Activity 1
Paper Helicopters and the Methods of Science

Objectives
Students will be able to state the steps in the scientific method. Students will be able to distinguish between dependent and independent variables in an experiment. They will be able to measure descent time with a stopwatch, accurately record data on a data sheet, and compute averages.

Terminology
Science, scientific method, observation, hypothesis, prediction, measure, variable, independent and dependent variable, control, repeated trial, procedure, methods, experiment, analysis, inference, quantitative, qualitative, error, data, classify

Grade level: 3rd-6th

Ideal class size
24 students divided into six groups of four, and then subdivide each group into pairs.

Subject areas
Life science, Physical science, Inquiry Skills, and Math

Time required
1-hour introduction and presentation
1-hour hands-on paper helicopter experiment

Materials needed
- Flip chart or writing board and erasable colored markers
- Posters:
  - "Methods of Science"
  - "SAFE Rules"
  - "Plants and Seeds"
  - "Group Data Sheet" enlarged version
  - "Descent Time" blank laminated graph
  - "Descent Time" previous experiment's data graph
- Stopwatches (12-18)
- Scissors (24-26)
- Paperclips
- Paper for demonstration helicopters
- Metric tape measure to establish drop height
- Masking tape
- 40 meters of string
- Yard stick & meter stick
- Small electronic scale (if available)
- Metric measuring devices – calipers…
- Five senses props – binoculars...
  - Sugar-free chocolate

- Pencils and clip boards
- Handouts (1/student)
    - Paper helicopter directions
    - Colored pre-marked paper helicopters paper
    - Student Group Data Sheets
    - My Observations From Activity 1 Follow-up Questions sheet
    - Activity 1 Let's Do Science and Test Your Powers of Observation (and Answer Key)
    - Scientific method definitions

Advanced Preparation

1) Construct the following demonstration helicopter models on the appropriate color paper following the directions for:
    - Box Elder (purple paper, 24 lb.)
    - Maple (green paper, 24 lb.)
    - Ash (red paper, 24 lb.)
    - Pine (blue paper, 24 lb.)

2) Set up a drop line in order to standardize the height from which the helicopters will be dropped. Space out the drop lines because you may have as many as 12-15 pairs of students who need access to the drop lines all at the same time. Measure 2-2.5m from the floor and make a line at this height with string taped up on the wall. The length of the line will vary depending on how many students need to have access to the drop line. Younger students may have to stand on stools to reach this height.

    The drop line height can be whatever height the instructor wants it to be, but should be at least 2m high so the helicopters will be able to twirl a few times before they hit the ground. The higher the drop point, the more revolutions each helicopter can complete during its descent.

3) Copy the "Workshop Outline," onto a writing board or flip chart. This will help you complete all the steps in the scheduled amount of time.

Activity 1-5th Grade
Paper Helicopters and the Methods of Science
Workshop Outline

LECTURE AND DEMONSTRATIONS (1 hour)

I. Introduction (10 minutes)
- A. What is SREL, who works there, and who are we?
- B. Why is the Outreach Program coming to your classroom?
- C. What is science?
- D. Today's task list
- E. Science class rules on SREL visiting days

II. Methods of Science (15 minutes)
- A. Review "Methods of Science" poster
- B. PowerPoint slide presentation

III. How do scientists find things out? (10 minutes)
- A. Observations using the five senses
- B. Improving our senses using technological devises
- C. Mystery object demonstration

IV. Measurement systems (10 minutes)
- A. Metric vs. standard measurements
- B. Measuring tool demonstration

V. Experimental design (15 minutes)
- A. Observe an experiment

EXPERIMENT (1 hour)

I. Conduct an experiment (40 minutes)
- A. Helicopter designs, experimental design, and constructing helicopters
- B. Set up the drop zones, make your predictions, and fly the helicopters

II. Science seminar (10 minutes)
- A. Collect, graph, and interpret your data
- B. Complete experimental observations on student work sheet

III. Closure (10 minutes)
- A. Wrap-up questions
- B. Follow-up activities

LECTURE AND DEMONSTRATIONS (1 HOUR)

I. Introduction (10 minutes)

A. What is SREL and who works there?
[Talk about SREL, where it is located, who works there, and introduce any guest scientists and/or outreach educators who might be present for the class.]

The Savannah River Ecology Lab (SREL) is a research facility located near the Savannah River about ten miles south of Aiken, SC. There are over 100 scientists employed at the lab who study and monitor the ecology of the more than 300-square mile Savannah River Site. Scientists have the opportunity to observe and monitor the local ecology by conducting experiments to investigate water quality, soil chemistry, and plant and animal biodiversity. This workshop was developed by the SREL Outreach Program to introduce students to real scientists who live and work in their neighborhoods.

B. Why is the Outreach Program coming to your classroom?
You are studying science. Some people think science is extremely complicated and because of that, they might not even try to understand it. Sometimes people even give complicated definitions of what science is, but we like the definition of science that a Nobel Prize winning physicist, Richard Feynman, gave once in a talk. He said, **"Science is a special method of finding things out."** That's pretty simple, isn't it! So what we want to do today is tell you a little about science and this "special method" and then do some science with you.

We all wonder about things. We all have questions we want answers to, and sometimes one question leads to another. For example, have you ever wondered where the dirt and oil on the roads goes after it rains, or why you're supposed to eat vegetables, or why male birds are usually more brightly colored than female birds? Many of the questions that we have are ones that science can help us answer. To use science, to "do science," we must learn that special method that Richard Feynman mentioned, but first let's take a look at the tasks we want to accomplish by the end of this lesson.

C. Today's task list/workshop outline: *[Review the workshop outline that was prepared before class.]*
This outline will help keep us on task to complete all the steps in the scheduled amount of time.

D. Science class rules on SREL visiting days
1) Use the restroom before you come to class
2) Always come prepared: bring sharpened pencils, name badges, and science folders with you
3) Stay in your assigned group
4) Follow any QUIET PROCEDURES given to you by the instructors. (There are times during this lesson when students will be involved with several activities at once. It is useful to establish a signal that will get everyone's attention quickly: lights out, hand up, whistle, etc.)
5) SAFE Rules *[Direct students' attention to the SAFE Rules poster. It is important to go over the rules for safety in the lab. Have the students give examples of each of the*

rules below and describe what their behavior would look like if they followed the rules correctly.]

S – Share Politely
A – Actively Listen
F – Follow Directions
E – Enjoy Science

II. Methods of Science (15 minutes)

A. <u>Review "Methods of Science" poster</u>

[Have the students read the steps in the Methods of Science and ask them which terms are new to them, which ones they remember from last year.]

You will be hearing these words a lot during science class and you should pay close attention as each term is defined and examples given: observe, wonder, question, hypothesis, predictions, data, variables, independent variables, dependent variables, design experiments, controls, repeated trials, observations, analysis, conclusions, and further questions.

III. How do scientists find things out? (10 minutes)

A. Scientists make observations using their five senses

As you just heard in the slideshow, science is the knowledge of all aspects of the universe and the way it works. You learned that scientists are people who observe and study the world around them. They are problem solvers. You also observe, study, and solve problems. Does this mean that you are a scientist? Yes, in many ways you are! It is your curiosity that gives you the questions to study.

What are the five senses? *[sight, sound, touch, smell, and taste]*

How can we tell if a banana is not ready to eat? If it is ripe? Did you use all your sense to determine the answers to your questions? *[use bananas as props]*

Scientists use their senses to make observations of the world around them. I want to tell you true story. What do toads like to eat? Flies, right? So, you wouldn't be surprised to see a toad eat a fly. But what if you saw a fly eat a toad? That is exactly what happened to a biologist, Thomas Eisner, in Arizona. Eisner was out in the field collecting insects. He was assisted by a graduate student and a photographer. Photographers are usually people who have good observation skills, and sure enough, the photographer noticed something very strange going on.

The photographer was looking at the hundreds of tiny spadefoot toads about 1.5 to 2 centimeters. *[show on a metric ruler how small.]* We have similar spadefoot toads here in Aiken. *[use a live spadefoot toad as a prop]*. Anyway, the photographer came over and tried to pull the toads out to see what was wrong. But something very unusual happened. When Eisner pulled on the toads, he felt a strong pull in the opposite direction! What could it be? Eisner discovered that the larvae of a horsefly was the culprit. The larvae were large, worm-like organisms that bury themselves in the mud. You can only see their heads and their hook-like mouth parts above the surface of the mud The horsefly larvae use their mouth parts to grab the tiny toads and inject it with a toxic substance. Then, it would feed on its body fluids. Before this accidental discovery, biologists didn't know that horsefly larvae would eat such large critters. They thought they only ate other insects. So, hopefully as you go through our workshops, you will come to understand how accidental observations, curious minds, and smart detective work can lead to important scientific discoveries…just like the case of the fly-eating toad!

B. Improving our senses using technological devises

All of us share a desire to explore and understand the world around us. Science developed out of this curiosity. We like to say that science is based on empiricism, which is a big word that means to search for knowledge based on experimentation and observation. Sometimes we make observations using our five senses, as we just talked about, and sometimes technological devices can help.

Which devices might help a person see better? *[magnifying glass, microscope, x-rays, glasses, binoculars, telescope, observatory, Braille…]*
Which devices might help a person hear better? *[hearing aid, megaphone, earphones…]*

So without meaningful observations based on thoughtful use of experience, the evidence (data) needed to understand a problem will be incomplete.

If you had to choose, which of your five senses would you least like to live without? If you had to choose, which of your five senses would you want to live without?

C. Mystery object demonstration: *The mystery object is a piece of sugar-free chocolate wrapped in very appealing paper. Bring up a pre-selected volunteer who is not allergic to chocolate or artificial sweeteners. Hand the student one piece of candy and tell them to pretend that they have never seen or heard of candy before. Then tell them that we are going to collect some* **QUALITATIVE DATA** *by having our volunteer* **DESCRIBE** *the mystery object using their 5 senses: sight, sound, touch, smell, and taste. List all of the descriptions on the board, one by one, as the student describes the mystery object.*

STOP the student from tasting the chocolate and say:
Before you TASTE our mystery object, can you make an **INFERENCE** about what it will taste like based on your observations?

Tell them that an **INFERENCE** *is a logical explanation based on your observations. Have the class make some inferences about how they think the snack will taste based on what it looks like. Let the student eat the Mystery Object and report their taste findings to the class. Add this information to the list. The student may sit down.*

D. Different types of observations
[Write the word ***QUALITATIVE DATA*** *over the top of their observation list.]*
QUALITATIVE DATA is data that can be collected without sophisticated tools – just using their five senses.

[Now write the word **QUANTITATIVE DATA** *above a new, empty column.]*

QUANTITY is a measurement word. Can you provide some **QUANTITATIVE DATA** about the Mystery Object? *[They might suggest measuring it, weighing it, or analyzing its ingredients.]*

Quantitative Data always produces numbers. Why do scientists use numbers? Because they are accurate. If I decided to pass a bag of sweet chocolate around to share, would you care if I said, "Oh, just take a handful and pass the bag on?" You might not get any if the five people before you had big hands or were greedy, right?

I might decide to collect some **QUANTITATIVE DATA** by counting the total number of pieces of chocolate in the bag and dividing it by the number of students in the class. Then I could say, "You each may have 10 pieces of chocolate." Wouldn't that be a much more accurate way to divvy up the candy?

IV. Measurement Systems (10 minutes)

A. Metric vs. Standard

When scientists collect **QUANTITATIVE DATA** they use a special kind of measurement system called the Metric System. It's based on the number 10, so it makes adding and subtracting and multiplying and dividing simple. What is 10 x 2? What is 50 divided by 5? What is 100 plus 20?

[Show the students a meter stick and a yardstick and have them add 36 inches plus 36 inches in their heads, and then have them add 100 cm plus 100 cm in their heads. Which was easier? Review the metric units for distance (meter), weight/mass (grams) and volume (liters).]

[Have the kids give examples of professions where they might need accurate measurements: chef, nurse, referee, carpenter, etc.]

B. Measuring tools *[Demonstrate several types of measuring tools, how they are read, and when they are used.]*

Why would you use a tape measure instead of a meter stick to measure the length of your back yard? It's easier! Using the appropriate tools for the job makes the job easier and more accurate.

[Teach the students how to use a stopwatch for our helicopter activity.]

V. Experimental Design (15 minutes)

A. Experiments based on observations

*[Tell the students that we need their help finding the **best** paper helicopter design based on some of the plants we have seen on the Savannah River site. Show the large poster "Plants and Seeds." Briefly discuss the different plants and their seeds, as well as their methods of dispersal.*

Demonstrate how different seeds disperse by throwing seeds in the air and watching them fall. Distribute a variety of seeds to students so they can throw the seeds and make observations about their dispersal methods. Have students compare their seeds with the types of dispersal on the poster.

Tell the story that it is important for the trees that all the seeds don't just fall right underneath the branches. The seeds would be shaded and some may not be shade tolerant. Any seedlings that sprouted would have to compete for resources such as food, water, space, and sunlight.]

Has anyone ever made a paper helicopter before? I know most of you have made paper airplanes, but I wonder about helicopters. You will all be making your own helicopters and testing them. *[Show 4 pre-made helicopter models.]*

B. Collecting qualitative data: *[Ask the students to* **DESCRIBE** *the helicopters using the criteria of color, texture, size, weight, shape. etc.]*

C. Collecting quantitative data: *[Ask the students for* **MEASURABLE** *characteristics about the helicopters: how much does it really weigh, how long and wide are the blades, etc. Use a ruler or small electronic scale to measure and weigh accurately.]*

D. Making predictions

Now are our test pilots ready to fly their helicopters to see who has the best one? Ready, Set – WAIT! Scientists make **PREDICTIONS** based on what they already know from past experiences.

Now that you know a little about each of the helicopters, which one do you think will fly the best? *[Have students dialog about why they think their choice will fly the best. Explain that the word "best" must be defined.]*

We need some CRITERIA, a CHARACTERISTIC, a **VARIABLE** that can be measured. Will the helicopter with the widest blades stay in the air the longest, which blades will spin the fastest? Will the helicopter with the short fat blades fly the fastest if released by an SREL staff person?

E. Variables

DEPENDENT VARIABLE

We will be measuring the DESCENT TIME or the time it takes the helicopter to reach the floor to determine which helicopter is the "best," more accurately, that one which meets our chosen criteria. This variable of descent time, as opposed to distance thrown for paper airplanes, is called the **DEPENDENT VARIABLE** because it **DEPENDS** on the things we can change or manipulate like the size of the blades of the helicopter, the thrower, etc. For example, do you think the helicopter will stay in the air longer if we change the length or width of the blades?

INDEPENDENT VARIABLES

If "descent time" is our **DEPENDENT VARIABLE,** then we have to give a name to the things that **WE** change, like the length or width of the helicopter's blades. These kinds of variables that **WE CHANGE** are called **INDEPENDENT VARIABLES**. **INDEPENDENT**

VARIABLES affect our **DEPENDENT VARIABLE**. When we change the size of the blades (an independent variable), our dependent variable may change…the helicopter may stay in the air a different amount of time!

There is one more word we need to teach you that scientists use when they are designing an experiment and that word is **CONTROL**. Scientists usually leave one of their test samples completely alone. A sample that they don't manipulate. A sample that they can compare all of their other samples to. All of the other helicopters will have an independent variable manipulated, adding 1 and then 2 paper clips.

VI: CONDUCT AN EXPERIMENT USING PAPER HELICOPTERS

See Appendix B. Follow the directions in Appendix B so the students can make their helicopters and conduct an experiment. Instructors should demonstrate how to fly the helicopters and record the data.

VII. Science Seminar (10 minutes)

A. Collecting and graphing data

So, whose helicopter was the BEST? Remember we have to define what "best" means—which design is "best" depends on your frame of reference. It might be "best" to land quickest, or it might be "best" to stay aloft the longest. Whose helicopter stayed in the air the longest? Now we have some REAL DATA. The results of our experiment will help determine which helicopter stayed in the air the longest without having to guess. Scientists often come together to compare the results of their separate experiments in **SCIENCE SEMINARS**. That is what we are going to do right now.

Have you ever heard the saying, "A picture is worth a thousand words?" Graphs help us to see numbers in a picture format. Scientists use all kinds of graphs to help them see numbers better and today we are going to use a **BAR GRAPH** to see the data you collected.

[Hang the large, blank Bar Chart on the wall and explain that the X axis represents the helicopter design and the Y axis the Descent Time in seconds.]

[Ask each group member how far their helicopter went on Flight 1. Record these numbers on the blank Bar Graph with colored, erasable markers. Proceed around the room until all the data have been collected. Repeat for Flights 2 through 4.]

B. Interpreting data:

[Now ask the students to look at the Bar Graph and indicate which helicopter design stayed aloft the longest by how tall the bars are on the graph.]

Did the results of your experiment confirm your prediction? Which helicopter design did you think would stay in the air the longest before you started? Which helicopter design actually stayed in the air the longest as shown by our experiment?

[Tell the students that their data will be compared with data from other classes at their school and data from classes at other schools. Show them the "Descent Time" Graph from previous experiment data. Were the results different last time?]

C. Completing the lesson
[Provide the students with the worksheet titled "My Observations from Activity 1." They should take a few minutes to complete this worksheet before the class is over. It can also be done as a follow-up activity on another day.]

IV. Closure (10 minutes)

A. Wrap-up questions
Let's start off by talking about variables. Let's review some of the variables that we tried to control. Tell me again what a controlled variable is? (A controlled variable is a way of testing that is kept the same during all test trials.)

- Size of the helicopter shaft
- Material used to make the helicopters
- Height from which the helicopters were dropped
- How the helicopters were dropped
- Where the helicopter was held as it was dropped
- Where we added the paper clips to the helicopter

What was the experimental or independent variable when we tested these helicopters? The independent variable was the one that was changed during the trials. *[Length and width of the blades]*

Yes, we changed the number of paper clips, but we did it to all 4 helicopters.

Engage the students in a short discussion with some of the following questions:
(1) Which **INDEPENDENT VARIABLE** would you have changed to make your helicopter stay in the air longer?
(2) What were some **OBSERVATIONS** you made during class that you'd like to share?
(3) What kind of things would you like to study if you where a scientist?

[Encourage the students to remember what they did today because we will be using the information we learned today in future science workshops.]

Other possible questions:
What did you observe about the different helicopters? Relate their variables to their descent time.

What variable or variables do you think caused the differences in descent times?
The wider blades on the slowest helicopter kept it up in the air the longest.
The length of the longer helicopter could have made it the fastest.

How is your helicopter similar to a real helicopter? *[They both have blades that whirl on top. They both land by coming straight down.]* Check out a book on helicopters!

How is your helicopter's flight different from a real helicopter's flight?

[A helicopter can go straight up, turn corners, can go straight ahead.]

If you were real helicopter pilots, which helicopter would you rather be flying in?
[The paper helicopter with the wide wings? This one would be the slowest and have the softest landing.]

GREAT JOB Junior Scientists!!! You will get to keep your helicopters, but your teacher will keep them until the end of the school day. You may fly them at home but not at school.

[Hand out any additional "incentives" at this time.]

B. Follow-up

- Provide teachers with copies of the worksheet "Follow-up Questions for Activity 1" to do in class or to use as homework.
- Also provide the teacher with copies of SREL's experimental results for the students to interpret.

V. Follow-up activity:

Design a helicopter you think would be slower than Helicopter X.

Design a helicopter you think would be faster than Helicopter X.

Test your designs.

Usually a shorter helicopter with wider wings will be slower.

ACTIVITY 1: APPENDIX B
Paper Helicopters and the Methods of Science

1. Hand out colored pre-marked paper helicopters. There are 4 helicopter patterns so divide them up evenly based on the number of students you have. Each pair of students should receive the same model; each group at a table should have 2 different designs.

2. Demonstrate how to cut out and fold the pattern. It may be helpful to draw solid and dotted lines on the board for students who are not familiar with these terms.
   a. First, cut on the outer edge of the solid lines so all the helicopters will have the same dimensions. Remind students to cut on the two thinner black solid lines, too, so the helicopters will fold correctly.
   b. Demonstrate how to fold on the dotted or broken lines. Folding the shaft should be done like a fan—one third folded toward you and one folded away from you.
   c. Demonstrate how to carefully bend back the blades so the blades don't get torn off.

3. Explain how to fill out the Group Data Sheet.
   a. Students should fill in the top of the sheet with their name, school, date, teacher's name, and grade.

   b. HELICOPTER DESIGN: Remind students that it is important to note which helicopter it is that they are testing. Students should circle the model helicopter they have.

   c. JOB ASSIGNMENTS: This part is often difficult for students to understand, so make sure you have their attention. Go to a table and use 2 pairs of students to demonstrate how to determine job assignments. Students should have a numbers 1, 2, 3, or 4 taped on their tables. Ask students 1 and 3 to raise their hands. They are going to be the pilot for Flights 1 & 2 and the time and data recorder for Flights 3 & 4. Have these students write their name in the space where it says Student Name. Point this out on the large group data sheet poster. Now have students 2 and 4 raise their hands. They will be the timer and data recorder for Flights 1 & 2 and the pilot for Flights 3 & 4.

   d. MAKE A PREDICTION: Tell the students that it is important to make a prediction. Which helicopter design do they think will descend (which means to drop or fall) the fastest with no added weight (paper clips)? The design they choose does not have to be their own.

   e. CONDUCTING THE EXPERIMENT/RECORDING DATA:
      1. Tell the students that they will drop their helicopters and record the data. Demonstrate how the students will climb the stepstools (or inverted milk crates that are usually available at schools). Give a short safety briefing on climbing and descending stepstools.

      2. One student in each pair drops the helicopter while the other one uses the stopwatch to measure the descent time and then records the data on the sheet. Review how to use a stopwatch. The student who is using the stopwatch is the one to record the data. Some students find it easier to use the stopwatch themselves as they drop the helicopters. Stress that dropping the helicopters and recording the data should be a quick process.

3. Using the group data chart, write in made-up times to show students how they would add the descent times for all 4 flights and then divide by 4 to get the average descent time.

f. MY OBSERVATIONS FROM ACTIVITY 1: Students should answer the questions on the back of their data sheets while they are waiting for their classmates to finish the experiment.