

**Introduction to the Scientific Method**

# **How to ask questions**

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# Overview

- The scientific method
- Terms
- How to make a hypothesis
- Testing hypotheses
- How probable is an answer?

# The Scientific Method

- **Why do we need it?**
  - We want to find the truth
  - Already know the answer? Maybe there is a better explanation!
  - Help convince people that you are right
    - Evidence is King

# The Scientific Method

- **What is it?**

- A process to find the most likely explanation to a question based on evidence that supports or refutes the explanation
- A process to let you show why you are correct

# Not Science

- **Person 1:** “When you are cold drink something warm so you won't get sick.”
- **Person 2:** “How does that reduce your chance of being sick?”
- **Person 1:** “My grandma said so.”

# Science

- **With the scientific method we can show why something is correct or incorrect**
- **Facts are true regardless of authority**

# Steps of the Scientific Method

- 1) Ask a question** (what do we want to prove?)
- 2) Do background research**
- 3) Guess what the answer is**
- 4) Test if your answer is supported by evidence**
- 5) Analyze the results** (is your answer supported or refuted by the evidence?)
- 6) Document and share your findings**

# Terms

- **Scientist**
  - A person who applies the scientific method to find if a claim is true or false
- **Research question**
  - The question you want to answer
- **Prior works / Prior research**
  - All of the information you can find related to your research question
- **Hypothesis**
  - An educated guess that answers your research question – should be stated as **true** or **false**
- **Evidence**
  - Information that increases and/or decreases the probability of a hypothesis being true / false



# Terms

- **Experiment**

- A **repeatable** test designed to find evidence to support or deny your hypothesis

- **Theory**

- If a hypothesis is supported by evidence after a large number of experiments, the hypothesis may be considered by the scientist / community as a theory

- **Law**

- When a theory has been globally tested and largely accepted to be true it may be considered a law

- **Proof**

- Usually mathematical support for a claim

# Research questions and hypotheses

- Is the Earth flat?
- Is Korea the best country\*?
- Why is coffee addictive?
- Does everyone the same colors?

# Some problems to watch out for

- **We always want to be right**
  - If you already have the answer, the question is not **interesting**
  - If any answer is correct, the question is not **useful**
  - Easy to change the evidence to support your statements (even when it doesn't) – peer review needed
  - Being wrong is a **good** thing – we can learn a lot from it
- **Setting up experiments is difficult**
  - Must be precise
  - Must think about any **bias**

# The interesting thing about science

- **Trying to answer one question, usually brings up many more questions**
  - The Earth is not flat. Why not?
  - Motion forces Earth to sphere. Why is there motion?
  - Etc....

# All knowledge is probabilistic

- **It is impossible to know something is 100% true**
- **Not all evidence is equal - evidence has persuasive weight**

# All knowledge is probabilistic

- **Research Question: The Universe is 10,000 years old**
- **Evidence:**
  - (Against) Examine layers of rock deep in the Earth
  - (Against) Radiometric dating
  - (Against) Fossils / Oil
  - (Against) The farthest light observable in space
  - (For) Literal interpretation of the Bible

# A skeptical person that considers evidence

- **Probabilities Example:**
- **Earth is 10,000 years old  $P(0.5)$** 
  - Rock layers –  **$P(-0.25)$**
  - Radiometric dating –  **$P(-0.24)$**
  - Fossils / Oil –  **$P(-0.009)$**
  - Observable light –  **$P(-0.0009)$**
  - Literal Bible –  **$P(+0.0009)$**
- **Probability for 10,000 years: 0.001 (0.1%) = Not supported**

# A person that does not accept evidence

- **Probabilities Example:**
- **Earth is 10,000 years old  $P(0.5)$** 
  - Rock layers –  **$P(-0)$**
  - Radiometric dating –  **$P(-0)$**
  - Fossils / Oil –  **$P(-0)$**
  - Observable light –  **$P(-0)$**
  - Literal Bible –  **$P(+0.5)$**
- **Probability for 10,000 years: 1 (100%)  
= well supported “because I said so”**



# Bias

- **The persuasiveness of evidence is subjective**
- **Our belief systems and bias can make us ignore evidence (and come to very strange conclusions)**
- **Why is bias a problem?**
  - Does not lead to **Truth**
  - Policy based on bias always hurts the whole group

# Research questions, hypotheses, experiments

- **Is this woman a witch?**

- H1: This woman is a witch.
- H2: This woman is not a witch.
- How can we test these hypotheses?

- **Do hackers only drink soju?**

- H1: (for) Observed hackers drank soju.
- H2: (for) Observed hackers drank nothing.
- H2: (against) Observed hackers drank something other than soju.
- How can we test these hypotheses?

**Thank you**

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