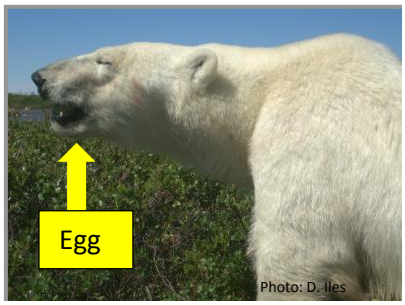
STUDENT PAGES: The Polar Bears of Summer
INDIVIDUAL ACTIVITIES

The activities in these pages correspond with the story "The Polar Bears of Summer: What Do You Eat While the Ice is Gone?". Read this story first, and then complete these activities individually. Read instructions carefully for each activity before diving in.

Have fun!

ACTIVTY 1: Estimate the number of Kcal the sub-adult polar bear consumed during the 96 hour period.



Information you need:

- The bear ate eggs from 220 nests
- The average eider nest contains 4 eggs
- Midway through the incubation period, each egg can provide a polar bear with approximately 206 Kcal in digestible protein and fat

Questions for Activity 1:

Question 1.1: How many Kcal did this sub-adult bear consume? Answer: _____

Question 1.2: A 600 pound male polar bear is thought to have an annual energy budget requirement of 4.44×10^6 Kcal. What percentage of his annual energy needs did this bear consume in 96 hours (Of course, this calculation does not account for any energy he lost capturing eggs, but this energy loss was not very high especially since **eggs do not run fast** and all 220 nests were within an area not much bigger than 4 football fields) Answer: _____

Question 1.3: For fun, calculate the energy of this feast in terms of the number of Big Macs. On average, a Big Mac contains 550 Kcal. Answer:_____

ACTIVITY 2: Use data to examine the possible overlap between polar bear onshore arrival and mean hatching date of snow geese eggs.

In the story you ready about polar bears and nesting snow geese, you learned that polar bears in western Hudson Bay are coming onshore earlier each year because the Arctic ice is melting sooner each year. Are snow geese arriving to the Arctic earlier, too? If so, that could affect whether or not snow goose eggs are available as potential food for polar bears.

Here's why: polar bears that arrive onshore relatively earlier (due to climate warming) will only have access to the eggs of incubating geese IF the geese are not also starting their 24-day incubation period earlier. We need two data sets to examine this phenomenon: 1) the rate of advance in onshore arrival by polar bears, and, 2) the rate of advance in mean hatching date for snow geese. Examining advances in both allows us to determine if there's overlap of polar bears and nesting snow geese.

DATASET 1: Rate of advance in onshore arrival by polar bears: Dr. Ian Stirling and his colleagues have shown that the date when the sea ice in western Hudson Bay reaches 50% dissolution (defined by DA Etkin as "breakup"), polar bears begin coming ashore. While other indicators may be as predictive of the onshore arrival of polar bears, the change in the date of ice breakup can be examined as a surrogate to predict the rate of advance of onshore arrival of polar bears in response to climate change. You will find this data set in an excel file called "Datasets for Students". These data are in the tab called "Overlap Data".

DATASET 2: Rate of advance in mean hatching date for snow geese: Changes in the mean date of hatching by snow geese can similarly be evaluated to compute the rate of advance of the 24-day incubation period when goose eggs would be an easy meal for polar bears. You will find this data set in an excel file called "Datasets for Students". These data are also in the tab called "Overlap Data".

LOOK -> The datasets use "Julian Day" as the date. What is a Julian Day? Answer: Number of elapsed days since the first day of the year. So in 2015, the Julian Day for July 4 = 185.

Instructions for Analyzing Data for Activity 2:

1. Open the excel file called "Datasets for Students" and look at the data in the tab called "Overlap Data".
2. Create one scatter plot showing: A) Mean Julian Day of Ice Breakup by Year, and, B) Mean Julian Hatch Day (Hint: place Year on the x-axis and Julian Day on the Y-axis)
3. Format the y-axis by changing the minimum number to "fixed" at 145
4. A good way to see if variables are changing over time is to run a linear regression that measures the relationship between changes in the variables (i.e., Mean Julian Day of Ice Breakup, and Mean Julian Hatch Day for Snow Geese) and time. The relationship is called the slope. If you compare the slopes of the two variables, you can see if one is changing faster than the other. Let's do that! How? Right click on the data set for "Mean Julian Day for Ice Breakup" and "add trendline". Keep the trendline "linear" and "display equation on chart"
5. Right click on the data set for "Mean Julian Hatch Day" and "add trendline". Keep the trendline "linear" and "display equation on chart"
6. Write the linear equations for both datasets here:
   Equation for "Mean Julian Day of Ice Breakup": _____
   Equation for "Mean Julian Hatch Day": _____

7. Name this Figure 1 and place the graph in the space below or on a separate sheet:

Questions for Activity 2:

Question 2.1: The Arctic sea is melting sooner each year. Use the equation from Step 4 to estimate the rate at which sea ice break-up is advancing: _____

Question 2.2: We are using the rate of sea ice break-up as our surrogate for the rate of advance of onshore arrival by polar bears. So, what is the rate of advance of onshore arrival by polar bears? _____

Question 2.3: Use the equation from Step 5 to estimate the rate of advance of mean hatch date for snow geese: _____

Question 2.4: Which process is advancing more quickly, polar bear onshore arrival or hatch date for snow geese? _____

Question 2.5: What do these results tell you about whether or not polar bear onshore arrival is predicted to overlap with the mean hatch date of snow geese?

_____
_____
_____
_____
_____
_____

ACTIVITY 3: There is extensive literature on matches/mismatches; read about matches/mismatches here: http://en.wikipedia.org/wiki/Match/mismatch. After you've read about matches/mismatches, provide one example of how climate change can affect trophic exchange with respect to match/mismatch:

Answer:

_____
_____
_____
_____

ACTIVITY 4: In 2006, there were 48,855 pairs of nesting snow geese on the Cape Churchill Peninsula. Your job is to calculate the energy available in the eggs in those nests in terms if Kcal and # of Seal Days.

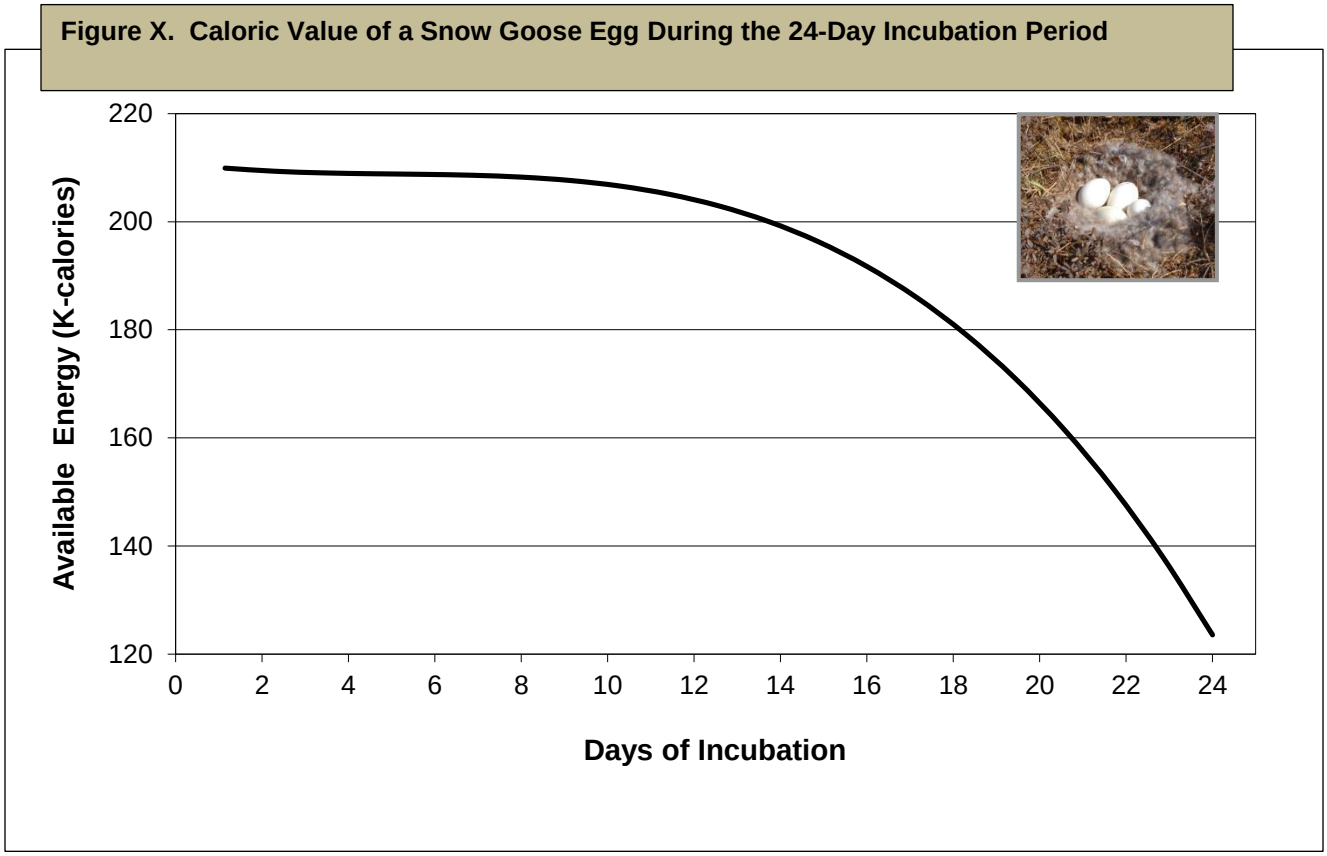
Here's some information you need:

1) Snow geese lay 1 egg per day
2) The average clutch size is 4 eggs
3) A female snow goose does not begin incubating until all 4 eggs are laid
4) The female geese in a colony do not all begin laying eggs on the same date. Instead, over a 7-day period the proportion of female geese that begin laying eggs on any given day is:

Day 1 = 0.06 of the population	Day 2 = 0.11 of the population	Day 3 = 0.18 of the population
Day 4 = 0.30 of the population	Day 5 = 0.18 of the population	Day 6 = 0.11 of the population
Day 7 = 0.06 of the population		

5) The average nesting period **for an entire colony** is 34 days; the average incubation period for **an individual snow goose** is 24 days
6) After a female lays all 4 eggs, the energy value in an egg that is digestible to polar bears begins declining as shown in Figure X below:

Figure X. Caloric Value of a Snow Goose Egg During the 24-Day Incubation Period



Using all of this information, it is possible to calculate the energy in nests of the snow goose colony. How? Open your excel file called "Datasets for Students" and go to the tab called "Energy Data". Then, follow the instructions below.

Instructions for analyzing the "Energy Data" for Activity 4:

1. Let's start by looking at the caloric value of a clutch: look at Column C. Day 1 of the incubation period has 1 fresh egg, Day 2 of the incubation period has 2 fresh eggs, Day 3 has 3 fresh eggs, Day 4 has 4 fresh eggs. On Day 5, the females begin to incubate the eggs in the nest and the amount of Kcal available in each egg in a nest that is digestible by polar bears begins to decline (Figure X). This decline continues through Day 27 and the amount of Kcal becomes 0 on Day 28 when the eggs hatch and become goslings which leave the nest.

Question 4.1: How many Kcal are available in a single nest on Day 4? Answer: _____
Question 4.2: How many Kcal are available in a single nest on Day 5? Answer: _____
Question 4.3: How many Kcal are available in a single nest on Day 17? Answer: _____

2. Next, look at the first day of nesting in the colony; Column E. The first day of nesting on the colony includes only 0.06% (6%) of the population of nesting females. Why? Remember, the females in a colony do not all begin laying eggs on the same day.

   Let's look at cell E6. How did we calculate this number and what does it mean?

   Cell E6 = **C1** * E4 * C6

   Total energy in all nests in the colony on this day = (total number of pairs of nesting snow geese) * (the proportion of geese nesting in the colony) * (Kcal in each nest)

   So, the value in cell E6 is equal to the total Kcal of energy available in the colony on Day 1 of the nesting period for the colony.

   You can see how we calculated the rest of the values in Column E; just look in each cell and you can see the equations!

   NOTE: All the numbers in the pink-shaded area in the data table are Kcal of energy available in the colony at different times during the nesting period of the colony.

3. Now let's look at Day 2 of nesting in the colony when 11% more females join in: Column F. Of course, these females are offset by 1 day so their first day of incubating is the colony's second day of nesting. So, to calculate the available Kcal in the nests of the females who started laying eggs on Day 2 of the colony nesting can be calculated as:

   Cell F7 = **C1** * F4 * C6

4. We can repeat these steps with another 1-day offset for the remaining 5 groups of females in Columns G, H, I J, and K

TASK 1: Calculate the values for Column I and for Column K.
Hint: fill in the yellow shaded cells in Column I and Column K

5. Column L is the sum of all Kcal in each female group, which equals the total Kcal available per day during the nesting period in the colony.

   Cell L6 = E6+F6+G6+H6+I6+J6+K6

TASK 2: Calculate the total Kcal available per day during the nesting period for the colony.
Hint: fill in the yellow shaded cells in Column L

Question 4.4: Which Julian Day during 2006 had the most Kcal available in the colony?
Answer: _____

TASK 3: Let's evaluate the relationship between total energy available in the nesting colony and Julian Day. To make things a little easier, let's first convert values in Column L into millions of Kcal. How? Simply divide each value in Column L by 1,000,000. Hint: fill in the yellow shaded cells in Column M.

TASK 4: Create a graph of total Millions of Kcal available in the nesting colony. Put Julian Day on the x-axis, include the Julian Day range 130-190. Name this Figure 2 and paste the graph in the space below or place it on a separate sheet:

6. Do you remember in the story the authors talked about the energy equivalent to a Seal Day? The amount of energy that equals 1 Seal Day is 22,432 Kcal. Let's convert the total Kcal available in the nesting colony into the total # of energy available as Seal Days.

TASK 5: Calculate the total energy in the nests of the colony as # of Seal Days available per day.
Hint: fill in the yellow shaded cells in Column O

TASK 6: Create a graph of total energy available in terms of # of Seal Days. Put Julian Day on the x-axis, include the Julian Day range 130-190. Name this Figure 3 and paste the graph in the space below or place it on a separate sheet:

Question 4.5: In 2006, polar bear onshore arrival at Cape Churchill Peninsula in western Hudson Bay was just beginning to overlap the incubation period of snow geese. This occurred around Julian Day 174. How much energy in Seal Days was available on Julian day 174?

Answer: _____

Question 4.6: If a polar bear were to have arrived 6 days earlier in 2006, how much energy in Seal Days would have been available?

Answer: _____

ACTIVITY 5: Evaluate foods eaten by polar bears on Cape Churchill Peninsula in western Hudson Bay, Canada.

Dr. Linda Gormezano and Dr. Robert Rockwell did a scientific field study during 2006-2008 to evaluate whether polar bears in western Hudson Bay ate while they were on land. These scientists used a non-invasive method, called a scat analysis. Dr. Gormezano trained her Dutch shepherd puppy named Quinoa (keen-wah) to find polar bear scats in western Hudson Bay. Quinoa found 1262 scats, 642 of these were used for analyses.

In the photo below, you can see some of the items found in those 642 polar bear scats.

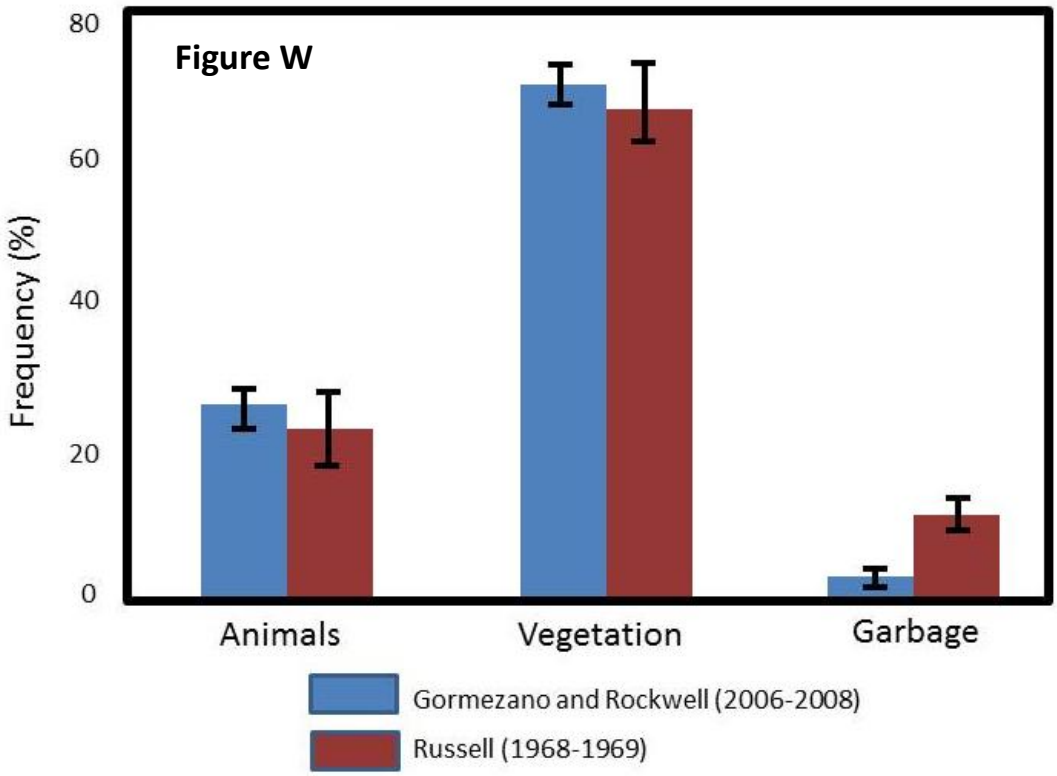
Remember, the Gormezano and Rockwell study was conducted in western Hudson Bay during the ice-free period during years 2006-2008. Dr. Russell did a similar scat study on polar bears in the west and south coasts of Hudson Bay during the years 1968-1969. Dr. Russell's study was done **before** we noticed that global warming had an effect on Arctic sea ice (which also affects polar bears, right?). The Gormezano and Rockwell study was done more recently, **after** we began noticing that global warming affects Arctic sea ice (and polar bears).

So, one research question is this: Did polar bears forage on land differently **before** global warming reduced the availability of Arctic sea ice, compared to how polar bears foraged on land **after** global warming reduced availability of Arctic sea ice?

Let's find out!

In the following pages, you will find 3 figures. Each figure shows some results from both polar bear studies. Look at each figure and answer the questions.

Figure W: Percent Frequencies of Different Food Types (Animal, Vegetation, Garbage) in Polar Bear Scats in Hudson Bay, Canada for 2 Different Scientific Studies



Questions About Figure W

Question W1: The black bars that look like this I are 95% confidence intervals around the mean frequency for each category of food type. Was the frequency of "Animals" in polar bear scats for the Gormezano and Rockwell study statistically different from the frequency of "Animal" in polar bear scats for the Russell study? Explain your answer in terms of interpreting 95% confidence intervals.

Answer:_____

_____

_____

Question W.2: Was the frequency of "Garbage" in polar bear scats for the Gormezano and Rockwell study statistically different from the frequency of "Garbage" in polar bear scats for the Russell study? Explain your answer in terms of interpreting 95% confidence intervals.

Answer:_____

_____

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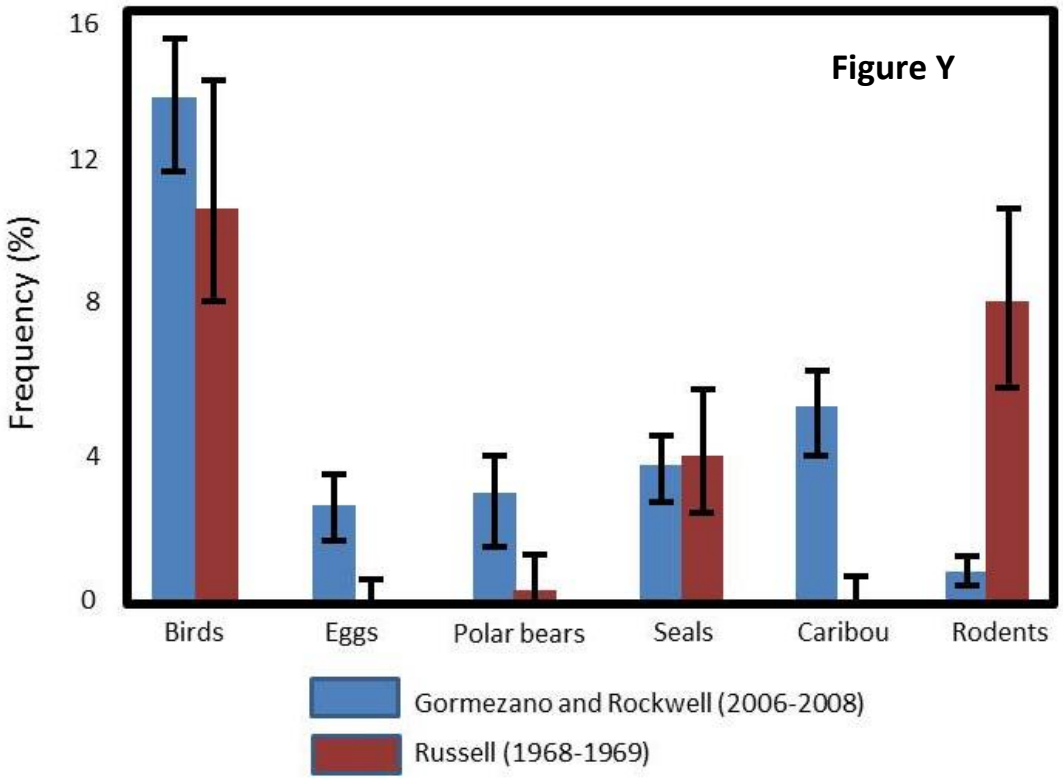
All figures were reproduced, with author permission, from the paper called "What to Eat Now? Shifts in Polar Bear Diet During the Ice-Free Season in Western Hudson Bay", by Dr. Gormezano and Dr. Rockwell.

Figure Y: Percent Frequencies of Different Types of Animal Matter (Birds, Eggs, Polar bears, Seals, Caribou, Rodents) in Polar Bear Scats in Hudson Bay, Canada for 2 Scientific Studies



Questions About Figure Y

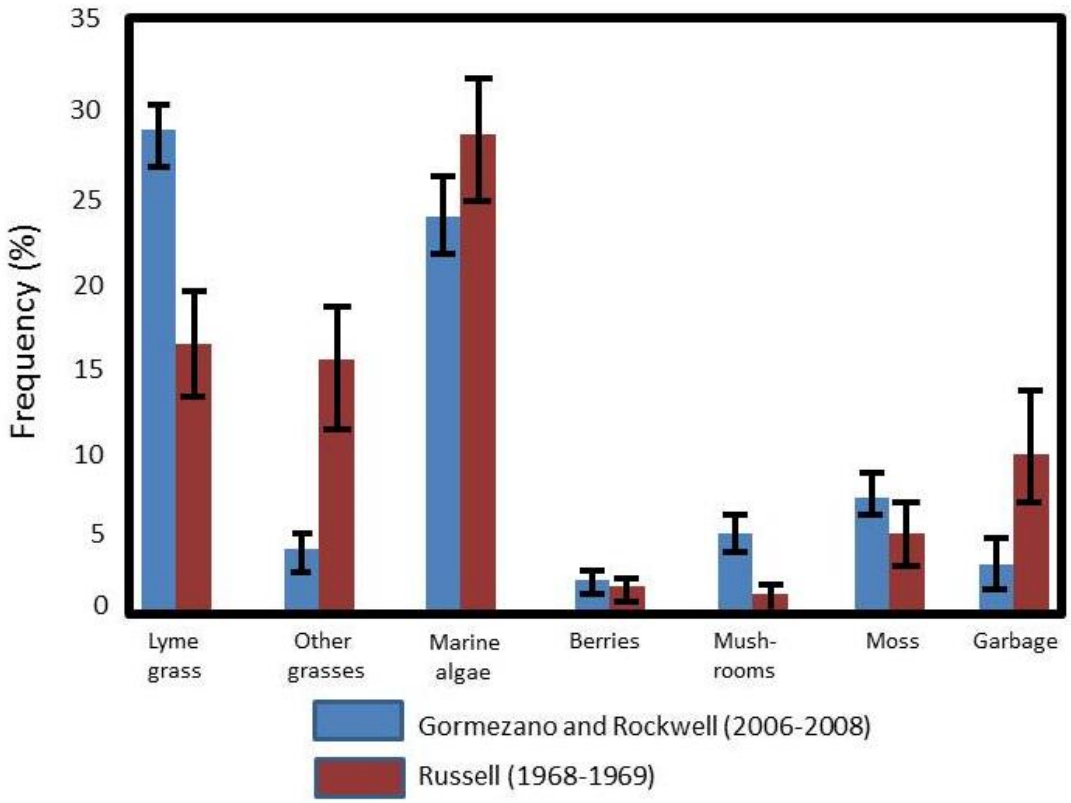
Question Y.1: Was the frequency of any animal category (i.e., Birds, Eggs, Polar Bears, Seals, Caribou, or Rodents) in polar bear scats for the Gormezano and Rockwell study statistically different from the frequency of the same animal category (i.e., Birds, Eggs, Polar Bears, Seals, Caribou, or Rodents) in polar bear scats for the Russell study? If so, which one/s?

Answer:_____
_____
_____

Question Y.2: When you looked at Figure W, there was not a statistical difference in frequency of "Animals" in polar bear scat between the 2 studies. Yet, when you look at Figure Y, there ARE some statistical differences in frequencies of some of animal categories between the two studies. How can this be?

Answer:_____
_____
_____
_____

Figure Z: Percent Frequencies of Different Types of Vegetation (Lyme grass, Other grasses, Marine algae, Berries, Mushrooms, Moss, Garbage) in Polar Bear Scats in Hudson Bay, Canada for 2 Scientific Studies



Question About Figure Z

Question Z.1: Was the frequency of any vegetation category (i.e., Lyme grass, Other grass, Marine algae, Berries, Mushrooms, Moss, Garbage) in polar bear scats for the Gormezano and Rockwell study statistically different from the frequency of the same vegetable category in polar bear scats for the Russell study? If so, which one/s?

Answer:_____

_____

_____

Citation: McMullin, E. (1987). Scientific controversy and its termination. In Engelhardt Jr., H. T., & Caplan, A. L. (Eds.). *Scientific controversies: Case studies in resolution and closure of disputes in science and technology.* Cambridge, MA: Cambridge University Press.

Lesson created by Dr. Melissa Reynolds-Hogland, Dr. Robert Rockwell, and Dr. Linda Gormezano