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Beautiful Biological Questions

BBQ1 - How do you distinguish Science from Pseudoscience?

Over the next few weeks you and your teammates will be constructing answers to the BBQ – How do you distinguish science from pseudoscience? You will start by answering **three** smaller/mini BBQs that will help you construct your answer to the big BBQ. Each mini-BBQ (BBQ1a, 1b, and 1c) explores a component of the answer to the question about distinguishing science from pseudoscience that you will answer and then integrate into your final post. During the next few weeks you will engage in some Individual Process Assignments (IPAs) that will help you explore information and resources related to the BBQs. You will also work with your teammates in class on Team Process Assignments (TPAs) that will further your understanding of the answer to the BBQ.

Assignment Calendar

Class meets on Monday and Friday from 2:30-3:45

BBQ1 – What distinguishes Science from Pseudoscience				
	Weekend	**Mon**	**Tues-Thurs**	**Fri**
Week 1 **BBQ1a** What is Science?	-No Homework (First Week of Classes)	-BBQ1a IPA I -BBQ1a TPA I	-BBQ1a IPA II	-Class Discussion -BBQ1a TPA II -BBQ1a Answer Post
Week 2 **BBQ1b** Who do you believe about science?	-BBQ1b IPA	-BBQ1b TPA	-BBQ1b Answer Post	-Class Discussion
Week 3 **BBQ1c** What is a reliable source about science?	-BBQ1c IPA	-BBQ1c TPA	-BBQ1c Answer Post	-Class Discussion
Week 4 **BBQ1** How do you distinguish science from pseudoscience?	- Begin Prep for next BBQ	-Class Discussion about BBQ1 and next BBQ	- BBQ1 Final Answer Post	-Select Next BBQ

<u>Calendar Key and Posting Details</u>

- IPA = Individual Process Assignment
- TPA = Team Process Assignment
- BBQ = Beautiful Biological Question

- IPAs and TPAs posted to the class Wiki
- BBQ Answer Posts to the BBQ Blog

BBQ1a: What is science?

I. Individual Process Assignment I – (Monday, week#1)

What is Science?

Many discussions of science and the scientific method may lead you to believe that the development and testing of hypotheses are so organized that, once a problem has been chosen for study, it all goes like clockwork. In truth, this is rarely the case and successful scientific investigation actually includes a considerable amount of creativity (especially in developing hypotheses), luck (especially in choosing a 'starting' hypothesis among several equally plausible, but competing, ones), and perseverance (especially in repeatedly testing and modifying a hypothesis using many different experimental approaches). Furthermore, even an experiment that doesn't turn out the way you expect is useful in that it allows you to eliminate a possible hypothesis. In fact, sometimes an experiment is performed precisely to see if indeed it will ''fail" since the experimenter's hypothesis predicts it to do so. Thus, there really is no such thing as a "failed" experiment, only a poorly designed or poorly executed one.

You should also gain an appreciation for the fact that scientific investigation is iterative (you just have to keep testing and modifying your hypothesis until it explains ALL of the related data - a single experiment is not sufficient), cooperative (since no one person can do ALL of the relevant experiments related to a hypothesis, the sharing of data among investigators is crucial), and tentative (you will never know for SURE that your hypothesis is absolutely true since it can never be tested in every conceivable way). You will often discover that unstated hypotheses are consistent with your experimental results thus allowing you to revise your original hypothesis.

Hypotheses

Observations of the natural world can reveal something entirely new or result in a new way of looking at a phenomenon. One way to explain phenomena about the natural world is to use science. The process of science begins by formulating a hypothesis. A hypothesis is a proposed explanation for a set of observations. A hypothesis must be testable to be useful - this is typically expressed in terms of being "falsifiable". A falsifiable hypothesis is one that has the potential to be shown false if it is indeed false. If a hypothesis cannot be tested (i.e. cannot be falsified), it cannot contribute to scientific progress.

Predictions

Once we have generated a hypothesis, we of course want to know whether that hypothesis is correct. To test the hypothesis, we first generate one or more predictions. When testing hypothesis, we actually test the predictions of the hypothesis and then infer whether the hypothesis is correct or not from whether our predictions are or are not supported by the results. Predictions are logical outcomes of hypotheses that describe what we expect to see under a given set of circumstances if the hypothesis is true. In other words, predictions help determine the type of study or experiment that needs to be done to test the hypothesis.

Descriptive Studies

In descriptive studies, the scientist is not testing a hypothesis, but simply making observations. For example, you might make observations of the pollinators that visit a particular species of flowering plant. You might record the different species of pollinators, how frequently they visit the flowers, the time of day that visits occur, and the amount of time individuals of each species spends at the flowers. You would then look for relationships among the observations and generate hypotheses that would explain the observations and relationships. Descriptive studies are common in new fields of science or when new systems are studied in established fields.

Test of Hypotheses

It is through the testing of hypotheses that scientists generate explanations for why natural phenomena occur the way they do. There are two general types of studies that are used to test hypotheses, non-experimental and experimental tests.

Non-Experimental Tests

In a non-experimental (or observational) test, the researcher does not manipulate any variable but merely gathers data needed to test the hypothesis. For example, if we wanted to test the hypothesis that the global temperature has increased in the past 100 years, we would get temperatures from weather stations around the world and determine if the average global temperature has increased, decreased, or remained the same.

Non-experimental tests are perfectly adequate for examining a relationship between two variables, but can be problematic exploring whether a causal relationship exists between variables. For example, we might want to test the hypothesis that taking Vitamin C reduces the risk of catching a cold. We could test this hypothesis with a non-experimental test by finding persons that do and do not take Vitamin C supplements and recording how many colds they catch in a year. Suppose we find that there is a strong correlation (association) between Vitamin C consumption and the incidence of colds. This result is certainly what is predicted by the hypothesis. However, this non-experimental test does NOT demonstrate a causal relationship between Vitamin C consumption and the incidence of colds. This type of test does not demonstrate that Vitamin C consumption prevents the onset of a cold. Can you think of an alternative explanation for the results? For example, persons that take Vitamin C may also exercise more than persons who do not take Vitamin C, and it may be the exercise, and not the Vitamin C, that is the real influence on susceptibility to common colds.

Experimental Tests

The best way to establish a causal relationship between variables is to conduct an experiment. In an experiment, the researcher manipulates the independent variable and measures the dependent variable, given this name because it depends on the independent variable. To test the Vitamin C hypothesis, the researcher manipulates Vitamin C consumption (the independent variable) by assigning subjects to the treatment groups and then measures the frequency of colds (dependent variable). In contrast, subjects in a non-experimental test assign themselves to the different "treatments." By manipulating the independent variable (and conducting the experiment properly), we can be sure that any differences we see among our treatment groups in the dependent variable are due to the manipulated independent variable and not to any other variable. This fact makes the experiment the most powerful method for testing causal hypotheses.

Experiments have a treatment (e.g., take Vitamin C) and usually (but not always) have a control (e.g., take a placebo). In the control the independent variable is held at an established level or omitted. The control allows us to determine what outcome we would expect in the absence of the treatment. The treatment group takes vitamin C in our Vitamin C experiment and the control group takes a placebo. For example, a group of individuals given a placebo supplement would tell us how many colds per year a person would catch, on average, if they did not take a Vitamin C supplement and therefore whether the average number of colds in the experimental group is lower.

The Importance of Quantifying

Science is an empirical endeavor; it relies on measurements of the real world. Scientists seek to quantify natural phenomena and seek to do so as precisely as possible. If you are conducting an experiment to determine whether one fertilizer works better than another, it is not enough to provide your subjective impression of which plants grew better. You must measure their height and weight, the number of leaves produced, and the proportion of leaves that exhibit spots (plus other variables). By quantifying your results, you will be able to determine precisely which fertilizer is more effective, as well as allow others to examine your data and reach their own conclusions. Just about every natural phenomenon can be quantified; even recording the presence or absence of a species in an area qualifies as quantifying. Data can be categorical (e.g., male, female), ordinal (low, medium, high), or continuous (e.g., height); however, all of these types of data are quantitative. The mathematical tools of statistics allow us to summarize data and determine whether observed relationships between variables are genuine or are likely to be due to chance alone.

Team Process Assignment I – (Monday, week#1, Wiki)

Generate one hypothesis for each of the two sets of scenarios listed below. Remember that a hypothesis is a proposed explanation for a set of observations. To be useful, hypotheses must be testable and lead to predictions. From each of your hypotheses, describe the experiment you would set up to test the hypothesis (indicate the independent variable, dependent variable, and control) then make one prediction.

a. *Scenario #A:* You have been interested in the behavior of two squirrels that inhabit the area around Miller Hall. After observing their behavior for a few weeks, you made the following observations. Each day during the first 3 weeks of August, the two squirrels would carry approximately 50 acorn nuts up to the roof on Miller Hall. However, during the last week of August, the squirrels were not observed going up to the Miller Hall roof. Rather, they were now bringing all of their acorns to a series of small holes near the two bench gardens along side the main entrance of Miller Hall. The interesting observation in this scenario is that the squirrels have CHANGED their storage location.
    1. Hypothesis:
    2. Experiment:
    3. Prediction:

b. *Scenario #B:* The incidence of colon cancer is much lower among Japanese populations living in Japan than the incidence of colon cancer among Caucasian populations in the United States. The incidence of colon cancer among Japanese living in the US approaches that of Caucasians living in the US.
    1. Hypothesis:
    2. Experiment:
    3. Prediction:

Individual Process Assignment II – (Tues-Thurs, week#1, Wiki)

Science in the News – provide answers to the following questions after reading each article.

1. Article I - Corn Insecticide Linked to Great Die-Off
   a. What natural phenomena are the researchers trying to explain or explore?
   b. What is the hypothesis the researchers tested?
   c. Identify the IV, DV and Control.
   d. What results did they obtain? (Describe the actual data presented in the article)
   e. Do these results support or falsify the hypothesis?

2. Article II – H1N1 Discovery Pays Off
   a. What natural phenomena are the researchers trying to explain or explore?
   b. What is the hypothesis the researchers tested?
   c. Identify the IV, DV and Control.
   d. What results did they obtain? (Describe the actual data presented in the article)
   e. Do these results support or falsify the hypothesis?

"Gimme a Minute"

Interview 3 biology majors (they are all over the place in the Bioscience building) ask them to answer the question … what is science … in a minute. Yes, you need to time them. Let them know they must speak for the entire minute. Record their responses using the voice recorder from your phone, or from a friend's phone. Submit a transcript of their answers to this question.

Team Process Assignment II – (Friday, week#1, Wiki)

- Review your graded answers and feedback to IPA II of this BBQ.
- Share and discuss interview transcripts.
- Submit two index cards to Dr. H. – one indicating areas of confidence and the other indicating areas of confusion regarding this BBQ.

BBQ1a Answer Post – (Friday, week#1, Blog)

- Compile a 1 minute spoken answer to the question "What is Science" using text from the interviews you and your teammates acquired.
- Use the "Gimme a Minute" Post Prompt and include text that explains what is missing from the answer as well as new insights you had as a result of this assignment.

BBQ1b: Who do you believe about science?

Individual Process Assignment (weekend, week#2, Wiki)

The Dilemma

About 5 years ago I was enjoying a lovely cappuccino and bagel on a lazy Sunday morning when I heard a story on the Today show on the NBC network. This story was about a potential cure for cancer called – ***Antineoplastons***. This potential cure for cancer was being promoted by Suzanne Somers (of Three's Company" and "Thigh Master" fame). She wrote a book on this topic praising the controversial work of Dr Burzynski. Well, this seems right up our alley – beautiful biological question, science, and controversy! Where to start? Google, of course! I found a bunch of websites and articles and then began to realize that it is pretty hard to know who to believe… So, during this assignment you are going to reflect on the scientific reliability of AUTHORs – I am not asking you to evaluate the reliability of a website, instead the person who authored the material you find in terms of their believability (ok, maybe I made up that word) about SCIENCE.

The Authors

- Suzanne Somers – celebrity author of the book, Knockout: Interviews with Doctors who are curing cancer and how to prevent getting in the first place. (you can read a few pages of this book on Amazon.com).
- Craig Malisow – journalist for Houston Press News, an online newspaper. He is the author of an article on one of the doctors in Somer's book – Cancer Doctor Stanislaw Burzynski sees himself as a crusading researcher, not a quack, published in 2008. Click on the title to read his article.
- Cancer Org.com – a group of authors who work at the Cancer.org website. They published some web materials about the treatment that Dr. Burzynski claims is the new cancer wonder drug, Antineoplastons.
- Dr. Burzynski – the doctor who runs a clinic where patients receive the treatment he developed using Antineoplastons. He is also the subject of various books and author of some scientific journal articles. I put a PDF copy of one of his journal articles that he published in 2004 in the scientific journal, ***Integrated Cancer Therapies***, on the Wiki for you to look at.
- Dr. Buckner and his team – a group of scientists who have also studied Antineoplastons and published their work in 1999 in a scientific journal called, ***Mayo Clinical Proceedings***. A PDF of this paper is also on the Wiki.

How do you decide?

1. What makes an author reliable? Do some research and then summarize your findings in a list. You do not need to cite sources.
2. What makes content in a book or website **scientifically** reliable? Again do a bit a research and then summarize your findings in a list. You do not need to cite sources.
3. Based on your findings make a list of the authors ranking them from most reliable (#1) to least reliable #5.
4. Explain why your selection for most reliable and least reliable.

Team Process Assignment (Monday, week#2, Wiki)

Reflecting and Debating – Reaching consensus on which author is most reliable and why.

1. Read over the responses posted by your teammates for BBQ1b IPA.
2. List the authors from most reliable to least reliable:
3. Explain why your answer to question #2. Incorporate your research on what makes an author reliable and what makes content scientifically reliable.

BBQ1b Answer Post – (Tues-Thurs, week#2, Blog)

Choose an assignment prompt from the BBQ blog to demonstrate the answer to this BBQ (Who do you believe about science?). I have selected a few that I think would work well for this BBQ, but feel free to use any you would like.

- **Pop Quiz** – using the answer to the BBQ create a pop quiz highlighting all aspects of the BBQ answer. Your quiz should have at least 8 questions addressing the essential aspects or misconceptions of the BBQ answer. You can make this in online quiz using online quiz service like PollSnack or other similar sites.
- **The Family Table –** everyone can recall memories of conversations around the family table. You know your family and these conversations better than anyone. Create a "family conversation" about the answer to the BBQ. Act out the various roles around the table as you explore the science that answers the BBQ. Post the script or audio recording of this conversation to the Blog
- **Over-Dramatic Reading** – draft the answer to the BBQ into an audio recording of a dramatic reading that you read in a way that overly emphasizes aspects of the answer (using an odd pace, being overly excited or sad, etc.). Post the audio recording to the Blog.

BBQ1c: What is a reliable resource about science?

BBQ1c Individual Process Assignment (weekend, week#3, Wiki)

The Dilemma – Truth or Death? (ok that is a bit overdramatic – one of my faults ☺)

Well, it looks like you and your classmates took a peak into the variables that influence the reliability of resources and authors. From your BBQ posts it seems that most of you think that credentials, timeliness, and sources make an author reliable. Does this mean we should believe all scientists, especially the younger, more recently published scientists? I guess I'm not convinced that all of the scientists are ***that*** trustworthy. But we shall see. There is also a sense that books are more reliable than websites and that the .edu or .com at the end of the website provide insights into reliability. Again, seems like there may be shades of grey in this story as well. So how can we wade through the weeds to find the real flowers? More importantly, how can we know whether what appears to be a highly reliable author is telling the truth, especially in situations related to serious health issues, like cancer? This week's quest is to figure out what makes good science, good and bad science, bad. Seems like a good time to start reading the book, **Bad Science: Quacks, Hacks, and Big Pharma Flacks** by Ben Goldacre.

Assignment

- Read chapters 1-4 in the **Bad Science** book. (again this is a short book, available in Kindle format for about $10; don't take copious notes, just sit down and read). Answer the following questions.

What resonates with you?

1. **Your Favorite Quote.** Select a line or two from the first four chapters that you find entertaining, interesting, or perplexing. Provide the quote, the quote's location, and explain why this quote made you stop and pause about science, scientists, or people who use science to do … well to do what they do.
2. **This Story.** Each chapter explores a different story about the ways that science can be used or misused to influence us. Which story did you find most compelling? Explain why.
3. **The New You.** So what? Draft a reflection paragraph (at least 200 words) telling your teammates and me how your views about science/scientists have changed after reading these chapters. I guess it is possible that your opinions about good and bad science/scientists hasn't changed, but even if you haven't changed how you are thinking, tell us why you still hold your views about science and scientists.

BBQ1c Team Process Assignment (Monday, week#3, Wiki)

How do scientists know what is a reliable source about science? In other words, how do scientists know whether another scientist is telling the truth? The answer is pretty simple, scientific communications are based on a socially constructed norming process called – Peer Review. During class you and your teammates will be exploring the process of peer review to enhance your understanding of how scientists (or anybody for that matter) knows who is telling the truth about science and who is not.

1. What is scientific peer---review and how does it differ from editorial review?
2. What kinds of publications utilize scientific---peer review?
3. What are peer---reviewers looking for when they peer---review material for publication?
4. How can you determine whether a publication has undergone scientific---peer review?
5. What if you can't understand a peer---reviewed publication? How do you know whether a source used peer---reviewed information?

BBQ1c Answer Post – (Tues-Thurs, week#3, Blog)

Choose an assignment prompt from the BBQ blog that you have not used for BBQ1a and BBQ1b Your post should use answers and feedback from your IPA and TPA for BBQ1c answer to the question – *What is a reliable source about science?*

BBQ1 Final Answer Post – (weekend, week#4, Blog)

Choose an assignment prompt from the BBQ blog – indicate which Blog assignment prompt you would like to use to demonstrate the answer to this BBQ. Your post should address the answer to BBQ1 – How do you distinguish between science and pseudoscience?