



Fragrant Pheromones

Experimental Design

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Grade Level	9th – 12th Grade	Time Frame	4-50 class period(s)
Subject	Science	Duration	200 minutes
Course	Biology I, Biology II		

Essential Question

How do we use scientific investigations to find answers to questions?

Summary

Students will practice experimental design by identifying key elements of an experiment such as a hypothesis, the variables, and a conclusion based on experimental scenarios. They will also design an experiment (through guided inquiry) centered around termite pheromones, then create and share their results in a lab report.

Snapshot

Engage

Students will watch a 1-minute video clip demonstrating experimental design in an everyday, real-world setting. Then, using the Justified True/False strategy, they will re-watch the video clip and answer the questions.

Explore

Students will do parts one and two (Making Observations & Testable Questions) using the online site developed by Howard Hughes Medical Institute Biointeractives using real world data collected at Gorongosa National Park, Mozambique.

Explain

Students will watch a video clip about the results of an online survey. In groups (of 2-4) they will infer experimental design and hypothesis, etc., which they will then explain to the class and teacher. The teacher will review the scientific method and experimental design.

Extend

Students will design an experiment through guided inquiry in which they test the pheromones of termites.

Evaluate

Students will create a formal lab report, and they will share the results with the class.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Oklahoma Academic Standards (Physics)

PH.PS4.5.DCI.2: Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

Attachments

- [Big Bang Theory Experimental Design - Spanish.docx](#)
- [Big Bang Theory Experimental Design - Spanish.pdf](#)
- [Big Bang Theory Experimental Design.docx](#)
- [Big Bang Theory Experimental Design.pdf](#)
- [Experimental Design Notes.pdf](#)
- [Experimental Design Notes.pptx](#)
- [Gorongosa WildCam Activity.docx](#)
- [Gorongosa WildCam Activity.pdf](#)
- [Lab Reports Format - Spanish.docx](#)
- [Lab Reports Format - Spanish.pdf](#)
- [Lab Reports Format.docx](#)
- [Lab Reports Format.pdf](#)
- [Racial Preference Video Instructions.pdf](#)
- [Racial Preference Video Instructions.pptx](#)
- [Termite Inquiry Lab - Spanish.docx](#)
- [Termite Inquiry Lab - Spanish.pdf](#)
- [Termite Inquiry Lab.docx](#)
- [Termite Inquiry Lab.pdf](#)

Materials

- Video clip of experimental design on Big Bang Theory (linked under Engage and in Resources)
- Student copies of "Big Bang Theory Experimental Design" handout (located under "Attachments," two copies of handout on each page)
- Technology (e.g., laptops/Chromebooks/computer lab)—one per pair of students
- "Gorongosa WildCam Activity" handout (located under Attachments)
- Overhead projector with computer and Internet access
- Video clip of "Do You Have a Racial Preference?" (linked under Explain and in Resources)
- "Racial Preference Video Instructions" PowerPoint/pdf of questions for video (located under Attachments)
- "Experimental Design Notes" Powerpoint/pdf (located under Attachments)
- Worker termites (notes on how to obtain these are in the Extend section)
- Cotton swabs
- Three brands of ink pens (one brand must be Paper Mate), each with 3 different colors (red, black, blue)
- Blank white paper
- Index cards
- Graph paper
- "Termite Inquiry Lab" handout (located under Attachments, one per student)
- Poster board or easel-sized Post-it paper

- "Lab Reports Format" handout for students (located under Attachments)
- Markers
- Colored pencils
- Scissors
- Colored paper

Engage

This section is used to access prior student knowledge about experimental design. This will allow the teacher to determine where students are at cognitively for the topic/lesson.

Before beginning the lesson, emphasize the essential question and reference it as the lesson progresses.

1. Students will watch the 1-minute clip of the Big Bang Theory (linked here and URL in Resources). Warn students that the clip is short and fast, and encourage them to watch the video carefully the first time, ignoring the handout.
2. Students will then receive a handout which asks them to use the Justified True/False strategy as they watch the clip again. Provide directions to the strategy and have them look over the categories they will have to mark as true or false. Start the clip for the second time.
3. Once the clip is finished, have students answer the T/F on their handouts (1 or 2 minutes).
4. Pair students with an elbow partner to have them answer the justification section and final question (10 min). Altogether, entire section should be around 15 minutes.

Lesson Variation

Students can alternatively (or additionally) use the Inverted Pyramid Strategy. Have groups of two join with another group of two, to make groups of four, and review each other's answers, discuss the categories, etc. One person from each group can speak for the group and share out their justification for a (teacher picked) category—one student group to a category. Allow students to change their answers if they want.

Explore

This section is to allow students to become familiar with the beginning steps of designing an inquiry. Using the website at <https://www.wildcamgorongosa.org>, students will do the "Gorongosa WildCam Activity" (located under Attachments and adapted for this lesson from the original pdf from Howard Hughes Medical Institute). Students are to make observations and testable questions using the data collected from the wildlife camera set on the trails of Gorongosa National Park in Mozambique.

Teacher's Note

Teachers should familiarize themselves with the expectations of the website so they can eliminate any bugs and the lesson will flow smoothly. In other words, walk through it yourself ahead of time, as if you were the student. If computers are not available to students (groups, pairs, or individually), teachers can access the website on the overhead projector through a personal computer and students can observe in that way.

Lesson Variation

This part of the lesson uses an modified inquiry sheet that goes with the WildCam Lab activity. If teachers want to use the original, it and the teacher instructions (along with an Excel tutorial), are available for download here: <https://www.hhmi.org/biointeractive/scientific-inquiry-using-wildcam-gorongosa>. The original has multiple parts past the first two sections, which are the only ones used in and adapted for this lesson. However, as part of the 5E model under Extend, teachers may want to finish the original inquiry as part of the lesson on experimental design or wait after students have had more practice and return to it during another unit of instruction. The inquiry is very data-driven and mathematically-based and may be beyond the reach of early learners. The alternative provided here specifically for this lesson should be more than sufficient. Just be aware there is a choice. This activity should take around 30 minutes.

Explain

Students will watch a 2-3 minute video clip called "Do You have a Racial Preference?" at: https://www.youtube.com/watch?v=HjSh_esW9W4. The video describes online dating statistics that reveal users' racial preferences. Students will have a short question set on the methodology and experimental design at the end of the clip (approximately 5 minutes).

Together with an elbow partner, students will determine the study's possible question(s), hypotheses, data, and possible conclusion(s) and put their answers on a note card. Instructions for the activity can be found in the "Racial Preference Video Instructions" provided under Attachments.

Once again, this clip is very short and fast, so have students prepare their cards before viewing the video. Encourage students to watch the video carefully the first time and to ignore the card.

Play the clip for the second time. Once the clip is finished, have students answer the questions on their card (5 minutes), and then pair them with an elbow partner to discuss and/or change their answers (5 min). Altogether, entire section should be around 15 minutes.

Present key vocabulary and explain the scientific method as well as key elements of good experimental design using "Experimental Design Notes" (located under Attachments) as a lecture guide. Be sure to use examples from elements of the lesson thus far—both video clips and the Gorongosa activity. (Approx. 30 minutes)

Extend

Students will be designing a guided inquiry into the behavior of termites with the help of the "Termite Inquiry Lab" handout (located under Attachments). Have students read the scenario before they attempt to write their hypotheses and determine their variables. They will have to choose between three testable options: ink brands, ink colors, path shapes. The "Termite Inquiry Lab" handout for the inquiry is in Attachments as a modifiable word document or as a pdf. Teachers should read the inquiry handout for the students to familiarize themselves to the parameters of the lab.

A Case For A Guided Inquiry

A full inquiry would have students choose any number of methods with which to experiment upon their termite. A guided inquiry lends itself to student understanding better, at this point, by eliminating too many experimental errors in the beginners' experimental design. This also allows the teacher to monitor and problem-solve the ongoing experiments much easier (since, start-to-finish, the inquiry will be completed within one class period).

Alternative

Students can finish the inquiry for the Gorongosa activity (with the handout from the Howard Hughes Medical Institute, for which they have already done parts one and two) instead of the termite inquiry. If there is enough time, teachers can have students do both activities.

Teacher's Note

Students need to have a choice of three ink colors and three ink brands, but one of the ink brands must be Paper Mate as that brand provides a chemical attraction to the termites and mimics pheromones. Sometimes, other brands can do the same, but if the students run into this during their experiment, it shouldn't be a problem. This just provides another avenue of exploration and explanation.

Where To Find Termites

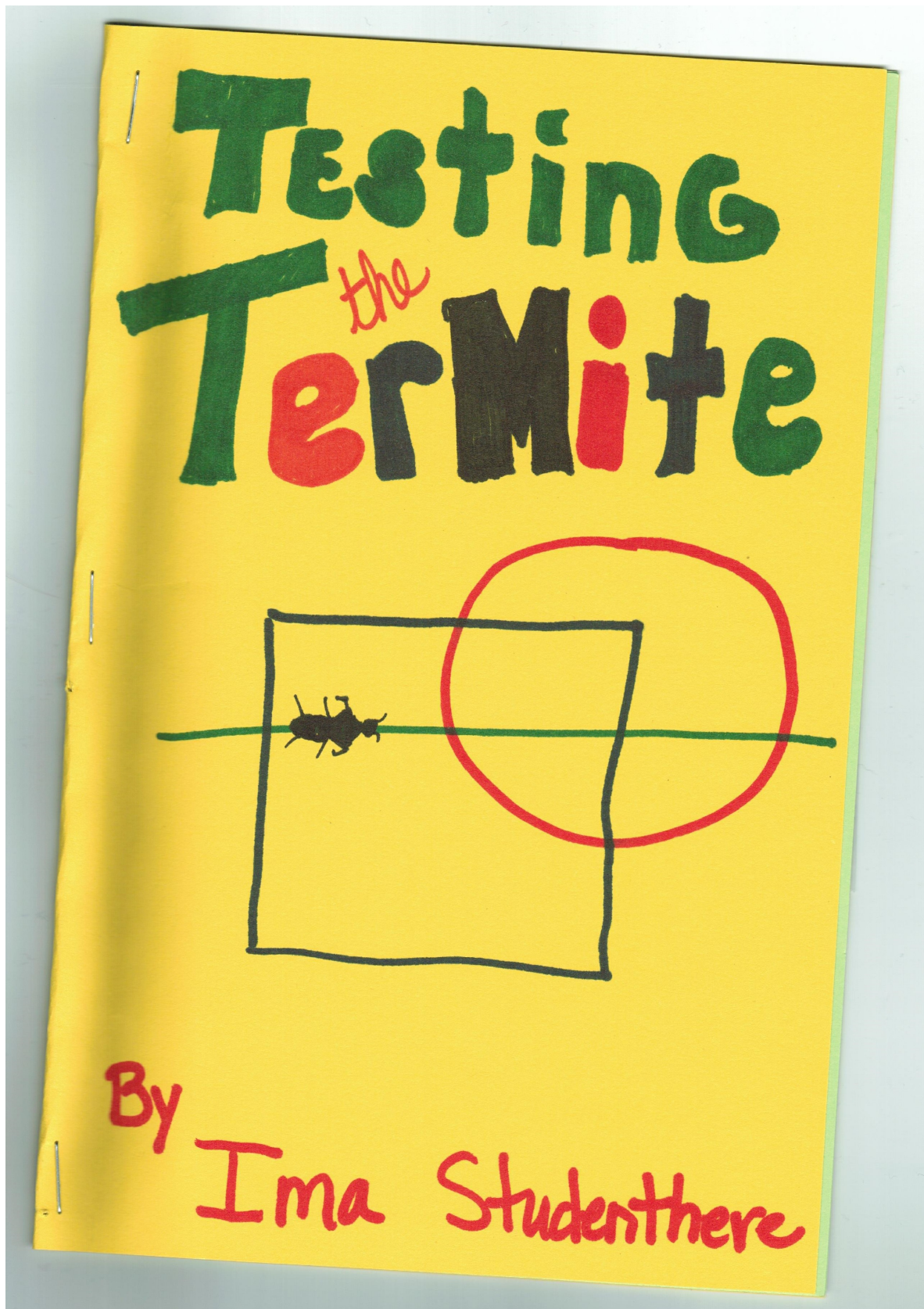
Termites can be found through several biological supply companies. You should check their websites for shipping times along with a lead time to clear purchase orders through your schools' finance secretary. Termites are easily kept alive if you order them and receive them earlier than the unit's start date. An example of costs: Carolina Biological Supply Company has worker termites, pack of 25 (item #143734), for \$18.75. They also sell worker termites, pack of 100 (item #143736), for \$44.75. A termite care sheet from Carolina Biological Supply Company can be found at: <http://www.carolina.com/teacher-resources/Document/termite-care-handling-instructions/tr10553.tr>

Evaluate

Student lab reports can be done in groups or individually, but the ideal group size would consist of two or three students. This allows students to help each other on this very early report. For this inquiry, they will be writing their lab reports on large poster board or poster-sized Post-it and sharing their findings with the class. The lab report format is one students will use all year for their lab reports, so this could be their first opportunity to write one. A copy of the lab report requirements is in Attachments as "Lab Reports Format." The format included is one students can cut out and tape or paste into the fronts or backs of their notebooks. Students can tape, paste, or staple their inquiry sheets (especially their data sheets) to the back of their reports as evidence of conducting the experiment.

Students don't have to limit themselves to creating a basic or traditional lab report. There is more than one way to create these reports, allowing students to showcase their creative side. Possible variations listed below with a few example images:

- Construction paper reports: Have students put all 10 lab report items on a folded (hamburger style) piece of construction paper. Get the larger sized construction paper if you can (this gives a little more room for everything).
- Card stock/colored paper reports: Same as construction paper. These can have two pages for extra writing space, just staple the spine.
- Flip book reports: If you do not know how to construct a flip book, go to <https://www.youtube.com/watch?v=jg8EJFcQ068>. It walks you through the process of creating a flip book, which you can show your students the first time you use this method. You will want four or five pieces of paper to create an eight or 10 page flip book per student. Each page in the book is a tab for each section of the lab report. If you go the eight-page route, page one will include the lab title and the picture/drawing and page two will include both the hypothesis and the variables.
- Typed report: If students have access to laptops/Chromebooks/computer lab, then they could type their reports on a Google Doc, share with an elbow or clock partner (for proof reading), and then they can print it out to turn in or share it for online grading. Alternatively, this can also be done as a part of Google Classroom.



Card stock lab report format - front cover

Materials:

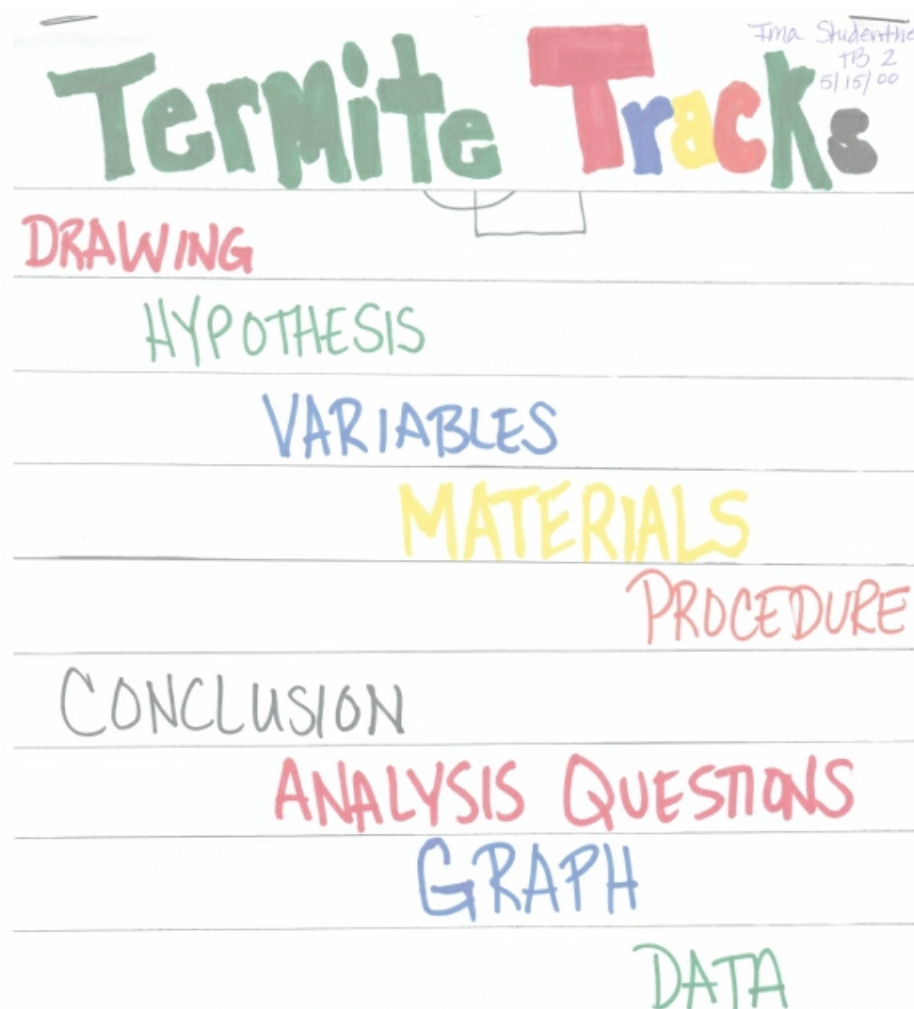
Procedure/Steps:

1.
2.
3.

GROUP DATA

MINUTE	INK COLOR	INK BRAND	PATH SHAPE	OBSERVATIONS
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Card stock lab report format - open to inside showing the sections where materials, procedures, and data would go



Flip book lab report format - large items (data tables and graphs) go on the larger, last pages while short sections (hypotheses) go on the shorter pages

Wrap up the lesson by re-emphasizing the essential question and having one last conversation about how science is done. Also, teachers might want students to do a rough draft (either in their notebooks or on white paper) and get approval/teacher sign-off on how the final report would look.

Optional Expansion

Once reports are done, students can hang them around the room and teachers can have them use the Gallery Walk strategy. Have students write comments on Post-its and leave them on the reports as a feedback tool. If Post-its are a luxury, place a piece of paper by each report and have student teams collaborate on their one feedback comment or question and write it on the page as they rotate through on the walk.

Resources

- The Big Bang Theory clip: April Couch. (2012, December 12). The Big Bang Theory scientific method clip season 6 episode 5 [Video file]. Retrieved from https://www.youtube.com/watch?v=_7sSuhQ1_24
- Racial preference video: BuzzFeed Yellow. (2014, April 9). Do you have a racial preference? [Video file]. Retrieved from https://www.youtube.com/watch?v=HjSh_esW9W4
- Scientific inquiry materials from Howard Hughes Medical Institute: Howard Hughes Medical Institute. (2016, March 14). Scientific inquiry using WildCam Gorongosa: Student worksheet. Retrieved from http://media.hhmi.org/biointeractive/activities/wildcam/inquiry/WildCam_Inquiry_Student.pdf?download=true&_ga=1.256284879.599851589.1466440285
- Gallery Walk or Carousel Instructional Strategy: K20 Center. (n.d.). Gallery walk/carousel. Instructional Strategy. Retrieved from <https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f505a54d>
- Justified True/False Instructional Strategy: K20 Center. (n.d.). Justified true/false. Instructional Strategies. Retrieved from <https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f507a9cc>
- Inverted Pyramid Instructional Strategy: K20 Center. (n.d.). Inverted pyramid. Instructional Strategies. Retrieved from <https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f507a918>
- How to make a flip book: Katherine Rearick. (2015, June 24). Making a foldable flip book [Video file]. Retrieved from <https://www.youtube.com/watch?v=jg8EJFcQ068>
- Termite Care Sheet: Carolina Biological Supply Company. (2012). Termites. Carolina CareSheet. Retrieved from <http://www.carolina.com/teacher-resources/Document/termite-care-handling-instructions/tr10553.tr>