Scientific Inquiry: What is inquiry-based learning?

The National Science Education Standards explain the importance of inquiry-based learning:

> *Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (National Research Council, 1996, p.105)*

What does it mean to do an inquiry-based project?

Inquiry is the heart of the learning process promoted in WINGS. In traditional teaching models, the teacher dispenses knowledge and the student passively absorbs it. With inquiry, youth actively reason and engage in investigations they design. Inquiry learning empowers youth to discover what interests them and encourages them to use their skills to further their knowledge. In general, inquiry includes three steps: question, investigate and communicate results.

Types of Inquiry

There are three types of inquiry. The descriptions will help you understand ways you can implement inquiry-based learning throughout the WINGS project. You can engage youth through any type of inquiry, but certainly guided and open are more empowering. Which ones you use may depend on the level and interests of the youth. Be flexible in your approach.

Structured

Leaders give youth a question to answer, a way to answer the question and the necessary materials, but not the expected outcomes. Example: "Let's investigate how many days it takes a Black Swallowtail to emerge as a butterfly from its pupa.We can raise the larvae we found in the garden to find the answer."

Guided

Youth must figure out a way to answer a question given by the leader. Example: "I notice we see the same kind of butterflies around the garden. How do you think we can increase the variety of butterflies in our garden?"

Open

Youth formulate the question they will investigate and determine ways to answer it. Example: Youth ask "How do the butterflies in my garden at home compare to the butterflies I see at this park?"

Sample investigation questions

Which butterflies are found in this area?
Observe the same site over time to develop a species list or checklist.

What new butterflies would these host plants attract to my site?
Monitor a site for a given period of time, then add various host plants and monitor the change in species and numbers.

How do changes in weather affect the presence of butterflies?
Make observations during different weather conditions to determine the effect of weather on butterfly activity.

When are butterflies most active?
Monitor a site hourly on the same day and under the same weather conditions to see when butterflies are most active and if different butterflies are active at different times of the day.

Which habitat has more butterflies?
Monitor species at different sites with similar weather conditions to compare habitats.

Who eats butterflies?
Observe and note butterfly predators.

Does my favorite butterfly have a favorite nectar plant? Is there a link between the size of the butterfly and the size of the flowers it nectars on?
Observe and note butterfly nectaring behavior.

Question quest: Scientific Inquiry

Activity
Plan and conduct an investigation to explore your questions about butterflies.

Science Connection
Plan and conduct an investigation–Scientists study the natural world, using evidence to develop explanations.

Stewardship Quest
Scientists know there is much left to learn about our world. What are you curious about? Will your discoveries have a positive impact on the world? Go for it!

"The wise man doesn't give the right answers, he poses the right questions." Claude Levi-Strauss

Scientists ask questions they are curious about and design investigations to find answers. The exciting thing about being a scientist is the questions you choose lead to a fascinating adventure.

Asking questions is one of the first steps in a scientific investigation. But often, scientists come up with additional questions throughout their investigation. You may find this happens when you investigate. You may repeat some steps or complete them in a different order as you collect data to develop an explanation from your evidence.

Explore questions you have about butterflies by designing your own investigation. Use scientific inquiry to guide your study.

Scientific Inquiry
1. Notice things about the world.
2. Ask questions about things you observe that can be answered through scientific investigations.
3. Design your investigation.
4. Gather and analyze your data.
5. Interpret your evidence to develop an explanation.
6. Share what you find.

Life Skills
Critical thinking
Communication

Let's Go!

The quest begins

Step 1: Notice things about the world
Now that you have started butterfly date lists, you are ready to begin your question quest! Think about the many observations you made.

Step 2: Ask questions about things you observe
Think about your experiences in WINGS. What are you still curious about?
Look through your journal entries to remind you.

Ask questions that lead to gathering and using data to develop explanations. Begin your questions with "how," "which" or "what." Many "why" questions cannot be addressed by science. Questions about beliefs or issues like good and evil cannot be studied in a scientific way.

Write your questions here.

Narrow it down
Look over your list. For each question you wrote, ask "Can I answer this question with an investigation?" "Will I be able to collect enough data to develop an explanation?"

Question quest ideas:

- **Date list**

  You can use what you have learned with your date list to design a question about butterflies. For example, you could compare the presence or abundance of butterfly species at different places, or at the same place during different times of day, weather conditions and seasons.

- **Favorite food**

  Compare which food sources get the most visitors: A butterfly feeder, various nectar plants and rotten fruits. Experiment by adding and removing the food sources to see if the most popular ones change.

Select a question for your quest and write it here.

Step 3: Design your investigation

As much as possible, scientists control the variables or conditions of their investigations to decrease the number things that may affect their evidence. Ideally, they vary one condition at a time. But often this is not possible, so it is critical to identify all the variables which could affect the investigation.

Look around where you are doing your investigation. Are there things that might affect your results? Try to eliminate as many of these variables as you can. For example, if your study involves three plants and one is always in the shade, pick a location where all three plants get the same amount of sunlight.

Describe how you will set up your investigation.

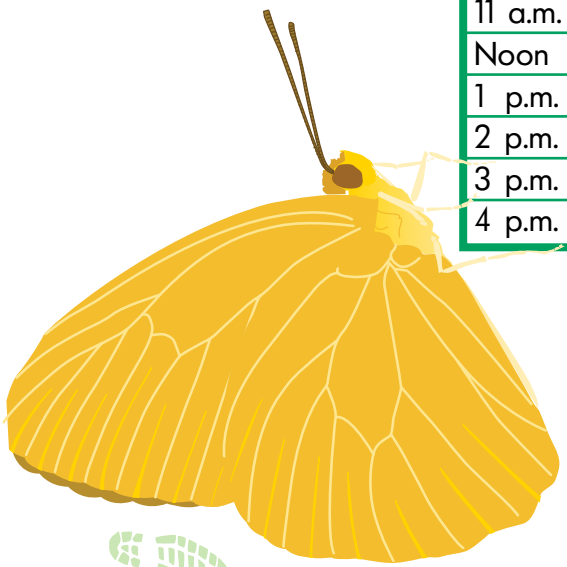
List materials for your investigation.

Describe how you will gather data, including the methods and any tools you will use. Include what you will observe and how often you will record your observations.

Prepare and label a data table so your data is well organized. If you want to investigate how active butterflies are during different times of day, your table might look like this. Why is it important to collect data over several days?

Numbers of Butterflies in My Garden at Different Times of Day

Time of day	Date	Date	Date	Date	Date	Date
9 a.m.						
10 a.m.						
11 a.m.						
Noon						
1 p.m.						
2 p.m.						
3 p.m.						
4 p.m.						



Step 4: Gather and analyze your data

Gather data
Record your observations on the journal pages. Include the date, time and any other notes about your observations. Photographs provide documentation.

Analyze data
Compile your data. What are your results?

Step 5: Interpret your evidence to develop an explanation

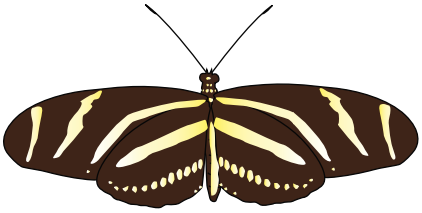
What did you learn during your investigation?

Were you able to get a clear answer to your question? If not, why? Do you need to repeat the investigation?

Are there other explanations? How much data do you need for an explanation?

Did you discover something else? If so, what?

What new questions do you have?



Step 6: Share what you find

Tell the story of your quest. Scientists share the results of their investigations. One scientist's discovery leads to questions by other scientists. Science knowledge changes as scientists explore new questions.

How can you take what you did in your question quest and tell the story in a way that is easy for others to understand? Here are some ways to tell your story:

1. Draw or take pictures. Show the steps from beginning to end. Label the pictures with short descriptions.

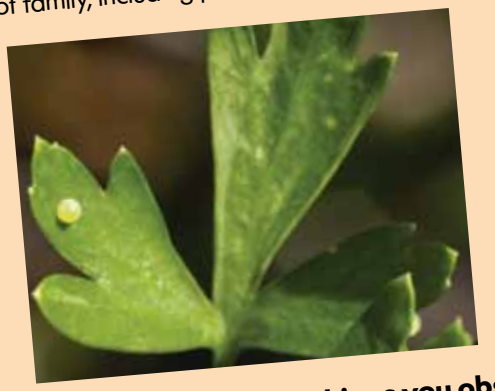
2. Use graphs. There are many types of graphs and creative ways to show what you found. Look at the data you collected during the quest and organize it into graphs.

BUTTERFLY TIMES

The McGuire Center for Lepidoptera and Biodiversity conducts sample question quest in Gainesville, Florida

You can model your question quest after this actual investigation or design one of your own!

Step 1: Notice things about the world
The Black and Anise Swallowtails lay eggs on members of the carrot family, including parsley, dill and fennel.



Step 2: Ask questions about things you observe
Which host plant does the Black Swallowtail prefer to lay her eggs on: dill, parsley or fennel?

Step 3: Design your investigation
Fill each planter with one of three Black Swallowtail host plants. To control variables, keep the planters and the sizes of the host plants the same. Use the same sizes and types of nectar plants in each planter, and the same amounts of soil. These are all conditions that could affect the data.

Materials
Host plants (dill, parsley and fennel)
Nectar plants
Potting soil
Gardening tools
Watering can or hose
Pots or planters

Describe how you will gather data to find answers
Examine the host plants at least three times a week to see which plant the Black Swallowtail lays eggs on first. Record the number of eggs and note the plants they are on.

Step 4: Gather and analyze your data
Gather data
Record dates, times and observations in a journal. Take pictures of the changes in the plants.

Analyze data
Calculate the findings. Add the numbers of eggs laid on each host plant. Look at the dates you first observed the eggs. The results: the Black Swallowtail laid eggs on the dill six weeks after the planters were set up. Black Swallowtails continued to lay eggs on all three host plants for the next two months.

Step 5: Interpret your evidence to develop an explanation
The Black Swallowtail laid eggs on dill first, but this does not mean dill is the favorite host plant. Location of the planters and other variables could have affected which host plant the butterfly saw first. The investigation should be repeated several times to see if the result changes.

New questions that came out of the investigation

1. How many eggs are laid on each plant? Does this affect survival of the larvae?
2. How long does it take the eggs to hatch?
3. Do larvae of different ages live on the same plant?
4. Do larvae kill the plants?
5. How many larvae survived to become pupae?
6. Which parts of the plants do the larvae eat?
7. Do other insects eat the same plants?
8. Do larvae travel from the host plant to pupate? If so, how far?

Step 6: Share what you find
Photos, along with data tables and graphs that summarize the results, can be included on a poster.