5.4 Plate Tectonics and the Notion of a Scientific Theory

In this dialogue, Plato and Rocky talk about the nature of theories and the meaning of words to better understand plate tectonic theory.

Plato: How was school today?

Rocky: Fine. Nothing too exciting. Ron wore mismatched shoes and Harry's pants zipper broke when he went to the restroom during science class. Pretty funny.

Plato: Besides those fascinating human interest stories, what else happened in science class?

Rocky: We are starting a new unit tomorrow on plate tectonics. Our teacher said it was a theory so I guess we are going to learn about someone's harebrained idea.

Plato: Why do you assume it will be a harebrained idea?

Rocky: You know. I have heard about all kinds of crazy theories. Like the conspiracy theories that say that we didn't really go the moon, but NASA set up some big stage to pull a hoax on the American people. And how about the theory that aliens are sending rays from their ships to suck the information out of our brains. So believers in that theory are lining their hats with aluminum foil. Most of the theories that I hear about are pretty nutso.

Plato: I see your point. The problem is with how people use the word theory.

Rocky: What do you mean? A theory is someone's idea. Sometimes good, sometimes bad. It is whatever you think.

Plato: That might be how people in general use that word but in science it has a very specific meaning.

Rocky: It has a different meaning to scientists?

Plato: That happens with lots of words. Let me give you an example. What does the word nano mean to you?

Rocky: That's easy. It means really small. I have a iPod Nano. It is this cool little MP3 player.

Plato: Right. We have iPod Nanos and NanoBot toy robots. I even saw a car that they named the Nano. It was small but not by scientists' standards.

Rocky: Doesn't it mean small in science.

Plato: Yes, but it is more specific than that. How much smaller is your iPod Nano than a regular iPod?

Rocky: I don't know exactly. Maybe one quarter as big, maybe one sixth, something like that.

Plato: If they were using the word nano in a scientifically accurate sense it would have to be $1X10^{-9}$ as big as the regular iPod. That means take the number 1 and move the decimal point 9 spaces to the left.

Rocky: If it were that small I would never be able to find it. Why are scientists so particular about what the word nano means?

Plato: For a couple of reasons. One is that scientists need to be able to communicate accurately with each other. Scientists around the world often speak different languages so we have to have some things that we all agree mean the same thing. So we all agree that the prefix nano- means 1×10^{-9}. So a nanometer is 1×10^{-9} the size of a meter.

Rocky: You said there were a couple of reasons. What is the other one?

Plato: The things that scientists figure out, their experiments, need to be reproducible. Other scientists need to be able to do the same experiment and get the same results. You can only do that if we all agree on what our words mean.

Rocky: So they copy each other? I'm gonna tell my science teacher that when I copy I am being a scientist!

Plato: Not so fast. Scientists recreate experiments so that we can be more sure of the results.

Rocky: That seems like a waste of time.

Plato: How about this analogy: if one scientist created and tested a new medicine on five people with stomach aches and then reported that four of them got better after taking the medicine, would you buy and take it if you had a stomachache?

Rocky: Probably not. That isn't much of a test. The people could have just gotten better on their own. Or maybe their stomachache was caused by something different from what is causing mine, or maybe all five were old people and it only works on them and not a kid like me.

Plato: How about if ten scientists tested it on 10,000 people and 80% got better. Then would you take it?

Rocky: Sure. It sounds like it helps most folks so it would probably help me too. But how did we get on medicine? We started talking about theories before we got sidetracked on to nanometers and medicine.

Plato: They are really all connected. We were talking about how many words mean one thing to scientists and another thing to the general population.

Rocky: How about theory? What do scientists mean by theory that is different from other people use the word?

Plato: To scientists, a theory is an explanation based on all the available data. It must also be able to make predictions.

Rocky: What happens when new data comes along?

Plato: That data will either support the theory or the theory will need to change to accommodate the new information.

Rocky: So it is kind of like a detective trying to solve a crime. He may think he has the right person because the shoe print and the blood-type fit and the motive was there. But then they found a fingerprint that didn't match his suspect. Now he either has to explain how that fingerprint got there or find a different suspect that fits all the evidence.

Plato: That isn't a perfect analogy but it is close enough. Remember that a scientific theory has to also make accurate predictions.

Rocky: Can you give me an example from the plate tectonic theory we are going to learn about?

Plato: Sure. You are going to learn about subduction zones and how large slabs of earth's crust are drawn down deep into the earth where they start to melt. If this melted rock comes out on to the surface of the earth we call it a volcano. So plate tectonic theory can predict the location of most volcanoes.

Rocky: I think I get it. Wouldn't it be easier if we all used the same words in the same way? Having scientists use words in a different way than other folks seems like a recipe for a lot of misunderstanding.

Plato: You are right there. I don't know exactly how it got this way but it is a big problem when scientists try to communicate with the public. Maybe that is why you are taking science in school. So you can understand the language of science.

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