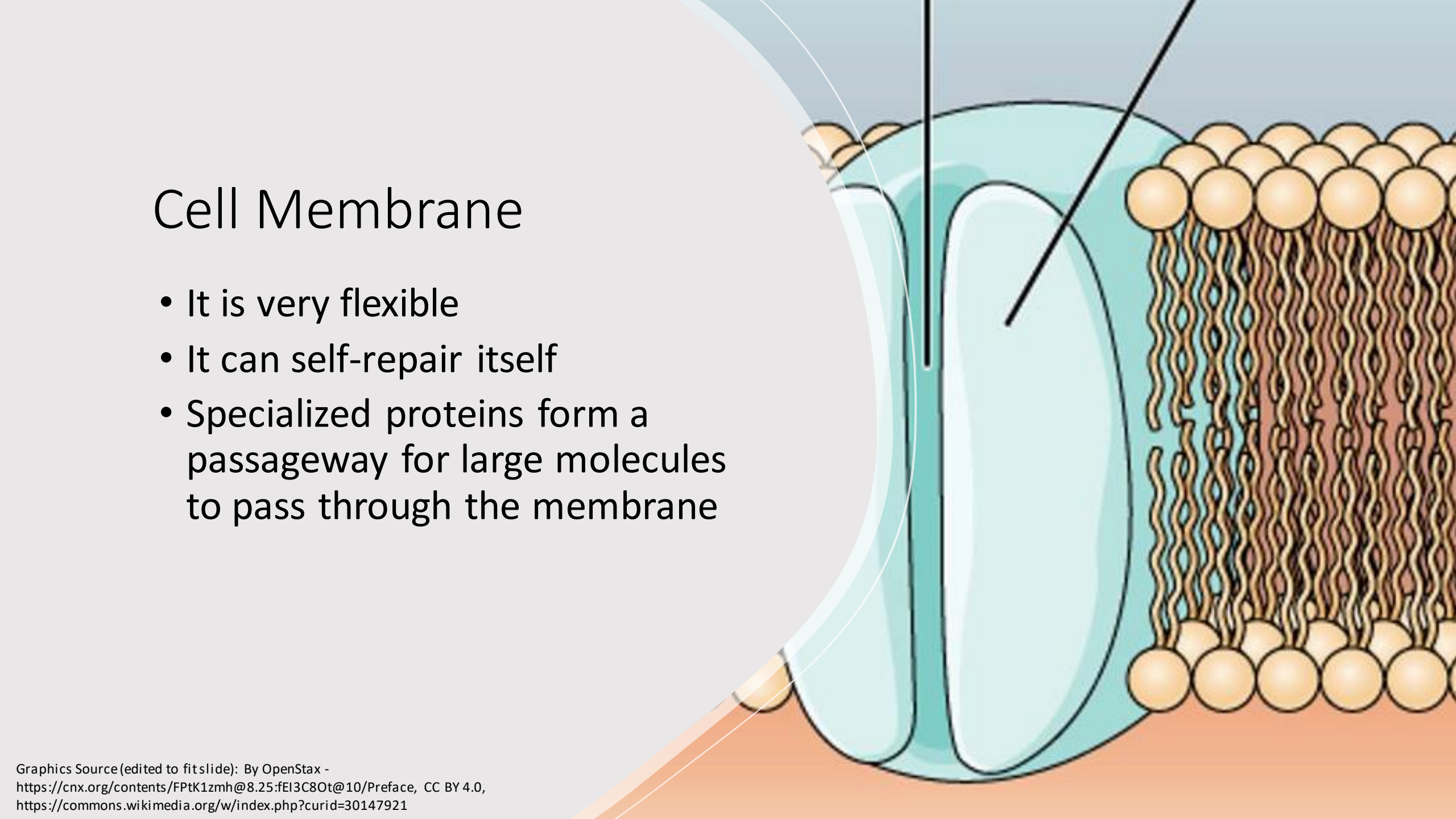
- All cells must have 4 parts:
  - Cell membrane (plasma membrane)
  - Ribosomes
  - Cytoplasm
  - DNA





Cell Membrane

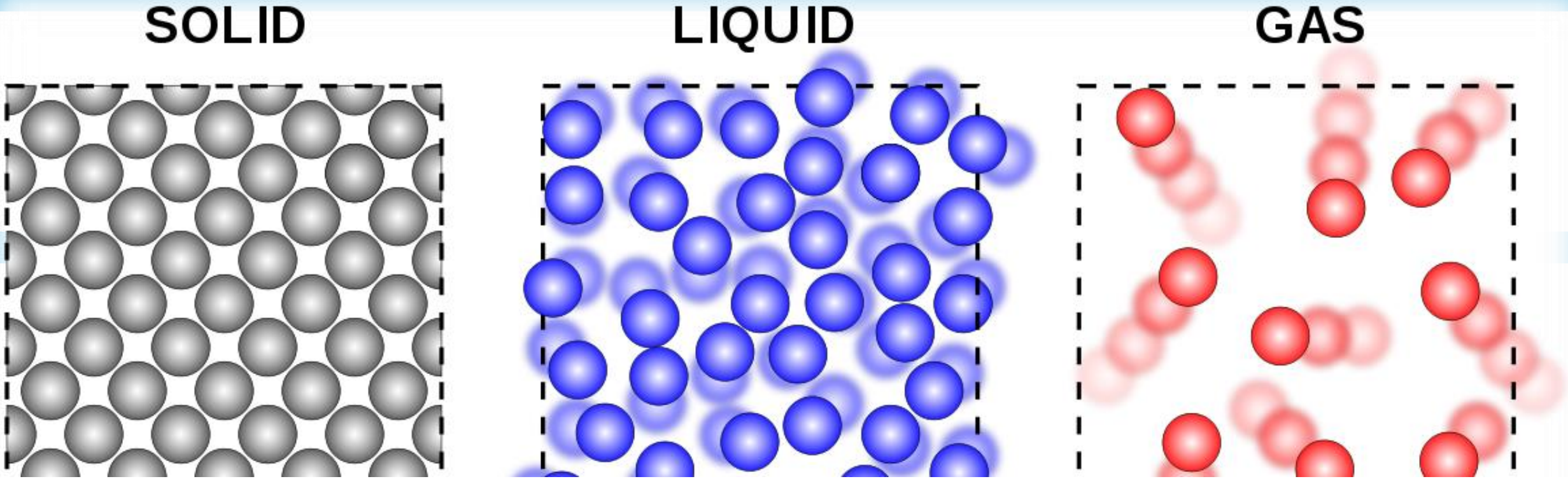
- It is very flexible
- It can self-repair itself
- Specialized proteins form a passageway for large molecules to pass through the membrane




Activity

CLOUD IN A JAR

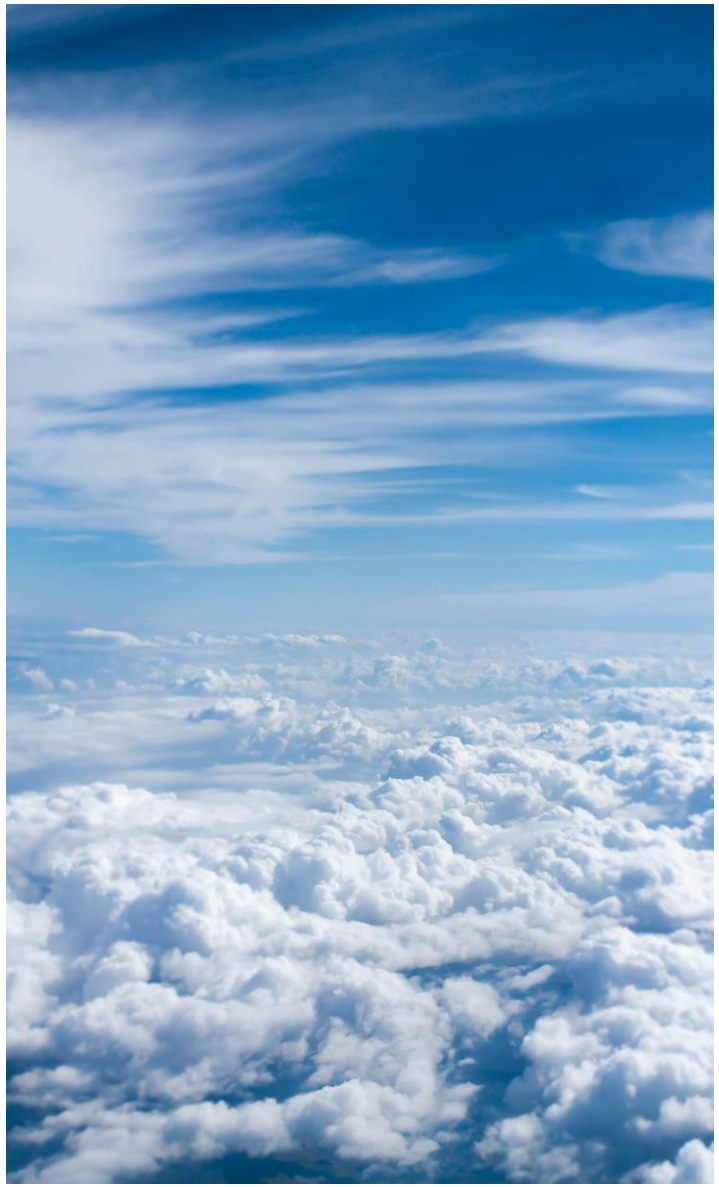
What is a cloud?



PHASES OF MATTER

CLOUDS

- Although clouds may appear solid, clouds are water vapor, a gas!
- They are made when hot and cold air collide.

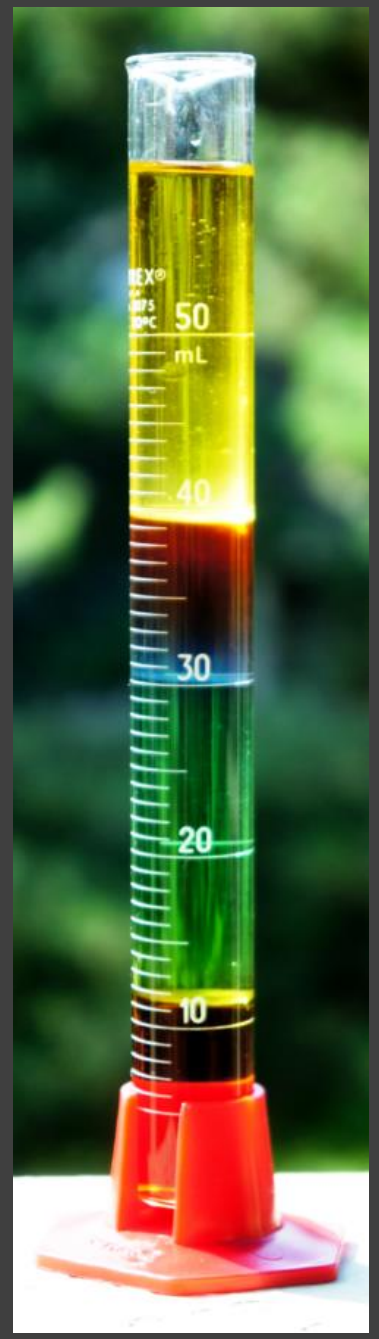


ACTIVITY TIME!

Chemistry

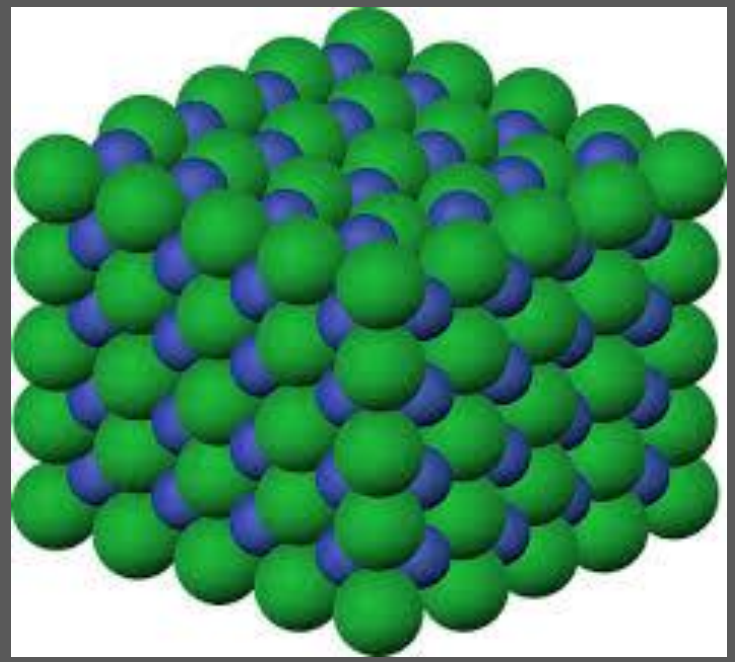
Chemistry Table of Contents

Density Testing



Introduction

- Do you know what density is?
- Have you ever mixed different liquids together before?



Density

- Density is the mass of a unit volume of a material substance
- If the particles are tightly packed together the object has a high density
- If the particles are loosely packed the object has a low density
- Density is equal to mass/volume

$$d = \frac{m}{v}$$

Density of a Liquid

- The density of a liquid determines if it sinks or floats.
- Liquids that are less dense will float towards the top of the jar whereas the denser liquids will sink to the bottom of the jar.

Density of Solid Objects

- Ice floats above the surface of water.
- Ice expands when it freezes but the mass is the same, which makes it less dense than water.
- Rocks sink to the bottom of most liquids
- Rocks molecules are tightly packed together, which makes them very dense.

Video!!!

Video Link - https://www.youtube.com/watch?v=Z7UeDBV9qmg

Experiment

Materials

- Clear Jar/Glass
- Paper Towel

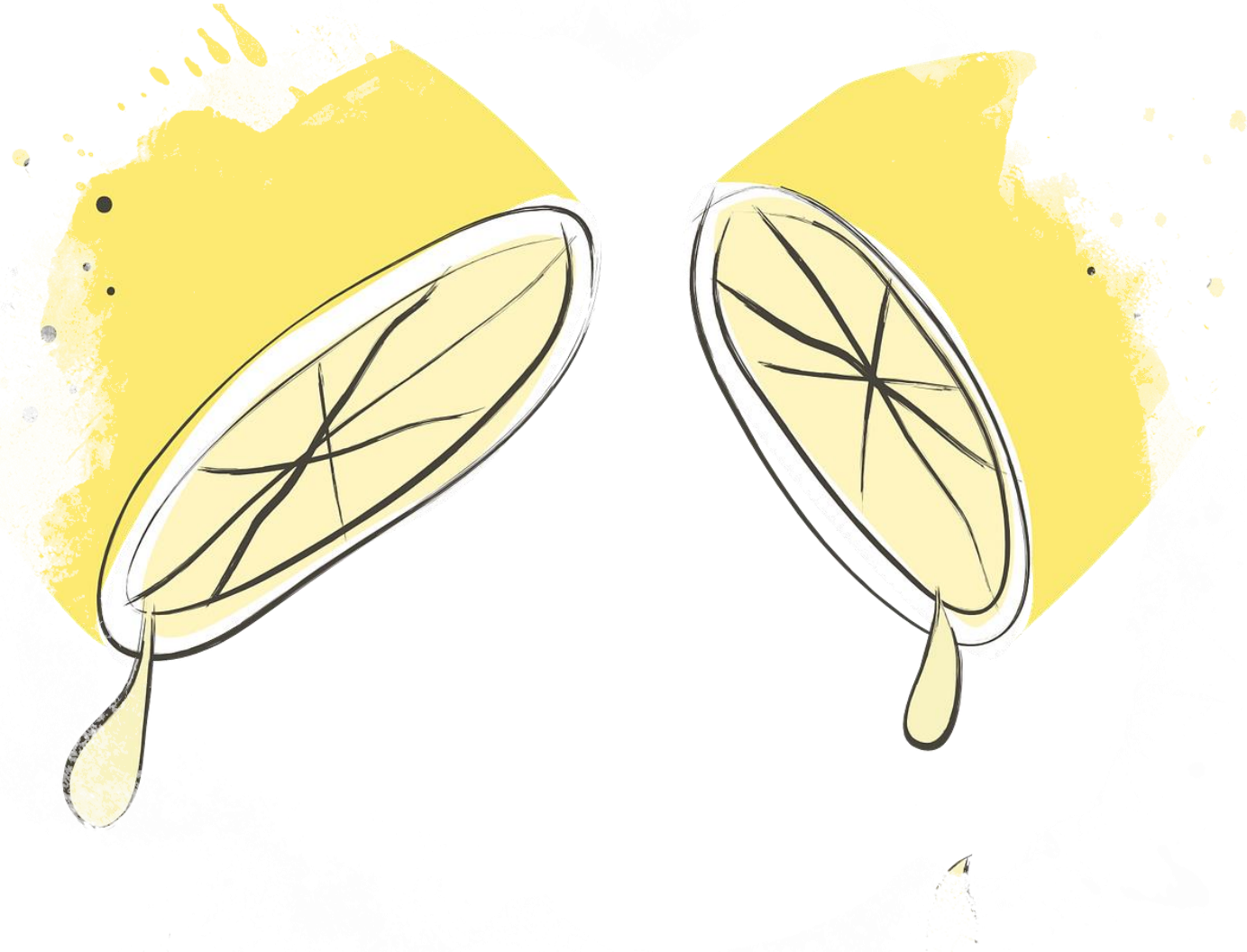
Liquids (Choose 3-4):

- Water
- Cooking Oil
- Orange juice
- Soda
- Syrup
- Honey

Solids:

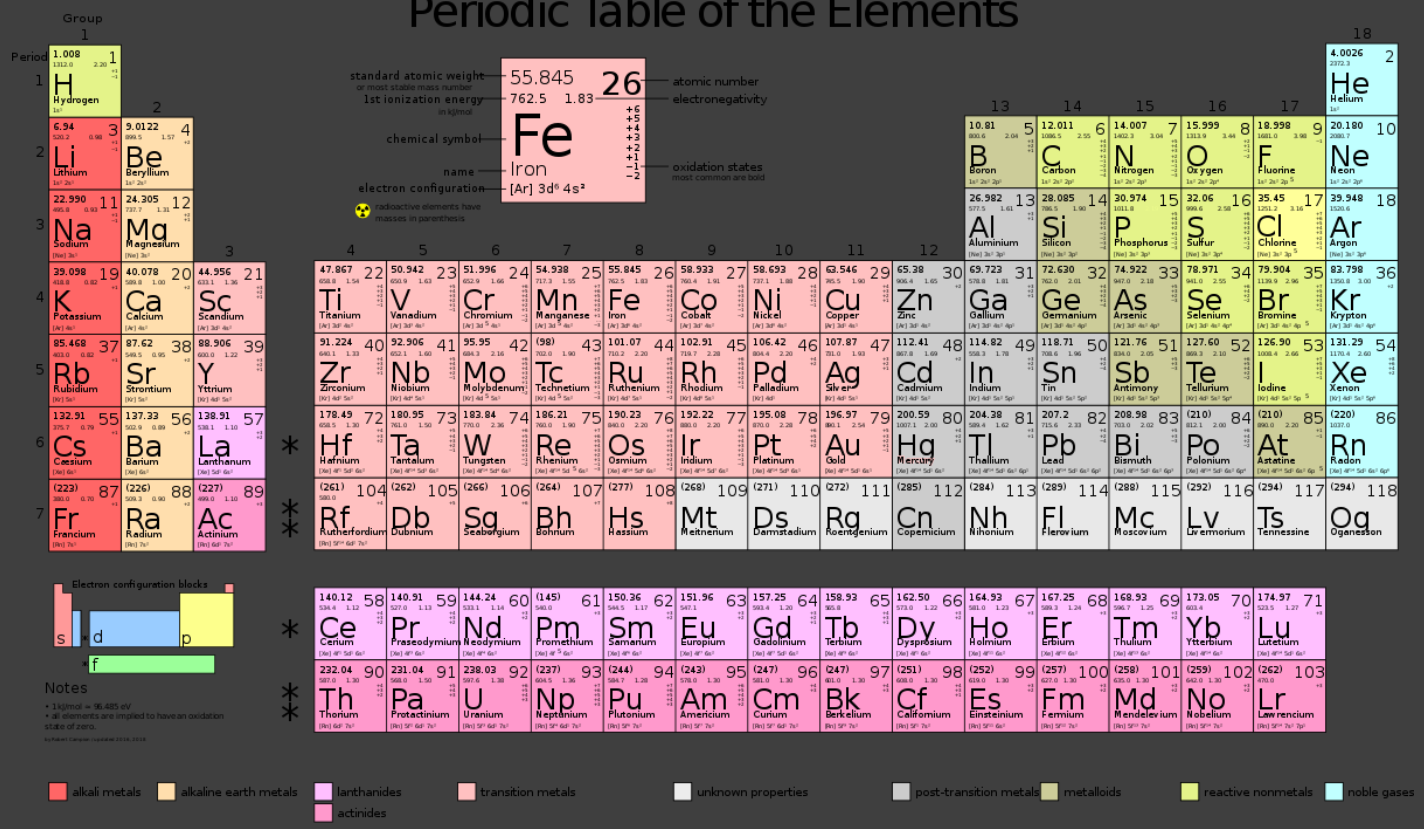
- Ice
- Rock

Invisible Ink With Lemon Juice



Have you ever wondered what it would be like to be a spy?

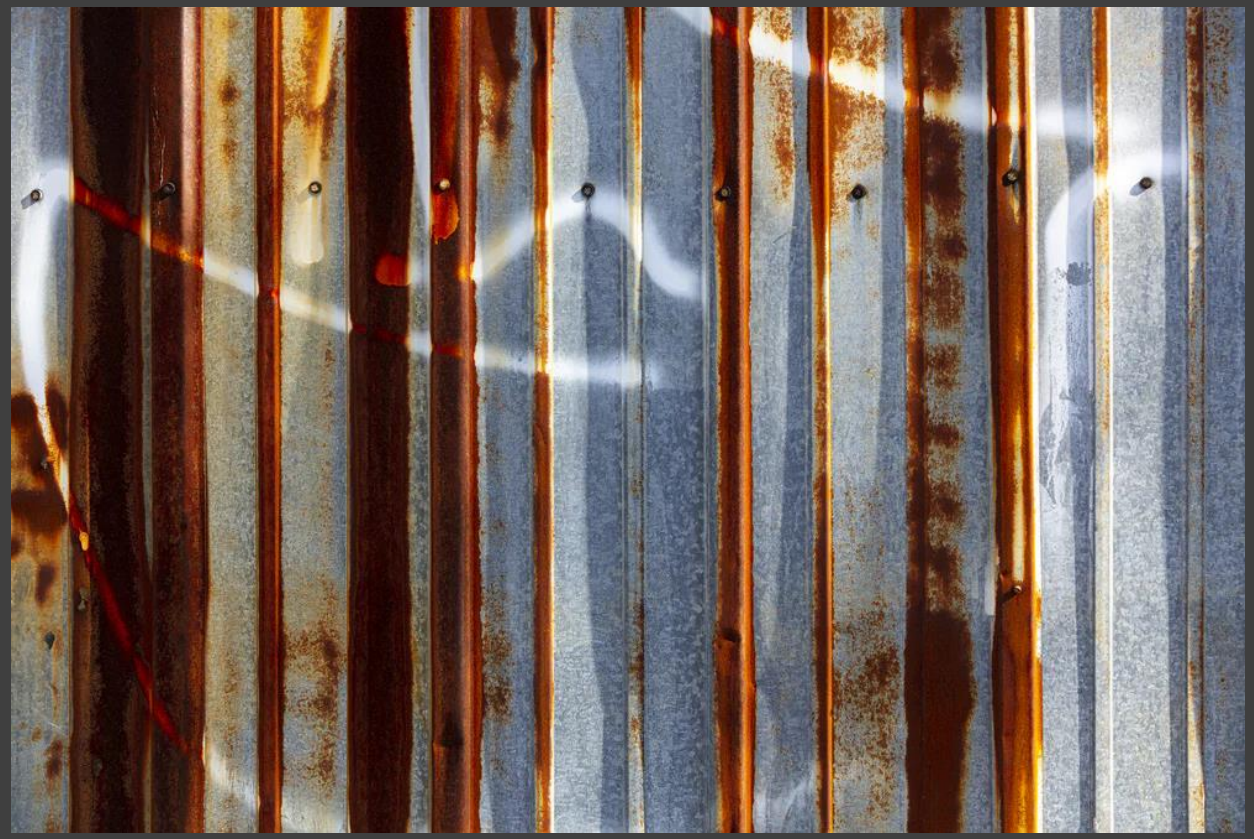
Organic vs Inorganic Compounds



- Organic Compounds are carbon-based
- There are natural and synthetic organic compounds!
  - Natural: Made by plants or animals
  - Synthetic: Made by humans
- Inorganic compounds are not carbon-based
  - There are multiple types of inorganic compounds

Image Source: By 2012rc - Own workNotes and font fixed: WilfredorUpdates 2016, 2018 (new names, atomic weights, ...): others, DePiep, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=8757312

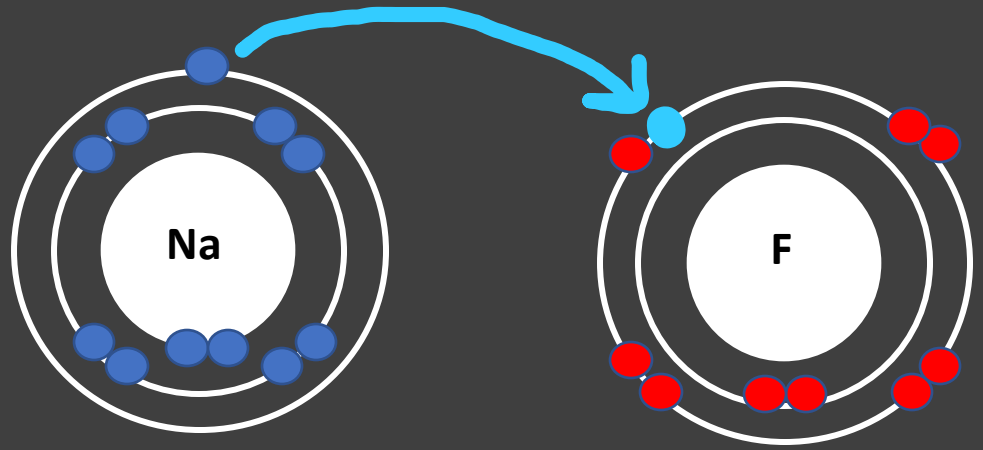
Oxidation and Reduction



- Any chemical reaction that involves the moving of electrons
  - The substance that gives away electrons is oxidized.
- The opposite of Oxidation is Reduction
  - For example:

  When iron reacts with oxygen, it oxidizes, and forms a chemical called rust (The iron has lost some electrons.) and the oxygen has been reduced (The oxygen has gained some electrons.)

Oxidation and Reduction in Motion



Which one is being Oxidized?

Which one is being Reduced?

Na: Sodium

F: Fluoride

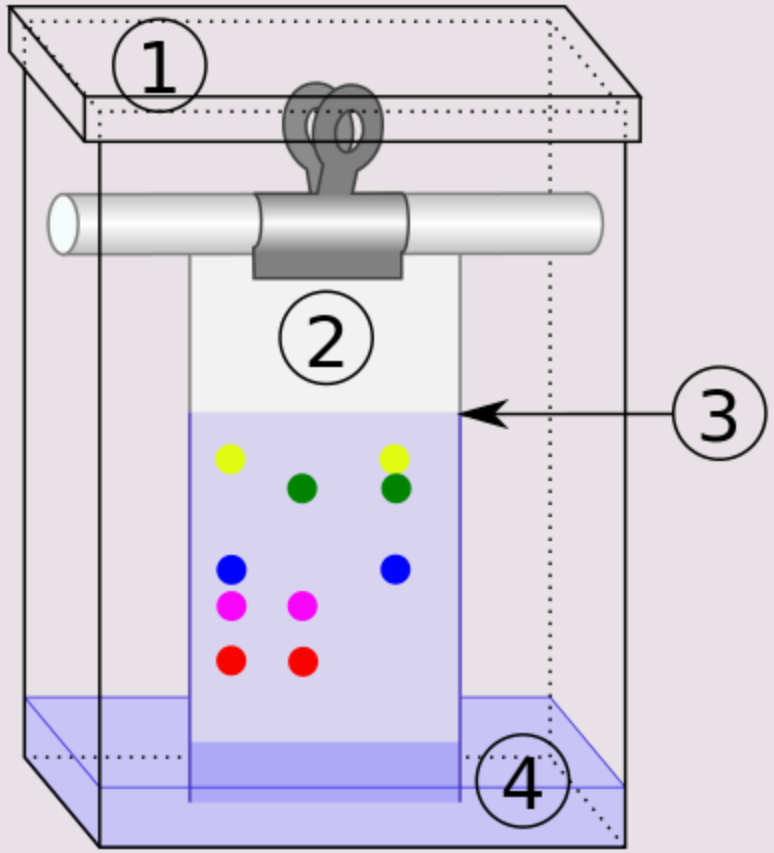
Activity Time!

PAPER CHROMATOGRAPHY

What is chromatography?

Chromatography

- Chromatography is a method of physically separating mixtures into individual components.
- It is a commonly used chemistry laboratory technique.
- Paper chromatography works by making a dot with pen at the end of a piece of paper and dipping the paper in a liquid right below the dot.
- The liquid can be anything ranging from water to acetone.



Ink Separation

- **Sometimes ink colors are pure or are a mixture of different colors. Using chromatography, we can tell whether the ink is pure or a mixture.**
- **It is possible to tell the separation of the ink because if it is a mix of colors, some colors will travel higher on the paper than the others.**

Prep Time!

- Pick two or three pens to use (try using different colors).
- On a horizontal line far away from each other, make a small spot of ink from each chosen pen.
- Go back over each ink spot a second time to ensure there is enough ink in the spot.

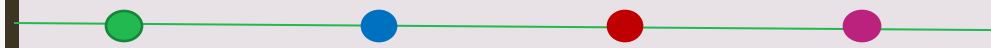


Image Source: By Amitchell125 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=76556776

Chromatography In Action

- Take a small cup and lean up the small piece of paper on one of the inside sides.
- Add a small amount of water into the cup. Make sure that it does not go over the ink dots on the piece of paper.
- Watch the magic happen!

Societal Science

Societal Sciences Table of Contents

What's on your plate?

A game of Geology and Geography

Intro Question:

Have you ever built a 3D puzzle?

Geology

- Geology is the study of the physical features and history of Earth.
- Scientists who work in geology are called geologists.

Why is Geology important?

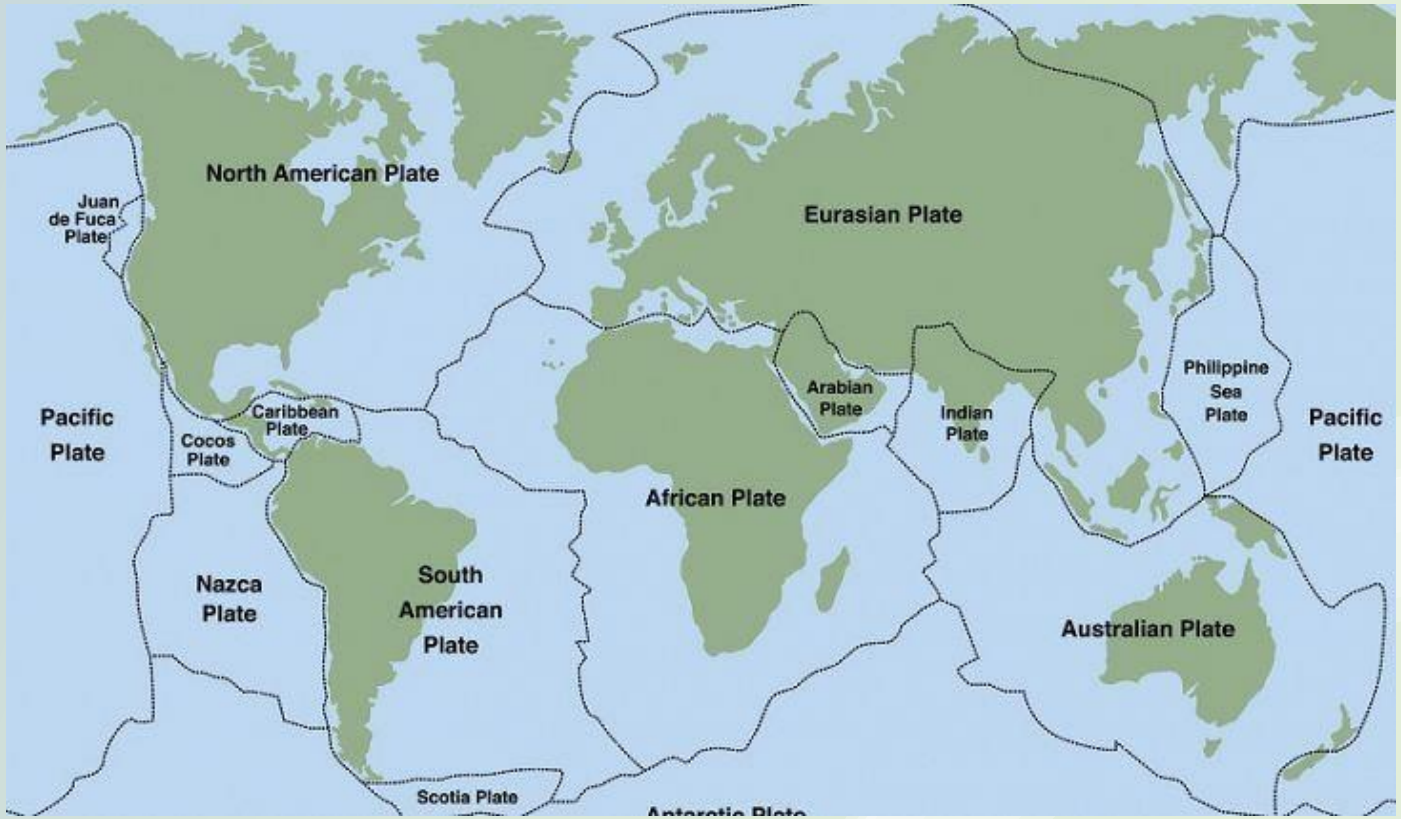
- Answers questions about how Earth came to have its present shape and form.
- Useful for finding important materials in Earth's crust, such as oil.
- Helpful for predicting earthquakes and other natural hazards.

Branches of Geology

- Rocks and minerals and how they are formed.
- The structure of Earth and the different forces and actions inside it.
- How landforms, such as mountains, on Earth's surface develop and change.
- Paleontologists, geologists who study fossils. (Fossils are the traces of prehistoric plants and animals.)
- How humans can use Earth's resources without harming the environment.

What are Plate Tectonics?

The theory, or idea, of plate tectonics says that Earth's outer layer is made up of large, moving pieces called plates.



Graphics Source: By Fathimahazara - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=90131289

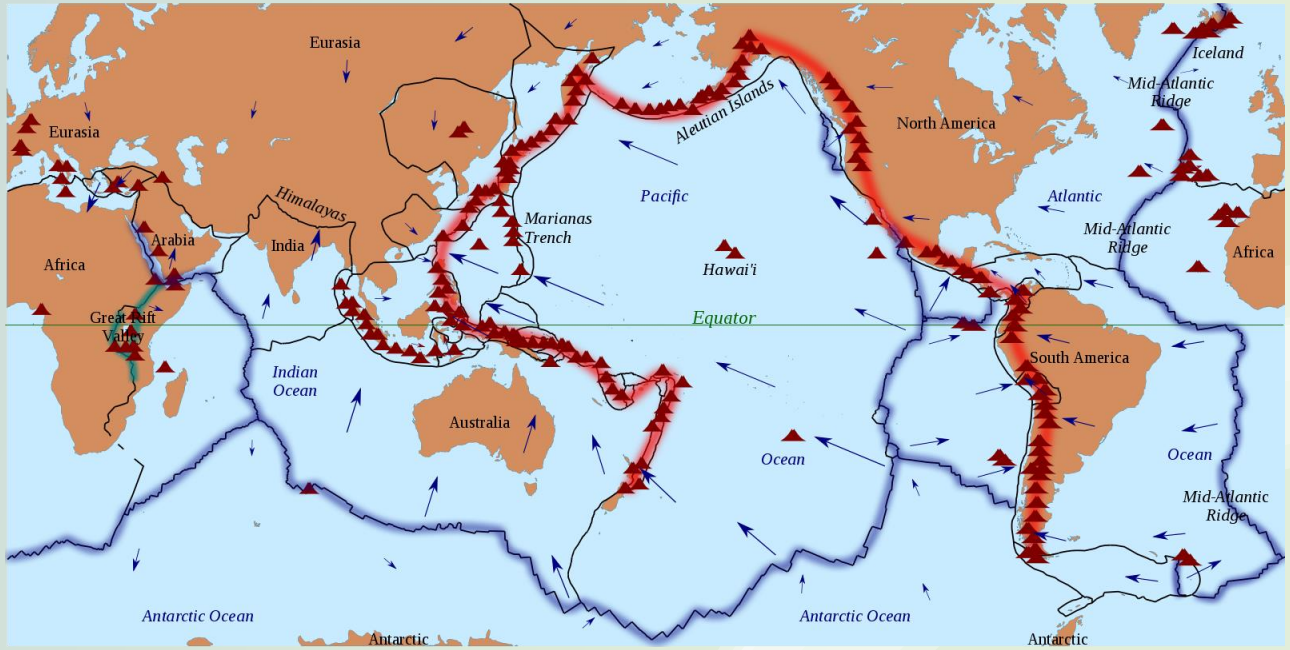
The Movement of Plates

- As the plates move, they interact at their boundaries in different ways:
  - Slide alongside each other
  - Crash into each other: can cause destruction of the edge of one plate, or cause both to rise and form mountains.
  - Move apart from each other, which causes the melted rock beneath the plates to rise. This melted rock, or magma, cools as it rises and forms new crust.

The Formation of Geological Features

Earthquakes and volcanoes often happen along plate boundaries.

- There are so many earthquakes and volcanoes at the edges of the Pacific Plate that this region is called the Ring of Fire.



Graphics Source: Public Domain,
https://commons.wikimedia.org/w/index.php?curid=318126

LEGO Ice Excavation

Archaeology

- The study of things that people made, used, and left behind.

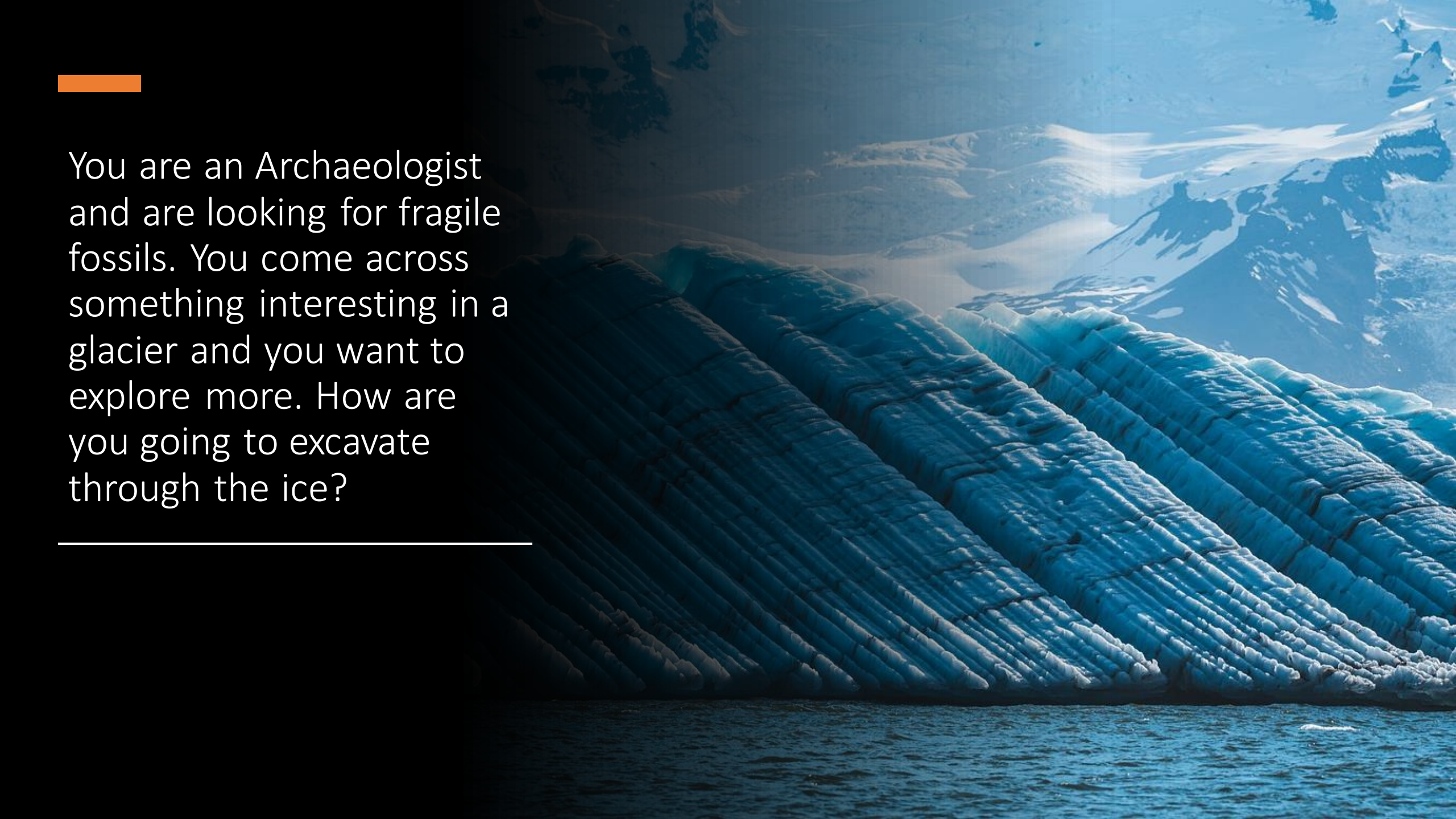
Excavation

- The process that archaeologists use to look for fossils or other objects left behind by other human civilizations.
- Excavation sites are where the digging occurs.

Ice & Salt

- The melting temperature of water is 32 °F
- When salt is added to ice, because of its ionic characteristics, it lowers ice's melting temperature.

You are an Archaeologist and are looking for fragile fossils. You come across something interesting in a glacier and you want to explore more. How are you going to excavate through the ice?



Excavation time!

Recyclable Car

Introduction

Have you ever made recyclable car?

Have you ever done a project or activity that requires you to make something out of recyclables?

If you said yes to either question, what was the most difficult part?

Importance of Recycling

Recycling is one of the best ways to have a positive impact on the world

Recycling helps:

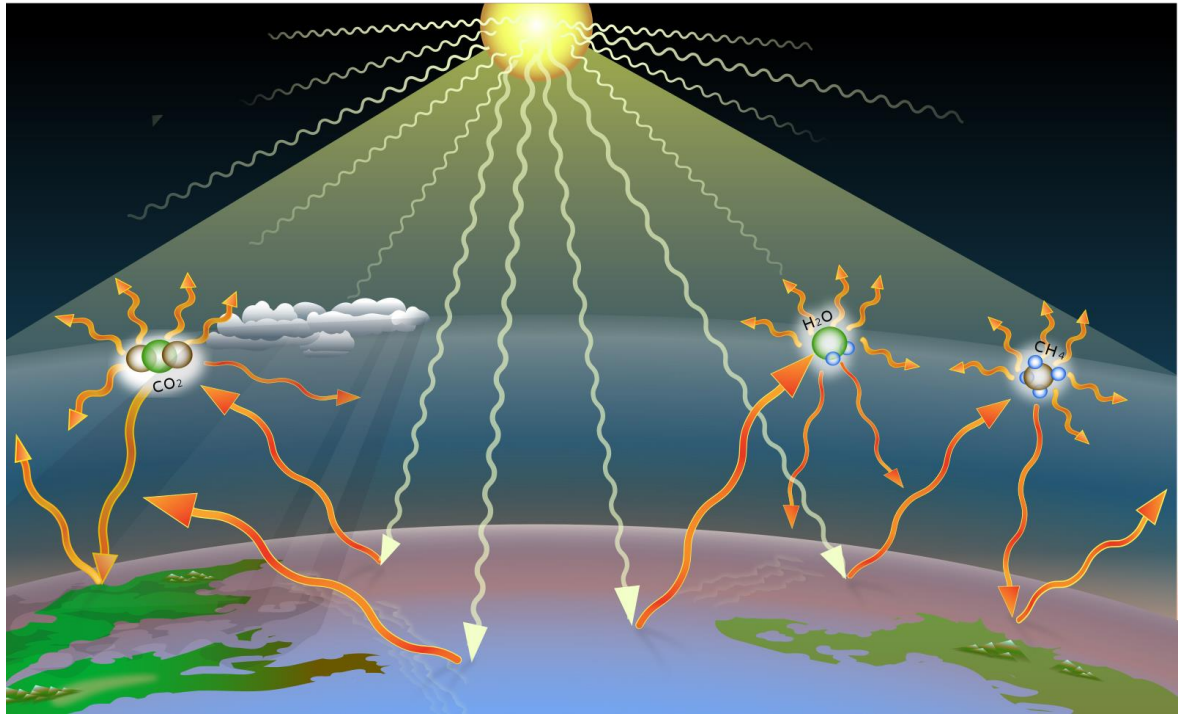
Maintain habitable places	Limit greenhouse gas emission

Maintaining Habitable Places

- Recycling can prevent:
  - Harmful chemicals
  - Greenhouse gasses
  - Deforestation
  - Global Warming
- These dangers are leading towards destruction of habitable places on Earth

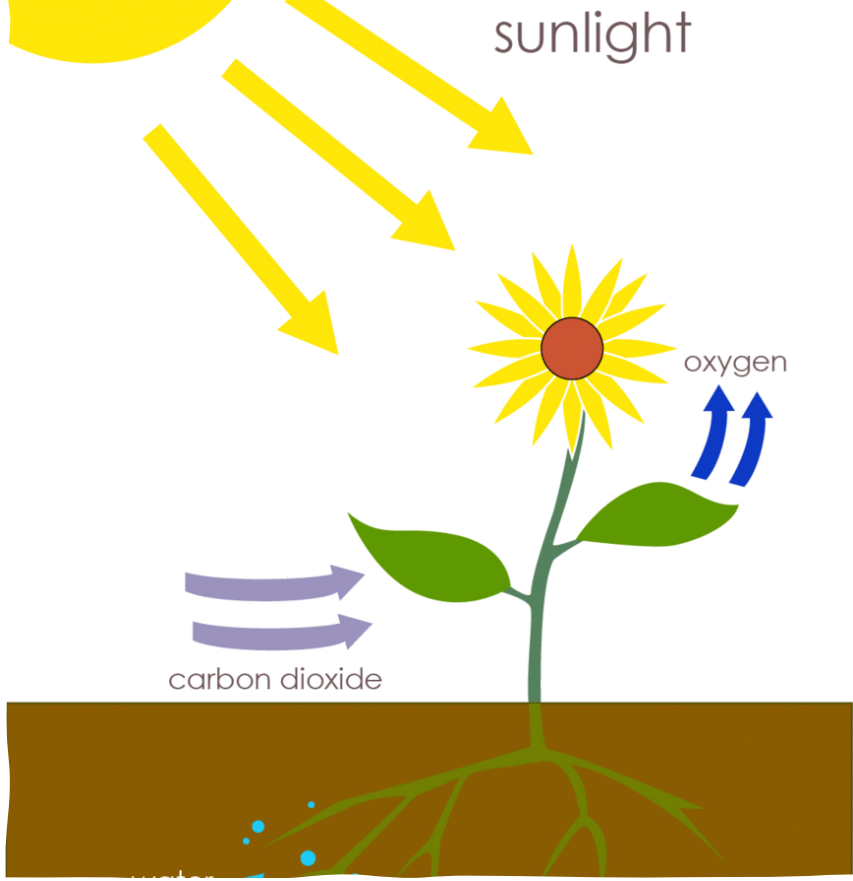
Greenhouse Gases & Global Warming

- Greenhouse gases are the number one cause of recent climate change
- These gases build up in the atmosphere and trap the heat from the Sun in Earth's atmosphere
- Most commonly produce during the transportation or collection of oils, natural gases, and coal



Deforestation

- Plants take in carbon dioxide and release oxygen, which is why we can live on Earth.
- Deforestation is the wide clearing of forests for materials or land.
- The clearing of large amounts of forests will cause carbon dioxide levels to rise, which is one of the major greenhouse gases



Graphics Source (Top): By At09kg - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=17219609

Recyclable Car Ideas

- Body
  - Water bottle
  - Toilet paper roll
  - Cardboard
- Wheels
  - Bottle caps
- Axel
  - Pencil
  - Toothpick
- Engine
  - Straw
  - Water bottle
  - Balloon

Technology

Technology Table of Contents

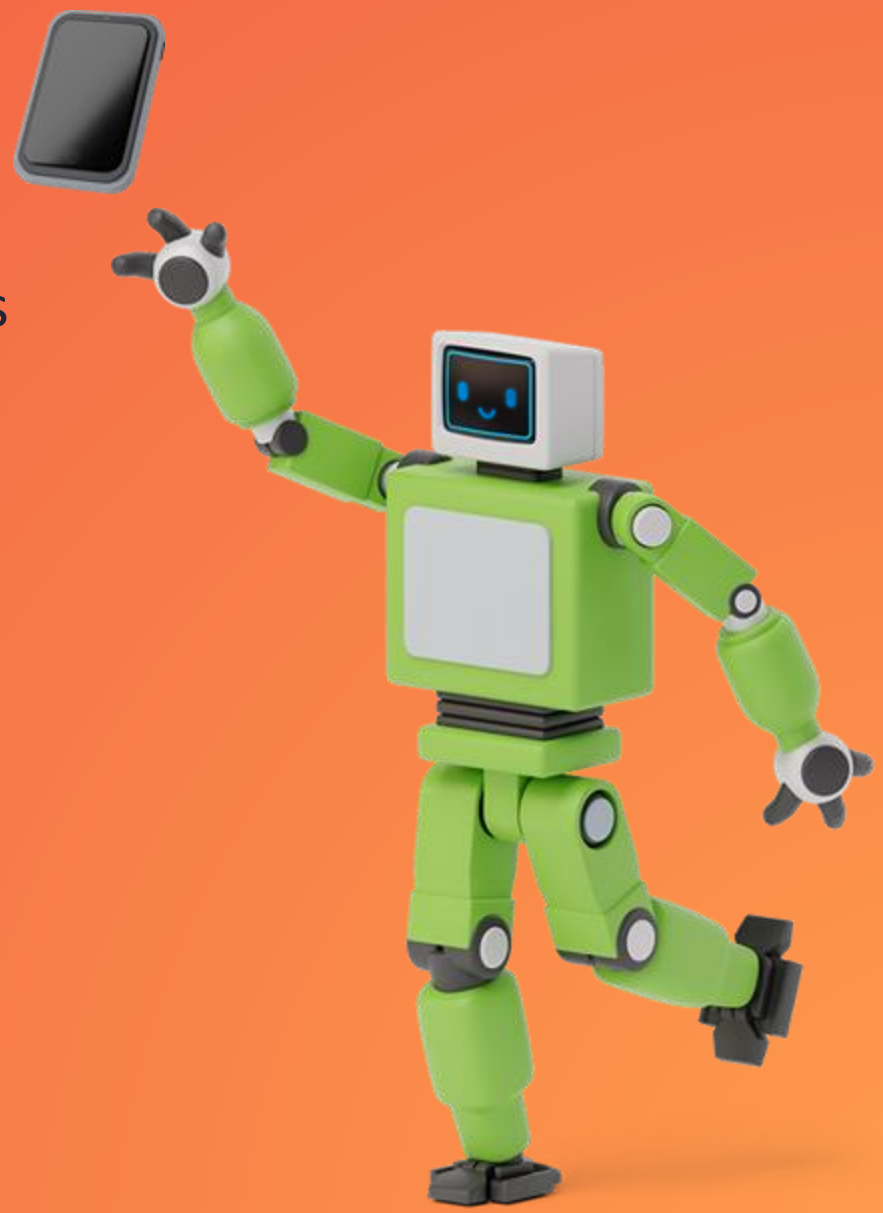
Let’s make a robot!

Intro Question

IF YOU HAD A ROBOT, WHAT WOULD YOU MAKE IT DO?

Let’s talk Robots

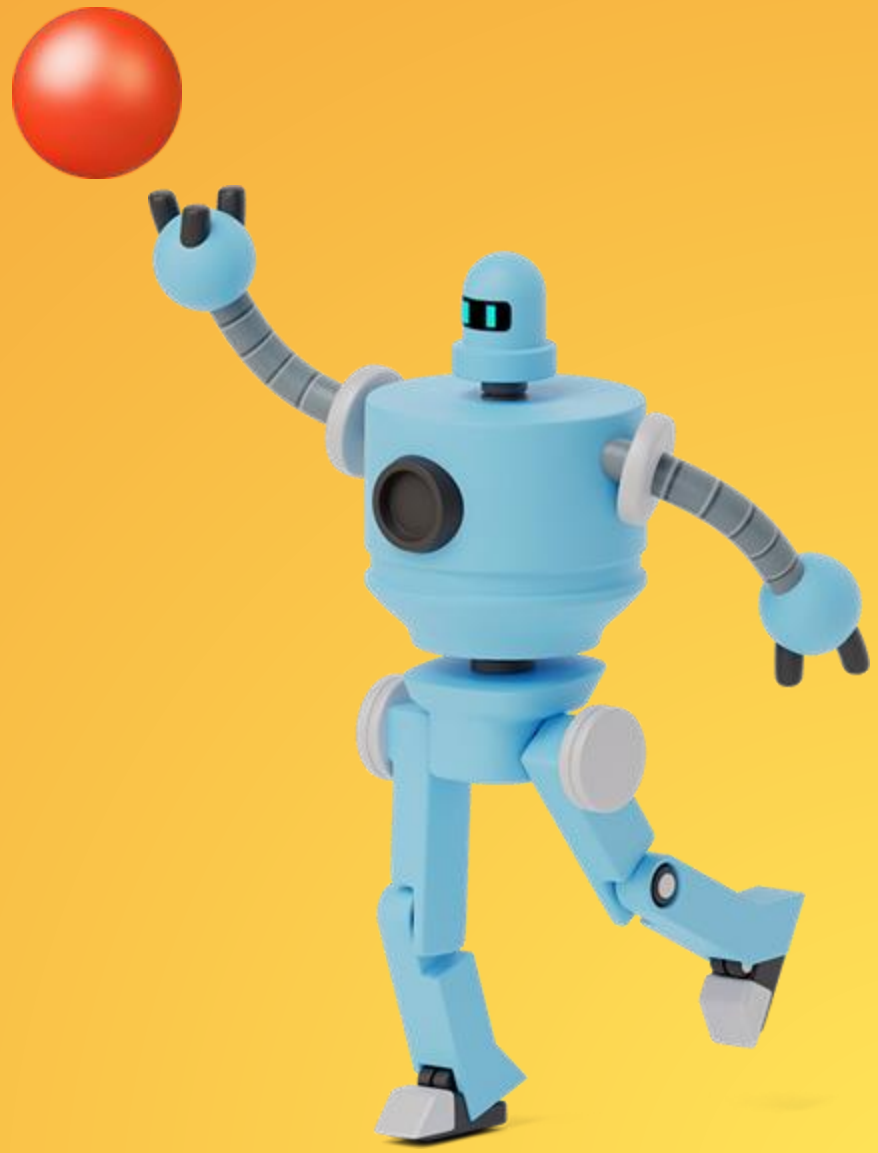
- Robots are machines that can do certain tasks easier, faster, and better than us humans.
- You probably have a robot in your home!
- Can you think of an example?



Who makes robots?

Robotics Engineers!

- They are scientists who:
  - Come up with a new idea for a robot
  - What it will do
  - What it will be made of
  - And how to make the robot work!



What is robotics engineering?

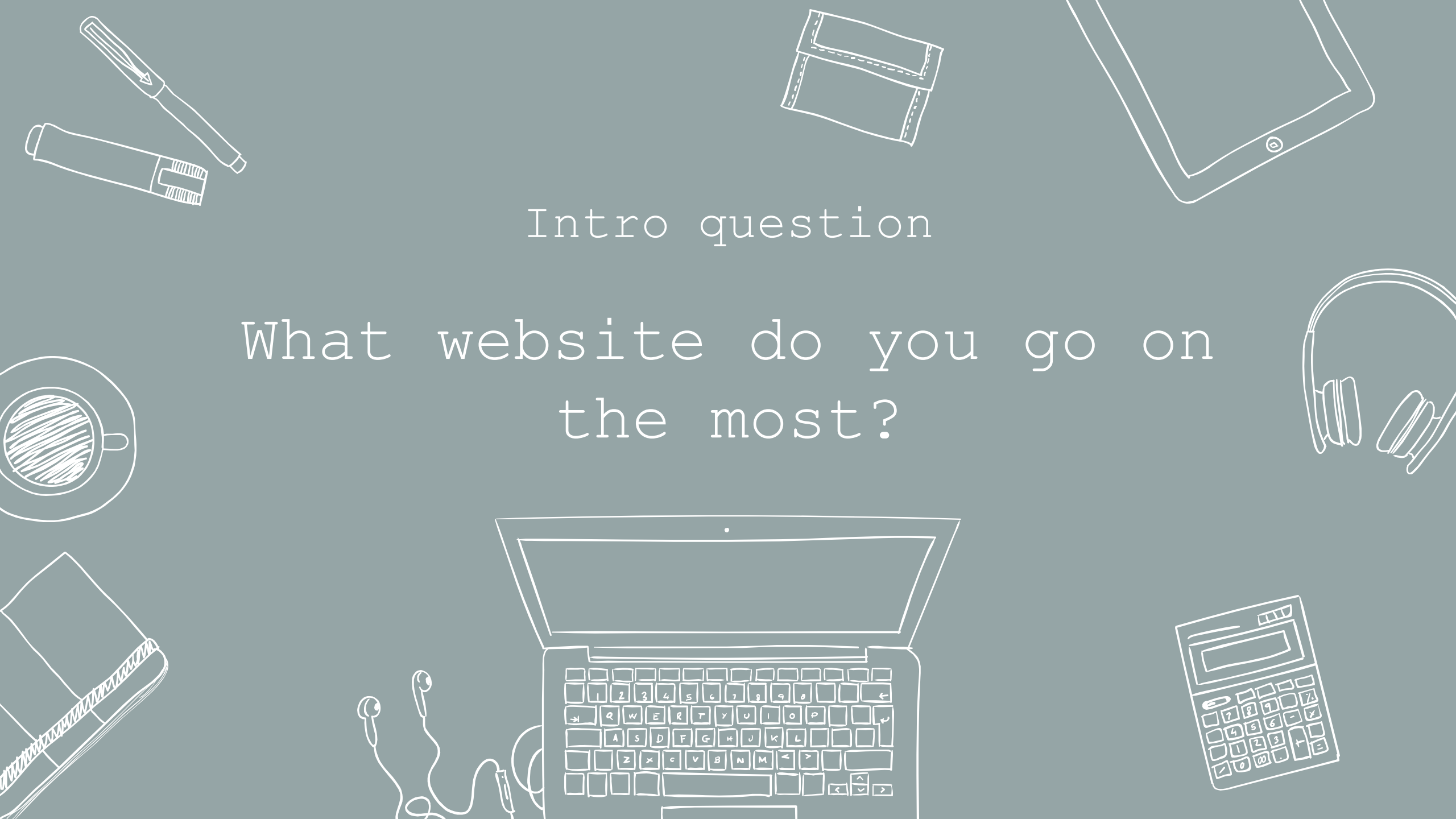
- Robotics Engineering, also known as RBE, is focused on the development and improvement of
  - Autonomous devices
  - Robots
  - Electro-mechanical systems.
- RBE is interdisciplinary, meaning you need skills from multiple fields:
  - Computer Science (writing code = programming)
  - Electrical Engineering (circuits, electrical cables)
  - Mechanical Engineering (building machines)

Activity time!

Design your own website

Intro question

What website do you go on the most?



945,357,100

The number of websites currently online! (Excluding inactive ones)

info.cern.ch/hypertext/WWW/TheProject.html

The first website! Ever! Made in 1991.

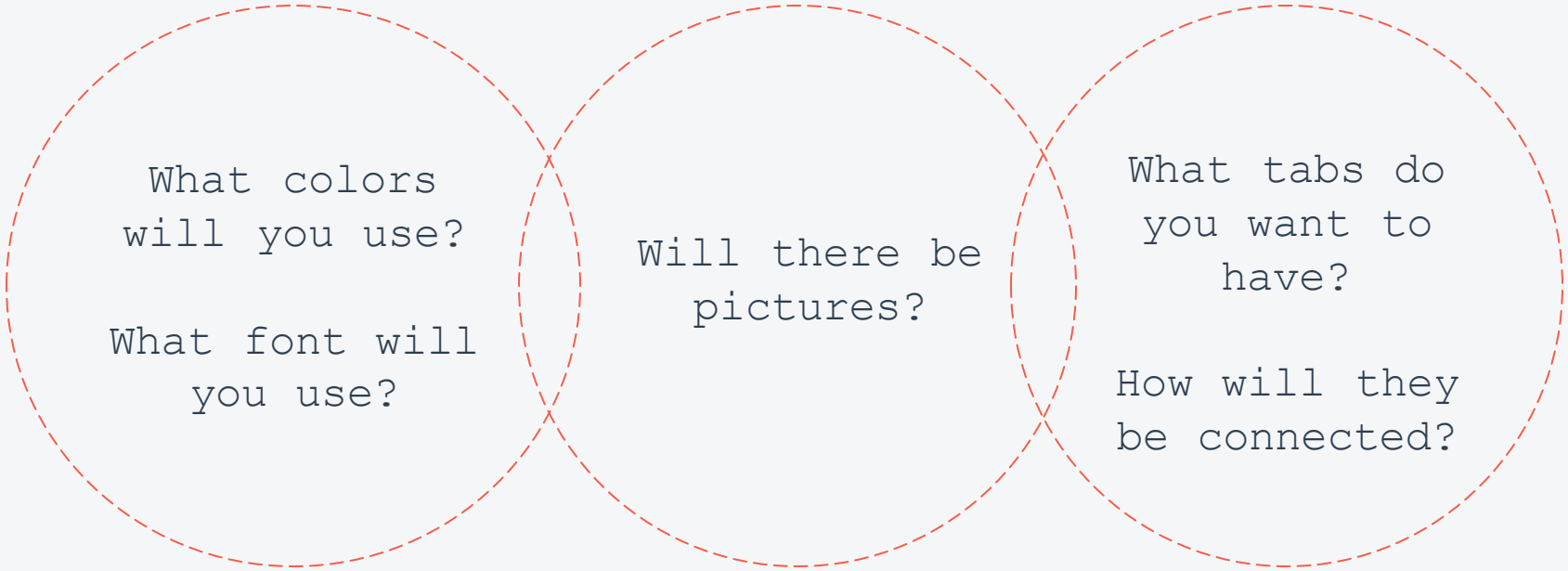
2010

Finland became the first country to make access to the internet a legal right to its citizens.

The Internet

- Websites are pages on the World Wide Web, WWW, or W3C.
- The proposal for the World Wide Web was written in 1989.
- The first ever webcam was not used for chatting. Can you guess what it was used for?

Things to think about when designing a website



These are all parts of the User Interface - what a user sees and interacts with when they get to your website!


Activity Time!!

Play That Tune

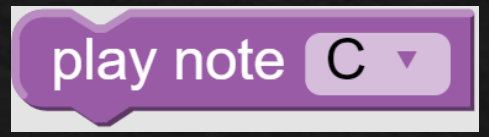
Music Technology

Computer Science (CS)

- CS is the coding behind all technology and the design behind how your computers work!
- In coding there is a concept called pseudocode which is the plain description of what the code means and how it works in steps.
- There are numerous functions that are used for specific purposes in order to make code shorter such as loops, if statements, and other things.

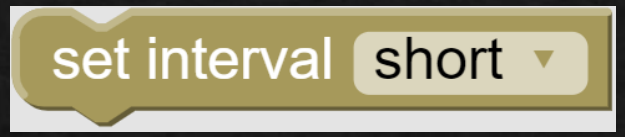
Play That Tune – How it Works

- In Play That Tune there are different levels of difficulty in which a series of notes on the piano will be played. The player will then have to create a pseudocode or layout that matches the played set of notes.
- Once finished deciding the correct order of notes place the code sequence in the “when PlayButton clicked do” box and click the “Play the Tune” button.



Play Note

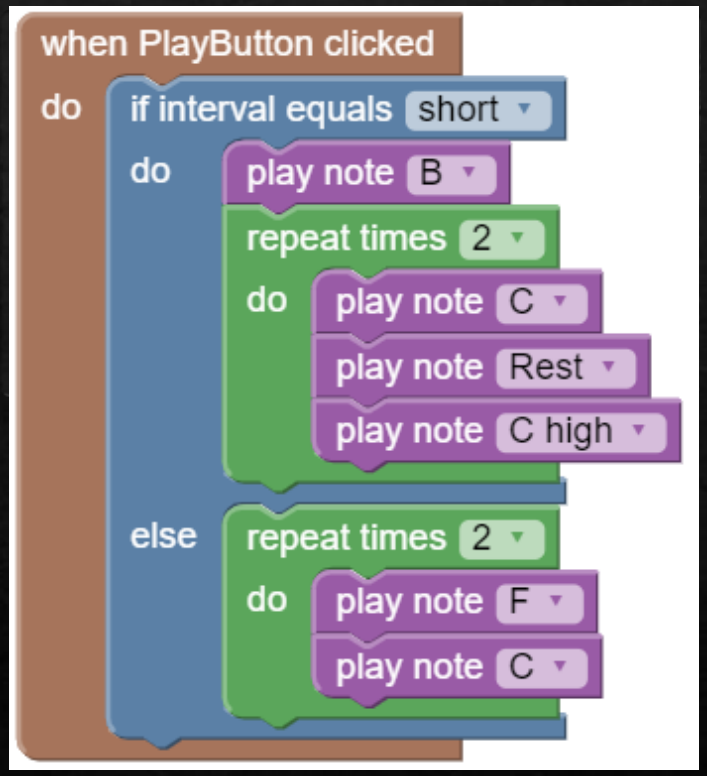
- This function allows you to choose the note you want to play.



Set Interval

- This function allows you to set the interval (the length of the note) from short to medium to long.

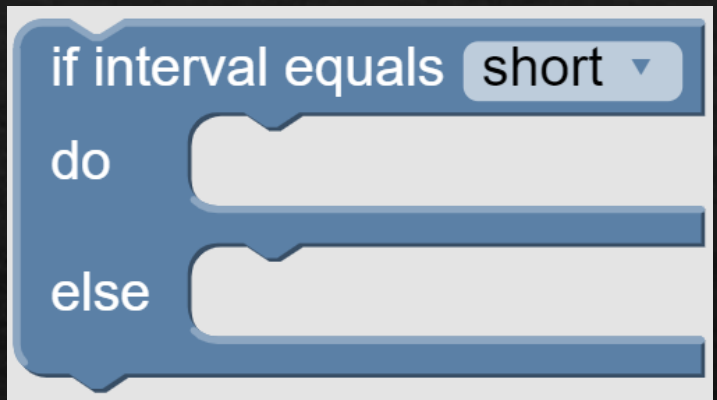
Play That Tune – CS Edition



Pseudocode

Loop

In coding, there is something called a loop which is used to repeat a task numerous times. In Play That Tune, the "repeat times" box is used to repeat a series of notes and represents a loop.



If Statement

An if statement is a function used to direct the path of a code depending on the characteristics of a variable. In Play That Tune, the "if interval equals" box is used in this case to say if interval is short or long do this, if it is not, do this instead.

Activity Time!

Play That Tune link - http://appinventor.cs.trincoll.edu/csp/hourofcode/q/apps/tunes/