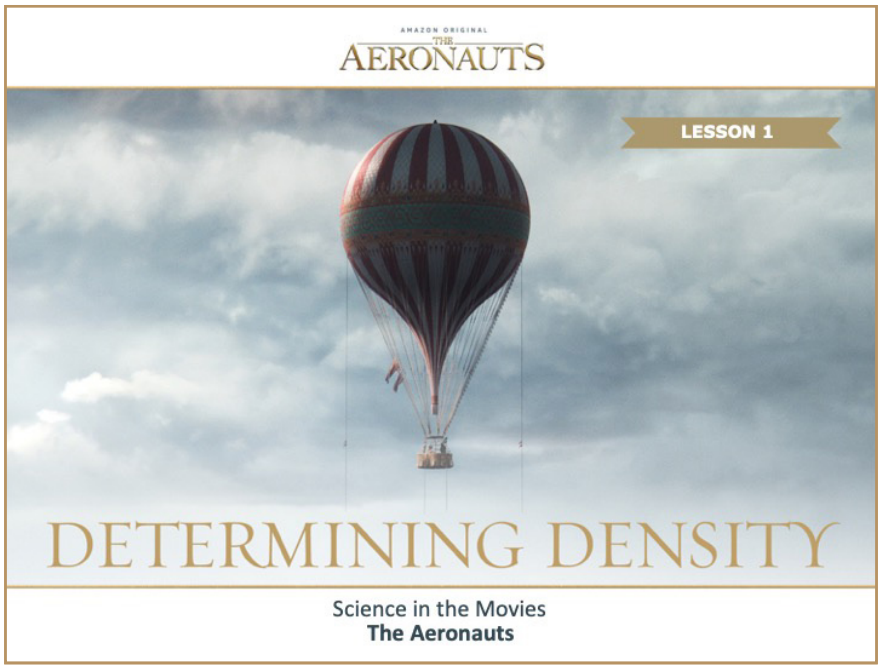
POWER POINT GUIDE: DETERMIINING DENSITY

SLIDE 1



Show the movie trailer. (click on image picture to link to movie trailer).

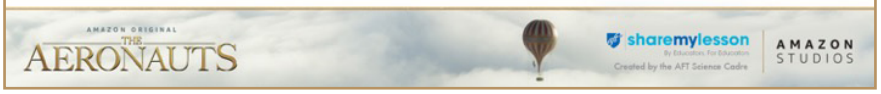
Ask students these questions following the trailer:

- What science concepts do you think Amelia Wren, and other aeronauts need to know to be able to operate their balloon?

https://www.dictionary.com/browse/aeronaut

LEARNING TARGETS

- Use a digital simulation to collect science data
- Use displacement to determine the volume of an object.
- Calculate density.
- Draw molecule diagrams to model the density of solids.
- Compare the density of the gas inside the balloon used in the movie *The Aeronauts* with the density of the gas in our atmosphere.




AGENDA
• Real world connections
• What is density
• Use an online simulation to gather data
• Calculate density
• Graph data
• Molecule diagrams
• Density in the movie The Aeronauts
AMAZON ORIGINAL
THE AERONAUTS
sharemylesson
By Educators, For Educators
Created by the AFT Science Cadre
AMAZON STUDIOS

Ask students:

- Why is an understanding of density important in the real world?
- What are some real-life situations where an understanding of density is important?

Safe boating requires an understanding of the concept of density.

Construction—If you know the density of a countertop, you know how strong you need to build the cabinets to support the weight of that countertop.

This type of work can be done by a general contractor. Right now, the average salary for a general contractor is $59,000 per year, but can be as high as $116,000 per year.[1]

[1] https://www.ziprecruiter.com/Salaries/General-Contractor-Salary

Does anyone know what this car is? – Bugatti, fastest street car manufactured?

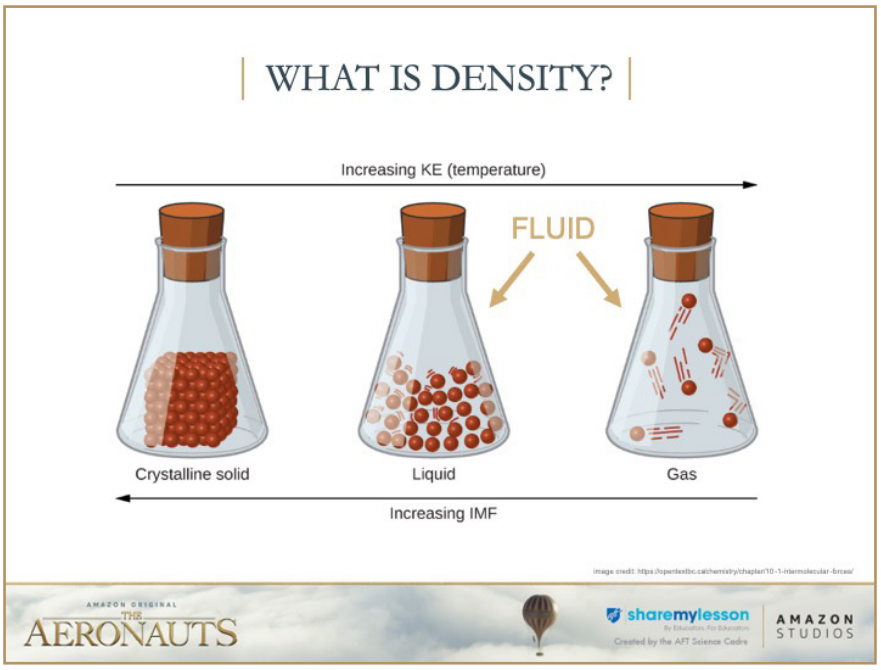
Engineers consider the density of materials that they use to build cars. The less dense the material that they use to make the car, the faster it will be able to go and it will get better gas mileage.

This work would be done by an automotive engineer.

The average salary for an automotive engineer is, $76,142, but can be as high as $121,000 per year.[1]

[1] https://www.glassdoor.com/Salaries/automotive-engineer-salary-SRCH_KO0,19.htm

Aeronauts of the 19th century and even today depend on the density of the gas inside their balloon. The density of the gas inside the balloon is what controls the behavior of the balloon, whether it will ascend or descend at any given time.

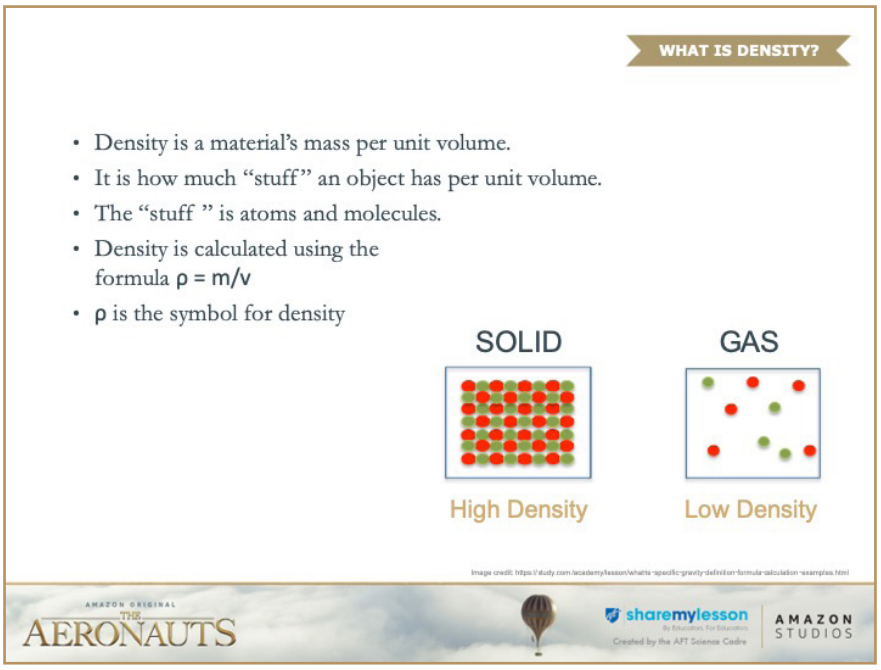


In our simulation, we are going to collect data that will allow us to determine the density of a variety of solids.

- The three states of matter that are common on earth are **solid, liquid, and gas.**
- In our lesson today we will be collecting data about the density of solids.
- In solids, the particles are packed tightly together. The intermolecular forces between molecules are strong enough that the particles cannot move freely. Therefore, solids have a definite shape and volume.[2]
- Liquids **AND** gases are considered fluids because they can flow.
- In liquids and gases, the forces between the molecules are weak enough that the molecules can move over or alongside one another[1], or flow.

[1] https://www.scientificamerican.com/article/go-with-the-flow/

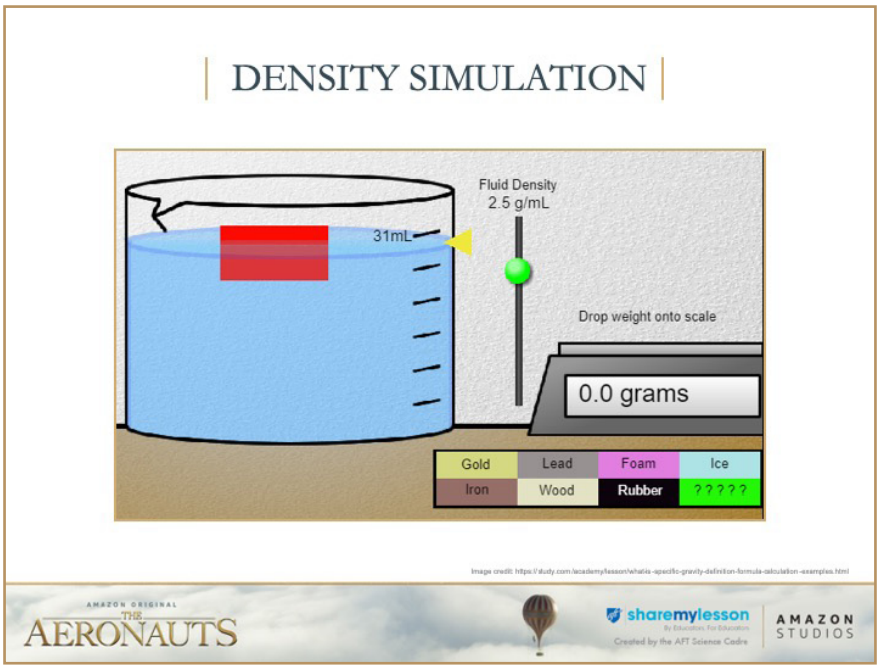
[2] https://courses.lumenlearning.com/boundless-chemistry/chapter/classification-of-matter/



Teacher Hint: If available, pass around density cubes so students can feel that objects that are the same size, do not necessarily have the same mass. If you don't have density cubes, consider filling plastic Easter eggs with different materials like sand, or marshmallows, etc

So, what is density?

- Density is a material's mass per unit volume.
- It is how much "stuff" an object has per unit volume.
- The "stuff" is atoms and molecules.
  - Look at the pictures. Both boxes have the **same** volume. The circles represent atoms. We can tell by the arrangement of the molecules that the box on the left is a solid and the box on the right is a gas. The solid has high density because there are more atoms. The gas has low density because there are fewer atoms. Solids have higher density than gas because the molecules are held close together by strong intermolecular forces. If we are comparing a solid to a gas, there are more molecules in the same size sample of a solid.
- Density is calculated using the formula **ρ = m/v**
- **ρ** is the symbol for density



We are going to explore density using an online simulation.

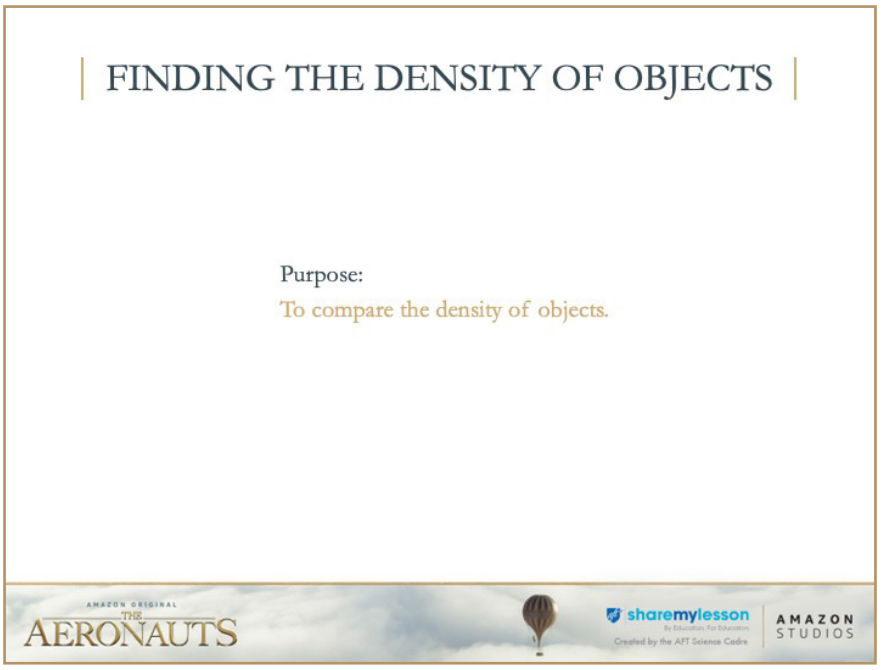
Teacher Hint: *Use the word "fluid" to describe the liquid in this simulation. The content knowledge in this simulation will be used to help students understand why the balloon in the movie the Aeronauts floats in air, which is also a fluid.

Give the students time to play with the simulation and see what all they can manipulate. When they are finished, have them share their favorite feature with a partner. Then have students come forward and demonstrate simulation features (on a white board or using the projecting computer)

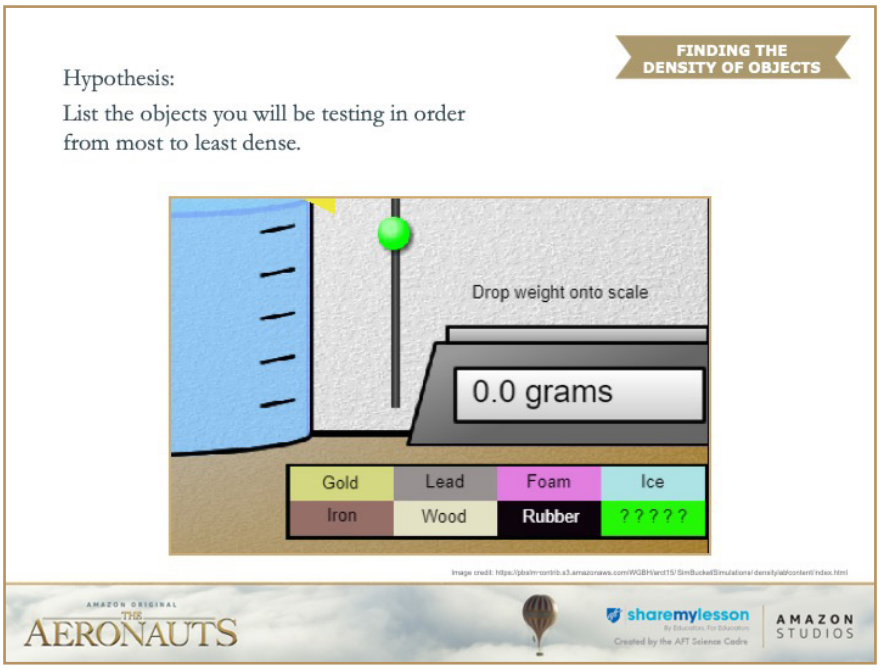
Make sure they know they can:

- Drag objects to the electronic balance
- Read the mass of the objects on the electronic balance
- Read the volume of water on the beaker
- Drag a floating object under water
- Change the fluid density (by moving the green circle up and down the vertical scroll bar)
- Change the mass and volume of an object (by moving the blue and red buttons along the horizontal scroll bars)
- Turn the fluid into water (click on the light blue button at the top left of the window)
- The randomize button drops objects of an unidentified substance into the simulation (pink button at the top of the window)
- The reset button refreshes the simulation to original settings. (black button at the top right of the window)

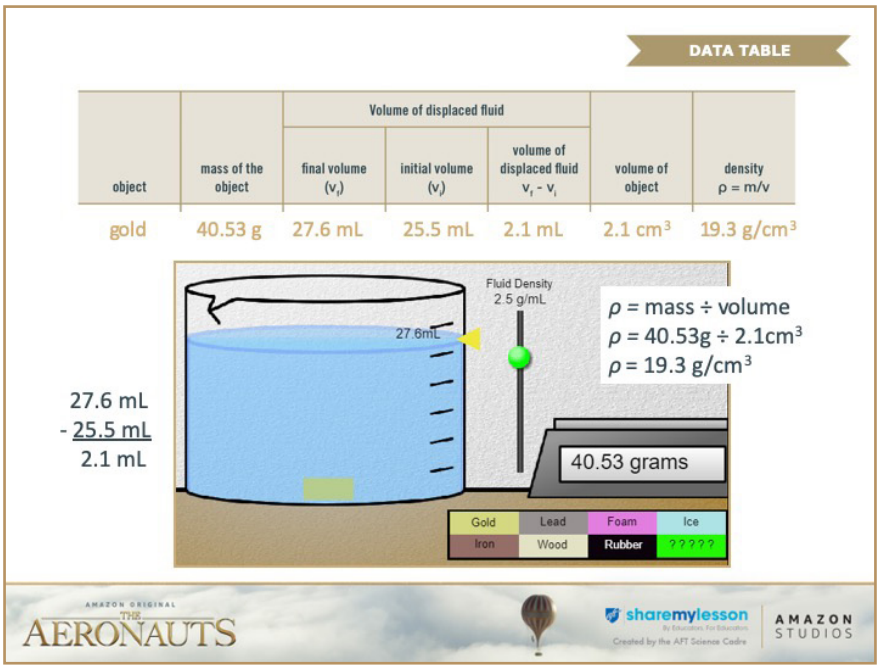
*Use the word “fluid” to describe the liquid in this simulation. This is building content knowledge that will help students understand the science behind their upcoming balloon engineering design challenge. Using the term “fluid” instead of water helps students understand that we are observing a phenomena that occurs in all fluids, including air, not just water.



Have students record the purpose for the lab on the "Determining density data recording sheet".



List the objects you will be testing in order from least to most dense.



To fill out the data table, we will find the mass of the objects using the digital balance. We will find the volume of the objects using displacement. Then we will calculate the density.

We will do gold together. Complete the data table for gold as we go along.

- Click on gold.
- A block of gold will drop into the beaker.
- Drag the gold from the beaker to the digital balance.
- Record the mass of the gold on your data recording sheet. Make sure you include the unit for mass, grams (g).
- Observe the volume of fluid. Record the volume of the fluid in the initial volume column (vi)
- Drag the gold into the beaker.
- The gold displaces water in the beaker so now the water level is higher. Record the new water level on the beaker in the final volume (v_i) column.

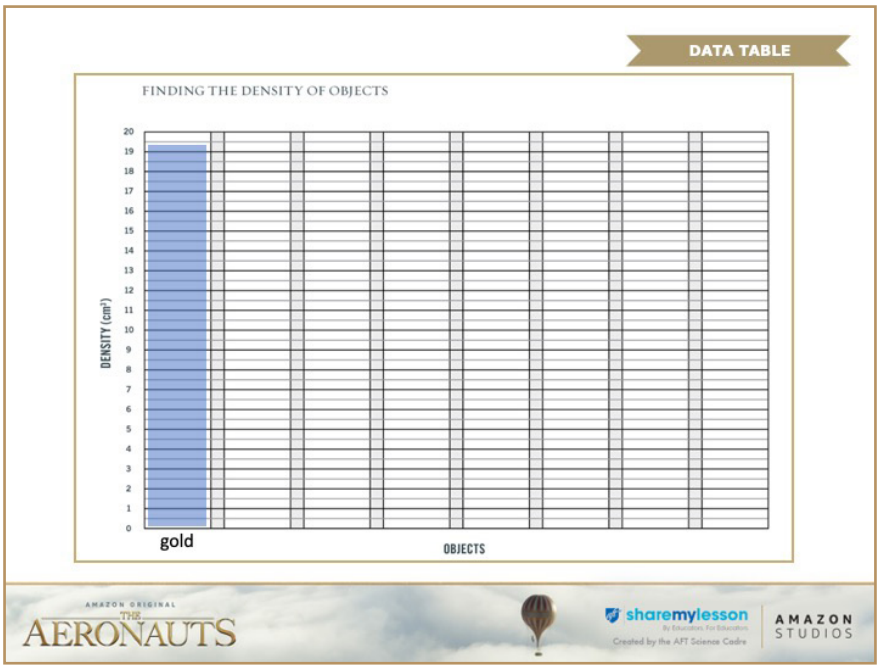
To find the volume of displaced water, subtract the initial volume from the final volume. (27.6mL – 25.5 mL is 2.1mL.)

- This means that the block of gold took up the space that was occupied by 2.1 mL of water.
- The volume of gold is the same as the volume of 2.1 mL of water.

Milliliters is a unit of measure that describes the volume of a liquid. The gold block is a solid. Cubic centimeters is a unit of measure that describes the volume of a solid. 1mL of liquid is the same volume as 1 cubic centimeter. Since our gold block displaced 2.1 mL of liquid, the volume of the gold bock is 2.1 cm^3.

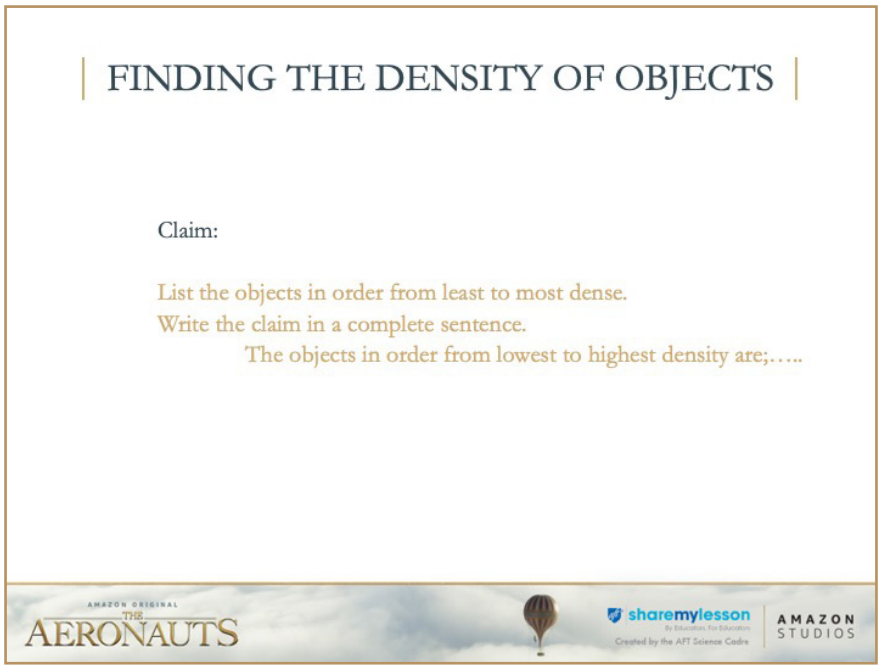
Now we know the mass of the gold and the volume of the gold so we can calculate the density.

Calculate density by dividing the mass of the object by the volume of the object. We divide 40.53 g by 2.1cm^3. The density of gold is 19.3 g/cm^3.



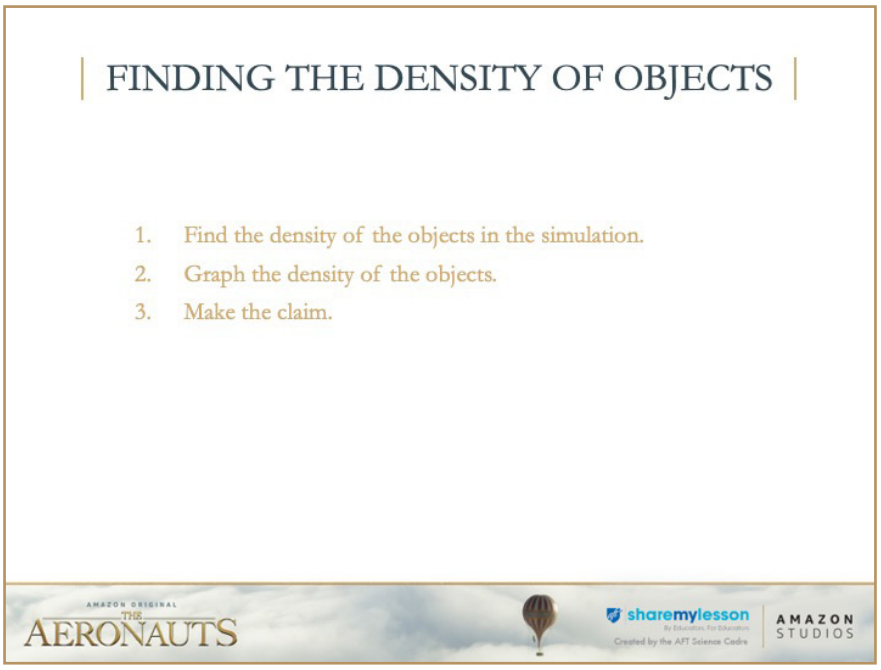
After you have found the density of the objects, graph the densities on the graph paper.

- The density of gold was 19.3 g/cm^3
- Label one of the columns gold.
- Fill in the column up to 19.3 g/cm^3 ,which would be a little more than halfway between 19 and 19.5.

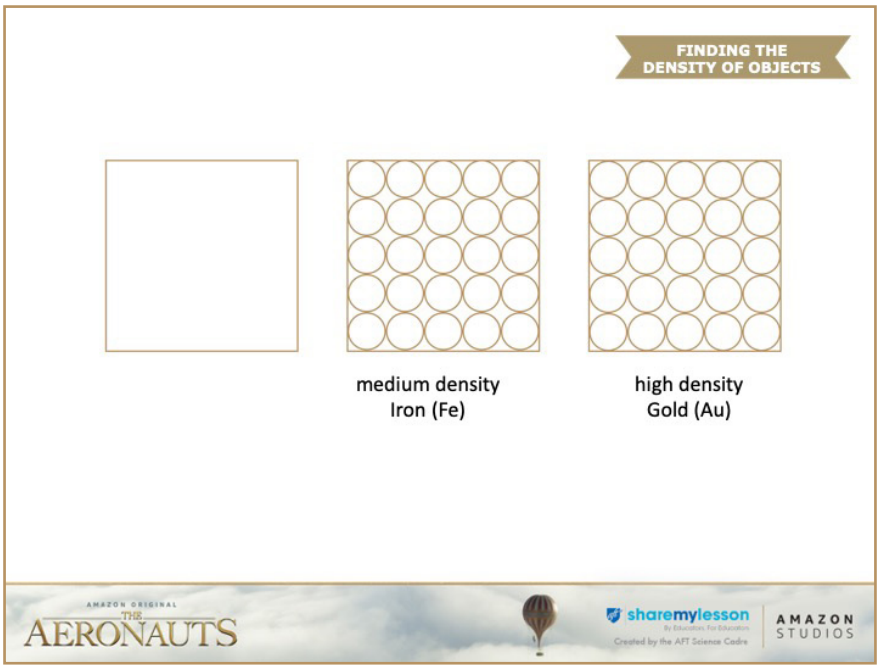


- After scientists gather data, they summarize their findings by making a claim.
- The data becomes the evidence to support the claim.

- For the claim, list the objects in order from least to most dense.
- Be clear in your communication by writing a complete sentence.



Project this slides while the students work to keep them on task.



REASONING

Good scientists do not just make a claim. They explain why. Why is gold denser than lead? Why is lead denser than foam? A good scientist explains the reason the results of their investigation turned out the way it did. One of the tools scientists use to communicate phenomena is models. Models represent a system or part of a system and are used to communicate ideas to others.

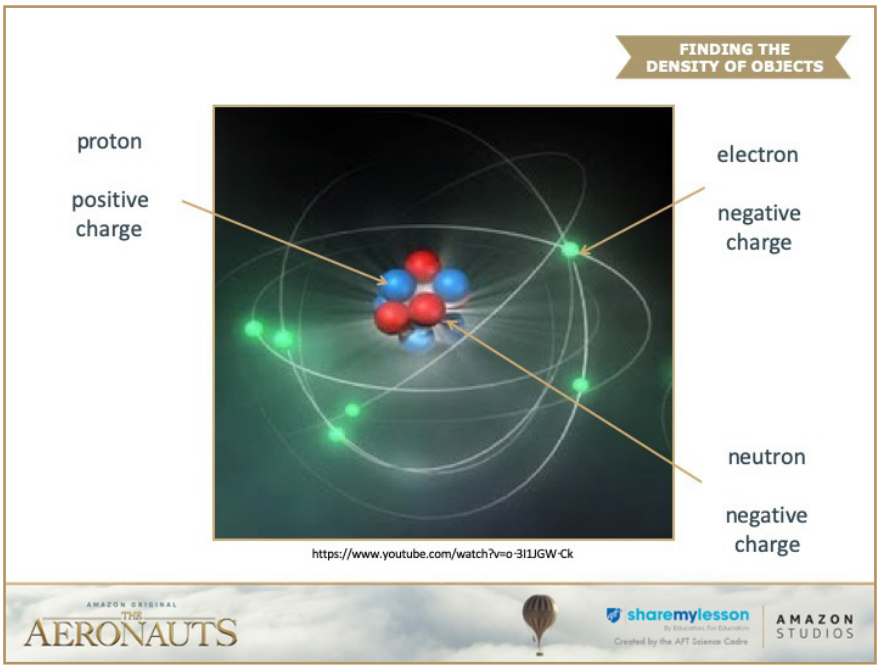
We are going to use particle models to communicate why our solids had different densities.

- Density is influenced by the number of particles (atoms/molecules) in a given volume. It is also influenced by the mass of those particles.
- The boxes represent one cm^3 samples from three of the objects you tested. We will look at a low, medium, and high-density material we explored in the simulation.
- Let's start in the middle. Iron had a density of 7.87 g/cm^3. Label the middle box medium density and iron (Fe).
- Add circles to the iron diagram to represent the iron atoms. Because this is a solid, the atoms are arranged in a regular pattern. Due to strong forces between the atoms the atoms stay in a fixed position. The atoms do vibrate in place while holding their fixed position.

Now let's look at the densest item in the simulation, which was gold. Label the box, high density and gold (Au).

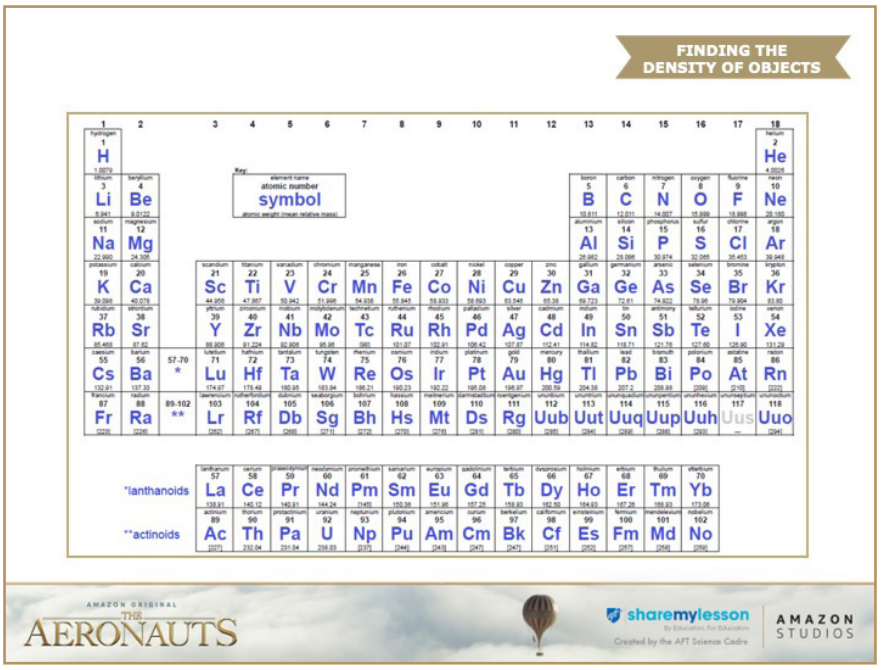
- Here is what the particle model would look like for gold.

The models for gold and iron look the same, don't they! Why?



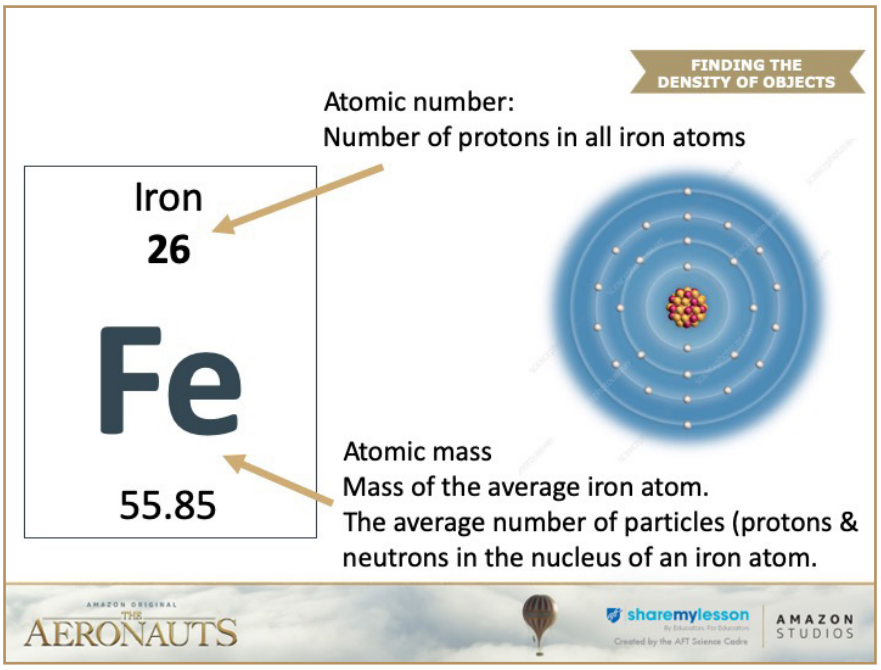
The iron cube is filled with iron atoms. The gold cube is filled with gold atoms. This is an atom.

- An atom has a center called a nucleus and an area around the nucleus called the electron could.
- The nucleus contains particles called neutrons and protons.
- The mass of the atom is determined by the number of protons and neutrons in the nucleus. The more protons and neutrons in the nucleus, the heavier the atom is. The electrons are so small that their mass is insignificant.



The periodic table of elements provides information about each known atom.

One of the facts we can look up on the periodic table is the mass of atoms.



One of the things the periodic tells us about an element is the mass of the element.

- This number is the atomic mass.
- This means the average Iron atom has a mass of 55.85 atomic mass units (AMU).
- Protons have a mass of 1 AMU.
- Neutrons have a mass of 1 AMU.
- Electrons are so small that their mass is insignificant.

This tells us that the average iron atom has about 56 particles (protons and neutrons) in the nucleus.

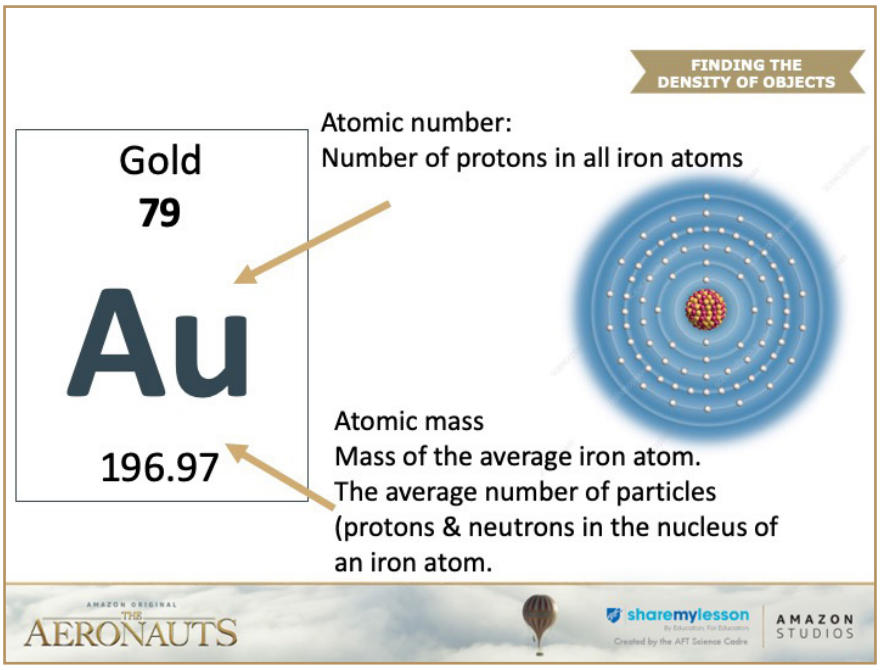
All iron atoms have 26 protons.

- Around 92% of iron atoms have 30 neutrons, giving it a total of 56 particles in the nucleus.
- Around 6% of iron atoms have 28 neutrons, giving it a total of 54 particles in the nucleus.
- Around 2% of iron atoms have 31 neutrons, giving it a total of 57 particles in the nucleus.
- Around .3% of iron atoms have 32 neutrons, giving it a total of 58 particles in the nucleus.1

These different versions of iron atoms are called isotopes.

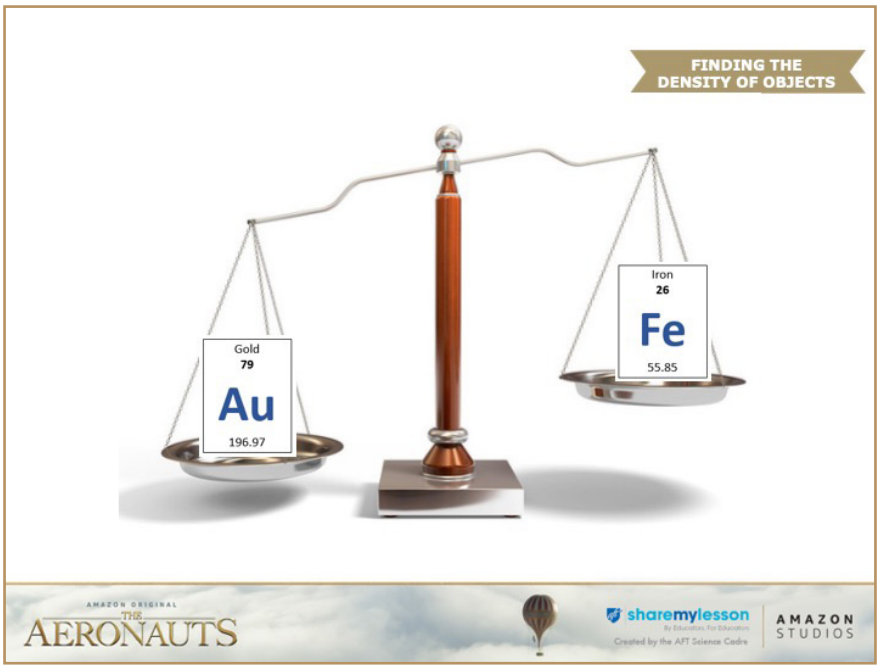
Given these percentages, the average iron atom has 55.845 particles in the nucleus, giving the average iron atom a mass of 55.845 AMU.

[1] https://education.jlab.org/itselemental/iso026.html



Here is gold.

- The average gold molecule has an atomic mass of 196.97 AMU.
- This means the average gold molecule has about 197 particles in the nucleus.

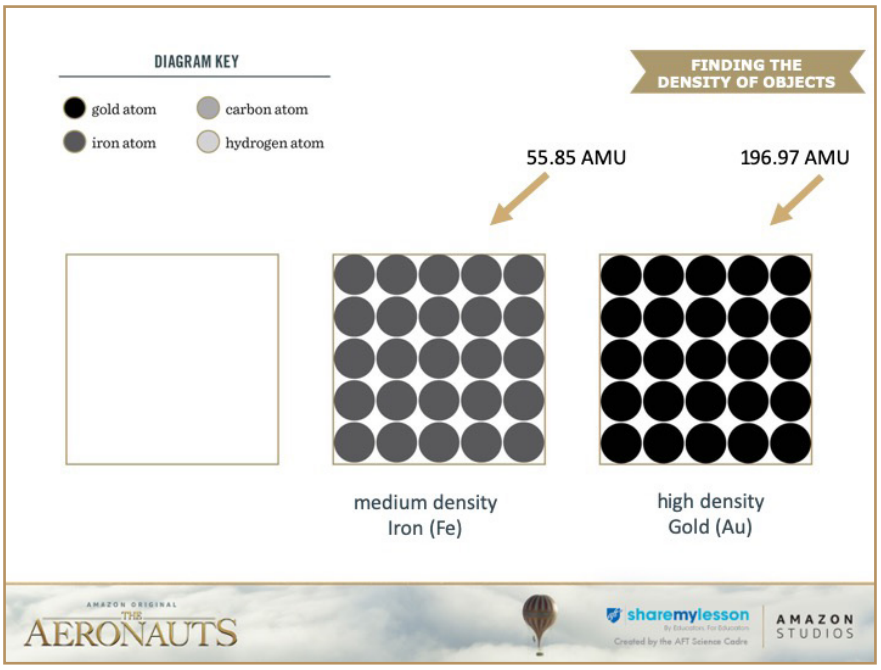


An atom of gold is heavier than an atom of iron. Each atom of gold weighs 4 times as much as an atom of iron.[1]

Because there are more protons and neutrons in a gold nucleus, the gold nucleus is a little bigger than the iron nucleus, but not much. There are nearly as many gold atoms as iron atoms in a $1cm^3$ sample.[1]

Gold is denser than iron because gold atoms are heavier than iron atoms.

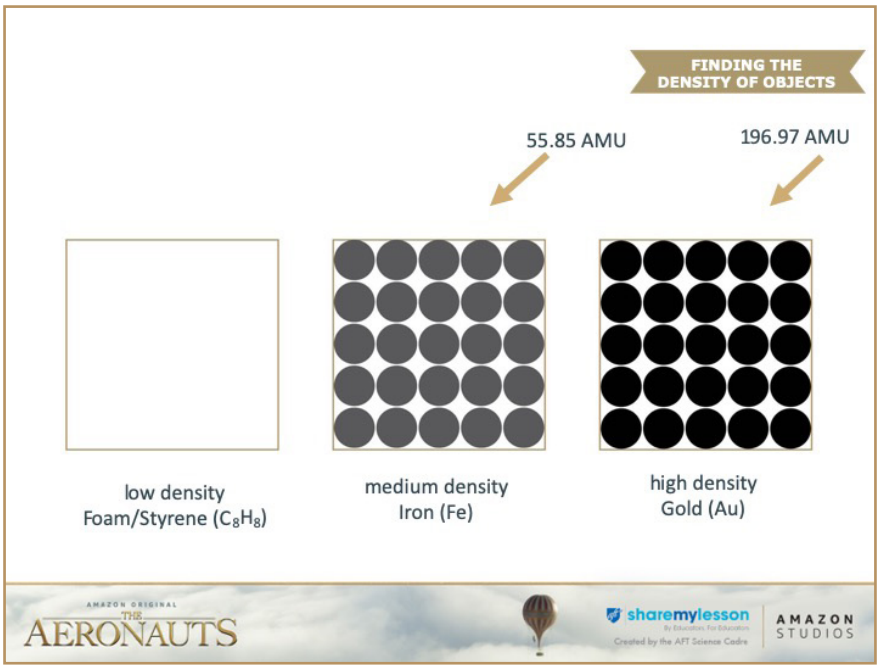
[1] https://van.physics.illinois.edu/qa/listing.php?id=606&t=gold-vs.-iron



We will use color to enhance our model to communicate why the gold cube is denser than the iron cube.

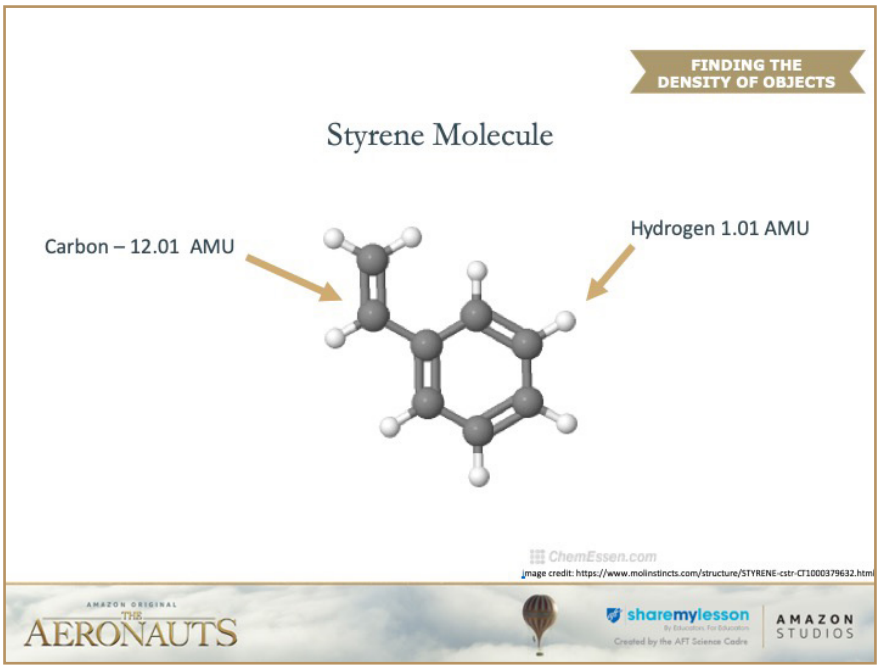
- Let's start by using color to communicate the fact that these cubes are made from different atoms. The darker the color, the greater the mass.
- Make the gold atoms in the gold cube black. Make the iron atoms in the iron cube gray.
- Next, label one of the atoms in each model to communicate the atomic mass.

Complete the key to communicate the color you used for the gold and iron atoms.



Let's look at a low-density sample from the simulation.

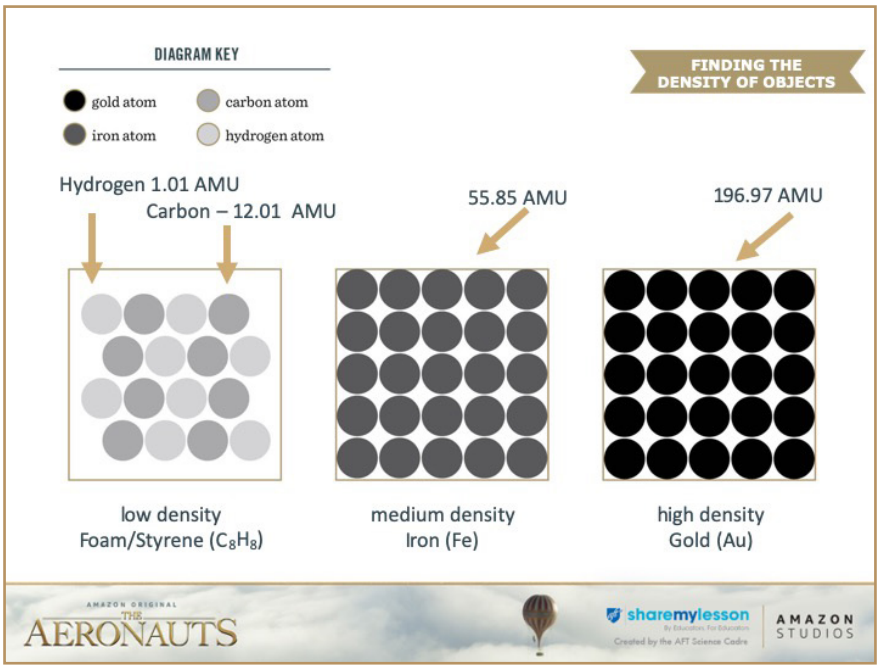
- The least dense block from the simulation which would be foam.



Styrofoam is made from a long chain of styrene molecules. The chains are called polystyrene. Styrene is made from Carbon and Hydrogen atoms.

- Carbon and Hydrogen atoms have a relatively low atomic mass.

Additionally, as part of the Styrofoam manufacturing process, polystyrene is expanded with air. As a result the molecules are not as tightly packed and there is empty space. Here is a picture of polystyrene foam from an electron scanning microscope.



This means that not only is Styrofoam made from very light atoms. But there would be fewer atoms in a $1cm^3$ sample as a result of the manufacturing process.

How can we represent the fact that there are fewer atoms in the sample?

- Draw fewer circles

How can we represent the fact that styrene is made from carbon and hydrogen atoms?

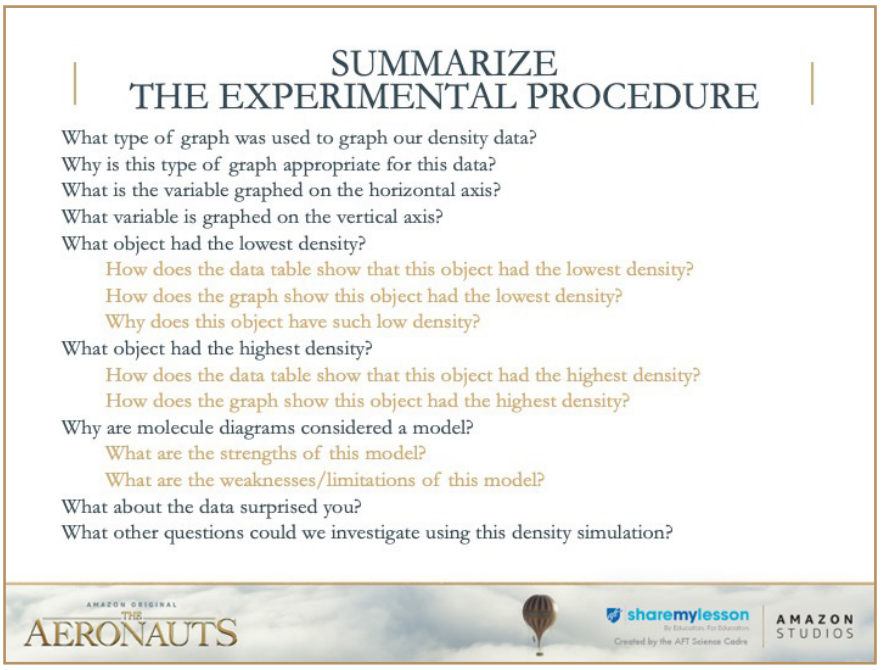
- Use different colors

How can we represent the fact that carbon atoms have a lower atomic mass than iron and gold? And hydrogen has an even lower atomic mass than carbon?

- Use light gray to represent the carbon atoms and white to represent the hydrogen molecules.

Label the atomic mass of your hydrogen and carbon atoms.

- Update the table to show the colors used to represent carbon and hydrogen.



Students should work together to answer these questions in groups of two or three. Use inside/outside circles strategy for students to share their answers with other classmates.

Summarize the procedure. **Use the digital balance to find the mass of the objects, use displacement to determine the volume of the object. Calculate the density of each object using the formula ρ = mass ÷ volume**

What type of graph was used to graph our density data? **bar graph**

Why is this type of graph appropriate for this data? **We were graphing the density of objects. Objects are qualitative data.**

What is the variable graphed on the horizontal axis? **Objects**

What variable is graphed on the vertical axis? **Density**

What object had the lowest density? **Foam had the lowest density.**

- How does the data table show that this object had the lowest density? **0.23 is the smallest density value on the data table.**
- How does the graph show this object had the lowest density? **The height of the bar communicates the density of the object. Foam has the shortest bar.**
- Why does this object have such low density? **Foam is made of hydrogen and carbon atoms which**

have a low atomic mass. Also, due to the manufacturing process, there is a lot of empty space between the molecules, so there are fewer molecules in a sample of foam.

What object had the highest density? **Gold had the highest density.**

- How does the data table show that this object had the highest density? 1**9.3 is the largest density value on the data table.**
- How does the graph show this object had the highest density? **The height of the bar communicates the density of the object. Gold has the tallest bar.**
- Why does this object have such high density? **Gold atoms have a higher atomic mass.**

Why are molecule diagrams considered a model? **Models are used to communicate ideas to others and include diagrams. This diagram communicates why different materials have different densities.**

- What are the strengths of this model? **It shows the molecular arrangement of solids, and shows why the foam was much less dense than the iron or gold.**
- What are the weaknesses/limitations of this model? **This model does not show that atoms are vibrating in place, it does not show that iron atoms are slightly smaller than gold atoms. It does not show the arrangement of atoms in the styrene molecules or the arrangement of styrene molecules into polystyrene chains.**

What about the data surprised you? **(answers will vary) I thought iron would be denser than gold.**

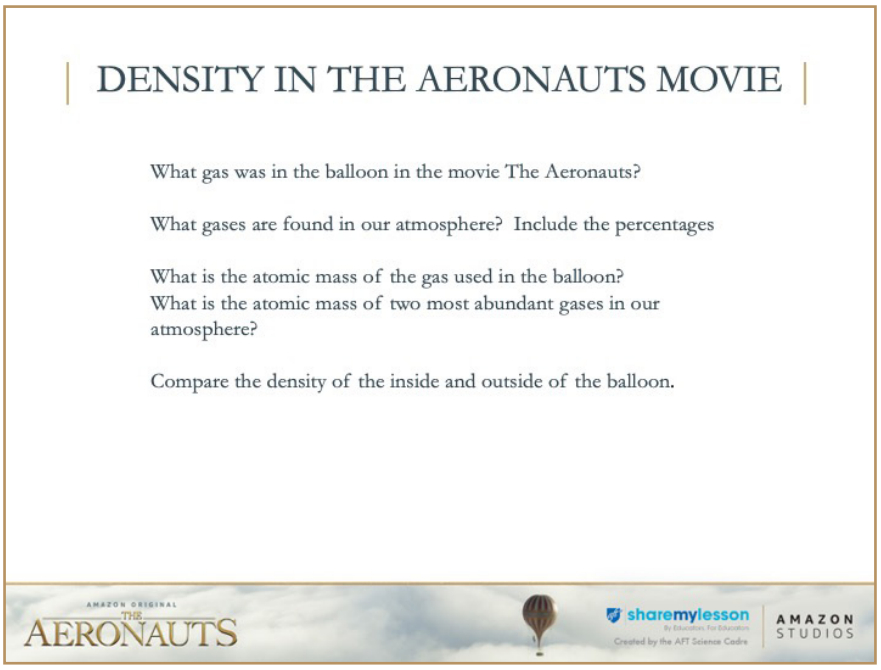
What other questions could we investigate using this density simulation? **Why some objects float and some do not. Relationship between mass and density. Relationship between volume and density.**

Aeronauts must understand density in order to operate their balloons.

- We just looked at densities of solids, but what about densities of gas?

The hot air balloon in the movie *The Aeronauts* was filled with helium gas.

- The fluid surrounding the balloon was gas in our atmosphere.



Use your textbook or the internet to look up the following information. Write a paragraph that answers the following questions. If you use the internet, cite your sources.

SAMPLE PARAGRAPH:

The gas used in the balloon featured in the movie *The Aeronauts* was Helium. The gases found in our atmosphere are Nitrogen (78%), Oxygen (21%), Argon (0.93%), Carbon Dioxide (0.04%), and trace amounts of Neon, Helium, Methane, Krypton, Hydrogen, and Water Vapor.[1] The atomic mass of Helium is 4.00 AMU. The atomic mass of Nitrogen is 14.01 and Oxygen is 16.00.[2] The density of the gas inside the balloon would be lower than the density of gas outside the balloon because helium atoms weigh less than the atoms found in high concentration in our atmosphere.

[1] https://www.space.com/17683-earth-atmosphere.html

[2] https://www.sigmaaldrich.com/content/dam/sigma-aldrich/articles/biology/marketing-assets/periodic-table-elements.png