Common Logical Fallacies in Science

Using critical thinking to evaluate reasoning in science

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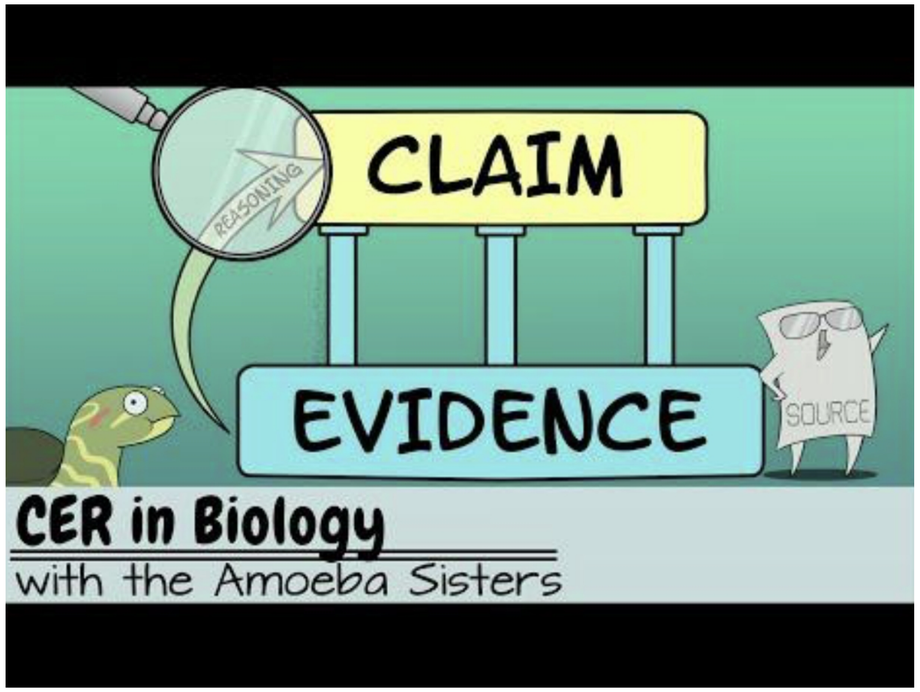
Overview

Reasoning is at the heart of doing and understanding science. Logical fallacies can create misunderstandings for scientists.

We will learn about common logical fallacies seen in science and use critical thinking to increase science comprehension.

Why do we care about critical thinking in science?

CER Review



Write down one word to summarize each:

- Claim
- Evidence
- Reasoning

Mystery Photo CER

What do you see in this image?

Claim

should be a complete sentence.

Evidence

includes observations.

Reasoning

links your **claim** to your **evidence.**

What does your pair/group think you are seeing?

Tongue

The tiny bumps on this muscular organ help you know if the food you eat is sweet, salty, or sour!

What misconceptions did we have?

Critical thinking can help us break down our thinking process into steps so that we don't jump to conclusions.

TED-Ed: A simple tool to improve critical thinking

Record the 5 tips in your notes.

Pick the one that stands out as the most interesting to you.

20 Word Gist:
Summarize why this tip is interesting, useful, confusing to you on your sticky note.

Critical Thinking Tips

Which tip would have been helpful with our Mystery Photo?

1. Formulate your question
2. Gather your information
3. Apply the information
4. Consider the implications
5. Explore other points of view

Vocabulary

Logic

(noun) the study of the formal principles of reasoning.

Evidence

something that provides proof (for a claim).

Claim

an assertion open to challenge.

Reasoning

(noun/verb) the use of logic to understand or judge something (evidence for a claim).

Logic (noun) is a set of rules which guide reasoning.

Reason (verb) is the act of using logic to understand or make a judgement.

We use claims, evidence and reasoning (CERs) to make sense of science.

Claim — The mystery image is a close image of grapefruit.

Evidence — The image is pink, bumpy and looks moist.

Reasoning — Grapefruit is pink, bumpy and moist. The item in this image is also pink, bumpy and moist. Therefore, the image is a grapefruit.

Can you come up with other examples?

CERs in Science

We can use CERs in science to make sense of the scientific process and to communicate our findings.

Hypotheses are usually **claims.**

The data that you collect is **evidence** for/against your claim.

Reasoning links your claims to your evidence. **This is where critical thinking comes in!**

Types of Reasoning

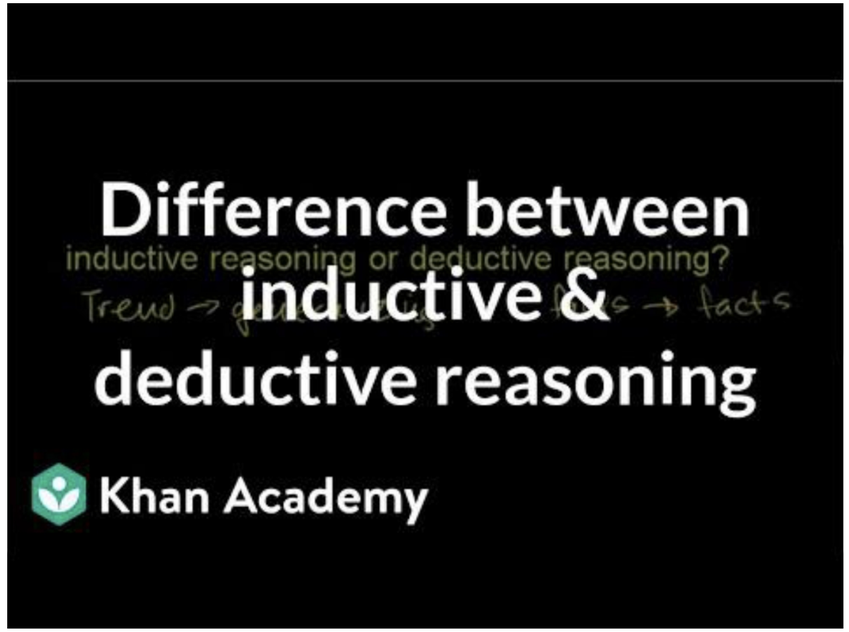
Inductive

Going from specific to general conclusions.

Deductive

Going from general to specific conclusions.

Comparing inductive and deductive reasoning



Record your own example of each type of reasoning in your notes.

Inductive Reasoning Example

Observation Dogs A & B have fleas (specific).

Pattern All observed dogs have fleas (specific).

Theory All dogs have fleas (general).

What are the weaknesses in this claim?

Using Critical Thinking to Evaluate Inductive Reasoning

If we jump from observing dogs A & B having fleas to the theory that ALL dogs have fleas, we may be experiencing the logical fallacy of **confirmation bias:**

believing or accepting only information that confirm your existing beliefs

Prevention strategies:

1. To prevent confirmation bias, we can collect additional data to test our premises.

2. We should also presume that we are wrong until we have collected enough data to provide strong support for our claim.

Preventing Confirmation Bias

Strategies

1. To prevent confirmation bias, we can collect additional data to test our premises.

2. We should also presume that we are wrong until we have collected enough data to provide strong support for our claim.

In science

1. Check your work multiple times to ensure it is error free.

2. Eliminate distractor information from word problems.

3. Compare multiple choice items carefully.

Deductive Reasoning Example

Theory	All dogs have fleas (general).
Hypothesis	All pet dogs in my neighborhood have fleas (specific).
Data	Test neighborhood dogs for fleas (specific).
Conclusion	Half didn't have fleas > reject hypothesis (specific).

What are the weaknesses in this claim?

Using Critical Thinking to Evaluate Deductive Reasoning

If we claim that all dogs have fleas based on the assumption that all dogs in the neighborhood have fleas, we may be experiencing the logical fallacy of **overgeneralization or hasty generalization bias:**

making a claim based on too little evidence

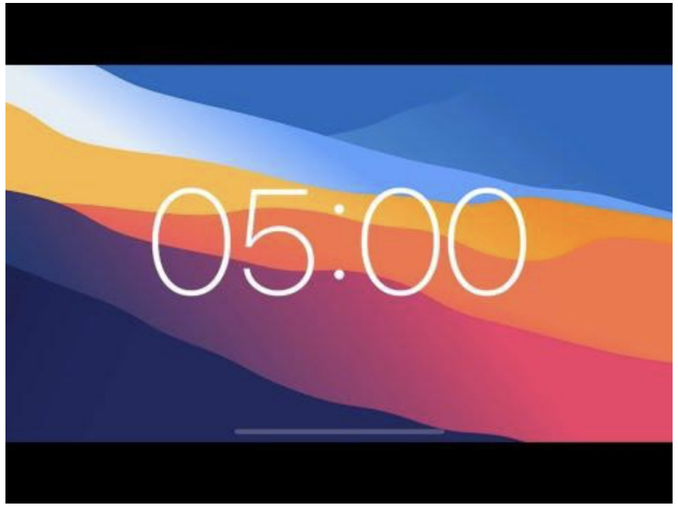
Prevention strategies:

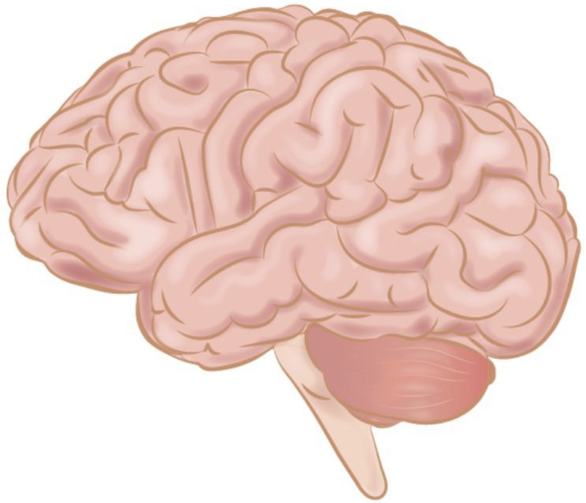
1. To prevent overgeneralization/hasty generalization bias, we can collect test our claim by collecting additional data.

2. Clearly defining our terms is also helpful to prevent this logical fallacy.

3. We should also presume that we are wrong until we have collected enough data to provide strong support for our claim.

Brain Break





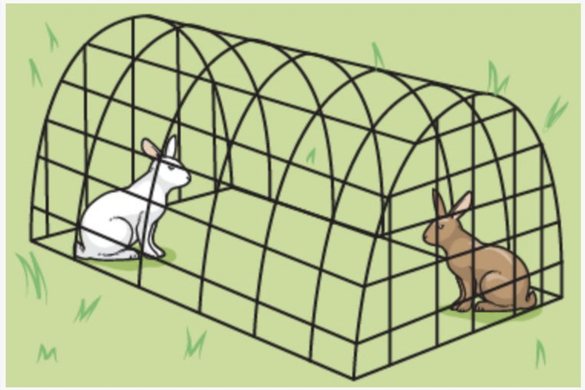
The next slide will show
a test question.

Choose the best
response to the question.

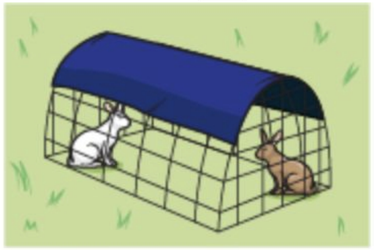
Which TWO designs are best? 1-2-3-4

Use the information to answer the question.

A student wants to make a new home for his pet rabbits. The new home must be outside and must reduce the warming effects of the Sun on hot days.

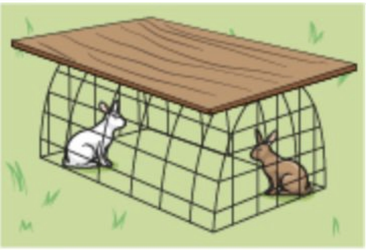


Which designs will best reduce the warming effects of the Sun? Choose two designs.

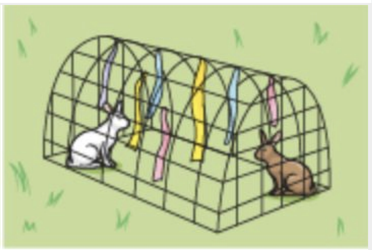


Adding a solid cover

Adding a clear cover



Adding a sheet of wood



Adding hanging ribbons

NWEA MAP Practice Test, 2022

Which designs did we choose?

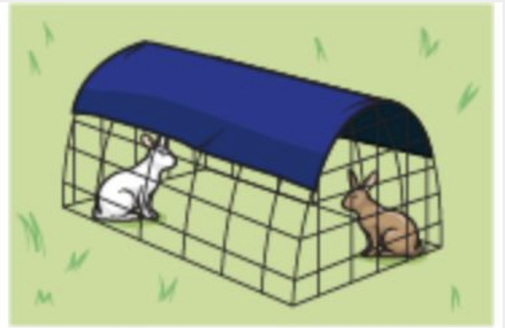
Why?

Appeal to Authority

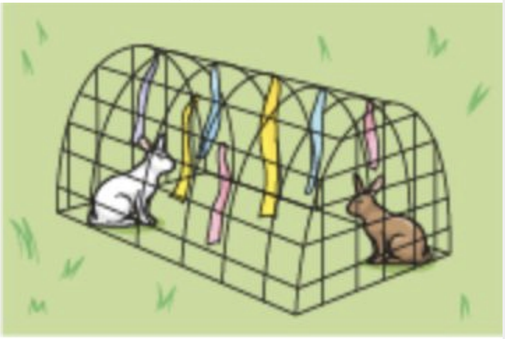
If an authority thinks something, it must be true.

Example

A student who is known to frequently score high on tests confidently states that we should add a solid cover and ribbons. Most of the class agrees that this is correct. What is the problem?



Adding a solid cover



Adding hanging ribbons

Prevention

Remember that there is no "smartest person in the room." Even teachers make mistakes sometimes!
Questioning authority can be a good thing.

Peer Pressure and Fallacies

Appeal to Authority is one of several fallacies driven by peer pressure. Here are two more that you might experience at school, especially during class discussion or group work time:

Bandwagon bias

We adopt certain behaviors or beliefs because many other people do the same.

Groupthink bias

We let social dynamics of a group situation override the best outcome.

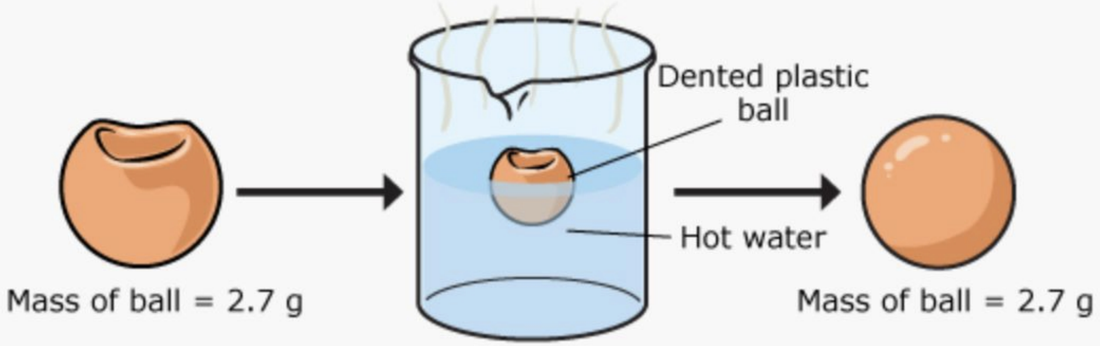
Prevention strategies:

1. Slow down the decision making process. Ask for additional time to think or discuss.

2. Try to make decisions in an environment where you don't feel pressured by other people.

3. Consider alternative options that go against the majority view.

A student wants to remove a dent from a hollow plastic ball used for table tennis. He reads that table tennis balls are filled with oxygen gas. He decides to put the dented ball into hot water to see what happens. The diagram shows the results.



Which statement explains the results of the investigation? Choose one explanation.

- ○ A. Oxygen molecules inside the ball move farther apart and push out the dent.
- ○ B. Oxygen molecules inside the ball fill with heat, grow larger, and push out the dent.
- ○ C. Hot air molecules enter the ball. The increased number of molecules pushes out the dent.
- ○ D. Hot water molecules enter the ball. The increased number of molecules pushes out the dent.

Which information is evidence that supports this explanation? Choose all the supporting evidence.

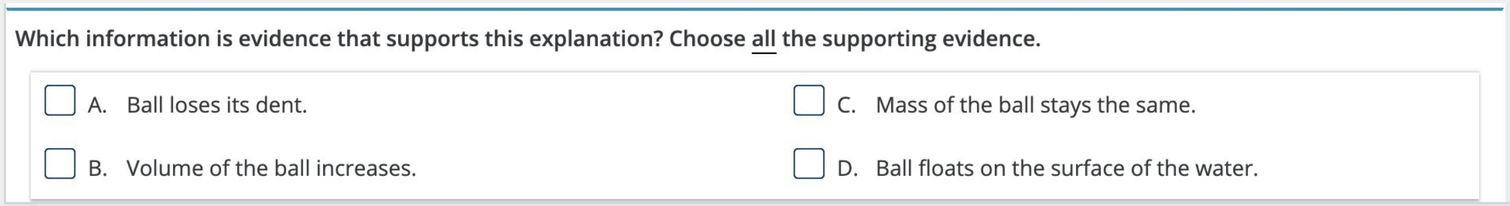
- ☐ A. Ball loses its dent.
- ☐ B. Volume of the ball increases.
- ☐ C. Mass of the ball stays the same.
- ☐ D. Ball floats on the surface of the water.

Availability Bias

We tend to use information that comes to mind quickly and easily when making decisions.

Example

You quickly choose A then move to the next question because you didn't notice that it said to choose ALL possible solutions. What else should you have chosen?



Prevention

Use lists and brainstorming to make sure that all possibilities are considered. If possible, ask for outside perspectives. Read, write and draw possible solutions. Re-read directions before submitting final answer.

False Dilemma

Only two choices are presented, but more exist. In the prior example, the student created their own false dilemma by assuming that there was only one correct answer.

Examples

It is either all right or all wrong.

It is either all good or all bad.

You either agree 100% or disagree 100%

Decomposition did not take place because there was not a rotting smell… other evidence of decomposition may be present (discoloration, expanding of container) to indicate decomposition. Smell is not the only indicator.

Prevention

1. Be sure to read the instructions slowly and carefully.

2. After choosing an answer, re-read the instructions to be sure that you are fully responding to the prompt.

3. Ask yourself, "is it possible that there could be more than one correct choice?"

Correlation is not Causation

Assumption that a real or perceived relationship between things means that one causes the other.

Examples

False: Ice cream sales cause a rise in sunburn.

False: Sunburn causes an increase in ice cream sales.

True: Hot weather causes an increase in ice cream sales and sunburn.

Ice cream sales and sunburn are correlated because they both increase with hot weather.

Prevention

1. Brainstorm all the possible causes for a phenomenon.

2. Consider relationships between all of your variables carefully.

3. Be sure to identify your independent (manipulated) and dependent (responding) variables.

Experimenter Bias

Occurs when experimenters allow their expectations to affect their interpretation of observations.

Examples

The researcher thinks that methane gas produced by cows is causing global warming.

The researcher only collects data on methane gas (not other types of gases).

The findings show a relationship between the increase of cows, methane gas and global warming.

Prevention

1. Consider your hypothesis and research questions carefully.

2. Be sure to identify your independent (manipulated) and dependent (responding) variables.

3. Have an outside party review your research and conclusions.

Sunk Cost Fallacy

We tend to follow through on something when we are invested in it, whether or not the costs outweigh the benefits.

Example

Your decomposition lab is leaking and stinking, you want to cut your losses and write your lab report and throw everything away but you need two more days of data!

Prevention

1. Take a break! If you have reached your frustration point or are struggling to think clearly, step away from the problem for a bit and come back to it later.

2. Check your work using another strategy.

3. Get feedback from an objective source.

What fallacies were present in our initial conversation about the Mystery Photo?

How can we use critical thinking in future investigations?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