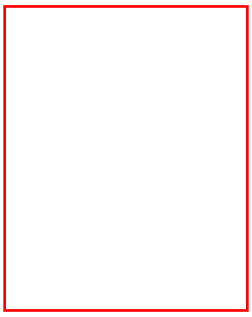
Unit #1



Activity 1
Up, Up and Away: Building a Hot Air Balloon

Activity Overview

The question of how a hot air balloon works sets the context for making the connection between the micro and macro scale worlds.

In this activity students investigate the question: "How does a hot air balloon work?" Students begin by building small hot air balloons and then launching them. Students then discuss how they think a hot air balloon floats. Finally, students are introduced to the use of models as a tool for understanding.

Learning Objectives

Students will:

- Construct and launch a hot air balloon.
- Propose hypotheses and make critical comments about each others' ideas.
- Define, in the simplest terms, what a model is.

Conceptual Prologue

Macro-Micro Connection

In this unit students will be exploring the basic characteristics of how atoms behave and how the behavior of invisibly small atoms (microscale) can explain what is observed with the eyes (macroscale). To draw students into a study of the abstract concept of invisible atoms, the hot air balloon is used. Throughout the unit the curriculum will refer back to how what was learned can further extend understanding of why the hot

air balloon flies. In this activity, students will begin their journey to the micro world by observing the macro behavior of a hot air balloon, and developing hypotheses about how it works.

Science Concepts

In this activity students build hot air balloons and are asked to consider how they might work. To really understand how they work, students need to understand the nature of the atomic scale world. Specifically, a full explanation would eventually require that they understand that all substances are made of atoms and molecules, that these particles move randomly, that the temperature of atoms and molecules are directly related to their kinetic energy which is the energy of motion related to mass and velocity, and that pressure is due to the repeated impacts of molecules. Throughout this module, as students learn more of these concepts, we will return to the idea of the hot air balloon to obtain a deeper understanding of how it works.

Naive Conceptions

Many issues may come up during the discussion of how the hot air balloon works. The point of this activity is to get students thinking, not to correct all of their naive science conceptions in this one lesson. As this is the intro to the curriculum this activity serves as a way to determine what students understand. It would be good to note what kinds of naive conceptions come up during the discussion of the hot air balloon, so that these can be addressed with the appropriate activities later in the unit.

Some possible naive conceptions that may come up include:

- Air is not matter.
  Air is matter. Anything that has mass is considered to be matter.
- All gasses are the same substance - air.
  Different gasses consist of different atoms or molecules. Even air is a mixture of several different molecules.
- Matter is continuous.
  Matter is particulate, consisting of atoms and molecules with empty space between them.
- Hot things expand because the molecules or atoms get bigger when they are hot.
  Hot things expand because the distance between their atoms or molecules expands.
- Heating something makes it lighter.
  Heating only speeds up the motion of the atoms or molecules; it does not affect their mass.
- The word "model" doesn't have any scientific meaning.

Model, in scientific terms, can mean several things. In this activity the term model is used most loosely to refer to an idea or theory of how something works. A more useful idea of a model which will be explored in later activities is something which based on certain rules can make predictions about various phenomena, like behavior of gasses, the weather, and the economy. Students may hear the word "model" and think: fashion, a good example, a small replica, etc.

Activity Design and Execution

Major Science Concepts:	• None
Assumed Previous Knowledge:	• None
Time:	• 50 minutes to build and launch the balloons • 20 minutes for the discussion
Materials:	OPTION A: for each group: • Scissors • Ruler • Pencil • 2 sheets of tissue paper (51 cm x 60 cm) • Glue stick • 4 paper clips • Bunsen burner for the entire class: • Fire Extinguisher (just in case) OPTION B: for each group: • Scissors • Ruler • Pencil • 9 sheets of tissue paper (51 cm x 60 cm) • Glue stick • 1 sheet of construction paper for the entire class: • hot air popcorn popper (~1440 watts) Option C: for each group: • A dry cleaning bag • Cellophane tape • 10 Paper clips for the whole class: • Hair dryer or hot air popcorn popper (~1440 watts)

Advanced Preparation: (if any)	• If option C is chosen below have students bring in dry cleaning bags the thinner the better. • Have students bring in a three ring binder and some lined paper to go in this binder. This will be the notebook in which they will keep all of their notes, assignments, worksheets, lab results, etc.

Investigative Question: How does a hot air balloon work?

Give the Prepost test

1. Explain to students that they will build a hot air balloon and try to come up with some explanation for how it works.
2. Have the students build a hot air balloon based on one of the three options below:
    a. Have groups of 2-3 students build a small hot air balloon out of tissue paper that will be launched using a Bunsen burner. PDF file of small balloon plans.
    2. Have 2-4 students each build a larger hot air balloon out of tissue paper that will be launched with a hot air popcorn popper. PDF file of large balloon plans. (Used with permission from the Science Learning Network as OMSI.)
    3. Have 2-3 students each build a hot air balloon from dry cleaning bags that will be launched with a hair dryer (or hot air popcorn popper). HTML page of plastic balloon plans.
3. After students launch their balloons, ask them “How does a hot air balloon float?” This will help us determine how students are currently thinking about the problem and what previous knowledge they have about heat, gasses, and why things float. The goal of this discussion is not to answer this question but to bring up questions which can be addressed with other activities later on. The discussion should be very open, encouraging students to comment upon each other's explanations.
4. When the class seems to have settled upon 2-3 different explanations, talk to the students about the concept of modeling. Tell them that each explanation could be called a different model of what is happening. Further explain that modeling can take many forms, and that we will use lots of different models in our quest to understand how a hot air balloon flies.

Assessment

Have students write several things in their notebooks:

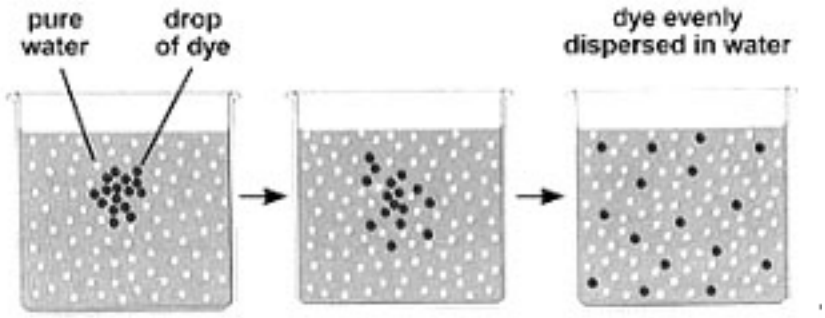
1. Define in their own words what a model is.
2. Write down the 2 or 3 models that the class came up with to explain how a hot air balloon works. Provide diagrams where necessary.

Extensions

• If there is time at the end of the module, it would be nice to close with the construction of a larger scale hot air balloon. This could be done with tissue paper or plastic bags.
• A mathematically advanced class could actually determine the temperature at which a balloon will begin to float.

Name_____
Date_____
Teacher _____
Block/Class_____

Atoms in Motion Pre/Post test



1. Can you explain why dye spreads across a solution as in the above illustration?

2. Imagine you are at a party where someone dared you to pop one of the helium balloons in a room that has all the windows and doors closed. Describe what would happen to those Helium atoms once they have been released from the balloon. Specifically talk about their eventual position inside the room and what their kinetic energies would be like if you could actually measure them.

3. Suppose you were the size of a molecule in a liquid in a glass. Someone takes that glass and puts it in the freezer. After a while the liquid freezes. How does what you see and feel change?

4. Draw a picture of a closed container that has 10 **oxygen molecules in a gaseous state**. Label the molecules A through J. Then draw a picture of the gas a "little while later." The second picture should show where you think the molecules A through J might be at this time.

5. Draw a picture of a closed container that has 10 **liquid water molecules**. Label the molecules A through J. Then draw a picture of the liquid a "little while later." The second picture should show where you think the molecules A through J might be at this time.

6. Could there be a compressible liquid? Explain your answer using molecules/atoms in your answer.

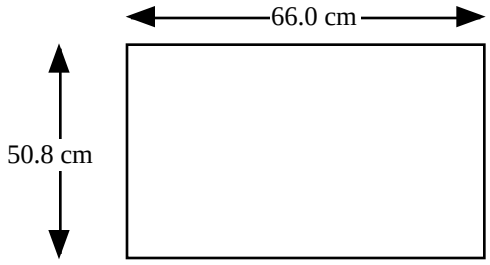
7. Why does a hot cup of coffee placed on a counter cool down? Why does a glass of iced tea warm up? Describe what is happening at the atomic level.

8. You have two boxes of equal size each containing a gas. The two gases are at the same temperature but on average particles in one box are moving faster than particles in the other box. How can that be?

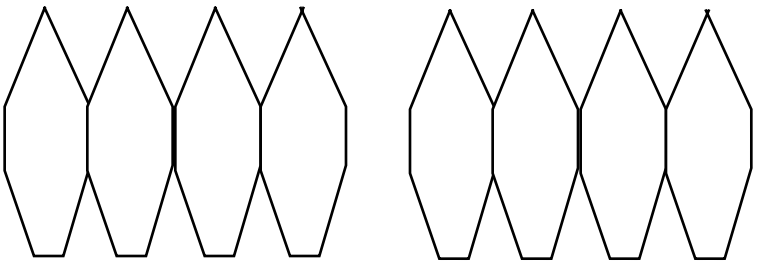
Floating on air. A Hot Idea.

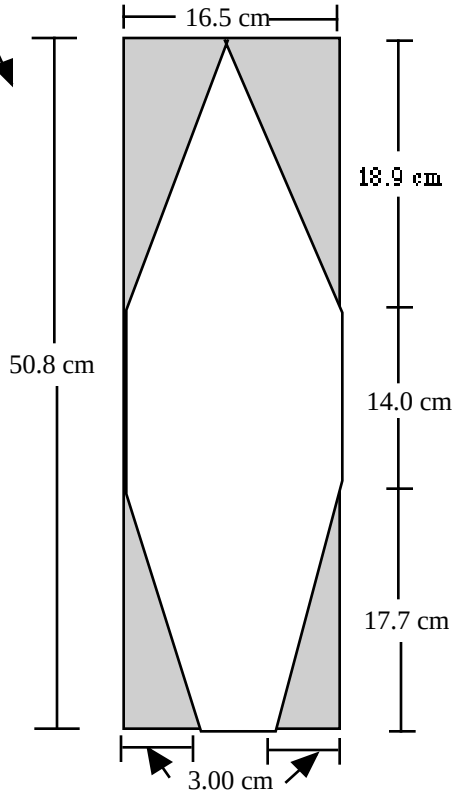
Directions for making a hot air balloon:

1. In order to build your balloon you will need two pieces of tissue paper, a stick of glue, a ruler, scissors, and 4 paper clips.
2. Place the two pieces of tissue paper on top or each other and orient them longways.

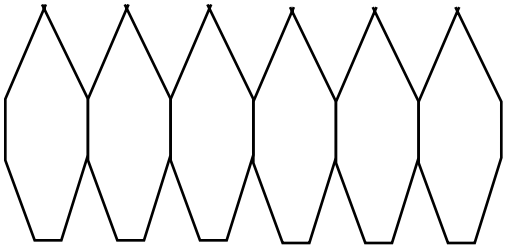


3. Fold them in half and in half again to form a rectangle 19.0 cm x 50.8cm.
4. Draw the following outline on your paper, and cut away the shaded areas.
5. Open up the paper. You should now have eight shapes, four of which are already joined together.

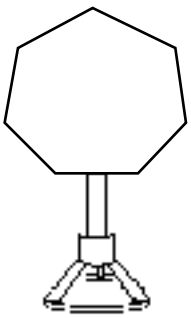




6. Cut one section from each piece and paste the two pieces together.

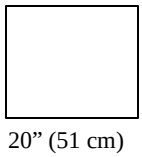


7. Now paste all of the edges together and put four paper clips on the bottom to stabilize your balloon.
8. Make sure there is nothing highly flammable within 6 feet of your Bunsen Burner.
9. Turn on your Bunsen burner and adjust it so that you have a very short and hot flame. It is important that your flame not be too tall or you will easily catch your balloon on fire.
10. Carefully lower the balloon so that the flame is inside the balloon just beyond the opening and hold it there for about a minute or more. You should start to feel the balloon begin to rise. Continue holding it for several more seconds, carefully lift the balloon straight up off of the burner and release it.

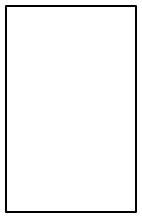


Hot Air Balloons

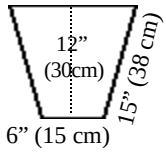
Make one square:



Make four rectangles:



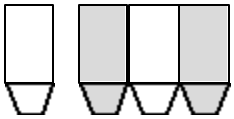
Make four trapezoids:



Materials:

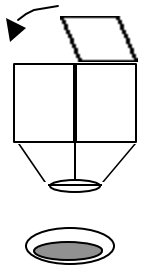
- tissue paper (9 sheets)
- construction paper strip
- glue stick, scissors, ruler, pencil
- hot air popcorn popper (~1440 watts)

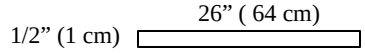
Glue the rectangles and trapezoids into panels. Glue the panels together.



Glue the square on top.

Make a construction paper ring. Glue it on to the bottom edge of the balloon.





Hold the balloon over the hot air popper.

How high does the balloon go when it is filled with hot air for a short time? a long time?

How can you tell when it's ready to fly?

Many things influence how well a balloon floats: the temperature and density of the air (both inside *and* outside the balloon), the mass of the balloon materials, and the distribution of weight. To learn more, check out *Air Travelers*, http://www.omsi.edu/sln/air

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Hot Air Balloons

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Make four trapezoids:

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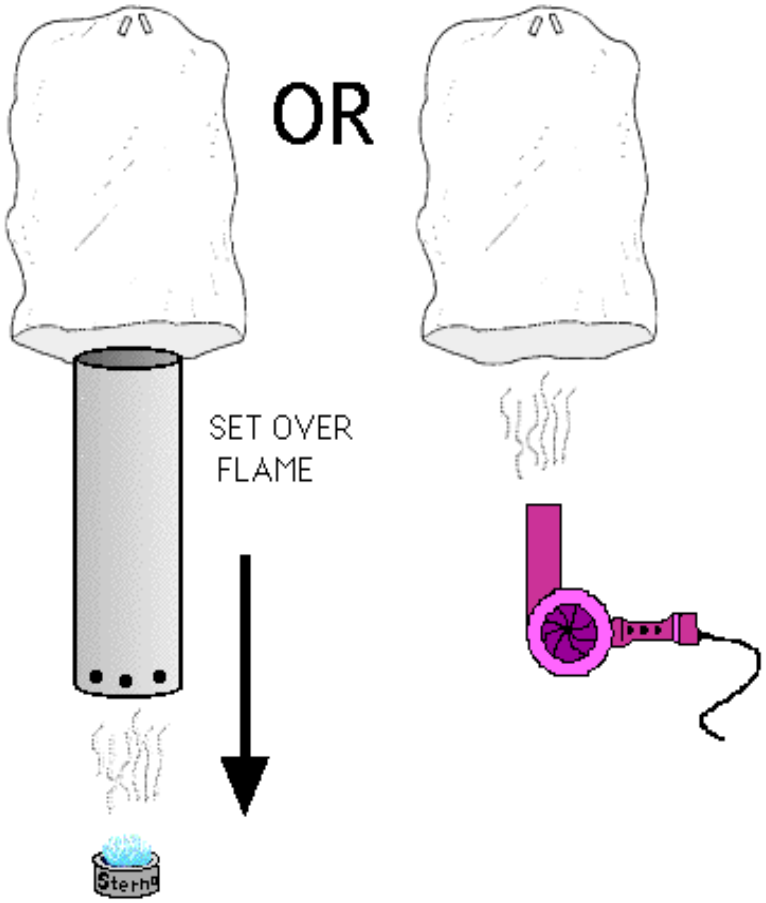
Hot Air Balloon

SUBJECT: Aeronautics
TOPIC: Lift
DESCRIPTION: An indoor hot air balloon made out of a plastic film dry cleaner bag.
CONTRIBUTED BY: Gregory Vogt (OSU)
EDITED BY: Roger Storm, NASA Glenn Research Center

MATERIALS:
Dry cleaner plastic film bags (select a bag with the thinnest possible plastic and have several on hand. You may have to experiment with bags of different thicknesses.)
Several small paper clips
Cellophane tape
Heat source (Blow dryer, sterno, backpacker camp stove, etc.)
Matches
Three feet of aluminum heat duct (if using open flame heat source)
Electric drill (to put holes in the heat duct)

PROCEDURE:
1. Seal any openings and tears in the upper end of the bag with a minimum of cellophane tape.
2. Attach several paper clips to the plastic around the lower opening. The number of paper clips to attach is determined by experimentation.
3. If using sterno or some other open flame heat source, prepare the heat duct by drilling several holes around the base to allow air to flow in.
4. Turn on the blow dryer (or light the Sterno or stove and then set the heat duct over it) Spread the bag opening wide to capture the rising hot air while supporting the upper end with your hand. It is best to have assistance in keeping the bag open so that it does not melt.
5. When the bag is inflated with hot air, test its buoyancy by letting it go for a moment. If it rises quickly, stand back and let it fly otherwise continue heating it for a little while longer.
6. If the bag tips over and spills its hot air before it reaches the ceiling, add a few more paper clips to weigh down the bottom slightly. If the bag will not rise at all, remove a few clips.



CAUTION: Be careful not to brush clothes or fingers into the flames or touch the metal heat duct. Keep a fire extinguisher handy if you use flames. If the bag starts to crumple and melt from the heat, set the blow dryer on a lower setting or hold the bag farther from the heat source.

DISCUSSION:
Hot air is less dense than cold air. Heat accelerates the motion of the air molecules causing fewer molecules to occupy the same space as a much greater number of molecules do at a lower temperature. With fewer molecules, the hot air has less mass, and therefore is buoyant than an equal volume of colder air.

Placing the dry cleaner bag over the heat source captures the hot air and forces out the cooler air in the bag. The bag becomes a mass of low-density air which floats upward in the higher denser air surrounding it. The paper clips are placed at the bottom of the bag to keep the open end downward in flight to prevent it from prematurely spilling the hot air and terminating the flight.

HOT AIR BALLOON WORLD

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Air Density

Aerospace Education Services Project
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