Name: ______________________________________ Date: ________________________

Guided Learning: Science and Testability (Part 4)

Controlled experiments… a closer look

Controlled experiments are useful for both supporting hypotheses and for refuting them. When Samoa began greeting you more regularly on Wednesdays after you started bringing home treats, it supported the second explanation—that Samoa had done the same thing earlier because you often brought her treats on your way home from marching band practice. However, it did not rule out any of the other remaining explanations for Samoa's original behavior.

An explanation can be compatible with an observation without the observation supporting the explanation. The fact that Samoa started greeting you more on Wednesdays after you began bringing her muffins does not rule out other explanations as the cause of her earlier behavior. For example, thirst could have been the reason for her earlier behavior even though it appears a desire for treats is the cause of her greeting you on Wednesdays now.

1. Your school decides to test a new schedule. On Fridays, students begin later, at 10:00 A.M., but they also leave school later. This means you start coming home on Fridays at 5 P.M., but you are away from Samoa for the same amount of time. She begins greeting you more frequently on Fridays after this change. Fill in the final (fifth) row of the table. (Explanation IV is not included in the fourth row because it was refuted by your second observation.)

Observation	Explanations		
	Refuted	Compatible with	Supported
Samoa greets you more often on Mondays and Thursdays during marching band season.		I, II, III, IV	
Samoa starts greeting you with equal frequency on every day after marching band season ends.	IV	II, III, IV	I, II, III
Samoa starts greeting you more frequently on Wednesdays after you start going by the bakery on those days.		I, III	II
You begin leaving school later and getting home later as well. Samoa begins greeting you more frequently on Fridays.			

Key to Explanations:

I: Samoa misses you

II. Samoa wants a treat

III. Samoa is thirsty

IV. Samoa learned pattern from mother.

2. Explain your reasoning: ____

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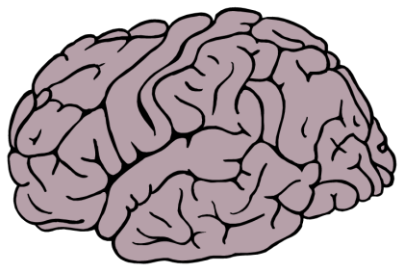
Thinking about… predictions and testability
An experiment can test an explanation if that explanation calls for an explicit outcome when the experiment is run. If the experiment's results match what would be predicted based on the explanation, the explanation is supported. If the experiment's results do not match what the explanation predicts, the explanation is refuted.

If an explanation does not clearly suggest a certain outcome for a given experiment, the experiment is much less useful as a test. Explanations I and III do not give any clear predictions about what would happen after you began bringing Samoa treats on Wednesday, so her resulting behavior was not useful for testing those explanations. Either result would be compatible with those explanations. No matter how Samoa reacted to this change, it would not support or disprove those two explanations.



Consider a new explanation:

Explanation V: Samoa is incredibly smart, and she is changing her behavior just to puzzle you.

No matter what experiment you run, and no matter what observations you made, you could explain the results by saying, "Samoa acted that way to puzzle me." Explanation V does not make any clear predictions, but it is compatible with practically any results. Hence, explanation V is not scientifically testable because there is no way to refute it.

Another reason why clear predictions are useful is that they allow a given explanation to be tested by independent scientists in different contexts. If a theory gives clear predictions, there is no question as to what results the explanation predicts in a particular situation.

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The discussion above shows that explanations can only be testable when they make clear predictions, but there are some explanations that are not testable even if they make predictions.

1. Imagine your little sister claimed that rocks like to be on the ground. When asked how she would test this claim, she says, "If I drop a rock, I predict it will fall to the ground." In your own words, describe why this is not a good test of her claim, even though it is a prediction:

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2. Imagine your little brother says, “I believe there are heat-resistant snails living in the core of the Sun.” When asked what experiment his explanation makes a prediction about, he says, “Simple. I predict that if you build a heat-resistant space shuttle and fly it into the center of the Sun, you will find little snails there.” Why is this not a good test?

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3. Based on these two scenarios, describe in your own words what makes an explanation capable of being fairly tested using science:

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Falsifiability

The two scenarios described in the last set of questions illustrate additional requirements for a scientific explanation. Not only must it make clear predictions about what happens when a certain experiment is done, but those experiments must be possible. Furthermore, the outcomes that are predicted must be different from what would be expected if the explanation were false. For example, rocks are expected to fall to the ground regardless of whether they “like” to be there. Because the prediction your little sister’s explanation made is one that would be expected even if her explanation were false, the experiment she suggested is not a good test.

An explanation is said to **falsifiable** if it gives predictions that are not otherwise expected about the outcome of a doable experiment.

A scientific explanation must be **falsifiable**.

Think about it: Why do you think an explanation must be falsifiable to be considered testable?

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Candles in jars

Imagine on Monday your friend told you that he ran an experiment last Friday. He lit two candles—one tall, the other short—and put them both under an overturned jar. He went to the restroom to wash some wax off his hands. When he returned, he noticed the taller candle had gone out but the shorter one was still lit. This contradicted what he had read, which said candles go out when they have consumed all the oxygen in the container. If that were so, the two candles should have gone out at the same time, when all of the jar's oxygen had been consumed. He was going to bring the candles to school to show the science teacher so she could run the experiment, but the backpack he had put them in was stolen over the weekend.

Consider the four possible explanations below.

I. The book is correct. Candles do go out when they consume all the oxygen, but there is a small random factor, so one candle may go out a little before the other. In your friend's experiment, the shorter one burned longer owing to chance.

II. The shorter candle was made by a more skilled candle-maker, so it burned longer.

III. Flames give off steam, which condenses to form water droplets at the top of the jar. While your friend was wiping the wax off his hand, one of these water droplets fell and extinguished the taller candle, so only the shorter one was still lit when he returned.

IV. The book is wrong. A burning candle gives off carbon dioxide, which accumulates at the top of the jar. This invisible cloud of carbon dioxide eventually expands far enough downward to snuff out the candle. So, the taller candle gets snuffed out first.

In your journal, on another piece of paper, or in an interactive notebook, explain which of these accounts are falsifiable and which are not. For those that are falsifiable, explain how you could test them. For those that are not falsifiable, explain why they cannot be fairly tested.