Science and its imitators

Astronomy 101
Syracuse University, Fall 2017
Walter Freeman

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"[T]he imagination of nature is far, far greater than the imagination of man (sic). For instance, how much more remarkable it is for us to be stuck – half of us upside down – by a mysterious attraction, to a spinning ball that has been swinging in space for billions of years, than to be carried on the back of an elephant supported on a tortoise swimming in a bottomless sea.

For instance, I stand at the seashore, alone, and start to think.

There are the rushing waves, mountains of molecules, each stupidly minding its own business, trillions apart, yet forming white surf in unison.

Ages on ages, before any eyes could see, year after year, thunderously pounding the shore as now.

For whom, for what? On a dead planet, with no life to entertain.

Never at rest, tortured by energy, wasted prodigiously by the sun, poured into space. A mite makes the sea roar.

Deep in the sea, all molecules repeat the patterns of one another till complex new ones are formed. They make others like themselves, and a new dance starts.

Growing in size and complexity: living things, masses of atoms, DNA, protein... dancing a pattern ever more intricate.

Out of the cradle onto the dry land, here it is standing: atoms with consciousness, matter with curiosity.

Stands at the sea, wonders at wondering: I, a universe of atoms, an atom in the universe."

–Richard Feynman (again), from *The Value of Science* (1955)

Announcements

- Grades for Form E's are up on Blackboard; sorry for the delay
- Exam 2 question suggestions will be accepted until Friday evening

The nature of science

The discoveries of Kepler, Galileo, and Newton did more than explain the solar system.

They merged disciplines that had been separate since the time of the Greeks:

- Natural philosophy: "what is the truth of Nature?" (truth-seeking)
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- Truth in precision
- Synergy between truth-seeking and practical observation
- Synergy between theory and experiment
  - Theory: "Use things we've already observed to design a model"
  - Exp't: "Carefully choose observations to make to inform/test models"

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- Body of supporting evidence grows
- Continually seek to expand the *scope* of the model with more observations

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- What about gravity very close to big things?
  - Scope of Newton's gravity had to be modified
  - Newtonian gravity only right for small accelerations
  - Einstein: "I think I have a new model"
  - Newtonian gravity still correct within its scope

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- Scientific explanations are not anthropocentric – they don't give humans (or Earth) a special role

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The natural, non-anthropocentric view *does* influence our outlook, though...

How do we relate to learning that Nature's laws have no special place for us?

"I believe that this knowledge does not detract. If you look at the many examples around us or even within our own biology, the universe has a tendency to veer towards two basic concepts: 1. It likes to build in multiples, (stars, planets, galaxies, and possibly even universes) the universe, and 2) everything in it seems to be built with a relatively few basic components: For example, the four nucleobases found in DNA make up [the genetic code of] all living things.... Likewise, people are made from similar compounds [as]... bodies in the heavens. For these reasons I find this apparent complexity derived from simplicity rather spiritual."

–Chris

"I believe the "clockwork universe" [picture] takes away from the romance of the world because it takes away from those stories of the angels and how they move the stars but actually knowing how everything works really gives our life more meaning. Truthfully, I enjoy knowing how everything works. It's incredibly interesting and using the knowledge we currently have, we can use it to learn even more about the world. Some of this knowledge is so cool that it tries to bring back some of that romance. For example, learning about the Northern Lights is incredible because you get to understand why it happens and how it create such a beautiful sight."

–Caroline

"Science tells us what the world is, not what it means. When one studies nature, they do not do it simply because it is useful or informative to do so. We study Nature because we take pleasure in discovering its beauty. If nature were not beautiful, it would not be worth knowing. This "clockwork universe" picture does not detract from the romance of beauty but rather enhances it. Because scientific theory expresses the harmonies or "clockwork" motions that exist in nature, we have to acknowledge that these theories have an aesthetic value. There is something beautiful in symmetry and watching each piece of the world work together in perfect harmony."

–Meghan

"I think the idea of the "clockwork universe" is incredibly inspiring because it makes every single thing on earth seem so much more magical. Instead of things being so simple as they seem on the surface, they are products of an infinite amount of factors all working together. (However, the modesty which hides this complexity is also kind of beautiful, too.) It also is incredibly moving that the same laws which govern our way of life are the same laws that govern everything in the universe; the laws of physics make us feel like we aren't disconnected from everything else out there, but rather, fundamentally connected."

–Haylee

Scientific integrity

"But this long history of learning how not to fool ourselves–of having utter scientific integrity–is, I'm sorry to say, something that we haven't specifically included in any particular course that I know of. We just hope you've caught on by osmosis.
The first principle is that you must not fool yourself–and you are the easiest person to fool. So you have to be very careful about that. After you've not fooled yourself, it's easy not to fool other scientists. You just have to be honest in a conventional way after that.

...

I'm talking about a specific, extra type of integrity that is not lying, but bending over backwards to show how you are maybe wrong, that you ought to have when acting as a scientist.

...

One example of the principle is this: If you've made up your mind to test a theory, or you want to explain some idea, you should always decide to publish it whichever way it comes out. If we only publish results of a certain kind, we can make the argument look good. We must publish both kinds of results."

–Feynman, commencement address at Caltech, 1974

There's an entire discipline of mathematics designed to, in an objective way, examine what results mean: statistics.

But it's only as honest as the people wielding it: `https://xkcd.com/882/`

Science: a powerful tool

This synergistic enterprise has been behind a vast amount of progress for humanity in the last 350 years.

As with anything powerful, this process can be corrupted:

- Confirmation bias / placebo effect
- Ulterior motives: young-earth creationism, climate science, politicization
- Profit motive: vaccines causing autism
- Publication bias (jellybeans!)
- Artificially limited scope (some psych studies)

Science vs. pseudoscience

Often people adopt the trappings of science to give nonscientific ideas a veneer of validity. This is called "pseudoscience" – fake science.

Science

- Universal models
- Natural principles
- Testable predictions
- Not anthropocentric
- Replicable results
- Self-skepticism

Pseudoscience

- Singular events
- Supernatural explanations
- Untestable predictions
- Different rules for people
- Results defy replication
- Self-promotion

What would you like to talk about?

- Astrology
- Economics and integrity
- Ghosts and such
- Homeopathy vs. desensitization therapy
- Climate change
- Genetically-modified crops and statistics
- Vaccination
- ESP / telepathy
- Exterrestrial life
- Radioactive medicine
- Drug testing
- Medical marijuana
- Scientific integrity more broadly
- Something else...

“Our time is distinguished by wonderful achievements in the fields of scientific understanding and the technical application of those insights. Who would not be cheered by this? But let us not forget that human knowledge and skills alone cannot lead humanity to a happy and dignified life. Humanity has every reason to place the proclaimers of high moral standards and values above the discoverers of objective truth. What humanity owes to personalities like Buddha, Moses, and Jesus ranks for me higher than all the achievements of the enquiring and constructive mind. What these blessed men have given us we must guard and try to keep alive with all our strength if humanity is not to lose its dignity, the security of its existence, and its joy in living.”

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"Tell your son to stop trying to fill your head with science, for to fill your heart with love is enough!"

–Richard Feynman, 1981

What would you all like to talk about?