Pollinators in Peril

Why are species disappearing? How can we save species and ourselves? How can we use science to better our world?

Project Description:

Bees are a main pollinator for flowering plants in many ecosystems. They are responsible for pollinating much of the food that we eat and many of the plants important to maintaining healthy ecosystems. Recently, there has been a significant decline in the number of honey bees and many species of native bees. One of the factors that has caused bees to die is predators. Yet little is known about how predators capture bees, or how bees avoid predators. You will design experiments to test bees' reactions to predators. This important research will be used by scientists, such as Dr. Eben Goodale and Dr. James Nieh, to better understand bees and their decline. <u>You</u> can help reverse bee colony collapse.

Project Deliverables:

- Scientific paper that summarizes your experiment and results
- PowerPoint presentation to the UCSD Nieh Lab scientists summarizing your experiment and results

National Science Standards Addressed:

- **6.1 Inquiry Standards:** Students understand scientific inquiry and demonstrate skills necessary to do scientific inquiry
- **6.3 Life Science Standards:** Students understand the interdependence of organisms and the behavior of organisms
- **6.6 Science in Personal and Social Perspectives Standards:** Students understand environmental quality and natural and human induced hazards

Project Benchmarks:

Date	Activity
9/1	TED Talk Clip: Dennis vanEngelsdorp's "A Plea for Bees" Guest lecture by Dr. Eben Goodale, *The Importance of Pollinators and Predators*
9/6	Draft of introduction to paper due
9/7	Biodiversity and Bees reading due
9/8	Field trip to UCSD Nieh Bee Lab and Bee Hives to observe bees in hive, training of bees, and mock experiment
9/9	Observations at Hives due
9/12	Field trip to Skeleton Canyon to collect and identify bee predators with entomologists, Jim Berrian and James Hung
9/13	Predator Identification due
9/16	Lesson on the process of science and brainstorm of experimental design
9/19	Lesson on writing a methods section and first draft of methods section due
10/6 & 10/11	**Experiments at the Hives at UCSD**
10/12	Revision of introduction and method due
10/13	Lesson on revising scientific paper. Third draft of introduction and method due
10/20	Guest lesson by Dr. Eben Goodale, *Statistical Analysis of Bee Response to Predators* First draft of results and conclusion due.
10/31	Abstract and literature cited due
11/2	**First draft of paper due; PowerPoint due**
11/9	Second draft of paper due
11/10	**Presentation to scientists** of the Nieh Lab at UCSD
11/14	Third draft of paper due
11/29	**Final paper due**
12/1-12/7	Exhibition preparation
12/7	**Exhibition** at OB Farmer's Market 3-7pm
12/15	**Exhibition** at HTH 6-8pm

UCSD/Nieh Research Lab

Waiver, Release and Indemnity Agreement
(Court approved Form)

We regret that participation cannot be allowed unless we have this completed form on file.

Waiver, Release, Assumption of Risk and Indemnity Agreement

Waiver: For and in consideration of permitting (child's name)______________________________ to enroll and participate in Bee Research Activities of the Nieh Research Lab at UCSD given by THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, in the City of San Diego, County of San Diego and State of California, beginning on the 8th day of the month of September, 2011, and ending on the 11th day in the month of October, 201, hereinafter called "The Activity", I, for myself, my heirs, personal representatives, or assigns, do hereby **release, discharge, waive and covenant not to sue** THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, its officers, employees and agents from liability **from any and all claims including the negligence of The Regents of the University of California, its officers, employees, and agents**, resulting in personal injury, accidents or illnesses (including death), and property loss arising from, but not limited to, participation in The Activity.

Assumption of Risks: I understand and acknowledge that participation in The Activity carries with it certain inherent risks that cannot be eliminated regardless of the care taken to avoid injuries. The specific risks vary from one activity to another, but the risks range from 1) minor injuries such as bee stings, scratches, bruises and sprains 2) major injuries such as eye injury and loss of sight, joint or back injuries, heart attacks, and concussions to 3) catastrophic injuries including paralysis and death. **I have read the previous paragraphs, and I know, understand and appreciate these and other risks that are inherent in** The Activity. **I hereby assert that my participation in The Activity is voluntary, and that I knowingly assume all such risks.**

Indemnification and Hold Harmless: I, also agree to IDEMNIFY AND HOLD The Regents of the University of California HARMLESS from any claims, actions, suits, procedures, costs, expenses, damages and liabilities, including attorney's fees brought as a result of my involvement in The Activity and to reimburse them for any such expenses incurred.

Severability: The undersigned further expressly agrees that the foregoing waiver and assumption of risks agreement is intended to be as broad and inclusive as is permitted by the law of the State of California and that if any portion thereof is held invalid, it is agreed that the balance shall, notwithstanding, continue in full legal force and effect.

Photographic Release: I authorize The Nieh Lab at UCSD to use my child's photograph and/or video image for education and public relations purposes related to The Bee Research Activities.

Acknowledgment of Understanding: I have read this waiver of liability, assumption of risk, and indemnity agreement, fully understand its terms, and **understand that I am giving up substantial rights, including my right to sue.** I acknowledge that I am signing the agreement freely and voluntarily, and **intend by my signature to be a complete and unconditional release of all liability** to the greatest extent allowed by law.

Preparing to visit the Bee Lab and Bee Hives: Please prepare your child to enter a university research lab and field research station. The students will need to be respectful of all equipment and mindful of directions. Safety instructions for how to work with the bees will be given. All students are expected to comply with the safety rules and wear all bee personal protective equipment at all times at the hives.

____
Name of Participant

____ ____________________________
Signature of Participant | Date

____ ____________________________
Signature of Parent/Guardian if Participant is a Minor | Date

The Gary and Jerri-Ann Jacobs
HIGH TECH HIGH

August 29, 2011

Dear students, parents, relatives, and guardians,

As you may know, we are embarking on a bee ecology project in Biology this semester. Recently, there has been a significant decline in the number of honey bees and many species of native bees. One of the factors that has caused bees to die is predators. Yet little is known about how predators capture bees, or how bees avoid predators. The students will have the unique opportunity to design experiments to test bees' reactions to predators. This important research will then be used by scientists studying bees and bee colony collapse.

We are very fortunate to be collaborating with Dr. Eben Goodale and the Nieh Bee Research Lab at UCSD for this project. Dr. Goodale and Dr. Nieh have graciously invited us to test our experiments out on the bees at the UCSD Greenhouse/Field Station Hives. Therefore, we will make two trips to the UCSD hives to conduct our experiments. One trip will be on September, 8th and the other will be on either October 6th or 11th. Before working at the bee hives, students must participate in a safety lecture and don bee personal protective equipment. No students will be allowed to work at the hives without being fully covered in a bee suit, protective shoes, and gloves.

In addition to their work at the hives, students will also work with some individual bees and bee predators in the lab and classroom. Primarily, they will be dissecting bees and raising bee predators. As at the hives, students will be expected to follow safety procedures .

Please let us know if your child has any allergies to bees or spiders. Also let us know if you would like to exclude your child from any of these activities. If you have any questions or would like to discuss this further, please email Jesse at jwade@hightechhigh.org or call 858-232-5998.

Sincerely,

Jesse Wade Robinson

Jesse Wade	David Berggren
Biology Instructor	Engineering Instructor
High Tech High	High Tech High

- ☐ My child has an allergy to ____.
- ☐ I would like to **exclude** my child from the field trip to the hives

____
Student Name Date

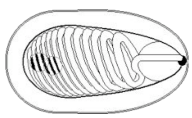
____
Parent Signature Date

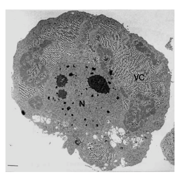
2861 Womble Road, San Diego, CA 92106-6025 • Tel: (619) 243-5000 • Fax: (619) 243-5050 • www.hightechhigh.org

Bees in peril: pesticides and predators

Eben Goodale
The Nieh Lab
UCSD

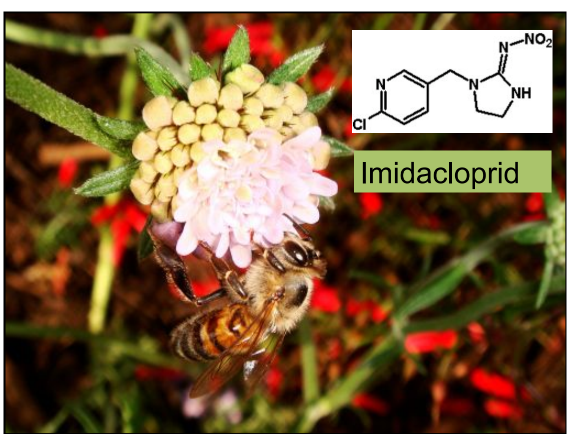

The New York Times
Science
WORLD U.S. N.Y. / REGION BUSINESS TECHNOLOGY SCIENCE HEALTH SPORTS OPINION
ENVIRONMENT SPACE & COSMOS
Scientists and Soldiers Solve a Bee Mystery


Nosema apis


Iridoviruses (in cell)

Are pesticides part of the problem?

Related to pesticide seed dressing?



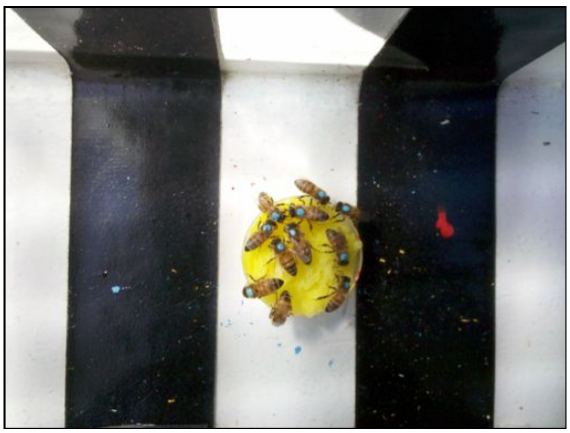
Imidacloprid and its effects on honey bees

- We use very low doses of imidacloprid (0.216 and 2.16 ng/bee) compared to LD_{50} average of 21.85 ng/bee (Schmuck 2001)
- We test bees' responsiveness to different sucrose concentrations and their ability to navigate

Work of Masters' student Daren Eiri in the Nieh Lab

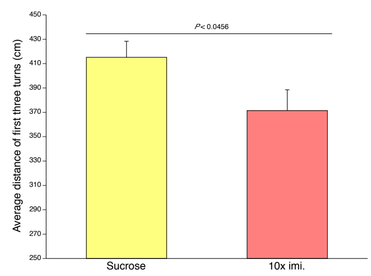
How does the insecticide alter their ability to navigate?

A flight of 6 m inside a tunnel is equivalent to a flight of 93 m outdoors (Srinivasan 2007)

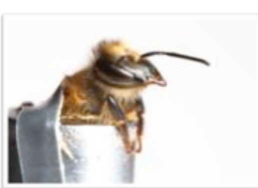


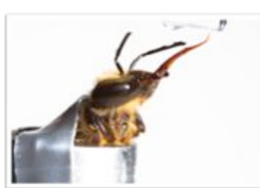
How does the insecticide alter their ability to navigate?

Bees treated with high concentration of imidacloprid search for food at significantly shorter distances than control bees



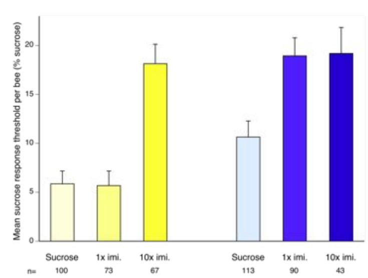
Honey Bee Sucrose Responsiveness





Honey Bee Responsiveness

- Pollen and nectar foragers become more picky with imidacloprid



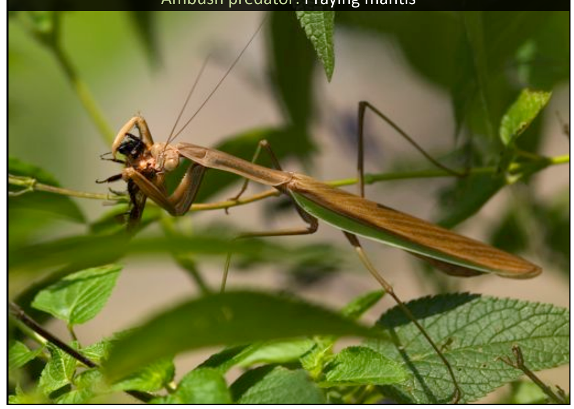
Sublethal effects of the pesticide imiacloprid on honey bees

- Pesticide-treated bees become more picky and may possibly affect division of labor, affecting colony health
- They also travel shorter distances than untreated bees to a trained location, providing evidence of cognitive disruption

Pollinators in peril

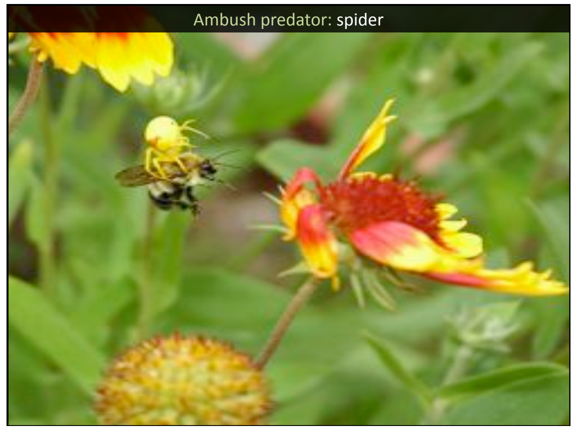
Bird predation : Bee eaters

Ambush predator: Praying mantis

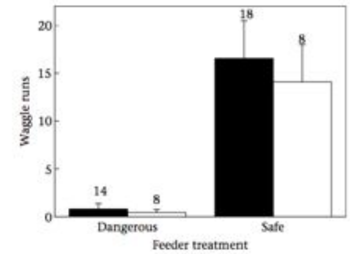


Ambush predator: Ambush bug

Ambush predator: spider



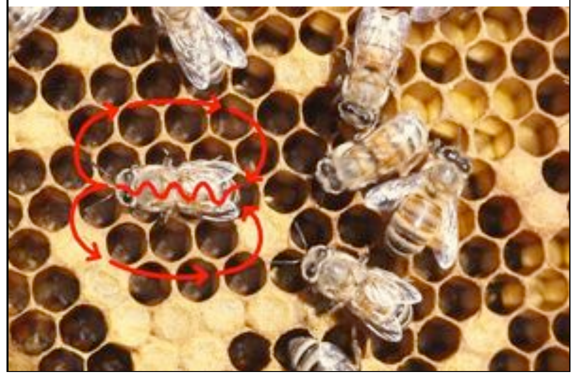
Are bees able to avoid predators?



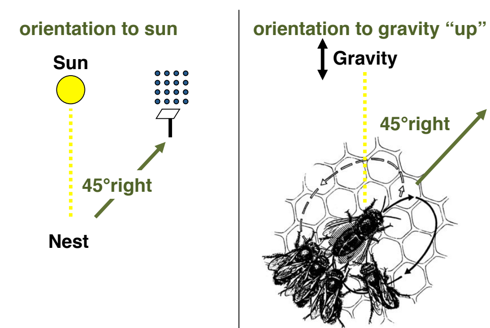
From Abbott & Dukas, 2009

But what is a waggle run?

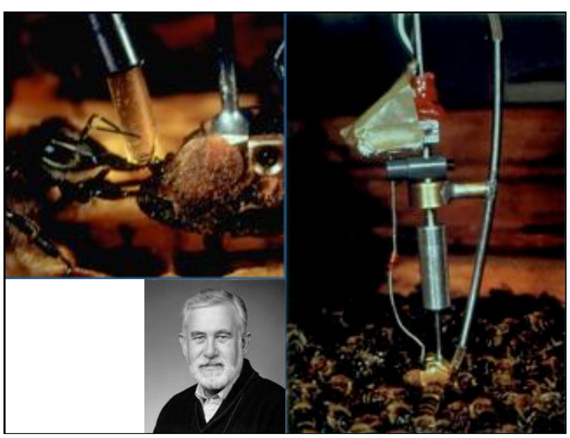
Honey bee waggle dance



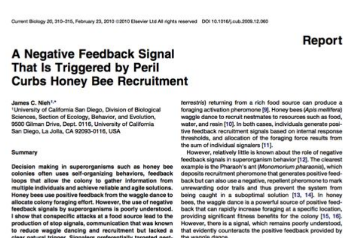
Transposing angle from sun to gravity



Apis mellifera



Do bees communicate about predators?



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Report

A Negative Feedback Signal That Is Triggered by Peril Curbs Honey Bee Recruitment

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Summary

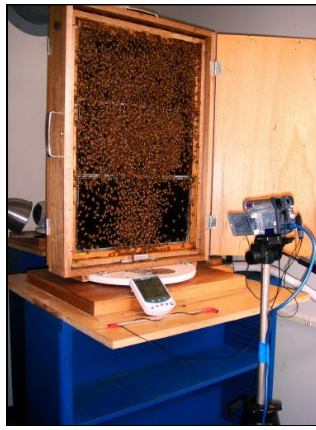
Decision making in superorganisms such as honey bee colonies often uses self-organizing behaviors, feedback loops that allow the colony to gather information from multiple individuals and achieve reliable and agile solutions. Honey bees use positive feedback from the waggle dance to allocate colony foraging effort. However, the use of negative feedback signals by superorganisms is poorly understood. I show that conspecific attacks at a food source lead to the production of stop signals, communication that was known to reduce waggle dancing and recruitment but lacked a clear natural trigger. Signalers preferentially targeted nest-

terrestris) returning from a rich food source can produce a foraging activation pheromone [9]. Honey bees (*Apis mellifera*) waggle dance to recruit nestmates to resources such as food, water, and resin [10]. In both cases, individuals generate positive feedback recruitment signals based on internal response thresholds, and allocation of the foraging force results from the sum of individual signalers [11].

However, relatively little is known about the role of negative feedback signals in superorganism behavior [12]. The clearest example is the Pharaoh's ant (*Monomorium pharaonis*), which deposits recruitment pheromone that generates positive feedback but can also use a negative, repellent pheromone to mark unrewarding odor trails and thus prevent the system from being caught in a suboptimal solution [13, 14]. In honey bees, the waggle dance is a powerful source of positive feedback that can rapidly increase foraging at a specific location, providing significant fitness benefits for the colony [15, 16]. However, there is a signal, which remains poorly understood, that evidently counteracts the positive feedback provided by the waggle dance.

Work of James C. Nieh

Bees make a special vibrational sound called a stop signal that stops bees from recruiting to a place.



Honey bee observation hive

UCSD Biology Field Station

(how we observe bee behavior)

Close up of microphone recording bee sounds

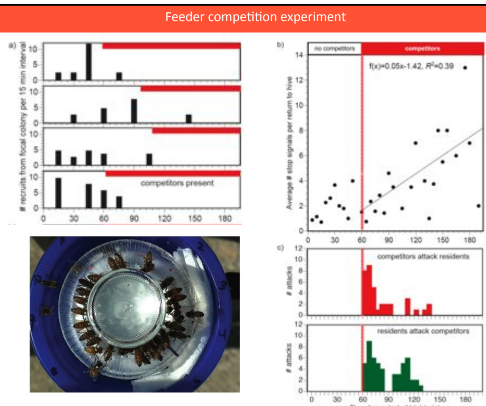
Feeder competition experiment

Beginning of competition trial

End of competition trial (2 hrs)

Focal bees labeled, competitors (feral bees) unmarked

Feeder competition experiment

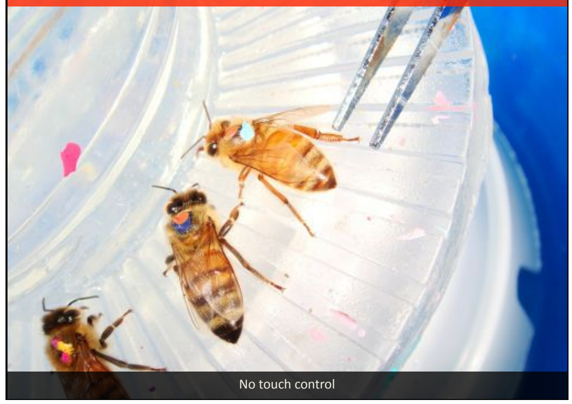


What are the proximate causes?

Biting commonly occurred during feeder aggression

Biting is a general strategy of many ambush predators

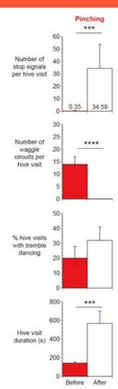
Pinching experiment



No touch control

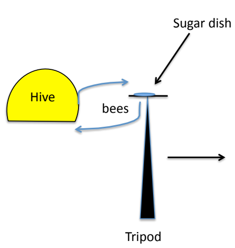
Feeder competition experiment

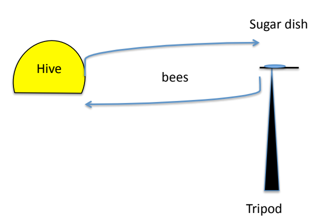
**$P<0.01$
***$P<0.001$
****$P<0.0001$



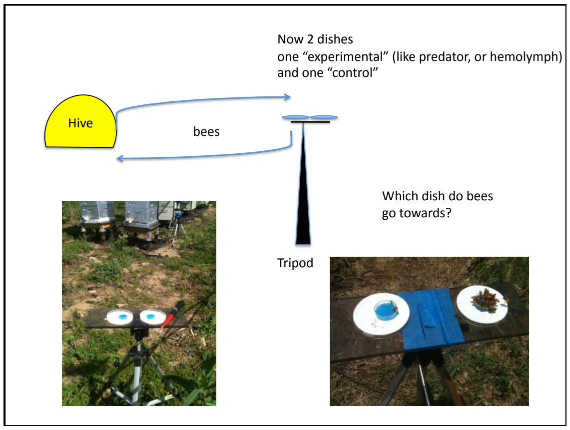
Goals of SD Bee Predator Studies

- What predators prey on bees in SD?
- Can bees avoid predators by picking up their scent, or by seeing them?
- Can bees avoid predators by using the cues of an attack (bee hemolymph)?





"training bees"



Thanks to

- SD Foundation
- Ms. Jesse Wade-Robinson and
Mr. David Berggren
- And to you!

My Name:

A Scientific Paper

Step One: Research and writing a draft of your introduction

WHAT IS AN INTRODUCTION?

A good introduction should ask the question **Why is this study of scientific interest and what is your objective?**

This section discusses the results and conclusions of previously published studies, to help explain why the current study is of scientific interest.

- **The Introduction is organized to move from general information to specific information**
- **The last sentences of the introduction should be a statement of objectives and a statement of hypotheses.** This will be a good transition to the next section, Methods, in which you will explain how you proceeded to meet your objectives and test your hypotheses.For example, you might write the following: "Our objective was to determine if the relationship between legumes and nitrogen-fixing bacteria is species-specific. We hypothesized that legumes would grow best when infected by the same *Rhizobium* species that it occurs with in the field."
- **You will need to cite your sources in your introduction section.** It is important to cite sources in the introduction section of your paper as evidence of the claims you are making. There are ways of citing sources in the text so that the reader can find the full reference in the literature cited section at the end of the paper, yet the flow of the reading is not badly interrupted.

LET'S GET STARTED!

Introductions start with the most general information possible.

1. As a general rule, always start by describing the organisms studied. The species that I will be experimenting on are:

Common Name:____

Scientific Name:____

MLA Citation for #1:

2. What is the reason for using this organism in your study (there are many reasons)? Cite the EVIDENCE for your reasons.

Reason #1:

Evidence #1:

Reason #2:

Evidence #2:

MLA Citations for #2:

3. What is the reason for studying how bees respond to predators?
   Reason:

   Evidence:

   MLA Citations for #3:

4. What do you think would be other important background information to include:
   Write a research question here

   e.g. Do bees communicate with the hive about dangers? If so, how?

   ____

   Notes on your first research question:

MLA Citation for #5:

Observations at the Hives

In your lab notebook, make detailed observations of the following:

- ☐ What you noticed at the **Observation** Hive.
- ☐ The **method** used to train the bees, and evaluate their choice of feeding dishes**(The Experimental Design).**
- ☐ The **methods** used to collect data and how it was recorded. ***What type of data is recorded?***
- ☐ The **questions asked by other scientists in the lab and how their experiments** are conducted.
- ☐ Write as many **questions** as you can in your lab notebook.

Name:

Group Members:

Bee Predator Identification

1. Each group will collect and document three bee predators by Monday of next week. Each student will need to document collect, document and care for at least **one** predator.

2. Photograph your predator either using the binoculars (upside down) or the dissecting scope. Save the photo in your documents and print a copy for your lab notebook.

3. Using either the field guides, or the web (I recommend Bug Guide.Net), find the following information. If you can't identify your species you can email Bug Guide.Net a photo. Please **cut and paste it** in your lab notebook.

Common Name:

Kingdom:

Phylum:

Class:

Order:

Family:

Scientific Name *(Genus species):*

Location found:

Identification:

Habitat:

Food:

Other:

You will be **responsible** for caring for your predator (keeping it alive for the experiments). First you will need to properly label your predator container. Do so by completing the following label and taping it to the container.

____

Name: _____________________________________ Date: _________________________

Common Name: ____

Family: ____

Scientific Name: ____

Location found: ____

____

Common Bee Predators Found in Southern California Coastal Sage Scrub

Identification Cards

Common Name: Barn Spider

Scientific Name: *Neoscona crucifera*

Family: Araneidae (orb weaver)

Identification: The size is 9-20 mm for the female and, 5-15 mm for the male. They have a rusty red color and the lack of pattern on the abdomen.

Food: Food sources vary, but typically any small insects they catch in their webs.

Common Name: Whitebanded Crab Spider

Scientific Name: Misumenoides formosipes

Identification: The identifying characteristic, according to Florida's Fabulous Spiders, is a white ridge on the spider's face below the eyes. They can be either white or yellow. They are also naked of setae (hairs).

Habitat: Its preferred lurking spot is in and around flowers.

Food: An ambush predator. It will attack and eat just about any creature that comes close enough- even some which are larger than it is.

Scientific Name: *Holoena curta*

Family: Agelenidae

Identification: Webs are of the typical funnel-shape for the family, Agelenidae. The total length is 9-12 mm. The color pattern is similar in males and females; the carapace is orange and covered with black and white hairs forming a medial white stripe that is bordered by black stripes. The abdomen has a dark border and medial brown band. Spinnerets are short.

Habitat: Found on shrubs.

Food: Insects and spiders.

Common Name: Johnson Jumper

Scientific Name: *Phidippus johnsoni*

Family: Salticidae (Jumping Spiders)

Identification: They are mostly black with a red abdomen. The male's abdomen is entirely red, whereas the female's abdomen has a black mark down the center. Their size is 9-14 mm.

Habitat: Found on shrubs.

Food: Insects and spiders.

Common Name: Green Lynx spiders

Scientific Name: *Peucetia viridans*

Identification: Bright green body. Cephalothorax is narrow and high in eye region and broadens behind it. It often has red spots in eye region and body. Legs are long, paler than body, green to yellow, with long black spines and many black spots. The green lynx has the ability to blend in with its background. In California, lynx's seem prefer the dull green leaves of the wild buckwheat and are yellow or even brown in color, and have the whole dorsum blotched with large red markings that often form a complete band. Some western lnyx's are also marked with blue.

Habitat: Found on shrubs, especially California buckwheat.

Food: Insects and spiders.

Common Name: Silver Garden Orbweaver

Scientific Name: *Argiope argentata*

Family: Araneidae

Identification: As a orb-weaver, they spiral wheel-shaped webs. The posterior half of the top side of the abdomen is dark-colored with "windows" of white. The division between the light-colored front half and the dark-colored back half is usually straight and unbroken. These orb weavers place a conspicuous zigzagging white silk banner in their webs called the "stabilimentum" which can be used to identify the species.

Habitat: On prickly pear cacti.

Food: Food sources vary, but typically any small insects they catch in their webs.

Process of Science Lesson Plan

Objective:

- Students will be able to develop a hypothesis and experimental design as evidenced by their ability to generate a testable hypothesis and an experimental method that is able to answer their hypothesis.

Standard(s):

Investigation and Experimentation

- 1. Scientific progress is made by asking meaningful questions and conducting careful investigations
- 1d. Formulate explanations by using logic and evidence
- 1f. Distinguish between hypothesis and theory as scientific terms
- 1l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science

Academic Language Considerations:

Vocabulary: Hypothesis, Prediction, Scientific Methods, Control, Variable, Quantative Data, Qualitative Data

Non-Vocabulary:

- List the Key Elements in the Process of Science:
    - Elements can also refer to chemical elements
- Determine a Control and Variable in your experiment
    - Students can mistake a control for it's common use meaning to exercise restraint over. It is important to make the distinction between the common term and a scientific control

Materials:

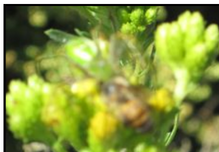
- PowerPoint Presentation on Process of Science
- Note-taking Guide on Process of Science
- Note-taking Guide on Designing Bee Experiment

Instructional Breakdown:

	Time Interval	Teacher Actions	Student Actions

Process of Science Lecture and Designing a Bee Experiment	50 min	• Explain the process of the scientific method
		• Address the difference between a hypothesis and a prediction
		• Explain deductive reasoning and how it is used to form a hypothesis
		• Model how to form a hypothesis using observations and questioning
		• How to make an "If…and …then" statement
		• Go over qualities of a good experiment
		    ○ Experimental Controls
		    ○ Sample size
			• Students take notes on the Process of Science Note-taking Guide
			• Students practice forming their own hypothesis and organize it to an if/then statement
			• Have students check to see if their experiment and prediction matches their hypothesis

Closure	5 min		• Students write down the difference between a hypothesis and prediction is in their own words



Process of Science

Using the experiments on
the effect of bee predators on bee feeding behavior
as a model

There is no single one way that scientists study the natural world, but **there is a general process that most scientists use.**

Key Elements in the Process of Science Are:

1. **Observations**
2. **Questions**
3. **Hypotheses**
4. **Predictions**
5. **Tests/ Experiments**
6. **Communicating**

Most people get hypotheses and predictions confused.

- **Hypothesis: A tentative explanation for a natural phenomenon.**
- **Prediction: A forecasted outcome of an event based on evidence or a hypothesis.**

Using Our Bee Experiment As a Model

- **Jesse observes that bees as a group will avoid areas where there are predators.**
- **So, she questions: Why do bees avoid areas with predators?**
- **She hypothesizes:**

1. **Maybe because bees can smell when a bee dies, and avoid these areas.**
2. **Maybe because bees can see large predators, and avoid these areas.**
3. **Maybe bees can smell the odors of predators**

Making Predictions

Scientists use deductive reasoning to predict the results of new observations and experiments.

Deductive reasoning follows:
an "if ….and…. then" logic.

- **If our hypothesis is correct, and we test it, then we can expect a particular outcome.**

Let's Use Our First Hypothesis

- Jesse observes that bees as a group will avoid areas where there are predators.
- So, she questions: Why do bees avoid areas with predators?
- She hypothesizes:
  1. Maybe because bees can smell when a bee dies, and avoid these areas.
  2. Maybe because bees can see large predators, and avoid these areas.
  3. Maybe bees can smell the pheromones of the predators

Making Our Own "If…and…then" Statement

- If the bees avoid predators because bees can smell when a bee dies, and avoid these areas,
- question and hypothesis
- And we have two feeding dishes and put a smashed bee on a filter paper next to one feeding dish,
- experiment
- Then the bees should avoid the feeding dish with the smashed bee.

prediction

Qualities of a Good Experiment

It is controlled.

- There are two parallel test groups
- The variable of interest is changed in one group (the test group), but everything else remains the same.
- Sample size

Now you design your own experiment

1. Generate three hypotheses
2. Choose a hypothesis
3. Write an If….and…then statement for your hypothesis.

Review the experiments

- Does the experiment match the hypothesis?
- Does the prediction match the experiment?

Name:

Date:

The Process of Science Notes

There is no single rigid method that all scientists use to study the natural world, but

____.

Key elements in the <u>process of science</u> are:

1.

2.

3.

4.

5.

6.

<u>Hypothesis:</u>

<u>Prediction:</u>

Making Predictions

Scientists use ______________________________to predict the results of new observations and experiments.

Deductive reasoning-

-

Process of Science Example:

Jesse observes

She questions

She hypothesizes

Making Your Own "If ….and …Then" Statement

If

And

Then

***Label the question, the hypothesis, the experiment and the prediction**

Qualities of Good Experiments

Name:

Group Members:

Designing Your Bee Experiment

Your question: Why do bees avoid areas with predators?

1. **Generate three or more hypotheses**

-
-
-

2. **Choose your favorite hypothesis and circle it.**

3. **Write an If….and…then statement for your hypothesis.**

<u>If</u>

<u>And</u>

<u>Then</u>

4. **Review and revise your experiment**

Lesson Plan on Writing a Method

Objective:

- Students will learn what is included in the Methods section of a scientific paper.
- Students will be able to write their own Method for their own experimental design.
- Students will be able to recognize errors and flaws in their current experimental design and be able to make the proper adjustment in their method.

Standard(s):

Investigation and Experimentation

- 1. Scientific progress is made by asking meaningful questions and conducting careful investigations
- 1a. Select and use appropriate tools and technology
- 1b. Identify and communicate sources of unavoidable experimental error
- 1d. Formulate explanations by using logic and evidence
- 1f. Distinguish between hypothesis and theory as scientific terms
- 1j. Recognize the issues of statistical variability and the need for controlled tests

Academic Language Considerations:

Vocabulary: Variable, Control, Quantitative Data, Qualitative Data, Statistically analysis

Non-Vocabulary:

- Determine a Control and Variable in your experiment
    - Students can mistake a control for it's common use meaning to exercise restraint over. It is important to make the distinction between the common term and a scientific control
- Make sure to include qualitative data
    - Students may misinterpret qualitative to mean the quality or accuracy of the data.

Materials:

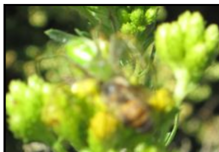
- PowerPoint presentation on Writing a Method
- Writing Your Methods Section Handout
- Computers for each student

Instructional Breakdown:

	Time Interval	**Teacher Action**	**Student Action**
Warm-Up	10 min	• Take out your notes on the Process of Science and Designing Your Experiment and students brainstorm. • After reading a description of what is included in a Methods section, on a separate piece of paper, brainstorm what will go in your Methods section.	• Students take out their Notes on the Process of Science and Designing the Experiment. • Students read the slide that explains what goes in a Methods section • On a separate piece of paper, students brainstorm what types of things will go in their own Methods section.

Method Revision	50 min	• Have students share out their ideas
		• Use PowerPoint and handout, Writing Your Methods Section, to explain what should be check list of items needed in methods. Explain that the sentence starters are there to help you organize your ideas.
		• Sit with each group to make sure they include everything on the checklist.
		  ○ Organisms used and how
		  ○ Training the bees
		  ○ Experimental set up and duration
		  ○ Variable and Control
		  ○ How data will be collected
			• Students share out their brainstorm
			• Students work in their bee experiment groups and write their methods.

Method Revision	50 min	• Have students share out their ideas • Use PowerPoint and handout, Writing Your Methods Section, to explain what should be check list of items needed in methods. Explain that the sentence starters are there to help you organize your ideas. • Sit with each group to make sure they include everything on the checklist	• Students share out their brainstorm • Students work in their bee experiment groups and write their methods.



Writing Your Methods

Methods Section

- **This section provides all the methodological details necessary for another scientist to duplicate your work.**
- It should be a narrative of the steps you took in your experiment or study, not a list of instructions such as you might find in a cookbook.
- You should assume that the other scientist has the same basic skills that you have, but does not know the specific details of your experiment.
- In the last paragraph, provide a brief description of statistical tests you used (**statistics are methods!**). Be sure not to include extraneous information, though, as scientists know all about null hypotheses and when to reject them.

Brainstorm what specific details should be included in your Methods section.

Start Writing your Method

Items to include in your method

- The materials that we used were….
  - **Organisms Used** -Use scientific names (e.g. *Apis mellifera)*
  - **Experimental set up-** Describe sugar dishes (color and size) , 2.5 Molar sucrose solution, and tripod
- First we trained the bees…
  - Several days before: Start at the entrance to the hive. Then once there are 7-8 bees there, move it back, at first 0.5 meters, then increasingly far, until it is 5 meters away.
  - Describe sugar dishes and tripod.
- On the day of the experiment, we will retrain the bees using the same method and stopping 5 meters from the hive.
- Then we set up our experiment…
  - Describe sugar dishes and tripod
  - Variable and Control
  - Describe how to create the experimental and control dish (attaching predator)
- We collected the following data…
  - (quantitative and qualitative)
  - Experimental duration
  - Switching the control and experiment dish every two minutes and thirty seconds
- We statistically analyzed the data by…

Name:

Date:

Writing Your Methods Section

What is a Methods Section?

This section provides all the methodological details necessary for another scientist to duplicate your work.

It should be a narrative of the steps you took in your experiment or study, not a list of instructions such as you might find in a cookbook.

You should assume that the other scientist has the same basic skills that you have, but does not know the specific details of your experiment.

In the last paragraph, provide a brief description of statistical tests you used (**statistics are methods!**). Be sure not to include extraneous information, though, as scientists know all about null hypotheses and when to reject them.

Now use the sentence starters below to write your Methods Section of your lab report:

- ***The materials that we used were….***
    - **Organisms Used** -Use scientific names (e.g. *Apis mellifera)*
    - **Experimental set up-** Describe sugar dishes (color and size) , 2.5 Molar sucrose solution, and tripod
- ***First we trained the bees…***
    - Several days before: Start at the entrance to the hive. Then once there are 7-8 bees there, move it back, at first 0.5 meters, then increasingly far, until it is 5 meters away.
    - Describe sugar dishes and tripod.
- ***On the day of the experiment, we re-trained the bees using the same method and stopping 5 meters from the hive.***
- ***Then we set up our experiment…***
    - Describe sugar dishes and tripod
    - Variable and Control

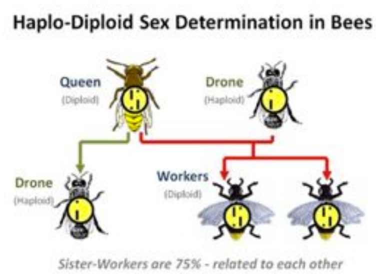
- Describe how to create the experimental and control dish (attaching predator)

- ***We collected the following data…***
  - Quantitative and qualitative data
  - Experimental duration
  - Switching the control and experiment dish every two minutes and thirty seconds

- ***We statistically analyzed the data by…***

Bee dissection

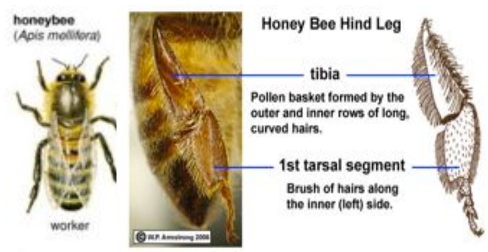
Bees are haploid-diploid



Bee castes

Queen: long abdomen, jaws help her make nest, smooth sting can be used repeatedly. Can lay 1500 eggs a day.

Bee castes



Workers: have hairs on legs to carry pollen, an anterior part of stomach called the honey sac to store nectar.

Bee castes

Drone: huge eyes, so better to see you, my dear. Live to mate; die after mating.

Lifecycle

Lifecycle of the worker bee

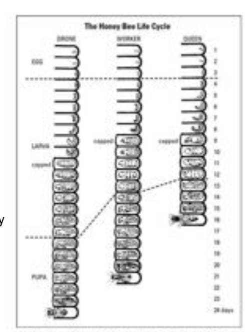
21 day incubation period, goes through series of larval stages

0-2 days, regulates temperature of hive

3-14 days, "nurse bee" feeds young, produces high energy royal jelly. All bees given royal jelly for a few days; queens given continuously.

14-21 days. Able to produce wax. Make comb and receives pollen and nectar from foragers. Stands sentry at hive entrance.

21-35 days. A forager. Travels outside hive.



This chart shows the daily development cycle of all three castes, from egg to adult.

Lifecycle

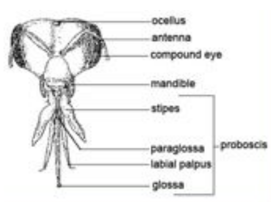
- Life of a queen
  - special queen cups
  - young queens fight to the death
  - nuptial flight. Mates with 12-14 drones. Stores sperm for lifetime (can be more than 3 yrs).
- Queen pheromone keeps other bees sterile, no new queen cups made
- when hive gets very big, new queens raised and bees swarm; % of hive leaves to form new hive.

The honeybee swarm

http://www.youtube.com/watch?v=FvjmyOAmP60

Dissection of honeybee

- The head



Mandible chews, proboscis laps nectar

Dissection of honeybees

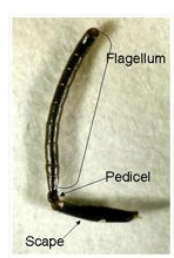
- The eyes
- Ocelli: 3 small organs that take information on light and dark.
- Compound eyes. Each eye has ~ 4,500 small ommatidia. Only 1/170 as spatially detailed as human vision.

http://andygiger.com/science/beye/beyehome.html

Dissection of honeybees

- The eyes
- What colors can bees see?

Dissection of honeybees



Antennae capable of picking up thousands
Of different chemical stimuli, and the direction
The stimulus is coming from.

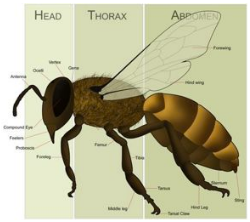
Can smell:
-Smell of hive
-Pheromones given out by queen, worker bees
--Flower odors
-- Bombs!

Can hear:
Sounds of bees waggle dancing inside the
Hive (in the dark)

Dissection of honeybees

- The thorax

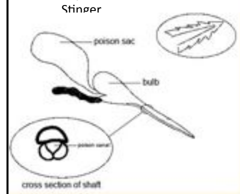
3 pair legs
2 pair wings

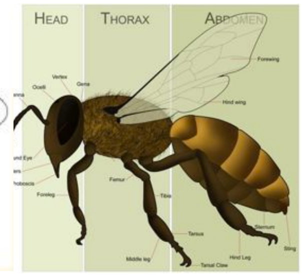


Dissection of honeybees

- The abdomen

Digestion,
Reproduction
Stinger

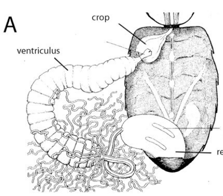




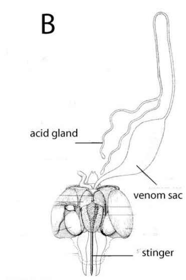
Dissection of honeybees

- Inside the abdomen

A



B




An Investigation into Bee Anatomy

Your name____

Group member names ____

I) Today we're going to concentrate on the anatomy of the worker bee, of which you have a specimen. Label the castes of bees below.

II) Now in the box below, sketch a picture of your bee, as detailed as you can, from the side.

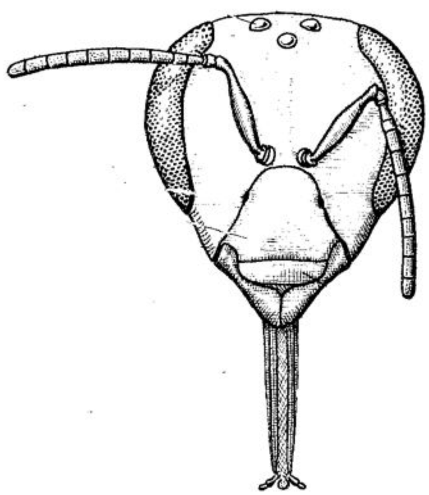
Label the three basic body segments, the **head**, the **thorax** and the **abdomen**. To where do the legs attach? To where do the wings attach? How many sets of legs and wings does the bee have?

Label a **tergite** (hardened plates). How many tergites are on the bee's thorax? On the abdomen?

Sketch of your specimen

III) Using these pictures, locate the following body structures:

a) antennae
b) proboscis (used for lapping nectar)
c) compound eye
d) ocelli
e) mandible (used for chewing)
f) corbicula (pollen basket)



Challenge! It's time to test your knowledge! Once you have reached this point in the activity, make sure that every group member can identify all the previously listed body parts ON THE SPECIMEN ITSELF UNDER THE MICROSCOPE. Tell your instructor when you are ready and they will ask a random member of the group to identify two different body parts under the microscope. When your group has completed the challenge, your instructor will initial here ________________________

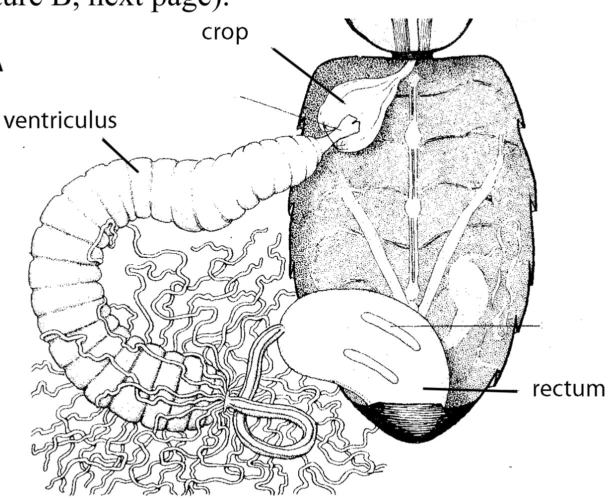
III) While you are waiting, answer the following questions:

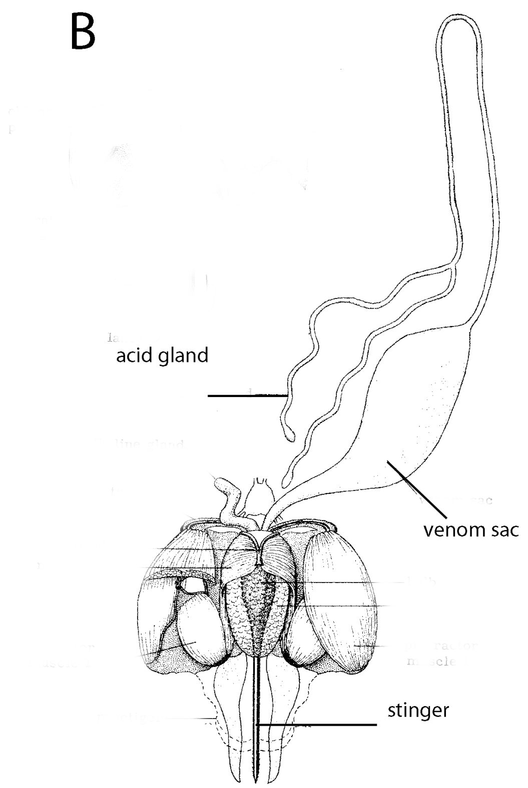
1) What sensory organs are found on the **anterior** (forward) part of the body? What sensory organs are found on the **posterior** (back) part of the body? What are found on the **dorsal** (upper) side? What on the **ventral** (bottom)?

2) Large flight muscles are necessary to drive a bee's wings. Where on the bee's body are the flight muscles probably located? If the muscles are large, what else is there room for in that body region?

IV) Now you're going to look on the inside of the abdomen of your bee. Cut off the abdomen with the scissors. Now with the pins, slowly take off each tergite. You should come to see something like the picture A. Identify the crop, the ventriculus, and the rectum. Attached to the sting, you should be able to see the venom sac, looking like a transparent balloon, with the acid gland looking like a thin thread coming off the balloon (picture B, next page).

A





Now for your experiment, your going to take some fluid from your bee, to test the response of bees towards.

You can take fluid from the ventriculus, the crop or the rectum. To get the fluid out, you can dissect the organ, put it onto a glass slide and then cut it into little pieces with a pin. The fluid can then be pipetted up and put into a small glass jar. The control fluid that you will compare to these fluids is water.

Alternatively, you can dissect out the venom sac. Pipette it into a glass jar. Then add hexane (this will break down the sac membrane), and store. What should the control fluid be when testing the venom sac?

Sting gland extract is known to be repulsive to bees foraging in the field. What do you hypothesize about the extract of the rectum or ventriculus? What about the extract of the crop (the crop is where bees store nectar on the way back to the hive)?

Lesson Plan for Revising the Scientific Paper

Objective: To write a good scientific paper.

Duration: 2 hours

State Standards: Investigation & Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
    a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
    b. Identify and communicate sources of unavoidable experimental error.
    c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
    d. Formulate explanations by using logic and evidence.
    e. Recognize the issues of statistical variability and the need for controlled tests.

Materials:

- Graphic Organizer, *Revising your Scientific Paper*
- Computers

Activity	Time	Teacher Action	Student Action
Warm Up	**6 minutes**	On board: Please take out your paper. On the back of your paper write a definition for thoroughness, transitions, and format in regards to writing.	Students write definitions on back of paper.
Warm Up Share Out	**4 minutes**	Teacher calls on students to share out. **Thoroughness**-what information is missing and needs to be added? **Transitions**-Does the writing progress in a logical order? **Format**-Double spaced, 12 point font, MLA citations **e**.g. In text citations look like this (Author, Year)	Selected students share their responses. Students write their definitions in the top of their worksheet.
Guided Critique	**15 minutes**	Teacher asks students to read the example papers and find examples of good or bad for each of these three categories Teacher has students share out their examples.	Students read the papers and write examples of positive or negative examples of thoroughness, transitions, and format. They write these examples in the bottom boxes of their handout.
Student Critique	**30 minutes**	1. Select someone that you feel comfortable asking for constructive feedback from. Trade papers. 2. Ask them for feedback in <u>one</u> of these 3 areas. Ask for feedback on the area that you think you need the most. 3. Do this two times. Second time, ask for feedback in a different area. 4. When critiquing try to stick to the topic of critique. Write feedback directly on paper.	Students read and comment on two different papers. Then they get their own paper back.
Revise Paper	**35 minutes**	Instruct students to log onto their computers prior to last critique. What is Due: Revised Paper emailed to Teacher by 8:40am	Students revise their papers according to feedback and email teacher their revised version

Name:

Date:

Revising Your Scientific Paper

Revising Your Methods Section

Re-read your methods section.

1. **Change all parts of the method to reflect what you really did!**

For example, did you conduct your experiment 1 meter from the hive, instead of 5 meters from the hive?

Did you tether your spider in a different way?

How long did you conduct our experiment?

2. **Re-write your Methods section in past tense**

3. **Create a figure to show your experimental set-up. Label your figure and refer to your figure in your text.**

4. **Add any details that you have not previously included.**

Save it. Send it to each member of your group. Then start typing your title and introduction before your methods.

Creating a Title for Your Experiment

The title should be written as "The effect of ___________on *Apis mellifera* feeding behavior"

Adding to Your Introduction

1. **First find your bee introduction research guide.**

2. **Use your research guide to type your introduction.** Your introduction should go from general to specific. A suggested order is as follows:

a. Describe the organism studied (European Honey Bees-use the scientific name) and the reason for studying this organism. Include your evidence for each reason.

b. Describe the reason for studying how bees respond to predators and cite your evidence.

c. Describe your predator (use scientific name) and why you choose to examine this predator.

d. In the last sentence of your introduction, write your question, hypothesis, experiment, and prediction (HINT: look at your "If…and ...then…" statement)

3. **Make sure that <u>each sentence</u> in your introduction is cited.** Use the MLA in-text citation method.

Create a Works Cited Section

Create a Works Cited Section at the end of your paper in MLA format.

Format Your Paper

1. Double space it.
2. Use 12 point font.

Name: ____Date: ____________________________Class: __________________________

Revising Your Scientific Paper

Thoroughness-	**Transitions-**	**Format-**

Using Statistics to Analyze your Results

Warm Up

1. What is a hypothesis?
2. What is a prediction?
3. How are they different?

Hypotheses and Predictions

- **Hypothesis:** is a possible explanation of a phenomenon that is testable
- **Prediction:** A forecasted outcome of an event based on evidence or a hypothesis.
- **Hypotheses lead to predictions**: if I do this, and the hypothesis is correct, _____ will happen.
- Methods are devised to test these predictions.

Null Hypothesis (H_0)

A **null hypothesis** is that the outcome is explained by chance.

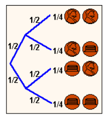
Why are statistics important?

- Once you have your result, you need to be able to explain what it means
- We use a statistical test to investigate whether our result can be explained by the null hypothesis (chance).

Statistics is just an extension of probability theory, so rather than starting with bees, let's talk about coins…

Flipping coins

- What's the odds that you flip a coin and get tails?
- What's the odds that you flip a coin twice and get 2 tails?
- What's the odds that you flip a coin two times and get one tail and one head?



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Flipping coins

- What's the odds that you flip a coin twice and get 2 tails?
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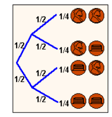

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These examples are simple enough that we can calculate by hand using some mathematical rules.

$$P(A \text{ and } B) = P(A \cap B) = P(A)P(B)$$

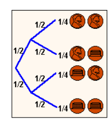
$$P(A \text{ or } B) = P(A \cup B) = P(A) + P(B)$$

Flipping coins

- Probability of getting heads twice in a row
  = P (getting heads 1st time AND getting heads 2nd time)
  = P (heads 1st time) * P (heads 2nd time) =
  = .5 * .5 = .25
- Probability of getting 1 head and 1 tail in two throws
  = P (getting heads 1st time AND getting tails 2nd time)
  OR P (getting tails 1st time AND getting heads 2nd time)
  = P (.5 * .5) + P (.5 * .5) = .50

Flipping coins

- What's the odds that you flip a coin 20 times and get 14 heads or more?
- Hard to calculate by hand! Need to use statistics.



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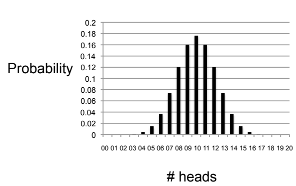
Probability distribution

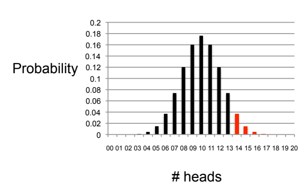
- What's the odds that you flip a coin 20 times and get 14 heads or more?
- Look at a "probability distribution" graph
- If we added up all the heights of all the columns, we would get 1 (100% of the time we get one of these outcomes)



This is a binomial distribution, similar to the normal distribution, or the familiar 'bell curve'

Probability distribution

- In our case, we need to add up the bars above 14, 15, 16, 17, 18, 19 and 20.
- We get about .06 or 6%.



Binomial test

It would be a bummer if we had to add up columns on graphs each time we did this (and not very accurate!).

Instead, we make the computer do the work for us, by doing a statistical test, specifically, a binomial test: A statistical test that allows us to calculate the probability that an outcome occurred by chance, used when there only two kinds of outcomes.

Binomial test in Excel

Result : You flip your coin 20 times, and 14 times it's heads. Question: What is the probability of getting 14 or more heads?

Calculate in Excel: We get 0.057

=BINOMDIST(6, 20, 0.5, TRUE).

6 = the number of times it is tails, 20-14= 6.

20 = the number of times you flipped the coin.

0.5 = the expected probability of getting heads

TRUE = calculating the sum of the probabilities of the observed number and all more extreme values (14 +15 + 16 + 17 +18 +19 +20)

Testing hypotheses

- Now when you get a result like 14/20 heads, what do you think?

Testing hypotheses

- Now when you get a result like 14/20 heads, what do you think?
- May be I'm really lucky (or unlucky!) and this occurred by chance This is the null hypothesis
- May be my coin is not fair.

Testing hypotheses

- When we do a statistical test, the computer returns a number called P, which is the percent chance that our result could have occurred by random.
- Generally, when P is < 0.05, we reject the null hypothesis.
- So for our example, P = 0.057. What do we conclude?

How does this relate to our bees?

Coin activity

- Using scotch tape and anything you can find, alter the tail side of a coin.
- Flip 20 times (make sure they're big, high flips).
- Which side came up more?
- What is P, the percent chance that randomly that side would come up that amount or more.
- Do you reject the null hypothesis?

Evaluate the Bee Data Given

- Here's some hypothetical bee data:

Dish	Number of Bees Landed
Control	21
Experiment	8
Total	**29**

Was the result significant? Do we accept the null hypothesis?

Bee Activity Share out

- P =BINOMDIST(8,29,0.5, TRUE)
- P = 0.012
- We rejected the null hypothesis because 0.012< 0.05 (This means that our data was statistically significant and the bee's did avoid the predators!)
- Why would scientists design experiments, so that they are binomial in nature?

Conclusion

- A **binomial test** is a statistical test that allows us to calculate the deviations observes from what was expected
- You calculate a binomial test in Excel by: =BINOMDIST(6, 20, 0.5, TRUE)
- **P** is the percent chance that what happened occurred randomly. Generally, **when P < .05 we reject the null hypothesis**
- A **null hypothesis** is that the outcome is explained by chance.

Now work on your own data

Open a new Word Document and Excel Document and title them your "group name bee results".

- Add up all of your bees on control and on your experimental dishes and create a table. You can analyze bees and wasps separately and/or together.
- Calculate your p value
- Gather data from other groups that tested the same thing and copy tables into your results, adding these data to yours.
- Again calculate a p value. Have your interpretations changed?

Now work on your own data

- Be sure to save your results in Excel and Word
- Email your work to the group.

Binomial Test and Probability

Teacher PowerPoint

- Teacher gives a brief introduction to the importance of good statistics in science.
- Teacher introduces the **binomial test, which** is an exact test of the statistical significance of deviations from a theoretically expected distribution of observations into two categories.
- The most common usage is in a situation where there are two kinds of outcomes.
- Teacher explains how to calculate in Excel and find P, the statistical significance of the result.

Engage:

Students, using a coin, scotch tape and any small piece of material they can find, alter the tail side of the coin.

Students make a prediction for how many times heads will come up, if they toss the coin 20 times.

Students share out their predictions.

Explore:

Students flip the coin and record results in a table.

Students write a short analysis of their results. Did their results match their prediction? Students use Excel to find P, the percent chance that the outcome occurred randomly.

Explain:

Student question: If you were just given the results, and didn't see your coin, what would you conclude about this coin?

Elaborate:

Students are given hypothetical bee data and asked to analyze these data to show whether they are significant.

Evaluate:

Why could scientists create experiments that are binomial tests?
Evaluate your own data in groups and save.

Standards:

Investigation & Experimentation - Grades 9 To 12
1.Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
b. Recognize the issues of statistical variability and the need for controlled tests.

Probability and Statistics- Grades 8-12

1. 0 Students know the definition of the notion of independent events and can use the rules for addition, multiplication, and complementation to solve for probabilities of particular events in finite sample spaces.

2.0 Students know the definition of conditional probability and use it to solve for probabilities in finite sample spaces.

3.0 Students demonstrate an understanding of the notion of discrete random variables by using them to solve for the probabilities of outcomes, such as the probability of the occurrence of five heads in 14 coin tosses.

4.0 Students are familiar with the standard distributions (normal, binomial, and exponential) and can use them to solve for events in problems in which the distribution belongs to those families.

Learning Objectives: After completing this activity the students will be able to:

- Calculate the P value for a binomial test using Excel.
- Either accept or reject the null hypothesis based on the p-value.

Materials:

Pennies for each student pair and scotch tape
Student Handout
Computer with Excel

Name : ____________________________________Date: __________________________Class: ___________________

Binomial Test and Probability

Warm Up:

1. **What is a hypothesis?**
2. **What is a prediction?**
3. **What is the difference between a hypothesis and a prediction?**

Null Hypothesis (H_0):

Probability Equations:

Binomial Test:

Calculating the binomial test in Excel:

Our Question:

=BINOMDIST(6, 20, 0.5, TRUE).
6 = the number of times it is tails, 20-14= 6.
20 = the number of times you flipped the coin.
0.5 = the expected probability of getting heads
TRUE = calculating the sum of the probabilities of the observed number and all more extreme values (14 +15 + 16 + 17 +18 +19 +20)

P:

Generally, when P is < 0.05, we reject the null hypothesis**.**

When P is <0.05 we ____________________the null hypothesis.

Name : ___________________________________Date: _________________________Class: __________________

Binomial Test and Probability

Introduction: In this activity you will learn how to do a **binomial test**, a statistical test that allows us to calculate the deviations observed from what was expected. You will learn how to calculate a binomial test in Excel, and how to calculate the **P value,** the percent chance that what happened occurred randomly. In this way, you will be able to tell whether or not your outcome was due to chance, **a null hypothesis (H_0)**, or happened because something else was changing the outcome.

Materials:
Pennies for each student pair
Scotch tape
Student Handout
Computer with Excel

<u>PART 1: COIN TOSS EXPERIMENTS</u>

<u>EXPERIMENT 1:</u>

Take the tail side of your coin and alter it with scotch tape and some piece of material. Now make a prediction as to how many times heads will come up if you toss the coin 20 times.

PREDICTION:

____

____

____

<u>Collect data:</u>

Record each time that your coin lands on heads or tails. Make big high flips!

Table 1: Heads or Tails in a Coin Toss (n=20)

	Toss 1	Toss 2	Toss 3	Toss 4	Toss 5	Toss 6	Toss 7	Toss 8	Toss 9	Toss 10	
Heads											
Tails											
	Toss 11	Toss 12	Toss 13	Toss 14	Toss 15	Toss 16	Toss 17	Toss 18	Toss 19	Toss 20	Total
Heads											
Tails											

QUESTIONS:

1. Did your results match your prediction? Why or why not?
   ____

   ____

2. Write a equation that you could enter into Excel to calculate the P value of the binomial test:

   P =BINOMDIST(_______, _________, _______, TRUE)

2. Now calculate P, the percent chance that what occurred happened randomly, using Excel.
   P =

3. Is P greater than or less than 0.05?

4. Would you accept or reject the null hypothesis? ____

5. What does it mean to accept the null hypothesis? ____

   ____.

   What does it mean to reject the null hypothesis? ____

   ____.

6. If you were given only the results, without seeing the coin itself, what would you conclude about the coin: is it fair or not? Explain.

   ____

   ____

PART 2: BEE EXPERIMENTS

EXPERIMENT 1:

Two dishes with sugar water were placed 10 meters from a bee hive. Both dishes were the same, except one dish, the experimental dish, had a bee predator glued to it, while the other, *the control dish*, did not. More bees landed on the control dish than the experimental dish.

Below is the data collected from the experiment:

Table 3: Number of Bees Landing on the Experimental and Control Sugar Dishes

Dish	Number of Bees Landed

Control	21
Experiment	8
Total	**29**

1. What is the question that you are asking? ____

   ____

2. Write a equation that you could enter into Excel to calculate the P value of the binomial test:

   P =BINOMDIST(_______, _________, _______, TRUE)

3. Calculate your P value by entering your equation into Excel

   P = _____________

4. Do you accept or reject the null hypothesis? Why? Show your work.

   ____

   ____

5. Explain what accepting or rejecting the null hypothesis means in the case of the bee experiments.

   ____

   ____

6. Why would scientists design experiments, so that they are binomial in nature?

   ____

   ____

<u>PART 3: ANALYZING YOUR OWN DATA</u>

Open a new Excel Document and title them your "group name bee results".

1. Add up all your bees landing on your control and experimental dishes, Create a table. You can analyze bees and wasps together and/or separately.

   e.g. Table 1: Number of Bees Landing on the Experimental and Control Sugar Dishes

Dish	Number of Bees Landed
Control	21
Experiment	8

Total	**29**

2. Make a bar graph of your results.
3. Calculate your P value.

4. Gather data from other groups that tested the same thing and copy their data into your results. Add the results together, as in the example below…

Dish	Exp 1: Number of Bees Landed	Exp 2: Number of Bees Landed	Total
Control	21	4	25
Experiment	8	3	11
Total	**29**	**7**	**36**

4. Calculate P for all the groups combined that did the same experiment. Does your result change? How do you interpret these combined results (could have the different groups have done things differently)?

Name: ___________________________Date: ___________________Class: _____________

FINISHING YOUR BEE SCIENTIFIC PAPER

Results (Do not analyze here):
This section presents the results of the experiment but does not attempt to interpret their meaning.

- Have at least one table or figure.
- Title your tables and figures.
- Do not include a table and figure of the same data.
- Include statistics.
- Explain your tables/figures **in words.**
- Refer to your figures by number in your text.

Example Results Section:

Results:

Figure 1 shows that the number of bees that went on the control dish were 20, compared to the 10 bees that went to the sugar dish of the predator, 20cm *Drosefinia grotesca*. When we conducted a binomial test p= 0.04, so we rejected the null hypothesis.

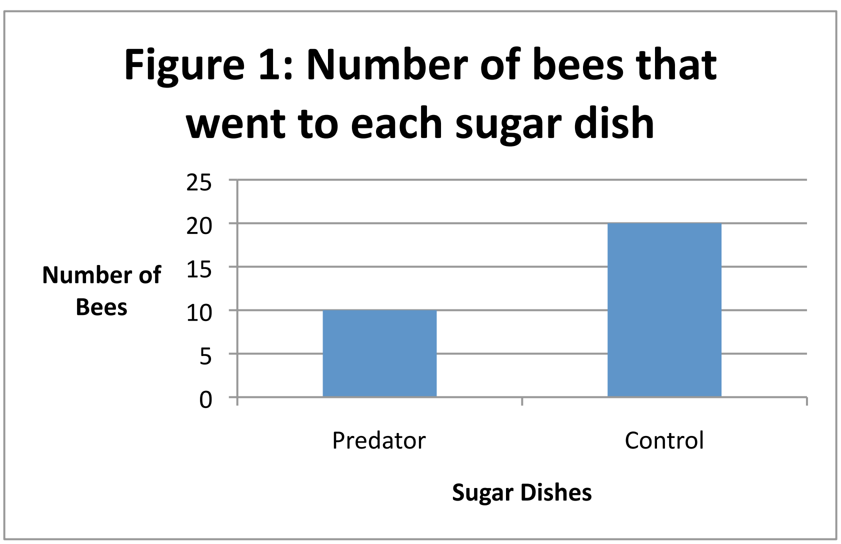


Figure 2 shows that number of that went on the control dish were 20, compared to the 10 bees that went to the sugar dish of the predator, 20cm *Drosefinia lessa*….

Conclusion (data analysis):

In this section, you are free to explain what the results mean or why they differ from what other workers have found.

- What do your results mean? Relate it back to your experimental question and prediction.
- Why do you think you got what you did?
- Explain what you might do differently next time or give suggestions for future experiments.

Conclusion:

Our hypothesis was that bees would avoid predators by sight. The results of the sugar dish preference test supported our hypothesis and matched our prediction that the bees did avoid the dish with the 20cm *Drosefinia grotesca,* a common bee predator. When conducting a binomial test, the difference in the number of bees on the control dish versus the dish with the predator, could not be explained by chance. This data was consistent with the other groups that also had bee predator, *Drosofinia lessa* (over 20cm) (See Figure 2). The data was inconsistent with one group, whose 22cm bee predator, *Apis eaticus*, was hidden in the corner of the white petri dish (Figure 3). This further gives evidence that bees avoid predators that they can see. We suggest that further studies be conducted to see the effect of camoflague on bee predator avoidance.


process. Thank you to the Nieh Lab for
hosting our experiments

Name:
Period/Class:
Date:

Guideline for PowerPoint Presentation: This graphic organizer will help you decide what are the essential diagrams and words that need to be on your presentation. Additionally, it is a guide for you to decide what are the important points you want to talk about in each slide.

	Title Page	**Introduction**	**Method**
What to Add on Slide			
What to Say			

Name:
Period/Class:
Date:

	Results	**Conclusion**	**Works Cited**	**Thank You**
What to Add on Slide				
What to Say				

Name:
Period/Class:
Date:

Title of Experiment

Names of students in each group

Introduction

- Background info
- Question
- Hypothesis (not prediction)

Method

- Experimental Design
- Data Collection
- Duration
- Sample size (n= ?)

Results

- Number of Controls vs. Experiment
- Binomial Test

Conclusion

- What does your data mean?
- Why is your data important?

Works Cited

- In MLA format

Thank You!

- Give a special thanks to someone who helped you (e.g. Dr. Eben Goodale, Jim Berrian, James Hung, etc.)

<table>
<tr><th colspan="2">Exhibition Group Choices</th></tr>
<tr><th>Jesse’s Per1/2</th><th>David’s Per 1/2</th></tr>
<tr><td>Bee Domicile Placard Group
1. Peter
2. Elijah
3. Jackson
Brochure on how to attract pollinators to your garden
1. Zach
2. Ehsan
3. Rebeka
Pollinators in Peril Project Poster (title, graphics, and short summary)in Photoshop
1. Luis
2. Grace
3. Lexi
Predator Identification*
1. jocelyne
2. Beyra
3.
Statistical Analysis Activity and info*
1.
2.
3.
Press Releases/Invites
1. Kate
2. Jackie
Blurb Book of Pollinators in Peril Curriculum and Student Work
1.
2.
EXTRA CREDIT: Exhibition Night Layout & Management*
1.Ross
2. Ambar</td><td>Brochure on Mason Bees and Domiciles
1. John
2. Kevin D.
3. Verenice
Brochure on Pollinators, Colony Collapse Disorder, and Our Experiments
1. Vincent
2. Cynthia
3. Wyatt
How to Build Your Own Bee Domicile Sheet
1. Grace W.
2. Yuduria
3. Thomas
Demonstration of Bee Predator Experiments *
1.Sam
2.
3.
Poster of experimental process and results (infographic) in Photoshop
1. Danielle
2. Tevin
3.
Slideshow of project*
1.Sierra
2. Gideon
Bee dissection*
1. Salvador
2. Christian

3.Jacob
Results of Experiments
1.
2.
3.
Article for Local Paper
1. Emilia
2. Jaclyn</td></tr>
</table>

	EXTRA CREDIT- Booth Layout Farmers Market 1.Azanaeh 2. Lizzie
Hive-explanation of project on 8.5 x 11 and demo plan with guests 1. Jack 2. Zoe 3. Ines Robotic Spider – explanation of project on 8.5 x 11 and demo plan with guests 1. Jeremy 2. Ben 3. LT 4. Eli S 5. Collin 6. Mike	

Name:_____ _______________________

Pollinators In Peril Presentations

First you will need to choose one component of exhibition prep, that you would like to work on. Please when choosing, consider the following: what you are most interested in, and who you work well with.

Exhibition Group Choices	
Jesse's Per1/2	**David's Per 1/2**
• Bee Domicile Placard Group –3 • Brochure on how to attract pollinators to your garden-3 • Pollinators in Peril Project Poster (title, graphics, and short summary)in Photoshop –3 • Predator Identification*-3 • Statistical Analysis Activity and info*-3 • Press Releases/Invites-2 • Blurb Book of Pollinators in Peril Curriculum and Student Work-2 • EXTRA CREDIT: Exhibition Night Layout & Management 2	• Brochure on Mason Bees and Domiciles-3 • Brochure on Pollinators, Colony Collapse Disorder, and Our Experiments-3 • How to Build Your Own Bee Domicile Sheet-3 • Demonstration of Bee Predator Experiments -3 • Poster of experimental process and results (infographic) in Photoshop-3 • Slideshow of project*-2 • Bee dissection*-3 • Results of Experiments-3 • Article for Local Paper-2 • EXTRA CREDIT- Booth Layout Farmers Market 2
• Hive-explanation of project on 8.5 x 11 and demo plan with guests *-3 • Robotic Spider – explanation of project on 8.5 x 11 and demo plan with guests *-6	

*This activity will primarily be showcased at the School Exhibition

My exhibition responsibility is: ____

My exhibition group members are: ____

Exhibition Deadlines:

Exhibition Plan – Due Wednesday, November 9, 2011

First Draft of Exhibition- Due Wednesday, November 16, 2011
Final Draft of Exhibition-Due Thursday, December 1, 2011

Exhibition Plan

Due on November 9, 2011

Exhibition responsibility: ____ Class:____

Names of group members: ____

Detailed Description of Exhibition Plan:

Graphic of Your Exhibition Layout:

Exhibition To-Do List:

Step	Procedure	Due Date	Person Responsible
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
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16			