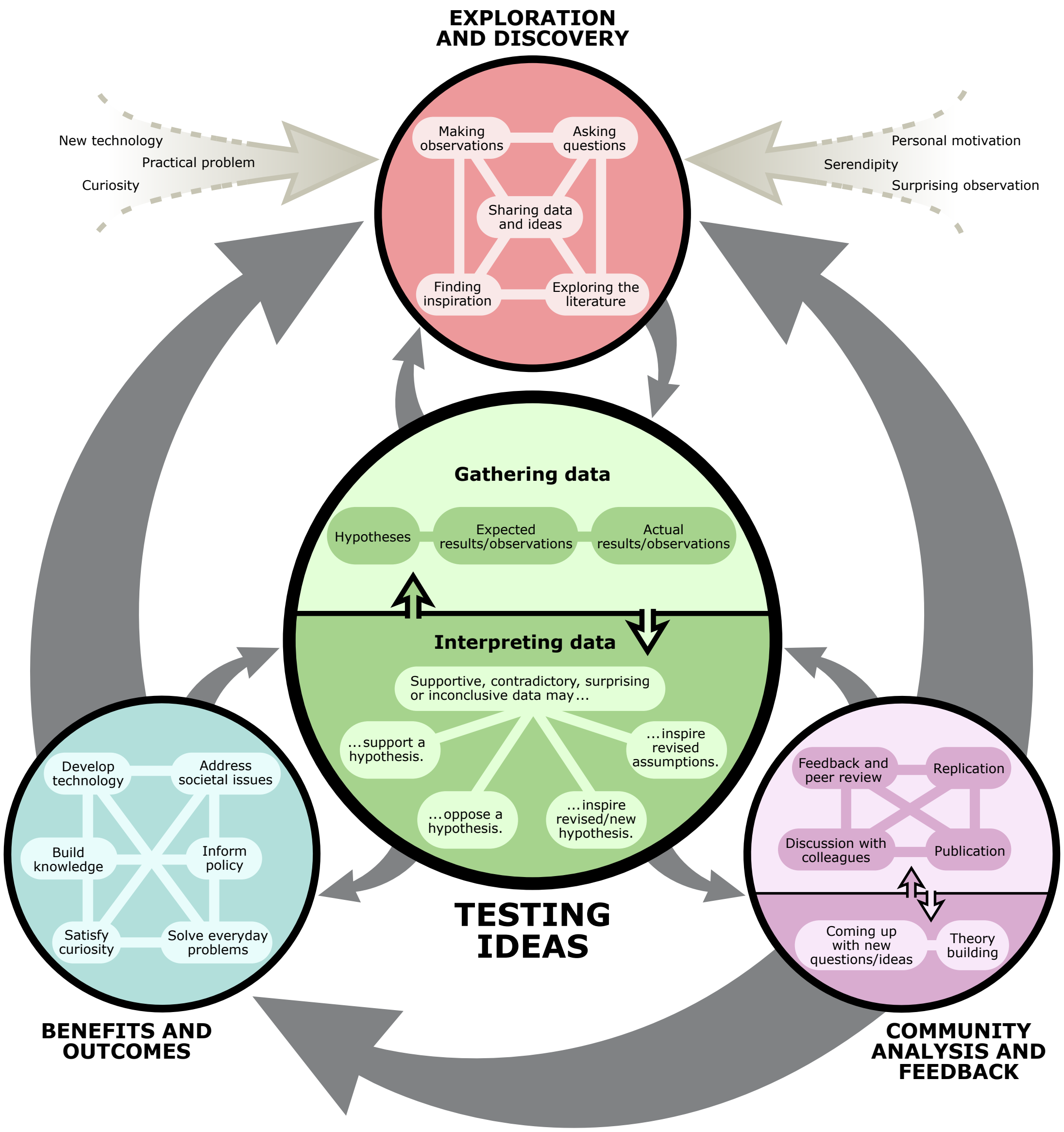
Designing your very own science experiment (for fun and enlightenment)

All of what we know in science, including everything written in your textbooks and all of the fun facts presented by your teachers, is based upon observations, experiments and other methods of discovery performed by inquisitive human beings. We call these folks scientists. As we learned last time, the process of science is complex, non-linear (it contains cycles and loops), and does not follow a single prescribed path. Real world science is less structured than most people realize—at times it can be very messy!

Here again is a flow chart that summarizes the real process of science:



One important feature of science is that it is an ongoing process. Whenever a scientist finds the answer to a question, there are at least a dozen new questions that emerge, and this is part of what makes science so intriguing, challenging, and fun. Regardless of how thick our science textbooks may be with all sorts of facts, there are an infinite number of questions yet to be asked about how the world works!

Before embarking on your own full-fledged scientific investigations, here are some important considerations to keep in mind:

- A scientific observation can be anything that we detect with the use of our senses—sight, sound, taste, touch, or smell. When appropriate, use your full complement of senses in making observations (obviously, you need to be judicious about using your sense of taste). Often we need to use technology as extensions of our senses. For example, we could use microscopes when we want to observe things very, very small, or use telescopes when we want to observe things very, very far away.
- A scientific question is one that has the potential to be answered by observation and experimentation and for which there is a potential natural explanation. Questions like, "How does temperature influence the rate of lemonade mix dissolving in water?" or "What kinds of nutrients will maximize the growth rate of my pet goldfish?" are perfectly fine scientific questions. On the other hand, a question like, "Does a benevolent supreme being rule the entire universe?" while a truly interesting one, is not an appropriate scientific question because no test can be performed using our senses that would potentially give us an answer.
- A scientific hypothesis is a tentative answer to a question—sort of an explanation on trial. If you are careful in formulating your hypotheses, they can act as predictions for the outcome of an experiment. We use hypotheses all the time in solving everyday problems. Let's say, for example, that your flashlight fails. That's an observation. The question is obvious: Why doesn't the flashlight work? A reasonable hypothesis based upon past experience is that the batteries in the flashlight are dead, or the bulb is faulty. And we all know of simple experiments to test these hypotheses!
- Hypotheses are often presented in "if … then … because" format. For example, "If I put new batteries in my flashlight, then I will be able to cast a light on the animal eating my food. I think that new batteries will revitalize my flashlight because dead batteries have been the problem in the past."
- Designing a good scientific experiment involves identifying the variables that are important in the process you are investigating. A variable is any factor that may differ or change in your experiment. There is an important group of variables that you will want to remain constant throughout your experiment, and these are called controlled variables. For example, let's say that you and your lab team are interested in the question, "What percentage of nitrogen in the soil will cause the garden tomatoes to grow the tallest?" A reasonable hypothesis might be, "If tomato plants in my garden are given additional nitrogen in the soil, then they will grow taller than plants that receive no nitrogen. This is a reasonable prediction because the textbook says that nitrogen is an essential mineral for plants." Constants, or controlled variables, in this experiment would include such factors as the particular variety of tomato plant used, the amount of light each plant receives, and the form in which the nitrogen is delivered to the soil.
- Your lab team would also need to identify two other important variables: the independent variable and the dependent variable. An independent variable is a factor that is purposefully changed by the experimenter. In the example being used, the independent variable is the percentage of nitrogen. There might be several levels of the independent variable, for example, nitrogen concentrations of 1%, 3%, 5%, 7%, and 10%. A dependent variable is the variable that responds to the change in the independent variable. In this experiment, the height of the plant would be the dependent variable.
- This experiment would also need to have a control, a group of plants that receive no additional nitrogen. In other words, a control group is one in which the independent variable is not changed. Control groups are a way to detect or measure the influence of unanticipated factors, and they establish a base line for comparing the experimental effects of no treatment.
- It is important to bear in mind that a good scientific experiment usually tests one independent variable at a time, and that is why it is important to keep all other potential variables constant and to use a control group. Also, in identifying independent and dependent variables, be sure that you specify ones that are measurable. For example, in our example, the dependent variable was specified as the height of the plant. If instead your group were to use a vague or fuzzy dependent variable like, "plant growth," "the health of the tomato plant," or the "general well-being of the plant," it is unclear as to exactly what your group would measure.

Ideally, your group would need to include repeated trials in the experimental design. These repeated trials reduce the probability that a change occurred because of chance, some random factor, or because of individual variations within the plants.