Making it Count

It's All in the Numbers

Activities to Accompany the Wonderfully Weird Giraffes Poster

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Target ages: 12–16 years

The goal of this group of activities is to use the **Wonderfully Weird Giraffes poster** to identify the unique characteristics of giraffes, and then, with the following activities, develop an understanding of the significance of those characteristics, how and why the characteristics evolved, and the overall effect they have in the role of giraffes in their savanna ecosystem.

Overall Objectives:

- Using the **Wonderfully Weird Giraffes poster** to conduct a research scavenger hunt, participants will be able to give a definition for adaptation, identify adaptive characteristics of giraffes, and explain the significance of those adaptations for the giraffe, its population, and its role in the savanna ecosystem.
- After participants are given an explanation of WildID and asked to discriminate individual giraffes by identifying the unique spot/coat patterns (an adaptation addressed in the research exercise) in various torso pictures of real giraffes taken in the field; they will recognize that there can be many variations of the same adaptation within a population of organisms.
- From a discussion of giraffe adaptations in relation to their African savanna ecosystem, the participants will hypothesize as to the general effect other individual adaptation variations could have on the size of any given population.
- Using a mark-recapture procedure, participants will be able to apply data collected to a simple proportional relationship (Peterson method) using multiplication and division skills to calculate an estimated population size.
- Comparing known quantities with calculated estimates, participants will be able to assess the accuracy of the mark-recapture technique in obtaining an estimate.
- From these assessments and analysis of the mark-recapture procedure they used, participants will be able to recommend and justify considerations that need to be made when using this technique on certain animal populations and explain the limitations that those considerations imply.
- In a review of the mark-recapture procedure participants will be able to identify how WildID uses the technique and explain the considerations that it makes for sampling and estimating giraffe populations.
- Upon reflection of their experience using the mark-recapture technique along with some research, the participants will be able to give examples of what population estimations can relate to wildlife researchers in terms of conservation practices.
- By actively engaging in and analyzing data from a predator/prey simulation game the participants will be able to identify the elements involved in the natural selection process, and make and test hypotheses related to them.
- Employing the identified elements of the natural selection process the participants will be able to explain and justify how certain unique giraffe characteristics could have evolved.

MATERIALS LIST:

- **Wonderfully Weird Giraffes poster**
- In Search of the Wonderfully Weird Worksheet and Labeling Page - Appendix A
- Giraffe Range Map - Appendix B
- What's In A Pattern? Worksheet - Appendix C
- Wild Nature Institute Blog Post - Appendix D
- Jar filled with 500–1000 jellybeans or dried beans
- Permanent marker
- Paper bags
- Beans
- Supplement 5: Mark-Recapture Theory - Appendix E
- Worksheet 1 - Mark-Recapture Data Sheet - Appendix F
- Butterfly Model Patterns - Appendix G
- Various colored and/or patterned paper
- Scissors
- Small baggies (snack size)
- Spring-hinged clothes pins
- Collecting boxes - 2
- Stopwatch or watch with second hand
- Worksheet 1 - Predator Preferences - Appendix H
- Worksheet 2 - Predator Preferences - Appendix I
- Worksheet 1 - Shifting Populations - Appendix J
- Worksheet 2 - Shifting Populations - Appendix K
- Possible answers and considerations for the In Search of the Wonderfully Weird discussion scenarios - Appendix L
- Giraffe Quiz for Bee - Appendix M

LESSON #1: IN SEARCH OF THE WONDERFULLY WEIRD

Summary:

This research activity is designed to get participants to identify adaptations or specific traits that giraffes have inherited that help them survive in their African savanna environment. They will search for facts to complete statements using the ***Wonderfully Weird Giraffes poster***, then locate the associated part of the giraffe on a labeling page (Appendix A). The completed statements and labeling exercise will guide them to identify these adaptations and help them explain why these traits are important for the giraffe's survival or reproduction. In a discussion following the exercise participants will be asked to consider the adaptations' importance to the giraffe population and ultimately the giraffe populations' importance to the savanna ecosystem in a series of "what would happen if…" scenarios. This activity might be extended to involve research about the African savanna because wild giraffes are ONLY found in the African savanna, so this could be part of a geography lesson. Appendix B is a map showing the range of the different types of giraffes that could be useful with this extension.

Subject Area:
Biology/Geography

Duration:
1 Hour

Setting:
Classroom

Skills:
Group Activity,
Research/Fact Finding

Objective:

Using the ***Wonderfully Weird Giraffes poster*** to conduct a research scavenger hunt, participants will be able to give a definition for adaptation, identify adaptive characteristics of giraffes and explain the significance of those adaptations for the giraffe, its population, and its role in the savanna ecosystem.

Materials:

Wonderfully Weird Giraffes poster
In Search of the ***Wonderfully Weird*** *Worksheet*
and Labeling Page - Appendix A
Giraffe Range Map - Appendix B

Procedure:

1. With a ***Wonderfully Weird Giraffes poster*** have the participants complete the In Search of the Wonderfully Weird exercise according to the instructions on the worksheet and using the labeling page; both provided in Appendix A. This can be done in small groups or individually.

2. After an appropriate amount of time has been given to complete the exercise, reconvene into a large group and ask for a definition of adaptation. Once that has been established and written on the board, conduct a review of the exercise by having each individual or small group contribute one of the giraffe adaptations they found and have them explain how it helps giraffes survive or reproduce. These can be listed on the board for everyone to have available for reference in the following discussion.

From this review a class discussion can start using any of the following scenarios related to giraffe adaptations:

If giraffes…

- could not eat acacia …
- did not have long necks …
- had a different coat pattern other than spots or no pattern at all …
- were not herbivores …
- did not digest most of what they eat …
- did not have chemicals on their skin …
- did not have long, agile legs with sharp hooves …
- had smaller eyes that did not have the ability to scan large areas …

… what would happen to the population and how would this ultimately affect the savanna ecosystem and the other populations living there?

4. Each of these scenarios can involve discussion of impacts on various topics such as food chains, predator-prey relationships, feeding (trophic) levels, and ultimately lead to the conclusion that these adaptations are not only necessary to the survival of the giraffes but the survival of their entire ecosystem. (Possible answers and considerations for these scenarios can be found in Appendix L.)

5. Because any one of these scenarios can involve a lengthy discussion on its own, there may be a need to divide up the remaining scenarios, after the first one is done together, and have small groups discuss and report on the outcomes, either orally or in writing, that will then be shared with the large group.

LESSON #2: WHAT'S IN A PATTERN?

Subject Area:
Biology/Scientific

Duration:
1 Hour

Setting:
Classroom

Skills:
Observation, Analysis

Summary:

In this activity the participants will be asked to explore one of the giraffe adaptations a little further in order to recognize that there are variations within the same adaptation.

Objectives:

After participants are given an explanation of WildID and asked to discriminate individual giraffes by identifying the unique spot/coat patterns (an adaptation addressed in the research exercise) in various torso pictures of real giraffes taken in the field; they will recognize that there can be many variations of the same adaptation within a population of organisms.

From a discussion of giraffe adaptations in relation to their African savanna ecosystem, the participants will hypothesize as to the general effect other individual adaptation variations could have on the size of any given population.

Materials:

What's In A Pattern? Worksheet – Appendix C
Wild Nature Institute Blog Post - Appendix D

Procedure:

1. Show participants the What's In A Pattern? worksheet (Appendix C) and ask them to tell what they see in the pictures. This can start very generally by identifying the part of the giraffe seen in each picture (torso) and proceed to more specific, as with the differences in spot patterns.

2. Explain that the pictures of giraffe torsos that they see are from photographs that wildlife scientists have taken in the field when they were counting the population size, also known as a survey. They use the pictures to document their counts. Scientists have found that although the giraffe's coat spot pattern is adaptive, acting as camouflage for ***all*** individuals within the species, the patterns vary from one individual giraffe to another. The patterns on giraffe fur are also unique to each individual—no other giraffe in the world has the same pattern, and the pattern never changes.

3. Ask them how many different giraffes would they say are pictured on this page?

4. After receiving a number of answers and explanations, tell them that there are actually 5 giraffes pictured from 2 different survey times in the two columns. Have them label the 2 columns as Survey 1 on the left and Survey 2 on the right.

5. Next explain that scientists can use the unique patterns to identify each giraffe in a population each time they encounter them in a survey and then be able to follow them over long time periods. A computer program called WildID helps to match the patterns from the photographs taken in the field so the scientists can keep track of hundreds and even thousands of giraffes and determine if they are seeing the same or different giraffes when they do their surveys.

6. Challenge the participants to see if they can match each giraffe picture from the Survey 1 column to the same giraffe pictured in the Survey 2 column by the coat spot patterns. They can draw lines between matches or have them letter the Survey 1 column A–E; and then number the Survey 2 column 1–5 from top to bottom and then match letter to number.
   Reveal these answers only after giving time for participants to work on this matching exercise.
   (ANSWERS: A-2, B-4, C-5, D-1, E-3)

7. Have the participants consider the following:
   Giraffe coat patterns, like all other adaptations in organisms, are caused by certain traits that are the expression of genes that are inherited. An organism's cells contain these genes. A gene is a unit of heredity which is passed from parent to offspring. Genes, together with the environment to which an individual is exposed, determine the expression of traits; everything from body weight to camouflage pattern to running speed.

   Then ask them to think about what they have seen in the photos from WildID:
   Although all five of these giraffe have different patterns that they inherited, their patterns still provide them with the same camouflage ability. What if that weren't the case? What if their camouflage ability was determined by the type of pattern they inherited? What would happen to the giraffe that didn't have a pattern that provided enough camouflage?

8. Give the participants the Wild Nature Institute Blog Post from January 19, 2016 (Appendix D). Ask the participants to explain this giraffe's coat pattern in terms of its gene makeup. This part of the discussion could involve the following explanation:
   This giraffe has a genetic mutation that causes its cells to produce less melanin (which makes color). Sometimes genes randomly mutate when they are passed on from parent to offspring—this mutation in the genes can cause variation in traits. If a new trait makes the offspring survive and reproduce better than individuals with other, less successful traits, then the new trait spreads throughout the population and the population evolves or changes.

   Then ask them to discuss the possibilities for this giraffe with its individual coat pattern and its camouflage abilities, and what it may mean to the group of giraffe to which it belongs.

LESSON #3: MAKING IT COUNT - POPULATION ESTIMATION

Subject Area:
Biology/Environmental

Duration:
1.5 Hours

Setting:
Classroom

Skills:
Multiplication/Division/ Ratios, Estimation, Experimentation/Data Collection, Analysis

Summary:

While WildID is used to identify individual giraffes by their unique coat spot patterns, this identification technique, done over time with many observations/photographs in the same area, can be used to make an estimation of the population size of giraffes in the given area. The results of these estimates are then used by wildlife scientists to determine many things about giraffe populations and help to protect them for many years to come.

The activities in this section will help to show participants how the size of wild animal populations can be estimated. They are adapted from ***Field Methods in Ecological Investigation For Secondary Science Teachers*** by Judith E. Bramble, Copyright 1995 Missouri Botanical Garden, pages 19–31.

Objectives:

Using a mark-recapture procedure, participants will be able to apply data collected to a simple proportional relationship (Peterson method) using multiplication and division skills to calculate an estimated population size.

Comparing known quantities with calculated estimates, participants will be able to assess the accuracy of the mark-recapture technique in obtaining an estimate.

From these assessments and analysis of the mark-recapture procedure they used, participants will be able to recommend and justify considerations that need to be made when using this technique on certain animal populations and explain the limitations that those considerations imply.

In a review of the mark-recapture procedure participants will be able to identify how WildID uses the technique and explain the considerations that it makes for sampling and estimating giraffe populations.

Upon reflection of their experience using the mark-recapture technique along with some research, the participants will be able to give examples of what population estimations can relate to wildlife researchers in terms of conservation practices.

Materials:

Jar filled with 500–1000 jellybeans or dried beans
Permanent marker
Paper bags
Beans
Supplement 5: Mark-Recapture Theory - Appendix E
Worksheet 1- Mark-Recapture Data Sheet - Appendix F

Procedure:

Background:

A population, the number of a specific organism living in a given area, is a very important piece of information for wildlife scientists to have. When the numbers are counted and followed over long periods of time scientists can determine what is happening to this group of organisms as far as food and shelter resources (habitat), relative birth and death rates, interactions with other species, including humans, and even the indication of disease.

It may seem like an easy number to determine; all you have to do is count the organisms. That may be so if you are counting organisms such as plants, or animals that stay more or less in one place, but moving animals are not as easy. A method for estimating populations of moving animals, known as the Peterson Method, named for and developed by C.G.J. Peterson in 1896, involves capturing and marking a certain number of organisms in the population, releasing them back into their environment, and then, after a short time, capturing again and determining the number of marked individuals in the second sample. This is commonly called the Mark-Recapture theory or method. With these numbers the scientist uses a simple proportional statement to come up with an estimated population size. For additional information, an advanced discussion of this method can be found in Appendix E. This is Supplement 5 from ***Field Methods in Ecological Investigation*** referenced at the beginning of this activity.

The following activities are designed to demonstrate this method by actively engaging participants in the process using nonliving objects and shaking/mixing to represent movement.

PART A: How Many Beans In A Jar? - An Invitation to Discover

1. Fill a jar with between 500–1000 jellybeans or dried beans. You should know exactly how many.

2. Show the jar to the participants and ask them to guess the number of beans in the jar. Have them write down their individual guess and record all of the guesses on the board.

3. Ask the participants who thinks they have the closest guess and then ask them if there is a method they used to make their guess. Ask them, if there was a method to do this and there was a reward for the best guess, would they like to know how to use it?

4. Tell the participants that there actually is a method for getting a better "guess" or estimate of the beans in the jar without counting all of them and that it is similar to the way scientists are able to make good estimates of the number of a certain type of animal moving around in a large area or population.

5. Explain a little about the Mark-Recapture method using the Introduction material provided above; then, lead the participants into the following lab activity by telling them that they will come back to the beans in the jar at the end to make better estimates when they have learned the method.

PART B: Capturing Beans in the Classroom

1. Give each group/individual a paper bag that is folded shut with two or more large handfuls (greater than 100) of white beans. Have them shake the bag and then write down a guess of how many beans they think are in the bag.

2. One individual from each group should then reach into the bag and take out a handful of beans (around 20). The beans should then be counted, marked with a marker, and the number recorded as "Marked Beans". When the marks on the beans are dry they should be returned to the bag.

3. The bag of beans should then be shaken well to mix up the beans.

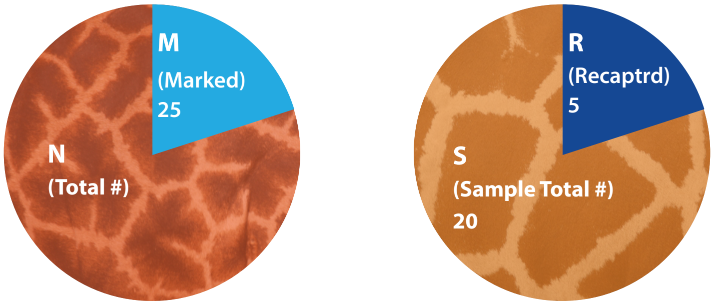
4. Again, one individual should remove another handful of beans.

5. This time two counts will be made. First, the total number of the beans in the handful or sample, the number recorded as "Sample"; then the number of marked or recaptured beans, within the sample, the number recorded as "Recaptured".

6. At this point the leader/instructor needs to make a decision of how best to present the reasoning behind the calculations based on the math skill levels of the participants.

A summary of the reasoning is as follows:
If there was enough movement of marked beans (shaking) to distribute them throughout the bag, then the proportion (fraction) of the number of marked beans from the first handful (M) to the total number of beans in the bag (N) should be equal to the proportion (fraction) of the number of recaptured marked (R) beans from the second handful and the total number of beans in the second handful sample (S). This will give an equation with three (M, R, and S) of the four values already given from the data collected, leaving the fourth, N, total number of beans in the bag, (i.e. the total population) able to be calculated.

The following visual may be used to aid this explanation:
Draw two pie charts, as shown below, one representing the total number of beans in the bag (N) with a slice representing the original number of marked beans (M); the second representing the sample (second handful) total number of beans (S) with a slice representing the recaptured marked beans (R) from the sample. Using data collected from one of the groups/individuals, make sure that the second pie chart accurately displays the proportion of the two known sample quantities (Total to Marked) and that the first one has the same proportions drawn since this method is based on the assumption that these should be equal if distribution is sufficient.



7. Depending on the math skill levels of the participants, the leader can do one or more of the following:
    - Write the fractions represented by each of the pie charts using the appropriate lettered symbols underneath each respectively (M/N; R/S) and set them equal to one another, thus forming the initial relationship equation, or if you prefer to use proportional notation instead you can write it M:N :: R:S and then translate it into fractional notation after;

    THEN, EITHER;

    - Give the participants the rearranged relationship equation and help them substitute the data for each of the lettered variables and then help with the order of operations (multiplication, then division) to determine the estimate;

    OR

    - Give participants Worksheet 1, from ***Field Methods in Ecological Investigation*** referenced at the beginning of this activity, in Appendix F, and have a discussion about the proportional relationship and the rearrangement. Then have them independently substitute and calculate the estimate.

8. Once the estimates have been determined, comparisons can be made with the guesses of the participants and then the actual number of beans in the bag can be counted by participants. Ask which was closer to the actual number, the calculated estimate or the participants' guesses?

9. If there are participants with advanced math skills the leader/instructor may want to talk about confidence limits as explained at the end of Supplement 5 (Appendix E) and then have the participants calculate the limits around their estimate. They may want to redo the exercise as suggested to determine how they can get better confidence limits.

10. Once the exercise is completed ask the participants to explain a method they could use to get a better estimate of the beans in the jar from the beginning of the activity. Then, have them actually carry it out and calculate an estimate that they should compare to their guess and finally, the actual number in the jar.

11. Discussion Questions: (Possible answers to expect and/or guide participants to are found at the end of Supplement 5 - Appendix E)
    - Remembering that the method is used on live animals, what would happen if the marks caused the animals to die or be eaten by predators?
    - What if you didn't shake the bag, i.e. there wasn't any movement of organisms?
    - What else could go wrong with the estimates when using it on live animal populations?
    - With what animals could this method be used to estimate population size?
    - How can animals be marked?

12. Further Applications - Ask the participants to think about and explain the following from their experience using the mark-recapture method of population estimation. These can be topics for discussion or for research/writing assignments.

- Wildlife scientists use WildID to help make estimates on the giraffe population using this Mark-Recapture technique. Propose how this is done in the field by comparing the procedure of the capturing bean exercise to how it would be done in the field using WildID.
- Wildlife scientists use population estimates to determine many things about the populations they are studying. Investigate what can be learned from population estimates and explain how the estimates give scientists information about the animals.

LESSON #4: SURVIVAL OF THE WONDERFULLY WEIRD
- IT'S ALL IN THE NUMBERS

Subject Area:
Biology
Environmental Science

Duration:
2–1.5 Hours

Setting:
Ideally, Outside Area, but can be adapted for Classroom

Skills:
Multiplication/Division/Ratios, Estimation, Experimentation/Data Collection, Analysis, Drawing Conclusions

Background/Summary:

So how did giraffes come to have all of these unique qualities? It all has to do with the way these characteristics helped them to survive in their environment and allow the survivors to produce more giraffes with the same characteristics and thus increasing populations with these adaptations. Those populations with giraffes that did not have these successful adaptations eventually became smaller in numbers because fewer individuals survived to produce more giraffes. This survival of populations with adaptations that outwit the environment is known as natural selection. What survives and what doesn't, all has to do with the numbers!

Natural selection is the most important mechanism enabling organisms to develop adaptations in nature, which are traits that help them survive and reproduce better than before. Natural selection also eliminates traits that result in lower survival and reproduction. Overall, the most important factor in natural selection is how successful an organism is at reproducing. If an individual lives half as long as others of its species, but has twice as many offspring surviving to adulthood, its genes will become more common in the adult population of the next generation.

These activities will help to demonstrate how this numbers game plays out using the simple example of a camouflage adaptation in butterflies. The same mechanism, then, can be extended to explain how the many giraffe adaptations came to be.

Objectives:

By actively engaging in and analyzing data from a predator/prey simulation game the participants will be able to identify the elements involved in the natural selection process, and make and test hypotheses related to them.

Employing the identified elements of the natural selection process the participants will be able to explain and justify how certain unique giraffe characteristics could have evolved.

Materials:

Butterfly Model Patterns - Appendix G
Various colored and/or patterned paper
Scissors
Small baggies (snack size)
Spring-hinged clothes pins
Collecting boxes - 2
Stopwatch or watch with second hand

Worksheet 1 - Predator Preferences - Appendix H
Worksheet 2 - Predator Preferences - Appendix I
Worksheet 1 - Shifting Populations - Appendix J
Worksheet 2 - Shifting Populations - Appendix K

Procedure:

The following are adapted from ***Field Methods in Ecological Investigation For Secondary Science Teachers*** by Judith E. Bramble, Copyright 1995 Missouri Botanical Garden, pages 123–142; with variations from ***Prentice Hall Biology*** by Kenneth R. Miller, Ph.D. and Joseph Levine, Ph.D., Copyright 2006 Pearson Education, Inc., page 401. There are a number of different materials with associated procedures suggested for use in these references; the material choice made here, along with its associated procedure, was thought to be most universally available.

PART A: The Survival Games - An Introduction to Natural Selection

Summary:

In this activity participants will act as predators "hunting" various colored paper butterflies scattered throughout chosen "habitats". The habitats should ideally be in an outdoor setting, such as grassy areas, but could be a variety of classroom settings if an outdoor space is not available. Participants will be asked to make hypotheses as to which color adaptation will survive the best and then test their hypotheses by actually being engaged in the process. To emphasize that survival is dependent on the environment in which the organism lives, the exercise will be done twice in two different areas with different environmental characteristics (i.e. sunny vs. shady; areas with slightly different background colors; indigenous vs. non-indigenous habitats, etc.). This will demonstrate the fundamental concept of natural selection.

1. As an introduction to this activity remind participants of the giraffe coat pattern adaptation and ask them how it helped all giraffe. Explain that color and pattern adaptations play an important role to the survival of many animals. Have the participants engage in a discussion of color adaptations in animal species. This may need to be researched depending on the participants' previous knowledge and experience. Ask them how animals use color in nature. Using the giraffe coat pattern as the opening example, have them give examples and explain the function of the coloration. Guide the discussion to show students that the purposes of coloration tend to fall into two categories: Reproduction (as in display and courtship colors) and Predator protection (either Blending [cryptic] coloration, also known as Camouflage; or Warning [aposematic] coloration).

2. When discussion is completed tell the participants that the color adaptation that is initially going to be studied in the coming activities is cryptic coloration or camouflage, like that of the giraffe coat pattern, but with a different animal species, a butterfly or moth.

3. To begin, make one copy of butterfly shapes (Appendix G) for each participant on each of three different colors of paper. Alternatively, give each participant three different colors of paper and a butterfly shaped pattern and have them trace ten shapes on each of the papers.

It should be noted, and stated for the participants, that, in general, but butterflies tend to have the colorful parts on the top of the wing and the camouflage on the bottom, and they rest with their wings folded so the camouflage parts show.

The following are some suggestions for creating these models:

- Colors should be chosen to depict different camouflage abilities in the area they are going to be "hunted".
- Red, orange or brown, green, and yellow are suggested for outdoor use, but be creative with choices.
- This may be an opportunity to have participants engaged in making color choices based on research and/or observations of butterflies in the area.
- Different patterned papers may be selected, if available, or maybe even drawing and/or coloring specific patterns on the paper butterfly models can be done.

4. Have participants cut out all shapes along solid lines and fold in half along dotted line to create a more three-dimensional shape.

5. Once made, ask participants to divide each color (type) of butterflies into two equal groups (5 each) and place each group into two different boxes that you provide. There should be an equal number of all three colors in each box. Explain to the participants that the three different colors represent the variations of the color adaptation in this kind of butterfly.

6. The boxes will be taken to two different playing areas of similar size where the "hunting" will take place. The playing areas are preferably in an outside location with two different environmental qualities. Since the natural habitat of butterflies is in or around flowering plants it is recommended that one of the outdoor playing areas is located in one such environment if possible. If indoor playing areas must be used make sure they are large enough to engage hunting by all participants and that there are differences in the "environmental qualities" of the two areas. The person(s) distributing the models should try to place them in the areas in ways that are varied, some conspicuous and others inconspicuous; just as they would be found in nature. Alternatively, depending on the number of participants, you could have half of the participants distribute the models in one area with the other half hunting; then reverse roles for the second area.

7. While the butterflies are being distributed in the two playing areas, engage the participants in developing hypotheses as to all of the general possibilities that can be tested by asking which color or colors they think will be captured most easily in each area. Rank the order for the class and record these predictions. Remind them that no color preference can also be a valid hypothesis to test.

8. Have participants line up along the perimeter of the first playing area. Give each participant a spring-hinged clothespin or other similar device to represent their mouth and a small bag (snack size baggie), only large enough to hold 4 butterflies comfortably, to represent their stomach. Explain that they must capture the butterflies with the clothespin and place them in the bag before going on to the next butterfly. Also explain that they will be given a certain amount of time to "hunt", but if their bag is full (4 butterflies), before time is called, so is their stomach and therefore they will stop "hunting" (collecting).

9. When a leader says start, participants as "predators" are to "capture" their prey. The leader should have a stopwatch or watch with a second hand to time the play. Play should be monitored and stopped when about half of the butterflies have been found. Although there is no set time because of the variety of environments and different numbers of students will change the capture rate; please take note of the amount of time in the first area so that it can be used throughout the remaining plays.

10. Once play has stopped have participants count the numbers of each color of butterfly that they captured, then combine all of the individual totals to arrive at a class total for each butterfly color. Give each participant Worksheet 1 Predator Preferences (Appendix H) and provide guidance to complete up through the first two columns using the class data. Use the Area #1 columns for all data and the line beside Playing area. The calculated values and analysis with conclusions on the rest of the worksheet will be completed after the second area data are collected.

11. Move participants to the second playing area and again line them up around its perimeter. Have them observe the conditions and ask if they think the results will be the same or different from the first area. Tell them to explain why they are making that hypothesis.

12. Repeat the same procedure as in the first area and use the same amount of "hunting" time. Same rules apply as to filled bags = full stomachs; play must stop for those who are full.

13. When play finishes, again count each color and combine individual totals for a class total for each color of butterfly. Record these on Worksheet 1 under Area #2 columns for all data and the line beside Playing area.

14. With the data recorded, calculations should be made to determine B, the number of each color predicted for each area if there were no preference or advantage to any color. This is explained in the note under the table to be simply the total number of butterflies captured (C) divided by the number of prey categories or colors. The resulting predicted numbers should be the same for each color of butterfly if there was no preference for or advantage of any color by the "predators" for the "prey".

15. You can use just these data and calculated values to determine which hypothesis seems to be the most accurate with the data presented. To help better visualized the results the participants can create a horizontal bar graph with the data on Worksheet 2 Predator Preferences (Appendix I).

16. The last two main columns in this table can be made optional, depending on the math skills of the participants. These columns are for calculating the Chi-Square statistical value that can be used to determine how close the data are to the expected result for the no color preference hypothesis. The critical value for 3 categories (the three colors of prey) is 5.991. If the calculated Chi-Square value (F) is greater than the critical value, the difference is considered significant and the data are considered to be dissimilar from what was expected; that is, different from no color preference, i.e. there is a color preference. It should be explained that this is a standard statistical test for data and can be used to validate conclusions about tested hypotheses.

17. After the calculations and graphing, have the participants first address their conclusions using the guiding questions at the bottom of each worksheet. Then, using these answers as an opening, engage the participants in a discussion using the following directional questioning:
    - Were some colors of butterfly found more often than others? If so, which color(s) and what do you think is the reason?
    - Was there any difference in color preference depending on the "hunting" areas? If so, which color(s) in which of the areas and what was the possible reason(s)?
    - Were any of the results surprising to you? What were they and why were they surprising?
    - Could a different (third) playing area, with different conditions than the two already used, produce another set of results for the same colors of butterflies?
    - Since the butterflies develop with their color already determined by their genes and have no ability to change color during their short lifespan, what is determining which color adaptation is more successful for survival?
    - What predictions can you make for the future numbers of each of the colors of butterflies in each of the areas? What would happen if "predator" preferences or abilities changed?

18. Conclude this portion of the activity by explaining to the participants that what they just experienced was the process of the natural selection, where the environment determines what adaptations are successful by giving organisms with more suitable characteristics more chance to survive and reproduce than an organism with less suitable ones. It is this process that, over time, will gradually change the types of characteristics in a population of that organism. Tell them that they will see how that happens in the next exercise.

PART B: Change is the Name of the Game - Shifting Population Characteristics

Summary:

This exercise will continue **The Survival Games** through a number of generations to demonstrate how the forces of natural selection can slowly change the prevalent characteristics of certain adaptations in populations of organisms over long periods of time. Game play will proceed as it did in the last exercise, but there will be a number of rounds representing successive generations created by those surviving individuals from the previous generation reproducing and passing on their color genes/trait to offspring.

1. Determine which of the playing areas from The Survival Games exercise showed the most selection potential. This should be the area that is used throughout this exercise.

2. Depending on the amount of time available, it may be determined to start this exercise on another day due to the length of time that this exercise alone may take. It can be easily started and stopped as needed at the beginning of each new generation time as long as data from the previous time are recorded before finishing.

3. Since this is to be a continuation of results from the previous exercise, the data that were obtained from that exercise will need to be transferred to the data table for this exercise. To start, give each participant a copy of Worksheet 1 Shifting Populations (Appendix J) which is the data table for this exercise. Have the participants record the **TOTAL NUMBER** of butterflies of each color that was first distributed in the chosen area. That would be 5 x the number of participants for each color and should be the same for each color. This number is to be placed in the **Time 1** row in the box under Number for each color. If the colors given in boxes at the top of the columns are different from those used, have the participants change the colors to correspond to those that they are using. Add all three color totals to get the **TOTAL NUMBER** and record that in that top box in the last column.

4. Using the results from the first two columns of data table on Worksheet 1 Predator Preferences from The Survival Games, for the area chosen to use in this exercise, have participants record the number of butterflies that were captured of each color in the box in the # found row in the appropriate color column of the Shifting Populations data table.

5. Have the participants calculate the # surviving data for each color by subtracting the number in the # found row from the total number in the Time 1 row and record those numbers in the corresponding color column boxes in the # surviving row.

6. Now you are ready to begin the play for this exercise. Explain to the participants that you are going to pick up the story where it ended in the last exercise. The butterflies surviving after the first round of hunting have been given time to reproduce, in other words, a generation time. Each surviving butterfly will produce one offspring. Put the number of offspring for each color (the same number as # surviving) in the reproduction box underneath each of the # surviving boxes.

7. This means that there will be 2 x the number of the surviving butterflies of each color at the beginning of the next generation. Have the participants multiply the # surviving by 2 for each color (or add # surviving and reproduction) and record that result in the correct color column in the Time 2 row.

7. Gather up enough butterfly models of each color to equal the Time 2 numbers and place in a box to be distributed into the chosen area for play.

8. As before, once the butterflies are distributed, have the participants line up on the perimeter of the area and give them their hunting supplies (spring-hinged clothespin and small bag).

9. Giving them the same amount of time and the same hunting rules (filled bag = full stomach) have them start to hunt on your mark.

10. Once play is stopped, begin to count, first as individuals, and then compile into class results.

11. Complete the data table for the second round of hunting for each color; # found from count; # surviving = Time 2 Number - # found; reproduction = # surviving, and finally Time 3 = #surviving + reproduction.

12. Continue play and records (Steps 7–11) through three more rounds.

13. When play is complete and records have been made, have participants calculate the percentage of each color at the start of each new generation. To do this the Time Number for each color at each generation time must be divided by the TOTAL Number and then multiplied by 100 (Color Time Number / **TOTAL NUMBER** x 100 = %).

14. Have participants use these calculated percentages to create a line graph for each of the colors of butterflies on Worksheet 2 Shifting Populations (Appendix K). This will show the changes in the frequencies of each color of butterfly.

15. Once the graph has been produced, have the participants engage in a discussion of the results using the following guided questioning:
    - Was there a change in the frequency of a butterfly color over the five generations?
    - Which colors increased in population size? Which decreased?
    - How was the total population of butterflies changing over time?
    - What was causing these changes to happen?

16. Have the participants consider the following:

The giraffe is an excellent example from the east African savanna of how the natural selection process works. Primitive ancestors of giraffes did not have the exceptionally long neck seen in our modern giraffe. Early in its evolutionary history, giraffe ancestors with genetic mutations that resulted in slightly longer necks could reach nutritious leaves higher in the trees that other browsers—of their own species as well as other species—could not reach. The longer-necked individuals survived and reproduced better than those with shorter necks, and over time the long-neck trait spread through the population and resulted in the evolution of the very long neck we see in today's giraffe. Additional genetic adaptations evolved in tandem with the longer neck and tall body, including a specialized cardiovascular system and metabolism.

Plants also have developed adaptations through the natural selection process to protect them from the impact of predation by herbivores. In fact, the giraffe's main food source, the Acacia tree, is actually in an "evolutionary arms race" with the giraffe. The Acacia trees that survive the giraffe's browsing grow in an umbrella shape to escape browsing in the center and have spines and thorns, and tannins (toxins). Meanwhile the giraffe has not only evolved the long neck to reach leaves no other herbivores can reach, but has a thick tongue, lips, and saliva to deal with the thorns and digest the leaves.

Challenge:

Using all of the information you have gathered from participating in the Survival Games activities, describe the "evolutionary arms race" between the Acacia and giraffe in those terms associated with the natural selection process

Further Challenge:

There are many types of adaptations other than those associated with structures. Consider the following set of complex interactions that involves a number of different species with various types of adaptations that are impacting the population size of each species involved. See how many species interactions you can identify and draw a diagram to depict all of the connections. Then, using that diagram, explain what population size fluctuations occur with each successive interaction.

The Importance of Giraffes in the Savanna: The whistling thorn acacia tree is stimulated by browsing (an animal eating its leaves) to produce nectar, which is eaten by cocktail ants. The tree also grows galls, in which cocktail ants live and care for their larvae. In turn, when a giraffe begins to eat the tree's leaves, the ants defend the tree by biting the animal to prevent it from eating too many of the leaves. The giraffe eats only a few leaves and then moves on. This is a mutualistic relationship between the cocktail ants and the whistling thorn acacia. However, a very interesting thing happens when giraffes are kept away from the whistling thorns by fences—the tree is no longer stimulated to produce nectar and galls, so the defensive cocktail ants leave the tree. The tree is then invaded by a different species of ant that lives in holes produced by wood-boring beetles, which the ants attract to the tree by sending out signals to the beetles. The wood-boring beetles weaken and eventually kill the trees.

CONCLUDING ACTIVITY: GIRAFFE BEE OR TRIVIA TEAM CHALLENGE

See Appendix M for sample questions for a Giraffe Bee.

CONCLUDING ACTIVITY: ESSAY ABOUT WHY I THINK GIRAFFES ARE WONDERFULLY WEIRD

Participants are asked to write an essay about giraffes. Why are they so special? What have the participants learned?

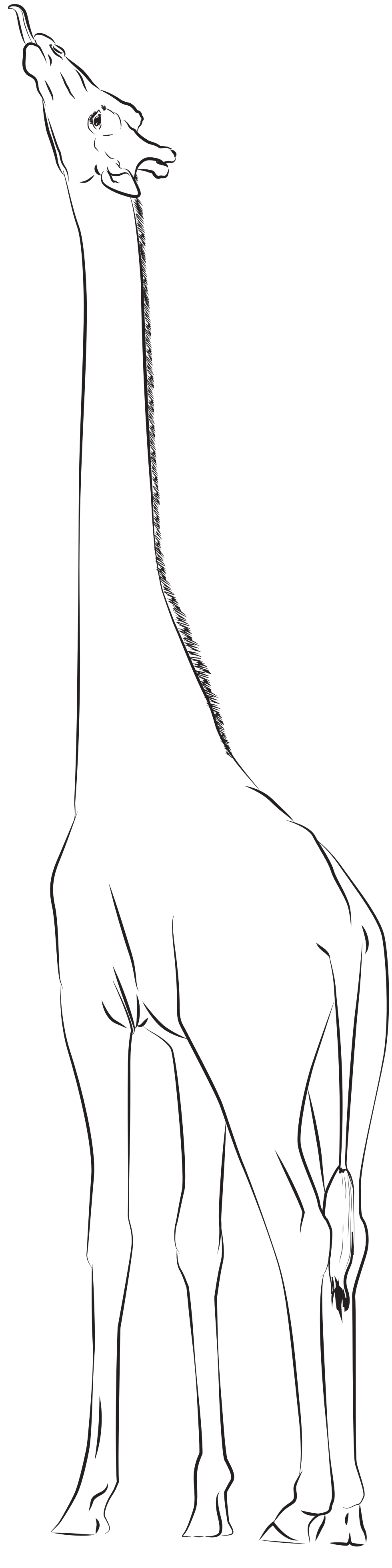
In Search of the Wonderfully Weird

Giraffes are wonderfully weird for a number of reasons. The characteristics that make them this way are ***adaptations*** that they have inherited that help them survive in their environment on the African savannah.

Using the Giraffes poster, find and complete the following facts about these adaptations. Then, on the giraffe silhouette labeling page, identify and/or draw in the part(s) of the giraffe that is associated with each of these facts and include its number from this page or write down the fact next to the labeled/drawn part(s).

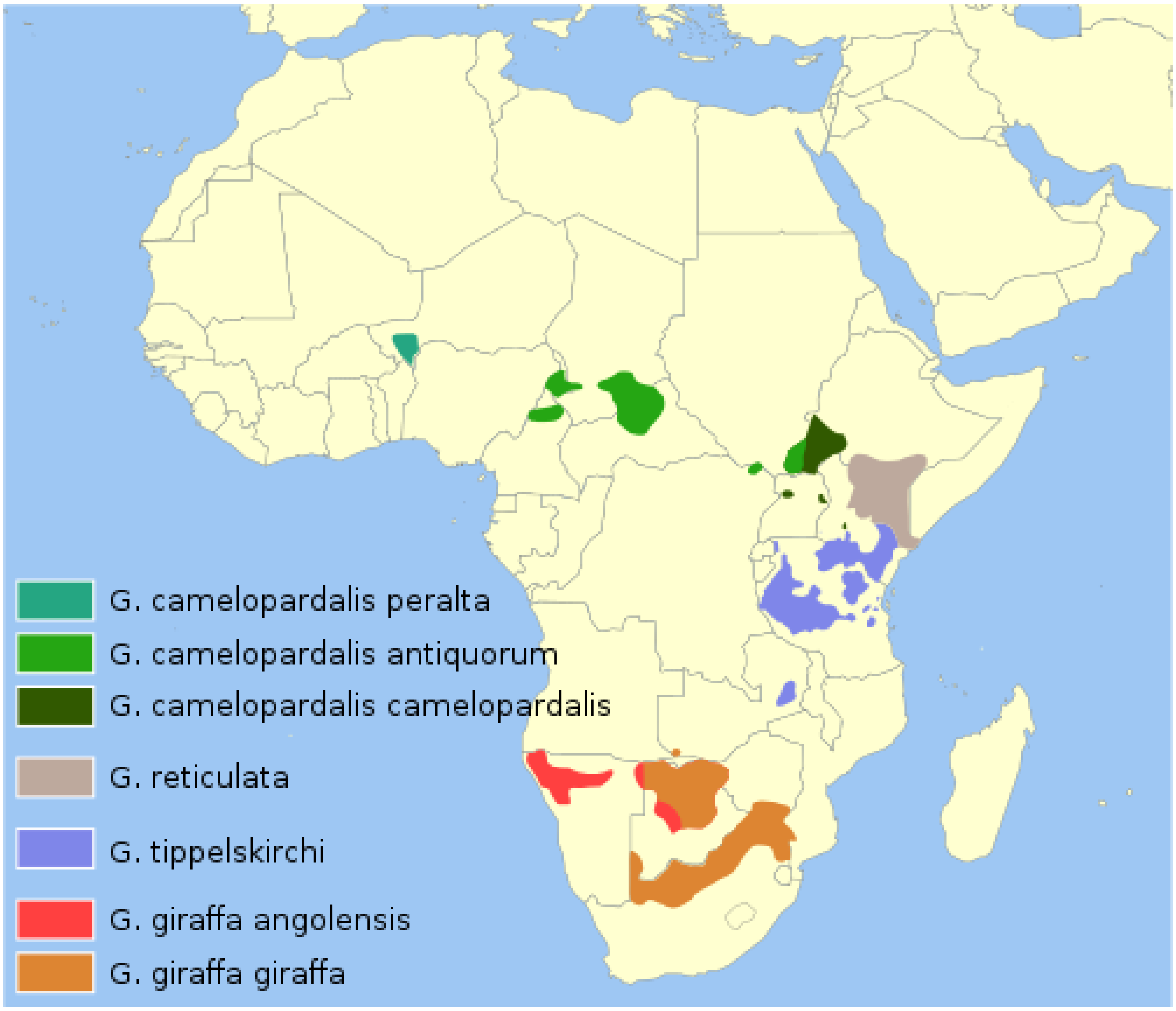
1. The giraffe's main thorny food source is … .
2. Protection against microbes and possibly mosquito bites is provided by … .
3. The ability of these largest structures of any hoofed mammal, that makes giraffe "living watchtowers" is … .
4. The uniqueness of this adaptation in each giraffe can be used by scientists to identify individuals and helps the giraffe to … .
5. The protective built in sunscreen for this constantly exposed part is … .
6. The reason for this being relatively small in comparison to the giraffe's size is … .
7. The number of this adaptation (not size) that is the same in giraffe and humans is … .
8. The ability of a structure to wrap around an object, giving giraffe an advantage in getting food, is … .
9. Giraffe have an advantage over other consumers like themselves that are called … . The giraffe has this advantage because … .
10. When male giraffe spar by whipping each other it is called… .
11. When a giraffe's "fly swatter" is found missing, it was most likely taken by …
12. The giraffe with a missing "fly swatter" is alive because of its lethal weapon which is … .

GIRAFFES:



Appendix B

Giraffe Range



Source: https://en.wikipedia.org/wiki/Giraffe

Appendix C

WHAT'S IN A PATTERN?

____________________ ____________________

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___.

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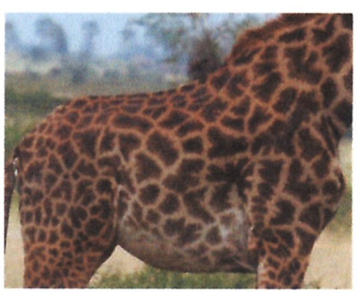

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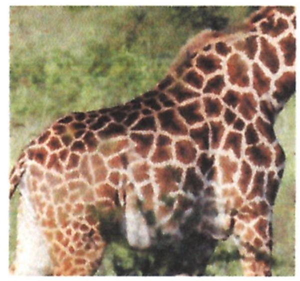

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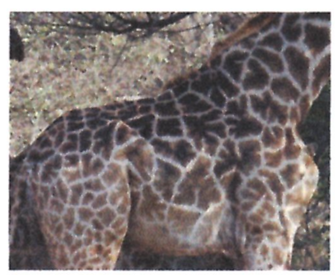

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Appendix D

Leucistic Giraffe Alive and Well in Tarangire

1/19/2016 86 Comments

Last year we reported on our blog our sighting of a beautiful leucistic giraffe calf in Tarangire National Park. Her body surface cells are not capable of making pigment, but she is not an albino. We were lucky enough to resight her again this January, almost exactly one year later. We are thrilled that she is still alive and well. Below are photos of the leucistic giraffe calf, then and now. A local lodge guide christened her Omo, after a popular brand of detergent here. Alternative names are welcome, or vote for Omo as her moniker.

January 17, 2015

January 16, 2016

From: http://www.wildnatureinstitute.org/blog/archives/01-2016

Supplement 5:

Mark-Recapture Theory

The bean exercise illustrates a standard method of mark and recapture developed by the Danish biologist C. G. J. Peterson nearly a century ago for studying fish populations. It has been used since for vertebrates, insects, snails and other organisms that can be marked and released back into the population. Extensions include ongoing mark and release (more than two captures) and using different marks for different capture periods. These methods permit the estimation of recruitment (births and immigration) as well as losses from the population (death and emigration).

Much work has been done on marking techniques. These include the use of paint or dye markers, radioactive tracers, leg banding, ear tagging and fin or toe clipping. Clearly one assumption of the method is that marking the animal does not harm it or make it more likely to be eaten by predators once released. This is sometimes a difficult assumption to meet.

For the Peterson method, once the animals are marked, released and captured a second time, the following data are obtained:

M (Marked)	Number of marked individuals in the population (# captured and marked the first time).
S (Sample)	Number of individuals captured the second time
R (Recaptured)	Number of marked (recaptured) individuals in the sample.

To estimate the total number in the population, use the following relationship:

$$\hat{N}=\frac{SM}{R}$$

where $\hat{N}$ = The estimated population size.

Because this is an estimate, we want to put limits on how much larger and smaller the population is likely to be. Confidence limits at the 95% level (that is, the odds are 95% that the true population size varies within these limits) are approximately calculated as:

$$\hat{N} \pm 2\,\hat{N}\sqrt{\frac{(\hat{N}-M)(\hat{N}-S)}{MS(\hat{N}-1)}}$$

Calculate the confidence limits around your estimate of the number of beans in the bag. Redo the exercise and mark and capture more beans. What does this do to the population estimates and the confidence limits?

Discussion:

1. **What would happen if the marks caused the animals to die, leave the area or be eaten by predators?** The estimate would be too high because the number of recaptures, R, will be lower than it should be. Try this by removing some of the marked beans before the second capture.

2. **What if you didn't shake the bag?** Depends on whether you recaptured where the marked ones are or where they aren't. Either way, you'll be off! Try this be leaving the marked beans on the top (don't shake) and recapturing from the same area.

3. **What else could cause the estimatę to be wrong?** if the animals were reproducing, if the marks fell off the animals, if the marked animals were easier to see and therefore recapture.

4. **What animals could this be used for?** Grasshoppers, fish, snails, pillbugs, salamanders, lizards, beetles, people!

5. **How would you mark these animals?** Much work has been done on marking organisms and biologists use ear tags, leg bands, toe and fin clips, dye and radioactive tracers Nail polish on the back is an easy way to mark many animals (see below). With people, you could pin a note to their back.

Missouri Botanical Garden

Worksheet 1

Field Methods

Mark-Recapture Data Sheet

Names of group members:________________________________

Organism Studied:________________________________

Study Site:________________________________

Dates of Captures 1 and 2:________________________________

Data (tally your observations):

number marked, time 1 (M): __________________

number in sample, time 2 (S): __________________

number recaptured, time 2 (R): __________________

To calculate the estimate, use this relationship:

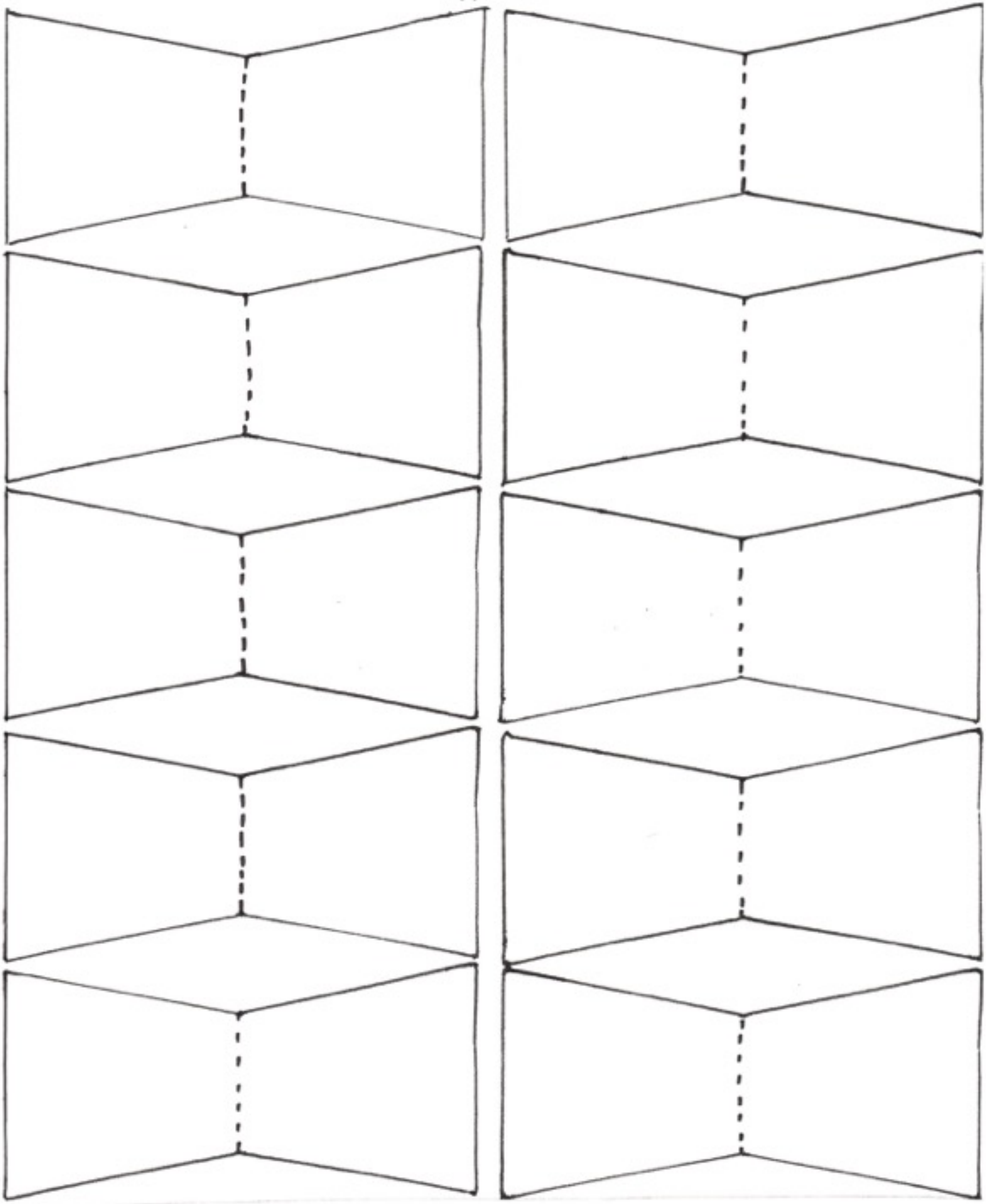
$$\frac{\textit{sample marked animals } (R)}{\textit{sample size}(S)} = \frac{\textit{total marked animals } (M)}{\textit{total population size } (N)}$$

So, to estimate the total number in the population:

$$\frac{R}{S} = \frac{M}{N} \quad \textit{and, re-arranging,} \quad N = \frac{SM}{R}$$

What is your population estimate?

Appendix G



Butterfly Models

Missouri Botanical Garden

Worksheet 1

Field Methods

Predator Preferences

Name:____

Date:______________ Playing area (describe): Area 1 ______________________

Area 2 ______________________

Hypotheses:

1. Prey are captured in proportion to their abundance (no color preference).
2. Prey are captured in the rank order we predicted.

Color of Prey *(list in order of predicted preference)*	**A: # prey captured**		**B: # predicted-no preference** (see note below)		**A-B**		**$\frac{(A-B)^2}{B}$**	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
TOTAL	C:		D:		E:		F:	

Note: the number predicted (B) is the total number captured (C) divided by the number of prey categories. Check your math: C=D, E=0.

Statistical test of hypothesis #1:
Is the Chi-Square value obtained, F, greater than the critical value for your number of categories? _____ What is your conclusion?

Qualitative evaluation of hypothesis #2:
Were your predictions for prey preference met? If not, why not?

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Appendix I

Worksheet 2

Field Methods

Predator Preferences

Name:_______________________________ Date:____________

Playing area 1 (describe):____

Playing area 2 (describe):____

Hypothesis: Prey are captured in the same relative proportion in the two playing areas.

Plot the class data from each of the two playing areas. Order the colors in the rank order for playing area 1.

Prey Color	Area															
	1															
	2															
	1															
	2															
	1															
	2															
	1															
	2															
	1															
	2															
	1															
	2															
	1															
	2															
Frequency → *(provide scale)*																

Were the prey captured similarly in the two areas? Which prey were not?

Why do you think there were differences?

Missouri Botanical Garden

Appendix J

Worksheet 1
Field Methods

Shifting Populations

Name:________________________________

	RED		YELLOW		GREEN		TOTAL
	Number	%	Number	%	Number	%	Number
Time 1							
# found							
# surviving							
reproduction							
Time 2							
# found							
# surviving							
reproduction							
Time 3							
# found							
# surviving							
reproduction							
Time 4							
# found							
# surviving							
reproduction							
Time 5							
# found							
# surviving							
reproduction							
Time 6							

Missouri Botanical Garden

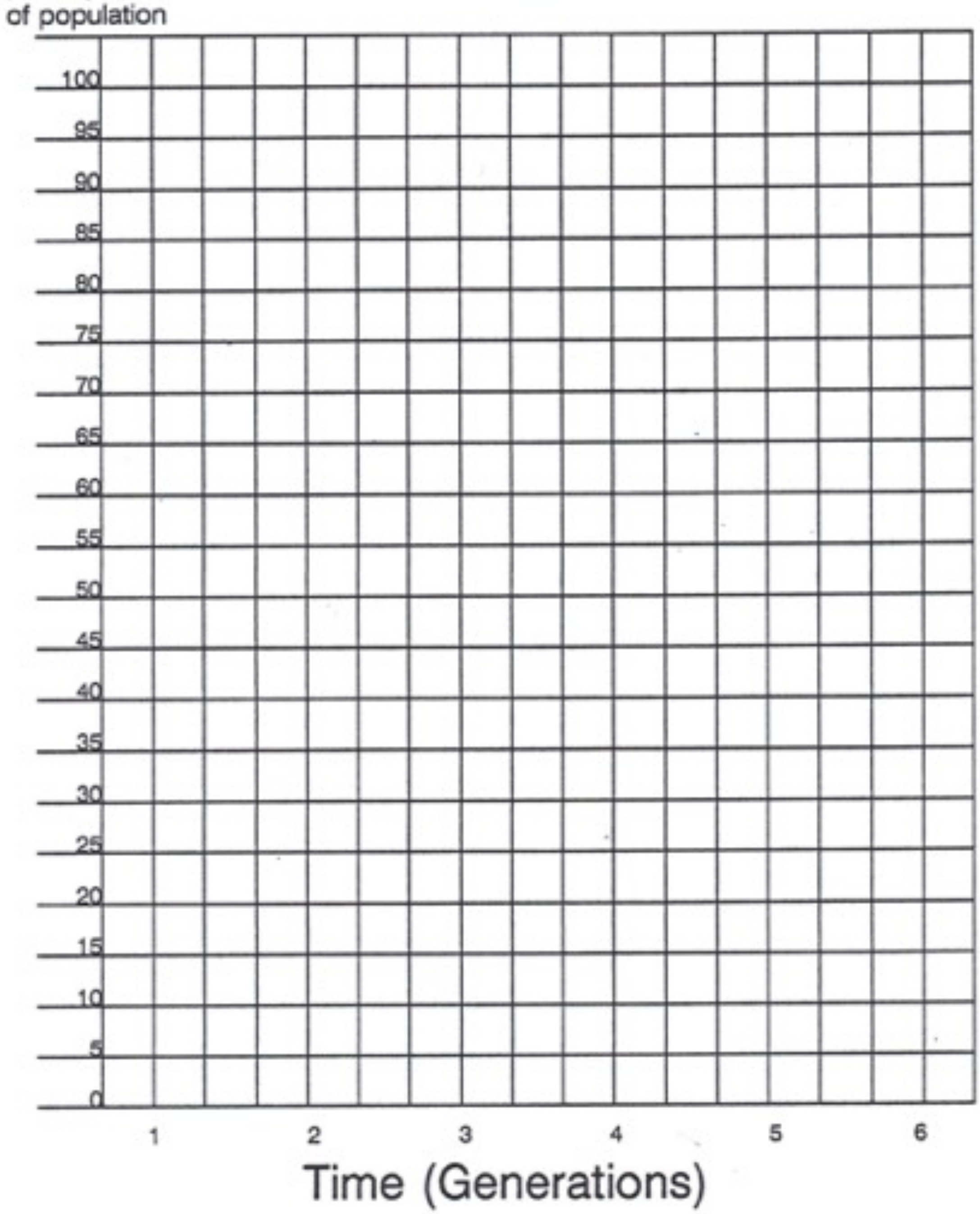
Appendix K

Worksheet 2

Field Methods

Shifting Populations

Name:______________________________



Appendix L

Possible answers and considerations for the **IN SEARCH OF THE WONDERFULLY WEIRD** discussion scenarios:

If giraffes…

- could not eat Acacia …
  There would be competition with other herbivores for other vegetation putting a strain on the available food supply that is already stressed.

- did not have long necks …
  They would not be able to reach the upper tree branches for exclusive feeding and again would be in competition with other herbivores.
  They would not be able to see long range and therefore would be more vulnerable to predation.

- had a different coat pattern other than spots or no pattern at all …
  They would not be able to hide through camouflage and therefore would be more vulnerable to predation.

- were not herbivores …
  This would change the entire food web and food pyramid in the African savanna.

- did not digest most of what they eat …
  This would probably affect the microbial ecology of the region as well as the chemical makeup of the soil. With a change in the chemical makeup of the soil there may be a change in the vegetation that can be supported. Giraffes might have to eat more food to obtain the same amount of nutrition.

- did not have chemicals on their skin …
  Without the antimicrobial protection these chemicals provide giraffe would be more susceptible to disease and possibly any mosquito borne diseases as well. This would greatly reduce the longevity of the individuals and result in the possibility of extinction.

- did not have long, agile legs with sharp hooves …
  They would not being able to defend themselves which would open up the possibility of more predation.

- had smaller eyes that did not have the ability to scan large areas …
  They would not be as able to detect danger as quickly and react effectively, thus making them vulnerable to increased predation.

… what would happen to the population and how would this ultimately affect the savanna ecosystem and the other populations living there?

Ultimately, a change in the population size of giraffes, increase or decrease, will change the dynamics of the savanna ecosystem in some way. Some populations will benefit and increase for a time, such as predators and possibly producers in some instances. But once *the population of giraffes is taken from the ecosystem by extinction there will have to be a complete change in the interactions among the surviving species.*

Appendix M

GIRAFFE QUIZ

Questions:

1. Giraffe do not have horns; instead they have ___________ which are skin-covered bones attached to their skulls.

2. Wild giraffe are found only on the continent of ___________.

3. The closest relative to a giraffe is called an ___________ (hint: the word begins with an “o”).

4. Giraffe have the same number of bones in their necks as people. How many bones? ______.

5. The subspecies of giraffe in Tanzania is the ___________ giraffe.

6. Giraffes can run as fast as ___________ kilometers per hour.

7. Name two advantages of the giraffe’s long neck.

8. A giraffe’s prehensile tongue grows to be ___________ centimeters long.

9. The giraffe’s tongue is ___________ in color.

10. The giraffe’s tail is used for swatting away ___________

Answers:

1. Ossicones

2. Africa

3. Okapi

4. 7

5. Masai

6. 56

7. (a) Allows the giraffe to reach leaves higher than other herbivores; (b) Enables them to watch for danger; (c) built-in weaponry for males to fight.

8. 50 cm (half a meter)

9. Blue

10. Biting insects (tsetse flies and mosquitoes)