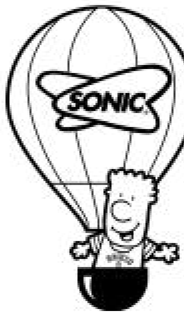


SONIC JUNIOR BALLOONIST LESSON PLAN

OVERVIEW & OBJECTIVES

Students will construct and fly a hot air balloon

- To learn why hot air balloons fly
- To learn how temperature affects air density
- To learn and/or reinforce metric distance measurement skills
- To observe events and predict outcomes

PRIORITY ACADEMIC STUDENT SKILLS (see Appendix A for a detailed list)

You will need to complete the Inquiry Activities to complete all the P.A.S.S. objectives listed.

Process Skills

Observing
Measuring
Classifying
Experimenting
Interpreting
Communicating
Safety
Inquiry

Content Skills

Properties
Motions & Forces
Transfer of Energy

SCIENCE CONCEPT - "Buoyancy"

A hot air balloon rises because of the buoyancy created when the air inside the balloon is less dense than the surrounding air.

QUESTIONS FOR STUDENTS (typical sequence)

Why do hot air balloons fly? (Typical response, "Because hot air rises.")
Why does hot air rise? (Typical response, "Because it's lighter than cold air.")
Why is hot air lighter than cold air? (Typically no response.)

PRELIMINARY ACTIVITY

Draw a circle on the floor 2-3 meters in diameter. See how many students can fit inside the circle. Tell the students they are air molecules. When air molecules are cold they stay very close together, just like the students in the circle. But when air molecules heat up, they start to move around and get further apart. Have the students move at least arm's length apart in all directions. Some students will have to step outside the circle.

Since all air molecules weigh the same, which is heavier, the number of molecules in the circle when they are cold or the number of molecules in the circle when they are hot?

DEMONSTRATION

Adapted from an Internet article by Brian Queen
Illustrations by Brian Queen

Materials

For each balloon you will need the following materials -

- Sixteen sheets of tissue paper 52 x 66 centimeters.
- One sheet of kraft paper 30 x 120 centimeters to make a template. (You could also make the template out of two sheets of poster board taped end to end.)
- A solid glue stick. (Liquid glue is not recommended.)
- A 60 centimeter length of wire for the bottom ring. (Use 16 or 18 gauge wire. A coat hanger is too heavy for this size balloon.)

To launch the balloons you will need -

- A camp stove, hair dryer or industrial heat gun.
- If you use a camp stove for your source of heat, you will also need a stovepipe of at least 60 centimeters in length and 15 centimeters in diameter. (Use a vent pipe for a gas water heater available for about $3 at your local hardware store.)
- A 30 centimeter length of string to make a loop at the top of the balloon.
- A broom handle or stick with a hook on the end to support the balloon while being filled with hot air.

Assembly

The balloon is assembled from panels called "gores" which are glued together to form the envelope of the balloon.

Step 1 - make a template out of the kraft paper or poster board using the "Gore Template" sheet included with this lesson.

Step 2 - Make 8 tissue paper panels, each 150-centimeters long, by gluing two sheets of tissue paper together end to end. Use a 1-centimeter overlap for the glue joint.

NOTE *- Depending on variations in the glue seams in Step 2 and slight variations in tissue paper size, the panels may not be a full 150 centimeters. This "shortfall" will be handled in Steps 4 and 14.*

Step 3 - Stack the eight panels on top of one another and staple them together at the four corners.

Step 4 - Lay the gore pattern template on top of the panels and trace its outline onto the stack using a fine felt tip marker.

Note*- When laying out the pattern, make certain that any "short fall" from Step 2 is at the top of the gore. The crown in Step 14 will cover the resulting hole at the top.*

Also *- place the pattern to one side of the panel to allow a large enough scrap piece to cut out the crown in Step 6.*

Step 5 - Using scissors, cut out the pattern through all eight sheets at once. Save the excess paper for the crown and for future repairs.

Step 6 - Cut a 25-centimeter diameter circle out of the leftover tissue paper to be used as the crown. Set aside until Step 14.

Step 7 - Take two of the gores and lay one on top of the other, slightly offsetting the top gore to one side by 1 centimeter (see Figure 1). Apply glue to the lower panel along the 1cm margin and fold it over onto the top panel. Glue and fold immediately as you work along the length of the panel.

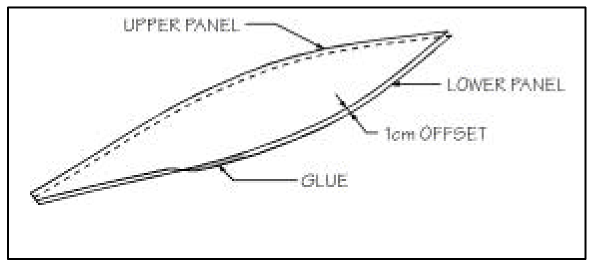


Figure 1 – Assembly of First Two Gores

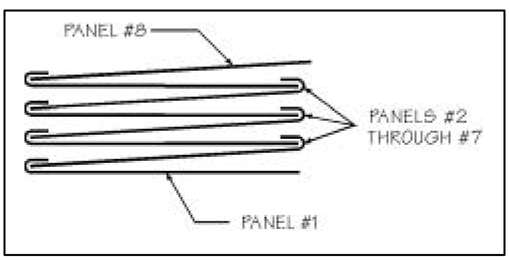


Figure 2 – End View of Panels

Step 8 - Lay a third panel on top of the two just glued, but this time offset the panel to the opposite side (see Figure 2). Glue and fold as you did the first time creating an accordion fold. Continue in this manner until you have glued all eight gores. Check often to see if any of the panels are being glued in the wrong place.

Step 9 - Now lift the unglued edge of the top or eighth panel and fold panels two through seven in half into the center leaving the edges of panels one and eight to be glued together like the rest, completing the circle (see Figure 3). Check once again that there are no areas glued that should not be.

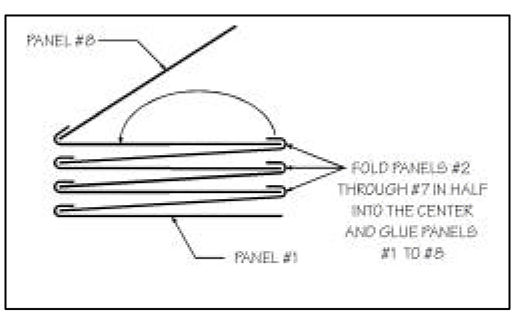


Figure 3 – Gluing Panel #1 and #8

Step 10 - Open the mouth of the balloon and make eight tabs in the neck of the balloon by cutting one-inch deep cuts between each of the eight seams (Figure 4).

Step 11 - Make a hoop from the 60-centimeter piece of wire. Size the hoop by opening it inside the neck of the balloon along the end of the cuts you made for the tabs.

Step 12 - Secure the wire hoop in place by gluing and folding the tabs over it (Figure 4). The wire hoop serves two purposes: 1) to weigh down the bottom of the balloon so that it is more stable in flight and 2) to hold the mouth of the balloon open making it easier to fill with hot air.

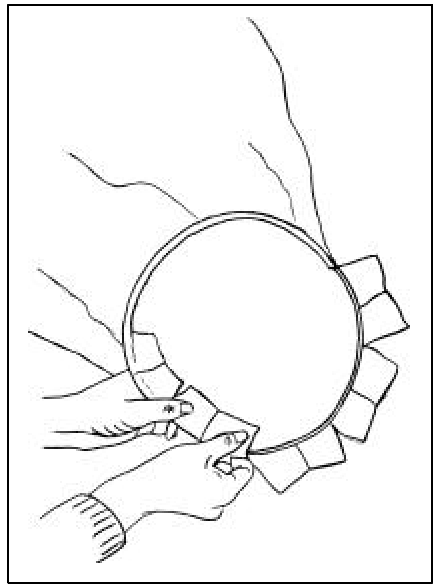


Figure 4 – Gluing in Wire Hoop

Step 13 - Inflate the balloon using a small fan or hair dryer and repair any unglued seams or holes.

Step 14 - Stand the inflated balloon upright and deflate it by slowly pushing down on the top. By deflating in this manner it is easier to glue the crown you made in Step 6 to the top of the balloon. This crown covers any mismatched gores. It also reinforces the balloon and helps slow the cooling of the air in the envelope.

Tip - fold the crown in half and then in half again. The creases will cross in the center of the crown. Glue along the creases and around the perimeter of the crown then apply it to the center of the top of the deflated balloon.

Step 15 -Tape a small loop of string to the top of the balloon to provide a handhold while inflating the balloon.

Your tissue paper hot air balloon is now ready to launch!

Launching

Hot air balloons fly best on still, cool mornings. You must have a large space to launch your balloon because, like the real thing, it is at the mercy of the wind, except that there is no one controlling it. Depending on the size and weight of the balloon, temperature and wind conditions, you may have to chase the balloon for a couple of miles. Choose an open field and only fly the balloon in very light wind. It can also be flown in a large auditorium for a more controlled flight. If you fly it in an auditorium, turn the air conditioning as low as possible to improve its flight. To fill the balloon, support the crown with a broom handle through the loop of kite string (see figure 5). Place the stovepipe over the lit camp stove and lower the neck over the stovepipe. Fill with hot air until a distinct upward pull is felt. Then let go and it will quickly ascend.

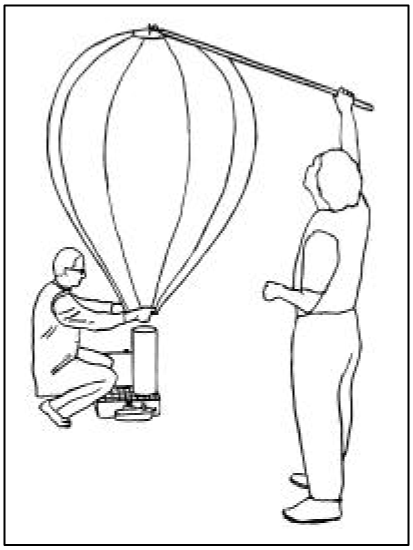


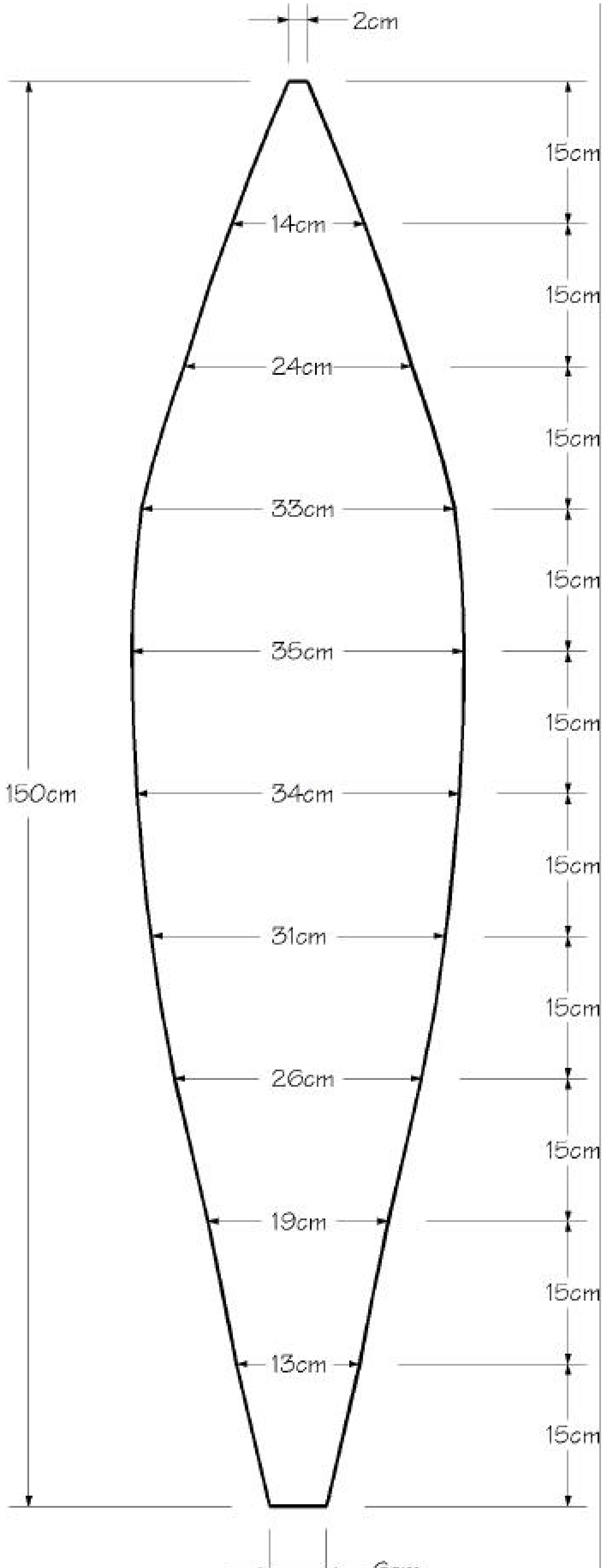
Figure 5 - Launching

DISCUSSION

When flying a hot air balloon, energy is transferred from the stove to the air in the balloon through heat. The energy of the heat accelerates the motion of the air molecules causing fewer molecules to occupy the same space as do at a lower temperature. With fewer molecules, the hot air has less mass than an equal volume of cold air. Therefore, hot air is less dense than cold air.

The greater the difference in the temperature between the air inside the balloon and the surrounding air, the greater the buoyancy. If this buoyant force is greater than the total weight of the balloon and its cargo, the balloon will rise. That's why hot air balloons work best on cool, still days.

Gore Template



MANAGEMENT SUGGESTIONS

1. Build the balloon in the privacy of your own home before you attempt it in class.

2. Building the balloon as outlined in this lesson plan can take as long as 4 hours. Flying the balloons and doing the extended activities will add even more time to the project.

3. By doubling all the dimensions listed on the gore template a balloon of 8 times the volume can be made while only quadrupling the surface area and because of reduced waste only twice the raw materials are used. This "super" balloon can fly for several miles.

4. A heat gun works well for flying the smaller balloons indoors. However, the best heat source is a propane camp stove using a 45-centimeter or longer stovepipe. Chances are you or one of your students already has one of these stoves. The stovepipe is readily available at home improvement and hardware stores for less than $5.

5. When launching outside, you may want to have additional adults to help supervise and serve on a "chase crew". This size balloon can easily fly one or two blocks. Under the right conditions it can fly further.

6. Students can decorate the gores with permanent markers if they wish. Be careful though. The moisture from the magic marker can cause the tissue to tear easily.

7. Tears in the tissue paper can be mended with scrap pieces of tissue paper and glue sticks. Cut your patch piece to size. Smear glue on the patch piece. Then, apply the patch piece like a piece of tape. Give the patch a few moments to set before inflating again.

8. Contact your local newspaper and TV stations to cover launch day. The media likes to highlight education and the balloons are very visual. Your school will benefit from the publicity.

9. Share your pictures with the Sonic Junior Balloonist Program. You can e-mail them or mail them to the address on the last page of this lesson plan. We'll post the photos on the Balloon Fest web site at www.balloonfest.com. Please share any comments or suggestions you have and we'll post those too.

SAFETY GUIDELINES

- **TRAFFIC**. Find a wide-open space to launch your balloons and be aware of which direction they will fly. The danger is that it may come down on a busy street or freeway or get caught in power lines.

- **AIRPLANES**. The 150-centimeter gore balloons as outlined in this lesson seldom fly higher than a house, nor farther than a block. The "super balloon" mentioned in Management Suggestion #3 can fly several hundred feet high and cover several miles. It is recommended that, if you build a balloon larger than the 150-centimeter balloon in this lesson, you launch it at least 3 miles away from and down wind of any airport. If launching a larger balloon within 3 miles of an airport, it is strongly recommended that you notify the airport manager in advance.

- **CAMP STOVES.** When using the camp stove you should always use a stovepipe. The teacher should be the one to hold the balloon over the stovepipe. A pair of leather gloves will help you keep from burning your hands during inflation. A camp stove should never be used indoors.

- **FIRE**. There is always a slight chance that a balloon might catch on fire. If a balloon does catch on fire let it go and it will rise into the air and burn itself out. DO NOT ATTEMPT TO PUT IT OUT OR YOUR CLOTHES MIGHT CATCH ON FIRE. It would also be a good idea to bring along a small fire extinguisher and keep it close at hand. Or use this opportunity for your local fire station to send out a fireman to watch. Though the fireman isn't really necessary, it enhances your flight day.

INQUIRY ACTIVITIES

1) Fly the same balloon several times, but hold it over the heat for different periods of time before each flight (60, 75, 90, 105 seconds). The longer the balloon is held over the heat the hotter the air inside the balloon. Measure the duration of each flight. Graph the differences with the "Y" axis as the duration of the flight and the "X" axis as the length of time the balloon was heated.

2) Use your template to make balloons out of different materials (paper bag, newspaper, plastic trash bag*, etc). By making these test balloons all the same size, the air volume will be the same in all balloons. Have the students weigh the balloons. Hold each balloon over the heat source the same length of time and fly them. Better yet, use a digital meat thermometer inserted in the top of the balloon to launch all balloons at the same temp. Be certain to find a thermometer that will measure up to 200 degrees celcius. Use a watch to measure the duration of each flight. Graph the differences with the "Y" axis as the duration and the "X" axis as the material used. Did all the balloons fly? What is the weight of the heaviest balloon that flew?

** Instead of glue, use masking tape to attach gores made of plastic.*

3) ***Math Integration.*** Make balloons of different sizes. Weigh each one. Find the volume of each balloon. How does the ratio of weight to volume affect the balloon's flight? How would you graph the results?

   Steps to find the volume of a balloon

   - Measure the equatorial circumference of each balloon when inflated.
   - Divide the circumference by pi (3.1416) to get the diameter.
   - Divide the diameter by 2 to get the radius (r)
   - To find the balloon's volume cube the radius (r x r x r)
   - Multiply that number by pi (3.1416)
   - Multiply that number by 4 and divide by 3

   Formulas used

   *Volume of a sphere = (4/3) * pi * r ^3*

   Circumference = diameter * pi

   Note - *This process would be exact if your balloon was a perfect sphere, which it is not. However, it will provide you with accurate enough numbers for your experiments.*

Inquiry Activities continued -

More math

4) Where an 8-gore balloon allows repeating patterns of 1, 2, 4 and 8 colors, a 12 gore balloon allows repeating patterns of 1, 2, 3, 4, 6 and 12 colors.

   What would be the dimensions of the gore pattern for a 12 gore balloon with the same volume as the one in this lesson?

   Answer. The length of the gore remains the same. The width is 75% of the original. The formula is:

   $12 * X = 8$
   $1/12^{th} * 12 * X = 8 * 1/12^{th}$
   $1 * X = 8/12^{th}$
   $X = 8/12^{th}$
   $X = .67$
   - or -
   $X = 67\%$

5) This activity is an extension of activities #2 and #3.

Fact - As you increase the radius/diameter/circumference of a sphere the surface area increases at the square of the factor of the increase and the volume increases at the cube of the increase.

So, if you increase the circumference of a balloon by 2, the surface area is four times larger (2^2 or 2x2) and the volume is eight times larger (2^3 or 2x2x2). Armed with your observations in activity #3, it is now possible to determine the size a balloon would have to be to fly when made out of any given material. Here's how -

- Find the volume of the balloon made from the template in this lesson plan using the instructions in activity #3. It should be about .35 cubic meters or 350 liters.

- Weigh the balloon. It should be about 50 to 55 grams or just under 2 ounces.

- Divide the volume in liters by the weight in grams. 350 liters / 50 grams = 7.

- 7 to 1 is the ratio of liters to grams of a balloon that will fly from altitudes of 300 to 400 meters (the Southern Plains States) when heated to a temperature 79 degrees celcius above the ambient temperature.

- Next we need to know the volume of a balloon with a surface area of 1 square meter ($1m^2$). To find the surface area of a sphere you multiply the square of the radius by 3.1416 and then multiply by 4 or *r^2 * pi * 4*. If we work this backwards we find that the radius of a $1m^2$ sphere is 28cm.

- If we plug the radius of a $1m^2$ balloon into the formula in activity #3, we find that the volume of a $1m^2$ balloon is 92 Liters (approx)

- Since we know that the volume increases at the cube of the increase factor while the surface area increases at the square, we can determine the size a balloon would have to be to fly based on the weight of the material used to make it using the following formulae -

(92 * x^3) / (y * x^2) > 7

This formula can be further reduced to

92x / y > 7

Where
y = the weight per square meter of the material used.
X = the factor you have to increase the radius to acheive the necessary volume to weight ratio.

- **VOCABULARY**

Gore	Volume
Chase Crew	Mass
Buoyancy	Archimede's Principle
Density	Gondola

WEB SITES

www.balloonfest.com - the official home page of Balloon Fest and the Sonic Junior Balloonist Program

www.cadvision.com/castle/balloons.htm - This is Brian Queen's web site that the balloon in this lesson was based on.

www.blastvalve.com - general ballooning web site with links to many different areas of interest including history, model ballooning, and more.

www.geocities.com/capecanaveral/hangar/5290/faq.htm - This is a model ballooning site with lots of information including a downloadable spreadsheet to help in designing balloons of any size.

www.overflite.com - This is a model ballooning web site with pictures, plans and discussions on how to make a candle powered balloon. It also includes a good history of model hot air ballooning.

http://amsd-www.larc.nasa.gov/~killough/vsgc/outreach/project2.html - A hot air balloon lesson plan from NASA

http://pw2.netcom.com/~airhead/model.htm - another model balloon builder site

www.norfolkne.com/math.htm - Math formulas for determining area and volume

www.balloonzone.com - a general ballooning web site with lots of good information about hot air ballooning.

HISTORY OF HOT AIR BALLOONING

The Montgolfier Brothers (mohn-gohl-fee-ay')
Brothers Joseph and Jacques Montgolfier owned a paper mill near Lyon, France. One day in the Spring of 1783 the brothers noticed a shirt that had been hung out to dry over a fire. It billowed upward and looked as if it had inflated.

They considered the smoke to be a special gas. They observed the ascending force of the smoke and came up with an idea. If they enclosed the smoke in an "envelope", the envelope would rise from the ground. They experimented with paper bags from their mill over fires made from varying materials. The brothers finally settled on a fire of straw and wool and called the smoky air it created "Montgolfier Gas".

The Montgolfiers experimented with larger and larger balloons until on September 19th, 1783 they put a sheep, a duck and a rooster in a tethered balloon for an eight minute flight. Then, on October 15th Francois Pilatre de Rozier, a professor of chemistry, went up in a Montgolfier balloon, again tethered. This event is considered the first manned lighter-than-air flight.

The Piccard Twins (pee-kahr')
Auguste and Jean Piccard, twin brothers, were born in Bassel, Switzerland, in 1884. Each earned a doctorate in natural science from the Swiss Institute of Technology. During their lives they contributed significantly to the advancement of scientific knowledge of the stratosphere, ballooning and of the means for man to survive in a high altitude environment.

Convinced that survival in the stratosphere required a pressurized cabin, Auguste, in 1930, devised a spherical aluminum gondola which could be pressurized to approximate sea level pressure, and which was equipped with a system for reusing its own air supply. On 27 May 1931, Auguste and a young assistant ascended from Augsburg, Germany, and reached a record altitude of 15,785 m. Later, on 18 August 1932, he made a second record-breaking ascent to 16,200 m. Auguste's brilliant and innovative development of the pressurized gondola as well as his spectacular high altitude flights contributed substantially to the international body of aeronautical knowledge, and were important technical preliminaries to eventually putting man safely in space.

Jean Piccard, like his twin brother, was interested from an early age in high altitude balloon flight. He moved to the United States in 1926 and continued to collaborate with his brother in the development of the stratosphere balloon. Following his bother's record high altitude flights, Jean and his wife made a balloon ascension from Dearborn, Michigan on 23 October 1934 and reached an altitude of 17,672 m.

Appendix

PASS OBJECTIVES

I. OBSERVING AND MEASURING

The student will:

A. Identify similar or different characteristics of the living and nonliving world.

B. Select descriptive (qualitative) or numerical (quantitative) observations in a given set of objects, organisms, or events.

C. Identify qualitative and quantitative changes given conditions (e.g., temperature, mass, volume) before, during, and after an event.

D. Use Systems International (SI) units (grams, meters, liters, and degrees Celsius) to measure objects, organisms, or events.

II. CLASSIFYING

The student will:

A. Use observable properties to classify a set of objects, organisms, or events (e.g., living, nonliving, odor, size, texture, shape).

III. EXPERIMENTING

The student will:

A. Ask questions about the world and design investigations that lead to scientific inquiry.

B. Arrange the steps of a scientific problem in logical order.

C. Identify a simple variable and/or control in an experimental set-up.

D. Identify a testable hypothesis for an experiment.

E. Design and conduct experiments.

IV. INTERPRETING

The student will:

A. Report data in an appropriate method when given an experimental procedure or information.

B. Interpret line, bar, and circle graphs.

C. Recognize and describe patterns.

D. Select the most logical conclusion for given experimental data.

E. Accept or reject hypotheses when given results of an investigation.

V. COMMUNICATING

The student will:

A. Communicate scientific procedures and explanations.

B. Create a graph or chart from collected data.

VI. SAFETY IN THE SCIENCE CLASSROOM

The student will:

A. Recognize potential hazards within a science activity.

B. Practice safety procedures in all science activities.

PASS OBJECTIVES (Continued)

VII. INQUIRY
The student will:
A. Use systematic observations, make accurate measurements, and identify and control variables.
B. Use technology to gather data and analyze results of investigations.
C. Review data, summarize data and form logical conclusions.
D. Formulate and evaluate explanations proposed by examining and comparing evidence, pointing out statements that go beyond evidence, and suggesting alternative explanations.

VIII. PROPERTIES AND CHANGES OF PROPERTIES IN MATTER
A. Matter has characteristic properties that can be used for identification.

IX. MOTIONS AND FORCES
A. The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

X. TRANSFER OF ENERGY
C. Energy is transferred in many ways.

This Lesson Plan was produced by Balloon Fest, LLC in cooperation with the Oklahoma State Department of Education. Please direct any comments or questions about this lesson plan to Tom Libby, Balloon Fest, P.O. Box 14818, Oklahoma City, OK 73113 or call 405/948-4000 or e-mail juniorballoonist@yahoo.com.

Acknowledgements -

The Central Oklahoma Sonic Coop whose members provided the funding that created this lesson plan and provided the materials for 1500 Oklahoma Students to build these balloons in their science classrooms; as well as, 7 library workshops for 10 - 14 year olds and the teacher workshop.

Marcie Hickman is Science Director for the Oklahoma State Department of Education. Marcie was key in providing direction for the lesson plan, especially in meeting the Priority Academic Student Skills (P.A.S.S.) objectives.

Brian Queen wrote the original Internet article about making tissue paper hot air balloons and drew the illustrations used in this lesson plan. Like the Montgolfier Brothers, Brian is a papermaker. He is currently researching and writing a book entitled <u>Papermaking: Tools of the Trade</u> detailing the equipment and tools needed to set up a papermaking studio for the home hobbyist.

Brian lives in Northwest Calgary with his wife and their 12-year-old son, 14-year-old daughter and pet cockatiel.