Science for beginners- Grade 4+

What is Science?

Question- framed to be measured	+	Repeated Observations	-	Random chance	=	Conclusion

Science is a discipline like music or mathematics that has a set of rules to guide actions. Science is used to find truths by repeated measurements using the senses. This use of the senses makes it pretty much limited to understanding the physical world. The key is repeated observations. This repetition usually rules out chance.

If you flip a coin once and it comes up heads, does that mean it will always be heads?

Try an experiment: You will need 22 pieces of paper to write on, something to mark with, 11 classmates or friends, and 11 coins with different sides

Heads	one person	Tails
///		/

Heads	one person	Tails
//		//

Heads	group	Tails
///////		///////

examples of individual and group tally sheets

On each piece of paper make two headings; one for heads and one for tails.

Have one person flip a coin 10 times, and record the results on one piece of paper.

Have ten people each flip a coin 10 times and record the results on their individual papers. Add all the totals of heads or tails for the group of ten to get one total for 10 people and one total for one person. Is there a pattern of heads and tails? Does one occur a lot more than the other?

Now, have all 11 people flip their coins 60 times each, recording the number of times the coin is heads or tails. Add the results of the entire group of 11 and their sixty tosses.

You've just collected data from repeated observations. Now you need to figure out what the numbers tell you.

Make three fractions. One will be for the ten tosses of one person with the total number of times the coin came up heads on top (numerator position) and the total number of times it came up tails on the bottom (denominator position). A second fraction will be for the total of 100 tosses for the group of ten. The total number of times the toss came up heads will be on top, and the total number of times it came up tails will be on the bottom. The third fraction will be for the six hundred sixty tosses of the group of 11. Again, the total number of times it came up heads will be on top and the total number of times it came up tails will be on the bottom.

	1 person	10 people	11 people
heads/	4 /	52 /	329 /
tails	6	48	331

examples of possible results

ratios

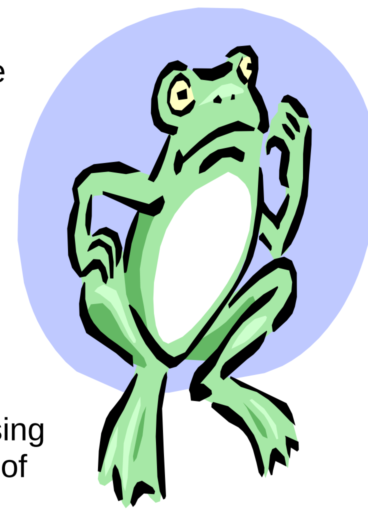
The three fractions are ratios of heads to tails for the three sets of tosses.

Reduced they come to 2/3 for one 13/12 for ten and about 109.7/110.3 for the group of 11. This last can be rounded off to 110/110.

Are the numerators and denominators pretty close to the same number for the second and third ratios? If you did more tosses, say a thousand, do you think they would get even closer to being a reduced ratio of 50/50? Scientists and mathematicians have done this often enough that we know now that the more tosses you make, the more likely it is that the numbers on top and bottom come out the same. This means that for every coin toss, the coin has about the same chance to come up heads, as it does to come up tails.

The Big Picture

Chance is important in science. Scientists have to know if what they are observing is random, or caused by something they are testing. Scientists also have to know if they are measuring things as a whole or just part of the picture. For years there was debate about thinning of arctic ice. Scientists in the US and Canada would say there was open ocean where there ought to be ice, at the same time scientists in Russia would say the ice was thicker than normal, or at least normal. It wasn't until we had satellites to look at the entire arctic region and 10 years of data that the total picture came into focus. If weather in Greenland dominated the air circulation, ice would build up on one side of the Earth. If weather in the Bahamas was dominant, ice would build up on the other side of the Earth. Measurements of the total ice showed there was less ice overall at the end of ten years than at the beginning, but the fluctuations of ice from one side of the arctic to the other were normal.



Sometimes scientists measure things directly like the ice. Sometimes it is easier to measure something related to what you want to measure. At the park we are monitoring water quality by measuring the number of frog calls we hear each year. Frog eggs have no hard shell, and frogs develop to adults in water. Water safe for us to drink could have chemicals in high enough concentrations to harm frog development or even stop it. Frogs are more sensitive to some chemicals than we are. Their sensitivity to chemicals makes frogs good indicators of water quality. If there are lots of frogs, the water can be presumed to be relatively safe.

If frogs are under physical stress from pollution or other factors, then chasing them or trying to catch them might kill them. A person could spend a lot of time looking for frogs to count them visually, but there is an easier way to monitor changes in their numbers. We measure remotely, by listening for their breeding calls. Remote sensing (measuring without touching) is used a lot in science. Listening for their calls is not going to show their actual numbers. Over time, however, it will tell us if there is a change in the numbers. It is fast and easy for the people doing the count, and will give us information about changes. Change over time is what we are looking for.

We have to identify the assumptions we are making with this count. There are things we know, and some really good assumptions, and some assumptions that are safe, and one we know may be false, but making it helps eliminate confusion.

Assumptions

We know each species of frog has its own particular call, and that frogs can be counted by species this way. We know that males call to attract females.

We make a good assumption, based on years of studies of other animals, that the ratio or balance in numbers of males to females will stay about the same from one year to the next.

We make the safe assumption, that, if conditions are right, males will call.

Even though we know it may not be true, we assume that male frogs keep enough distance between them, we can distinguish one call from another, and that they will not travel quickly.

We are counting frog calls through the spring and summer for 10 years. If the numbers of calls remain the same or constant over the ten years, we can assume that the frog population is also constant. If the frog population remains constant, we can assume that water quality is also constant or improving.

If we find that there are fewer frogs at the end of the study than there were at the beginning, then we will have to start a new investigation to find out why there are fewer frogs. We can not assume it is water. It might be weather, or a predator, or some disease that has nothing to do with water quality.

Water in a watershed

We know that water quality in one area affects water quality in other areas. You can do a simple study of water quality at home or in your neighborhood by looking at what is happening on the land. Stuff on the land washes downhill to the water. A watershed is the land water drains from.

Question to answer: Where is a watershed?

You will need a topographic map from an outdoor outfitter or the U.S. Geologic Service branch of the Department of Interior for the first method. For the second method you will need several jugs of tap water and a cup.

Two methods to answer the question.

A topography map has numbers printed on lines that show how high the land is above the ocean. The further apart the lines are, the flatter the land. The closer they are together, the steeper. There is a topography map and some practice questions at the end of this document.

Determine from a topography map or experimentation where your water drains into. On a topography map look for the nearest pond, stream, or lake to your location. These will be blue. If you can find where you are on the topography map, you can see how high above the ocean level you are (elevation). If there are no lines with bigger numbers than your elevation between your location and the water, you are in this water's watershed.

If you want to do an experiment, fill jugs with water. Bring them and a cup outside. Fill the cup about halfway with water from the jugs, and pour the water in the cup onto the ground.

We know water runs downhill because of gravity. If you follow the water downhill a bit, and pour some more out, eventually you will find a culvert or stream, or pond where your water collects. This is where what you do on the land enters the water habitat. If you could follow the water from there, you would come out in a stream or lake perhaps in your neighborhood, or perhaps some distance from home. Eventually, you would come to the ocean.

Jack said to Jill, "Let's go up this hill, to fetch a drink of water."

Puzzled, Jill thought, "Water runs down hill," but went obligingly after.

Jack searched for a well for quite a spell, which prompted Jill to laughter.

Skipping away, she said, "Have a nice day.

I'll trust to physics hereafter."

Question: How can we determine what effect we on the land have on the watershed?

You will need: two potted plants, as nearly identical as possible a small container of chemicals from your kitchen or home that would normally be flushed down a toilet or washed down a drain (detergent, bleach, etc.) tap water in two containers.

A way to investigate the impact of household chemicals on the watershed.

One way to find out what impacts people have on water, is to take two nearly identical plants and put them in a windowsill where they will get good light. On one, put just water. On the other, add different chemicals you find around your home or neighborhood to the water at about 1 part chemicals to 3 parts water. Mixing with water is needed because these chemicals are diluted by water in the watershed. Watch the plants for several weeks and see if they still look the same. Is one growing better than the other? Which one? Does this show an impact of chemicals in the water, or is there another explanation?

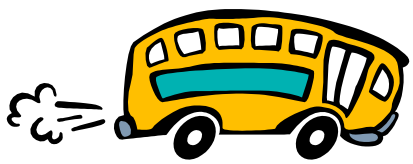
Question: Does air pollution from cars affect the watershed?

You will need:		
a large plastic bag	a way to measure pH	3 potted plants
access to a car	tap water & distilled water	baking soda and vinegar

A way to measure the impact of air pollution from cars on the watershed.

Are there busses, trucks, lawn mowers and grills producing exhaust that washes out with the rain? Does this impact the watershed? To find out, take a large plastic bag, and a cup of water. The pH is the level of acidity or alkalinity of something, usually a liquid. Test the pH of the water you will use before the experiment. Put a half cup of water in the bag and hold the open end of the bag behind the exhaust pipe of a car for only thirty seconds. Don't breath in the fumes! Close the top of the bag, and swish the water in the bag around, then let it collect in the bottom again. Test the pH again. Was there a difference in the pH?

Most life forms can only live in a small range of pH. To test the affects of pH on life forms, take three plants as nearly identical as possible and put them in a windowsill with good light. Using baking soda (alkaline), vinegar (acid), and distilled water make three solutions, one that is acid, one that is alkaline and one that is neutral. Be sure one matches the results from the car experiment. Acid is a pH below 7. Alkaline is a pH above 7, and 7 is neutral. Water one plant with the acid solution. Water a second plant with the alkaline solution and the third with the neutral solution for several weeks. In all other things keep them the same. Was there a difference in the plants after a few months? Can you make an assumption about the effect of auto exhaust on plant life in a watershed from your observations of the three plants?



Question: Will lawn and farm fertilizer affect the watershed?

You will need:

3 clear containers holding 3 cups or more   fertilizer

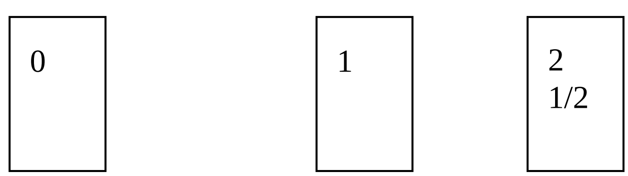
3 cups of water that has been in an aquarium or pond or stream

a marker for the containers   3 nearly identical water plants , gravel

Measuring the effects of fertilizer and sewage on the watershed.

Farms and many home yards and septic or sewer systems are sources of nitrogen and phosphate fertilizer. These may be present in such quantities that the plants on the farm or yard can't absorb them all, and the excess runs off with the rain. To see what affect this has on plants living in the water take three clear containers and fill them with water.

3 identical containers



Label the containers 0 for no fertilizer, 1 for a tiny bit of fertilizer, and one 21/2 for the most fertilizer. If you can get water from an open stream or pond, that will work best. If you can't, ask an aquarium store if you can have three cups of water from an aquarium they are cleaning. Add a cup of water from an aquarium's water change or pond or stream to each container. Take three nearly identical plants from an aquarium store and anchor one plant per container, in gravel at the bottom of the containers. Set them in a window where they will get light. Add a tiny bit of fertilizer to one, two-and-a-half times as much to the other, and leave the third container with just the plant and water. Over the next three weeks add water to the containers as water evaporates.   Also add tiny amounts of fertilizer to the one with a tiny amount, and 2 1/2 times that amount to the one marked 2 1/2. Just add water to the one marked 0. In three weeks look at the containers.

We know green plants must get sun to live. Which plant is getting the most sun through the water? Which the least? What impact could we assume fertilizer is having on plants in the wild that live in water?

Design your own study!

Consider what interests you in your immediate neighborhood. Then consider the elements of a science study.

1) Ask **what can be measured that interests you**. Which senses can be used? **How will it be measured**? **Are there safety precautions to take?**

In our frog study, the calls could be easily and safely measured without harming people or frogs. We used our ears to listen and our ears and eyes to map frog calls so we count frogs and not frog calls.

2) Is what you are measuring going to give **results you can use** to draw a conclusion?

Considering our assumptions about frogs, we can conclude that if we do the study long enough to rule out weather, then the number of frogs calling represents the same portion of the population of frogs from year to year. This will let us conclude that the population data we get reflects a change, if any, in the total population. It gives us no information on the total population, only changes over time. This is fine, because change over time will tell us what *we need to know about the water.*

3) What equipment or tracking methods do you need to make the measurements or observations? **Can you get what you need** to do the study and track results?

We use an audio tape to identify frog species by their calls, and maps to track where we hear the calls, and tally sheets to track the species at each station. We then keep a written record of the tallies over time.

4) How **can you be sure what you are measuring is not a random occurrence?**

For our frog count we know weather is a factor in their calling. By doing the study for at least ten years we will be able, through a lot of observations, to rule out weather as a factor. There is still an element of chance, but it is an acceptable level. We do the count the same way each time, important since different methods would give different results. If we suddenly switched to a visual count, it would give fewer frogs than the auditory count. If we changed what time of day we did the count, that might impact how many calls we heard. It has to be the done the same way each time.

5) What assumptions are you making in your study?

We identified several assumptions, some better than others, and take those into consideration in stating our results of the frog count.

6) **How will you know if your observation and conclusion are accurate**?

For our frog study, we have trained different schools including grade schools, and adults, repeating the study several times a month. A park ranger also monitors the counts while they are going on.

7) What are all the possible explanations for what you've observed?

For our frog study, we will be able to rule out, through repeated observations, weather as a reason for a lack of calling. Our research before the study showed a lack of food would cause frogs not to call, but this would also lead to a decline in frog numbers.

Suggestions for your study:

the number or diversity of insects in the soil and surface of the ground by vegetation type (turf, forest, wetland, meadow)

changes in birds species at a feeder through the year

plant diversity over an area and conditions that might cause it.

plants that attract the most variety of insects for feeding on flowers or leaves or stems affects of different kinds of land use on percolation of precipitation

Example of coin toss tally sheet

Individual toss

Heads Jim	Tails
//////	////
6	4

Total group tosses

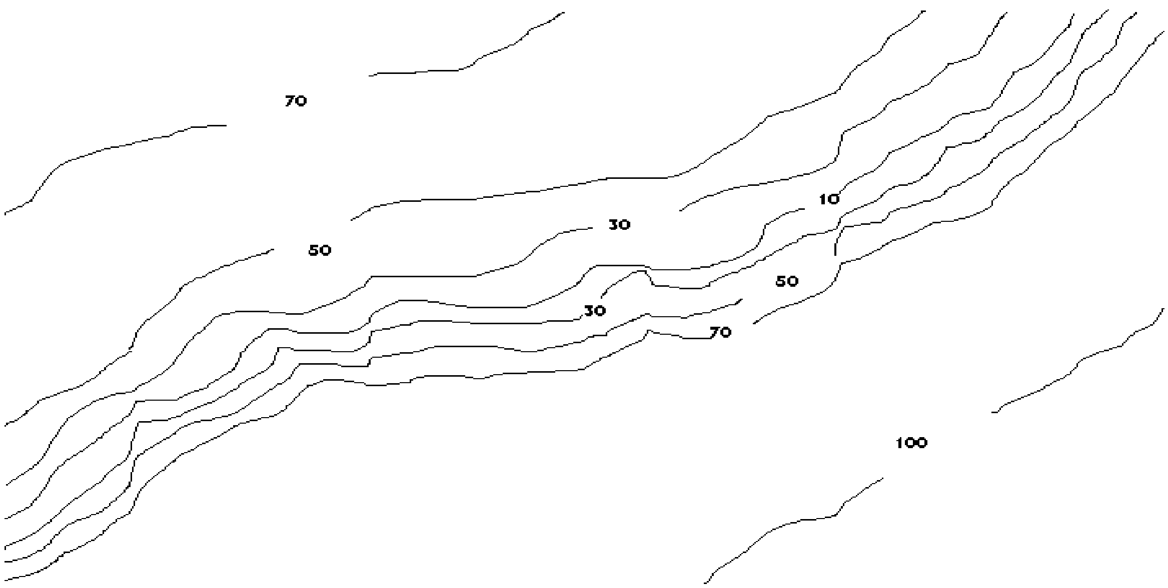
	Heads	Tails
Tom	5	5
Lou	4	6
Rochelle	7	3
Jean	6	4
Tanya	4	6
Matt	2	8
Nuy	7	3
Cathy	5	5
Kit	5	5
Pat	6	4
Totals	51	49

Ratios:

Jim: 6/4   100 tosses: 51/49   660 tosses: 333/333

Topographic Map Exercise

use the topography map below for the following exercises:



Note how each line has a break with a number in it. These numbers show how high the area is above the level of the sea. Answer the following questions, then check your answers on the next page

1. Which part of the map is the highest?
2. Find the 10 foot level. Is the land rising steeper to the right or the left?
3. Which side shows a gradual rise from the 10 foot level?
4. Note the elevation lines are only shown for every 20 feet of difference. Does this mean that 10 feet is as low as the land gets?
5. Where would you expect to find a creek if there was one?

Answers

1. The lower right side of the map is 100 feet. It is higher than other sections shown.

2. The right is showing a steeper rise (lines close together) that then levels off some between 70 and 100 feet.

3. The left shows a gradual rise to 30, then 50, then 70 feet. (lines wider apart)

4. No it just means 10 feet is the lowest level shown

5. Somewhere around the 10 foot elevation.