Science Forward--What is Science?

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http://cuny.is/scienceforward

[0:00] [background music]

Flora Lichtman: [0:00] Imagine for a moment that you are not you. That you're a tick. You live here in Van Cortlandt Park in the Bronx, and you're an adult, so that makes you about the size of George Washington's nose on a quarter. What would life be like? How would you make sense of your environment?

[0:18] In the late 1880s, Estonian biologist Jakob von Uexk¸ll played out this thought experiment. He distilled tick life into three parts. First, the tick climbs up to a blade of grass and waits for prey. Second, when prey walks by, like a mammal, it senses it. We now know that the tick does this through the carbon dioxide in the mammal's breath.

[0:39] Third, in Uexk¸ll's conception, the tick falls off the blade of grass, it drills its mouth into whatever it's landed on. If it feels warmth, it takes a drink. If cold, it climbs back up to the blade of grass to wait again.

[0:52] In this thought experiment, all of the tick's knowledge comes from its senses. Would you say the same is true for humans?

[0:59] [music]

Flora Lichtman: [1:08] When we systemically collect and analyze sensory data, we're doing science. This is the concept of empiricism, that knowledge comes primarily through observations through our senses, not just from thinking.

[1:21] But humans, unlike ticks, are limited to sensory data we can collect only through our bodies. Because we can build tools that let us see things our eyes could never pick up, eavesdrop on sounds our ears could never hear, and travel to environments our body could never survive.

[1:40] Scientists take those observations and transform them into a scientific body of knowledge. Now the skillset that scientists use to do this is something we're calling knowledge sense, and we're going to hear a lot more about that coming up. We're also going to talk about what science is.

[1:58] How would you define science?

Chanda Bennett: [2:00] Science is the process of developing hypotheses, asking questions, identifying methods to answer that question, and assessing the information that you gather. Science is part of everything that we do every day.

[2:17] I think some of the stereotypes about science may impede people from really understanding and engaging with science. You have this stereotype of what a scientist is, and we need to just shatter that. You have a stereotype of what science is and who science is for, and it's for everyone, and anyone with an interest can develop their scientific sense.

Flora Lichtman: [2:42] Massimo Pigliucci is a philosopher of science, which means it's his job to think about what science is.

Massimo Pigliucci: [2:49] One thing you want to think about when you're trying to understand science is that it is, first of all, empirically based. There has to be some kind of observation, experiment, factual matter that enters into your reasoning. Otherwise, you're not doing science.

Tammy Lewis: [3:04] People do science. Science doesn't do itself. There's no machine that you can put stuff in that's going to be plopped out the other end that's purely objective.

Flora Lichtman: [3:16] Humans have the capacity to take in information and learn something new about the world. But, as most of us also know, probably from personal experience, we also have the capacity to hold onto ideas because we believe them to be true, because we want them to be true.

[3:35] Our beliefs come from our lives, from our experience of the world, but not necessarily from data, or certainly not from controlled experiments. In fact, evidence suggests that when we get new data that conforms to our worldview, we are more likely to accept it. There's a term for this. It's confirmation bias, and here's a legend on just this subject.

[3:58] The year is 550-ish BC. We're in Greece, and this guy is a powerful cult figure. Pythagoras and his disciples have a mystical reverence for numbers. One of their beliefs is that the only numbers that exist are either whole numbers or the ratio of whole numbers. These are known as rational numbers.

[4:19] Enter Hippasus of Metapontum. He's contemplating the diagonal of a one-by-one box and figures out that the diagonal length is the square root of two. He then proves that no ratio of two rational numbers gives you the square root of two. In other words, he discovers that irrational numbers exist.

[4:41] His finding demolishes the Pythagoreans' worldview, so what do they do? The Pythagoreans drag him out to sea and drown him for the discovery. Or so the legend goes.

[4:53] In this story, the Pythagoreans held a belief that was impenetrable to new observations. That's not a model for science. On the other hand, skepticism is a crucial part of science. If new data overturns old beliefs, that's the scientific machine working well.

Tammy Lewis: [5:11] We should always have some skepticism around science, and we shouldn't just always say, "Oh, well the scientific study said it, it must be true." Right? Even science itself as a process says be skeptical. We don't just take one study and say, "Oh, we found this, it must be true," but we in fact replicate each other's studies so that we see, did what Flora found in this study, if I do that again, am I going to find the same results?

[5:43] If I do, I say, "Oh, great, so that might be true." But then somebody else does it again, and the more people who replicated it and the more that we find the same thing, then we have some confidence in that scientific law or truth.

Justin Garson: [5:57] You might say, "Well what's so good about science if we can't be absolutely sure that our theories are true?" What most of us want out of life is reliable theories. We want our beliefs to be reliable. We want our beliefs to be likely. They don't have to be absolutely certain.

[6:19] But when I'm trying to decide, for example, whether I should cut red wine out of my diet or whether to drink more of it, I want to know that the people who produce this kind of data, and the methods that they're using to produce this kind of data are reliable. I want to know that I'm resting on what scientists now take to be the most likely theory.

Flora Lichtman: [6:45] What are the mechanisms in science that help ensure reliability?

Massimo Pigliucci: [6:49] There's peer review. So there is a series of sociological interactions among scientists. If I am a scientist and I want to publish a new piece of research, what do I do? I submit it to the editor of a technical journal, the editor looks at it.

[7:04] If it's interesting enough, it sends it out to a number of reviewers who are scientists, peer scientists in the same area. Those people look at it, and they give me feedback, and eventually the paper gets accepted, and it becomes part of the edifice of knowledge that science builds.

Justin Garson: [7:20] We think of good scientific theories or good scientific disciplines as constantly revising themselves in light of new evidence. Science isn't a finished and done project. It's not a set of dogmas or doctrines that you have to either accept or reject once and for all. Science is always changing, our theories and hypotheses are changing in light of the kinds of evidence that we're constantly obtaining. Science is an adventure in this way.

Charles Liu: [7:55] This, perhaps more than any other way, is a way of establishing a human legacy, a chain that goes from the past to the present and into the future. It is a great thing. It is marvelous. It is fun.

[8:10] [music]