# Student Lab Manual for Argument-Driven Inquiry in BIOLOGY







# LAB INVESTIGATIONS for GRADES 9-12

Victor Sampson, Patrick Enderle, Leeanne Gleim, Jonathon Grooms, Melanie Hester, Sherry Southerland, and Kristin Wilson



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# **ABOUT THE AUTHORS**

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Leeanne Gleim received a BA in elementary education from the University of Southern Indiana and a MS in science education from FSU. While at FSU, she worked as a research assistant for Dr. Sampson. After graduating, she taught biology and honors biology at FSU Schools, where she participated in the development of the argument-driven inquiry (ADI) model. Leeanne was also responsible for writing and piloting many of the lab investigations included in this book.

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**Kristin Wilson** attended Florida State University and earned a BS in secondary science teaching with an emphasis in biology and Earth-space science. Kristin teaches biology at FSU School. She helped develop the ADI instructional model and was responsible for writing and piloting many of the lab investigations found in this book.

# SAFETY IN THE SCIENCE CLASSROOM, LABORATORY, OR FIELD SITES

Note to science teachers and supervisors/ administrators:

The following safety acknowledgment form is for your use in the classroom and should be given to students at the beginning of the school year to help them understand their role in ensuring a safer and productive science experience. Science is a process of discovering and exploring the natural world. Exploration occurs in the classroom/laboratory or in the field. As part of your science class, you will be doing many activities and investigations that will involve the use of various materials, equipment, and chemicals. Safety in the science classroom, laboratory, or field sites is the FIRST PRIORITY for students, instructors, and parents. To ensure safer classroom/ laboratory/field experiences, the following Science Rules and Regulations have been developed for the protection and safety of all. Your instructor will provide additional rules for specific situations or settings. The rules and regulations must be followed at all times. After you have reviewed them with your instructor, read and review the rules and regulations with your parent/guardian. Their signature and your signature on the safety acknowledgment form are required before you will be permitted to participate in any activities or investigations. Your signature indicates that you have read these rules and regulations, understand them, and agree to follow them at all times while working in the classroom/laboratory or in the field.

Source: National Science Teachers Association (NSTA). Safety in the Science Classroom. www.nsta.org/pdfs/SafetyInTheScienceClassroom.pdf.

### Safety Standards of Student Conduct in the Classroom, Laboratory, and in the Field

- 1. Conduct yourself in a responsible manner at all times. Frivolous activities, mischievous behavior, throwing items, and conducting pranks are prohibited.
- 2. Lab and safety information and procedures must be read ahead of time. All verbal and written instructions shall be followed in carrying out the activity or investigation.
- 3. Eating, drinking, gum chewing, applying cosmetics, manipulating contact lenses, and other unsafe activities are not permitted in the laboratory.
- 4. Working in the laboratory without the instructor present is prohibited.
- 5. Unauthorized activities or investigations are prohibited. Unsupervised work is not permitted.
- 6. Entering preparation or chemical storage areas is prohibited at all times.
- 7. Removing chemicals or equipment from the classroom or laboratory is prohibited unless authorized by the instructor.

## **Personal Safety**

- 8. Sanitized indirectly vented chemical splash goggles or safety glasses as appropriate (meeting the ANSI Z87.1 standard) shall be worn during activities or demonstrations in the classroom, laboratory, or field, including pre-laboratory work and clean-up, unless the instructor specifically states that the activity or demonstration does not require the use of eye protection.
- 9. When an activity requires the use of laboratory aprons, the apron shall be appropriate to the size of the student and the hazard associated with the activity or investigation. The apron shall remain tied throughout the activity or investigation.
- 10. All accidents, chemical spills, and injuries must be reported immediately to the instructor, no matter how trivial they may seem at the time. Follow your instructor's directions for immediate treatment.
- 11. Dress appropriately for laboratory work by protecting your body with clothing and shoes. This means that you should use hair ties to tie back long hair and tuck into the collar. Do not wear loose or baggy clothing or dangling jewelry on laboratory days. Acrylic nails are also a safety hazard near heat sources and should not be used. Sandals or open-toed shoes are not to be worn during any lab activities. Refer to pre-lab instructions. If in doubt, ask!

- 12. Know the location of all safety equipment in the room. This includes eye wash stations, the deluge shower, fire extinguishers, the fume hood, and the safety blanket. Know the location of emergency master electric and gas shut offs and exits.
- 13. Certain classrooms may have living organisms including plants in aquaria or other containers. Students must not handle organisms without specific instructor authorization. Wash your hands with soap and water after handling organisms and plants.
- 14. When an activity or investigation requires the use of laboratory gloves for hand protection, the gloves shall be appropriate for the hazard and worn throughout the activity.

## Specific Safety Precautions Involving Chemicals and Lab Equipment

- 15. Avoid inhaling in fumes that may be generated during an activity or investigation.
- 16. Never fill pipettes by mouth suction. Always use the suction bulbs or pumps.
- 17. Do not force glass tubing into rubber stoppers. Use glycerin as a lubricant and hold the tubing with a towel as you ease the glass into the stopper.
- 18. Proper procedures shall be followed when using any heating or flame producing device especially gas burners. Never leave a flame unattended.
- 19. Remember that hot glass looks the same as cold glass. After heating, glass remains hot for a very long time. Determine if an object is hot by placing your hand close to the object but do not touch it.
- 20. Should a fire drill, lockdown, or other emergency occur during an investigation or activity, make sure you turn off all gas burners and electrical equipment. During an evacuation emergency, exit the room as directed. During a lockdown, move out of the line of sight from doors and windows if possible or as directed.
- 21. Always read the reagent bottle labels twice before you use the reagent. Be certain the chemical you use is the correct one.
- 22. Replace the top on any reagent bottle as soon as you have finished using it and return the reagent to the designated location.
- 23. Do not return unused chemicals to the reagent container. Follow the instructor's directions for the storage or disposal of these materials.

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### Standards For Maintaining a Safer Laboratory Environment

- 24. Backpacks and books are to remain in an area designated by the instructor and shall not be brought into the laboratory area.
- 25. Never sit on laboratory tables.
- 26. Work areas should be kept clean and neat at all times. Work surfaces are to be cleaned at the end of each laboratory or activity.
- 27. Solid chemicals, metals, matches, filter papers, broken glass, and other materials designated by the instructor are to be deposited in the proper waste containers, not in the sink. Follow your instructor's directions for disposal of waste.
- 28. Sinks are to be used for the disposal of water and those solutions designated by the instructor. Other solutions must be placed in the designated waste disposal containers.
- 29. Glassware is to be washed with hot, soapy water and scrubbed with the appropriate type and sized brush, rinsed, dried, and returned to its original location.
- 30. Goggles are to be worn during the activity or investigation, clean up, and through hand washing.
- 31. Safety Data Sheets (SDSs) contain critical information about hazardous chemicals of which students need to be aware. Your instructor will review the salient points on the SDSs for the hazardous chemicals students will be working with and also post the SDSs in the lab for future reference.

# Safety Acknowledgment Form: Science Rules and Regulations

I have read the science rules and regulations in the *Student Lab Manual for Argument-Driven Inquiry in Biology,* and I agree to follow them during any science course, investigation, or activity. By signing this form, I acknowledge that the science classroom, laboratory, or field sites can be an unsafe place to work and learn. The safety rules and regulations are developed to help prevent accidents and to ensure my own safety and the safety of my fellow students. I will follow any additional instructions given by my instructor. I understand that I may ask my instructor at any time about the rules and regulations if they are not clear to me. My failure to follow these science laboratory rules and regulations may result in disciplinary action.

Student Signature

Date

Parent/Guardian Signature

Date



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# Lab 12. Explanations for Animal Behavior: Why Do Great White Sharks Travel Over Long Distances?

#### Lab Handout

#### Introduction

Shark populations worldwide are declining in areas where they were once common. As a result, the International Union for Conservation of Nature (IUCN), has classified many species of shark as threatened with extinction. One species of shark that is currently on the IUCN "Vulnerable" list is the great white shark (*Carcharodon carcharias*). The great white shark is found in coastal surface waters of all the major oceans. It can grow up to 6 m (20 ft.) in length and weigh nearly 2,268 kg (5,000 lb). The great white shark reaches sexual

maturity at around 15 years of age and can live for over 30 years. Great white sharks are apex predators (see the figure to the right). An apex predator is an animal that, as an adult, has no natural predators in its ecosystem and resides at the top of the food chain. These sharks prey on marine mammals, fish, and seabirds.

Great white shark conservation has become a global priority in recent years. However, our limited understanding of their behavior has hindered the development of effective conservation strategies for this species. For example, little is known about

#### A great white shark



where and when great white sharks mate, where they give birth, and where they spend their time as juveniles. We also know that some great white sharks travel long distances, such as from Baja California to Hawaii or from South Africa to Australia, but we do not know why they make these journeys. There are, however, a number of potential explanations that have been suggested by scientists. For example, great white sharks might travel long distances because they need to do one or more of the following:

- Find and establish a territory (an area that they defend that contains a mating site and sufficient food resources for them and their young) once they reach sexual maturity or after losing a territory to other great white sharks.
- Migrate between a foraging site and a mating site on an annual or seasonal basis.

# LAB 12

- Forage for food—slowly traveling over long distances allows the sharks to find, capture, and consume new sources of food along the way without expending a great deal of energy.
- Find a foraging site with other sharks in it and cooperate with them to capture prey and minimize the amount of energy required to capture and consume food.
- Follow their prey as the prey migrates on an annual or seasonal basis.
- Move between several different foraging areas because they quickly deplete their food source in a given area and must move onto new foraging areas to survive.

All of these potential explanations are plausible because they can help a great white shark survive longer or reproduce more. It is difficult, however, to determine which of these potential explanations is the most valid or acceptable because we know so little about the life history and long-range movements of the great white shark. Most research on this species has been carried out at specific aggregation sites (such as the one near Dyer Island in South Africa). Although this type of research has enabled scientists to learn a lot about the feeding behaviors and short-range movements of the great white shark, we know very little about how they act in other places. A group called OCEARCH (*www.ocearch.org*), however, is trying to facilitate more research on their life history and long-range movements so people can develop better conservation strategies to help protect the great white shark.

This group of researchers has been catching and tagging great white sharks to document where they go over time. To tag and track a great white shark, OCEARCH places a SPOT tag on the shark's dorsal fin. These tags emit a signal that is picked up by global positioning satellites. Unfortunately, the signal can only be detected when the shark's dorsal fin breaks the surface of the water and a satellite is directly overhead. Researchers at OCEARCH call these signals "pings." The time span between pings can vary a great deal (from once an hour to once in a three-week period) because of individual shark behavior and the orbit of a satellite.

OCEARCH has created the Global Shark Tracker database (*www.ocearch.org*) and a companion app for mobile devices (visit the Apple App Store or Google Play to download the free app) to share the real-time data they collect (see the figure on the opposite page). This database allows users to see the current location of all the sharks that the OCEARCH researchers have tagged. It also allows users to track the movement of each shark over time. Users can also search for sharks by name, sex (male or female), and stage of life (mature or immature).

#### Your Task

Use the OCEARCH Global Shark Tracker database to identify patterns in the long-range movements of the great white shark, and then develop an explanation for those patterns.



#### A screen shot of Global Shark Tracker from the OCEARCH website

The guiding question of this investigation is, **Why do great white sharks travel over long distances?** 

#### Materials

You will use an online database called Global Shark Tracker to conduct your investigation. You can access the database by going to the following website: *www.ocearch.org*.

#### Safety Precautions

- 1. Use caution when working with electrical equipment. Keep away from water sources in that they can cause shorts, fires, and shock hazards. Use only GFI-protected circuits.
- 2. Wash hands with soap and water after completing this lab.
- 3. Follow all normal lab safety rules.

#### Getting Started

Your first step in this investigation is to learn more about what is already known about the great white shark. To do this, check the following websites:

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- Animal Diversity Web (*http://animaldiversity.ummz.umich.edu/accounts/Carcharodon\_carcharias*)
- MarineBio (*http://marinebio.org/species.asp?id=38*)
- The Smithsonian National Museum of Natural History Ocean Portal (*http://ocean. si.edu/great-white-shark*)

You can then use the OCEARCH Global Shark Tracker database to identify patterns in the long-range movement of great white sharks. To accomplish this task, it is important for you to determine what type of data you will need to collect and how you will analyze it.

To determine what type of data you will need to collect, think about the following questions:

- What data will you need to determine if there are patterns in the long-range movements of great white sharks?
- What data will you need to determine if there are sex-related, age-related, or geographic region–related differences in the long-range movements of great white sharks?

To determine how you will analyze your data, think about the following questions:

- How can you identify a pattern in the ways great white sharks move over long distances?
- How can you determine if there are patterns in the way great white sharks move over long distances based on sex, age, or geographic region?
- What type of table or graph could you create to help make sense of your data?

Once you have identified patterns in the ways great white sharks move over long distances, you will then need to develop an explanation for those patterns. You can develop one of your own or see if one of the explanations outlined in the "Introduction" section of this investigation is consistent with the patterns you identified. These explanations stem from what scientists know about the behavior of other animals and reflect some of the theories that scientists currently use to explain animal behavior.

#### Investigation Proposal Required? Yes No

# Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- the importance of identifying patterns,
- the importance of identifying the underlying cause for observations,

- the importance of examining proportional relationships,
- how scientific knowledge can change over time, and
- how the methods used by scientists depend on what is being studied and the research question.

#### **Argumentation Session**

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure to the right.

To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

#### Argument presentation on a whiteboard

The Guiding Question:		
Our Claim:		
Our Evidence:	Our Justification of the Evidence:	

The goal of the argumentation session is not to

convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- Why did you decide to focus on those data?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

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Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

#### Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

- 1. What question were you trying to answer and why?
- 2. What did you do during your investigation and why did you conduct your investigation in this way?
- 3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!

# Lab 12. Explanations for Animal Behavior: Why Do Great White Sharks Travel Over Long Distances?

#### **Checkout Questions**

Nowhere in the world is there a movement of animals as spectacular as the wildebeest migration that occurs from July to October each year in Africa. Over 2 million wildebeest travel from Serengeti National Park in Tanzania to the greener pastures of Maasai Mara National Reserve in Kenya. The wildebeest expend a lot of energy to migrate because of the great distance they travel. The wildebeest also have to cross the Mara River in Maasai Mara, where crocodiles will prey on them. In addition, the wildebeest will be hunted, stalked, and run down by the large carnivores found in the Maasai Mara. Many wildebeest, as a result, do not survive the migration.

1. Given the fact that wildebeest must expend a lot of energy and may even die during a migration, why would wildebeest engage in this type of behavior?

- 2. There is a single, universal, step-by-step scientific method that all scientists follow regardless of the type of question that they are trying to answer.
  - a. I agree with this statement.
  - b. I disagree with this statement.

Explain your answer, using examples from your investigation about animal behavior.

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- 3. Scientific knowledge may be abandoned or modified in light of new evidence or because of the reconceptualization of prior evidence and knowledge.
  - a. I agree with this statement.
  - b. I disagree with this statement.

Explain your answer, using information from your investigation about animal behavior.

4. Scientists often attempt to identify patterns in nature. Explain why the identification of patterns is useful in science, using an example from your investigation about animal behavior.

- 5. Scientists often attempt to identify the underlying cause for the observations they make. Explain why the identification of underlying causes is so important in science, using an example from your investigation about animal behavior.
- 6. Scientists often need to look for proportional relationships. Explain what a proportional relationship is and why these relationships are important, using an example from your investigation about animal behavior.



re you interested in using argument-driven inquiry for high school lab instruction but aren't sure how to do it? You aren't alone. *Argument-Driven Inquiry in Biology* is a one-stop source of expertise, advice, and investigations, with the information and materials you need to start using this method right away.

The book includes 27 field-tested labs that cover molecules and organisms, ecosystems, heredity, and biological evolution. The investigations are designed to be more authentic scientific experiences than traditional laboratory activities. They give your students an opportunity to design their own methods, develop models, collect and analyze data, generate arguments, and critique claims and evidence.

Student Lab Manual for Argument-Driven Inquiry in Biology provides the student materials you need to guide your students through these investigations. With lab details, student handouts, and safety information, your students will be ready to start investigating.



