

Think Like a Scientist

The following story illustrates what I think the scientific method, is really all about. As with any fable, I'm going to tell the story first, and give the moral of the story afterward.

Once upon a time, there was a caveman named Fred. (I refuse to name him "Oog" or something similar). Fred was a very bright guy, but he had absolutely no knowledge of the laws of nature. Please don't ask how poor Fred managed to grow up this way: it's a sad sort of story, and not terribly relevant to my moral.

Where was I? Oh, yes...one day Fred was walking through the woods, incredibly hungry as cavemen often were, and he picked up a rock. He looked at it, maybe took an experimental bite or two, and decided that it was not particularly edible. Anyway he'd had rocks for breakfast that morning. So he let the rock go, content to move along his way. **Bam!!!** Down came the rock, right on his foot. This is the critical part of the story, so pay close attention: he *let go of the rock, and it fell on his foot.*

Has the science part started yet? No--actually, all Fred has right now is a hurt foot. This is because all Fred has so far is one incident, which by definition is not related to anything else. In science, it's pretty fair to say that if you only know one thing, you don't know anything.

Fred kept walking. Still hungry. He picked up another rock, let it go. **Bam!!!** It missed his foot this time, but other than that, it went pretty much the same way the first rock did: straight down. His mind racing, Fred began to suspect a pattern. If he were scientifically minded, he might have expressed it something like this.

Theory 1: When I let go of a rock, it falls down

Being a bright guy, Fred realized he had to test his theory. So he picked up another rock, and said aloud in cavemanese, "Oo Ah Mah Cowatay", which, for those of you reading this, means, "When I let go of this next rock, it will fall down." He gave it a try, and sure enough! This is the point where Fred really started feeling good about himself. Because the ability to make a prediction, and have it come true, is the key indicator that you are really on to something.

So, Fred kept going, dropping rocks in his wake with childish glee. But he was hungry. He picked up a pinecone, gave it a cautious sniff, and decided to let it go. Imagine his surprise when the pinecone clattered to his feet, in almost exactly the same way that the rock had! Now, you might think that Fred would conclude, "When I let go of a pine cone, it falls down." But Fred was smarter than that. He started picking up leaves, sticks, helpless cats, whatever he could get his hands on. Fred was on to a much more general theory! As before, he began to make predictions based on his new theory; and when his predictions came true, he decided confidently that.

Theory 2: When I let go of anything, it falls down.

Note that Fred did not have two theories at this point, he only had one: because theory 1, although still true, was no longer necessary! Theory 1 was now a special case of theory 2. Nothing made a cave scientist happier than finding one theory that explained a lot of different results. This is because cave scientists had to carve their theories on stone tablets and quite frankly, the fewer the better.

Fred was excitedly testing his theory on one of his own teeth when he happened to see a red balloon tied to a tree. Fred untied the balloon and let it go, fully ready for yet another vindication of his wonderful theory. The balloon drifted away. UP? It fell up!

Now, at this point, Fred was faced with his first serious scientific crisis. His predictions had been right hundreds of times: but now, it had gone wrong. So like any good scientist, Fred decided that it was a fluke, it hadn't really happened, and his original theory was right all along. Unfortunately, the next balloon went up too. And the next. The darn things were getting harder and harder to ignore, not to mention he couldn't figure out where all these balloons had come from and who had tied them to the trees.

Fred had two choices. He could tweak his theory, or he could throw it out and start over. Now, one thing a cave scientist always hated to do was throw out a theory and start over, so Fred started diligently keeping track of what things fell down, and what things fell up. Skipping ahead by a very long time, we find one of Fred's descendants carving the following:

Theory 3: Things that are lighter than air, fall up. Things that are heavier than air, fall down.

Note that we still have only one theory that explains everything! Both 1 and 2 are now special cases of this latest-and-greatest.

MORAL 1: Science consists of two processes, deduction and induction.

Deduction goes from the general to the specific: making predictions based on theories. Induction goes from the specific to the general: pulling observations together to create a new theory. The nice thing about deduction is if you do it right, the conclusion is always right (at least as right as the theory it starts with!) Induction, no matter how well you do it, is always suspect, and frequently wrong.

Nonetheless, real science consists primarily of induction.

MORAL 2: Everyone likes to have theories that are right. Scientists spend a lot of time making predictions, and hoping they will come true. But they actually don't learn much when they do. The real learning happens when the predictions don't come true. In many cases, the scientists themselves refuse to believe the key results that lead to the new theories. (Moral2: scientists are people too. They like to be right as much as anybody.)

MORAL 3: Wrong theories are still useful. Every one of Fred's theories was eventually proven wrong. Einstein is probably wrong too. But each one is a building block to the next, bigger theory. Each one is also useful, as long as you work within the domain in which it is true. Almost everything we build today is based on 19th century Physics, which has been known to be wrong for almost a hundred years. But it's still useful for making cars and bridges and rockets and anything else that isn't too fast or too big or too small.

MORAL 4: Sometimes you get so caught up in the excitement of science, you forget to eat. Which about wraps it up for Fred, I'm afraid.

Questions to ponder:

- 1) Why is it important for scientists to repeat experiments before jumping to conclusions?
- 2) In your own words, that you can use to help you understand the difference, compare and contrast deductive reasoning with inductive reasoning.
- 3) Go through the fable and list each time that Fred uses inductive reasoning to more generalize a situation.
- 4) Why was the first theory Fred induced not enough? Why did he continue to generalize?
- 5) Tell me...is it okay in science to make mistakes? Are these mistakes useful? Why?