Whoever tells the truth is chased from nine villages.

old Turkish proverb

Chapter 2

What is Science?

Hype vs. Hypotheses

- Science is built around slow (and often uncertain) progression
- Conclusions reached are generally tentative, especially for new findings
- Rarely are we completely certain of any conclusions

Media Coverage of Science

- Tends to rely on highly simplified, eye-catching headlines
- Little weight given to methods, or discussion of caveats
- As such, the "hype" is often misleading and wrong

Tipping Scales

- Each individual study can be thought of as a small weight, placed on a scale
- Enough weight leads us to accept a conclusion, but a new piece of evidence can always tip things the other way

Common Sense

- We are surrounded by information all day, every day of our lives
- This leads us to develop certain beliefs and attitudes, based on our experiences
- We all try to make sense of our world, developing stories about how things work

Common Sense

- These "common sense" ideas or rules or thumb are often pervasive in our lives
- "Look before you leap" and "you can't teach an old dog new tricks"
- But just because we think it, doesn't mean it's accurate

Common Sense

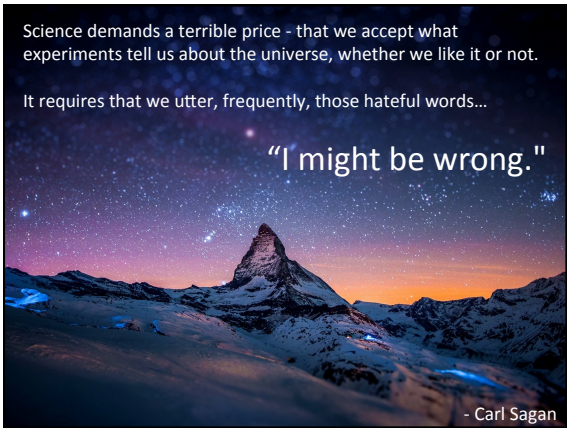
- "Look before you leap" but "He who hesitates is lost"
- "You can't teach an old dog new tricks" but "You are never too old to learn"
- How can we know which is actually correct? Or which is correct in what situations?

Common Sense

- Informed by personal anecdotes and small, unreliable amounts of information
- Influenced by *promixate* causes, *confirmation biases*, and *patternicity*
- Leads to unreliable beliefs or ideas, certainty about something we don't truly know

Fallibilism

- Absolute certainty doesn't exist in science
- Knowing something means "to the best of our current knowledge, this is accurate"
- It's okay (even good!) to be wrong



Science is…

"A set of **methods** designed to describe and interpret observed or inferred phenomena, past or present, and aimed at building a **testable** body of knowledge open to **rejection or confirmation**."

Shermer (2002)

Science is…

- A toolbox of skills designed to prevent us from fooling ourselves
- Learning to minimize your thinking errors
- Self-correcting
- Realist, naturalist, and empirical

Biases

- Given how good we (and others) are at fooling ourselves, science can help overcome biases in
  - Methodology
  - Analysis
  - Dissemination efforts
- This makes understanding the world more likely to be accurate

Scientific Method Building Blocks

- Hypotheses
- Laws
- Theories
- Facts
- These are all used by laypersons, but often not in a scientifically meaningful way

Hypothesis

- A testable statement that accounts for a set of observations
- Should be stated clearly enough to give guidance on *how* to test it
  - Observationally, experimentally, etc.

Law

- A well-established hypothesis
- Do not give explanations for why something occurs, just descriptions
- May only apply under certain conditions
  - Newton's law of universal gravitation works only in weak gravitational field

Theory

- A set of well-tested, well-supported hypotheses and laws
- Allows us to make broad predictions for a wide range of situations

Fact

- A conclusion confirmed to such an extent that it is reasonable to offer *provisional* agreement
- Is *not* 100% certain, can change in the face of new evidence

Steps of Scientific Reasoning

1. Identify a problem or observation in need of explanation
2. Gathering information about the problem or observation
3. Formulating explanations (hypotheses) regarding the problem or observation

Steps of Scientific Reasoning

4. Conducting tests or experiments to see which, if any, of the hypotheses provide a resolution for the problem or explain the observation
5. Derive a conclusion that accurately captures the resolution or observation
   - Should give guidance in terms of this or relevantly similar situations in the future

Inductive Reasoning

- Induction occurs when you use specific observations in the past to derive a principle for how things will be in the future
- For example, I ate at this restaurant five times, it's been good every time, so it will likely be good if I go there again

Deductive Reasoning

- Deduction occurs when you use empirical means of generating answers to questions
- Results in less chance of being wrong, but comes with sacrifices as well

Induction	Deduction
Used to develop hypotheses	Used to test hypotheses
Not truth-preserving	Truth-preserving
Broader in scope	Narrower in scope
Bottom-up reasoning / specific to general	Top-down reasoning / general to specific

Verification & Falsification

- There is a conflict between our natural inclinations and how scientific method works
- We tend to seek verification, science relies on falsification
- Confirmatory experiences can be highly subjective and unreliable

Verification & Falsification

- Science seeks out *disconfirming* instances and examples
- This allows us to rule out weaker hypotheses
- In turn, this gives helps us find strong, accurate hypotheses

Falsifiability

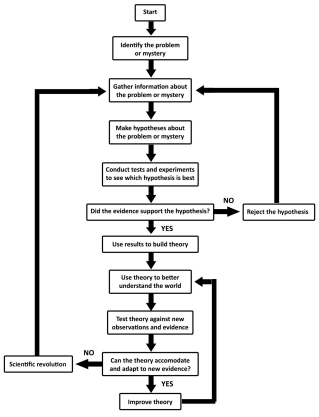
- Scientific claims must by falsifiable to be useful
- The more non-specific and general the claim is, the less falsifiable (and useful) it is
- Many pseudosciences fall prey to doing this

Astrology

- "December will a good month for you, professionally"
- Regardless of what happens, this can be spun as being true!

Triangulating the Truth

- Science moves forward by eliminating false hypotheses and using justified (true) ones
- Falsification means all truths are provisional, though – new data could always come to light that falsifies our "truths"
- The "flowchart of science" shows this process



Conclusions

- Science continually puts its ideas to the test
- We give up certainty in exchange for confidence that our ideas are correct…for now, at least!