Invertebrate Classification

There's a whole lot of phyla living in the garden!

Grades 6-8

Vetted by Riverside County Office of Education-STEM

UCCE Master Gardener Program of Riverside County

Why Is This Important?

"Insects and other invertebrates…. bring beauty into our lives, ensure we have food on our plates, and are at the heart of a healthy environment.

The services they perform—pollinating, dispersing seeds, becoming food for wildlife, recycling nutrients, cleaning water, building reefs—are critical to life on our planet.

Without them whole ecosystems would collapse. Yet invertebrates are often imperiled by human activities."

-Xerces Society for Invertebrate Conservation

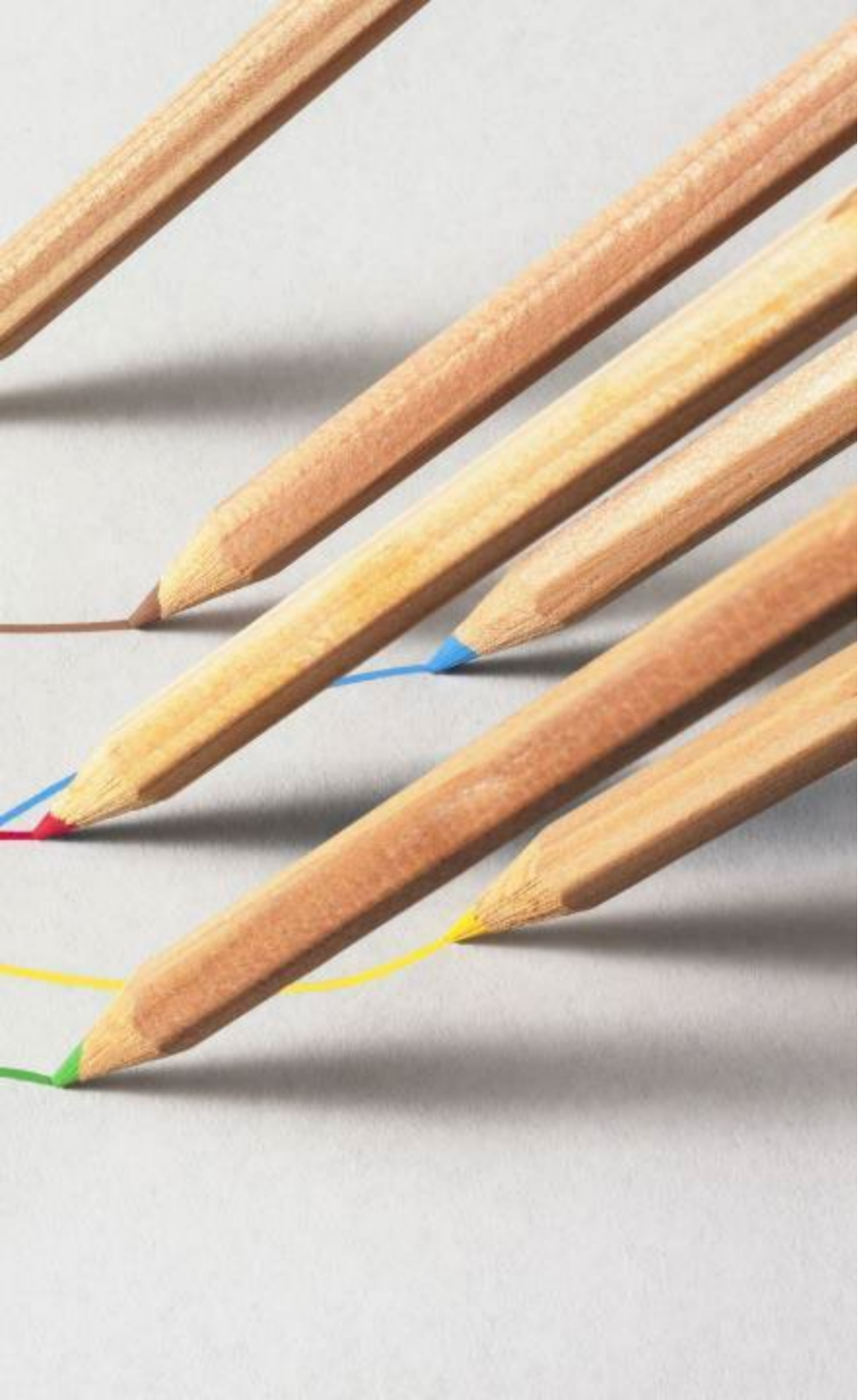
Learning Goals

Students will learn:

- the characteristics of invertebrates and the criteria used to classify invertebrates found in the garden;
- the critical role invertebrates have in the biodiversity of an ecosystem;
- to apply this knowledge to integrated management of “pests” in the garden.

Anchor Phenomena: Amazing Miniature World

Teachers: *Close out at the end of this video or it will continue into another video clip.*



Develop a Model to Describe the Phenomena

Draw a diagram showing the various animals that live in a garden and how they are classified by scientists. Include both observable and unobservable details.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing this phenomena.

Classification of the Animal Kingdom

Lesson One

What is Classification?

Classification is the process of creating categories based on common characteristics. Scientists classify or sort all living things into groups. Scientists primarily group living things based on:

- Their structure
- Their evolutionary relationships

➢Scientists begin by classifying all living things in very large groups called domains followed by a classification category called ***kingdom***.

A Closer Look at the Animal Kingdom

*How are the **structures** of these animals alike?*

*How are the **structures** of these animals different?*







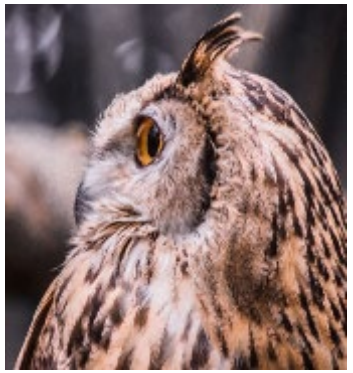




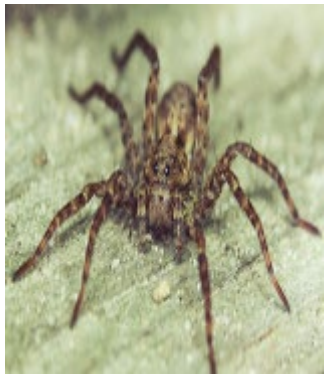

Based on their structure, these animals can be sorted into two groups

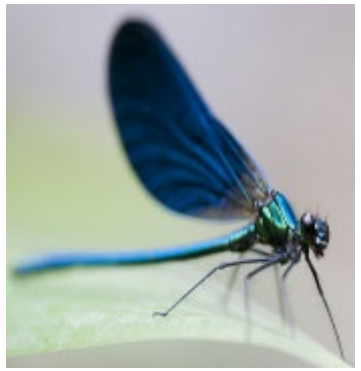
Vertebrates






Invertebrates






Vertebrates

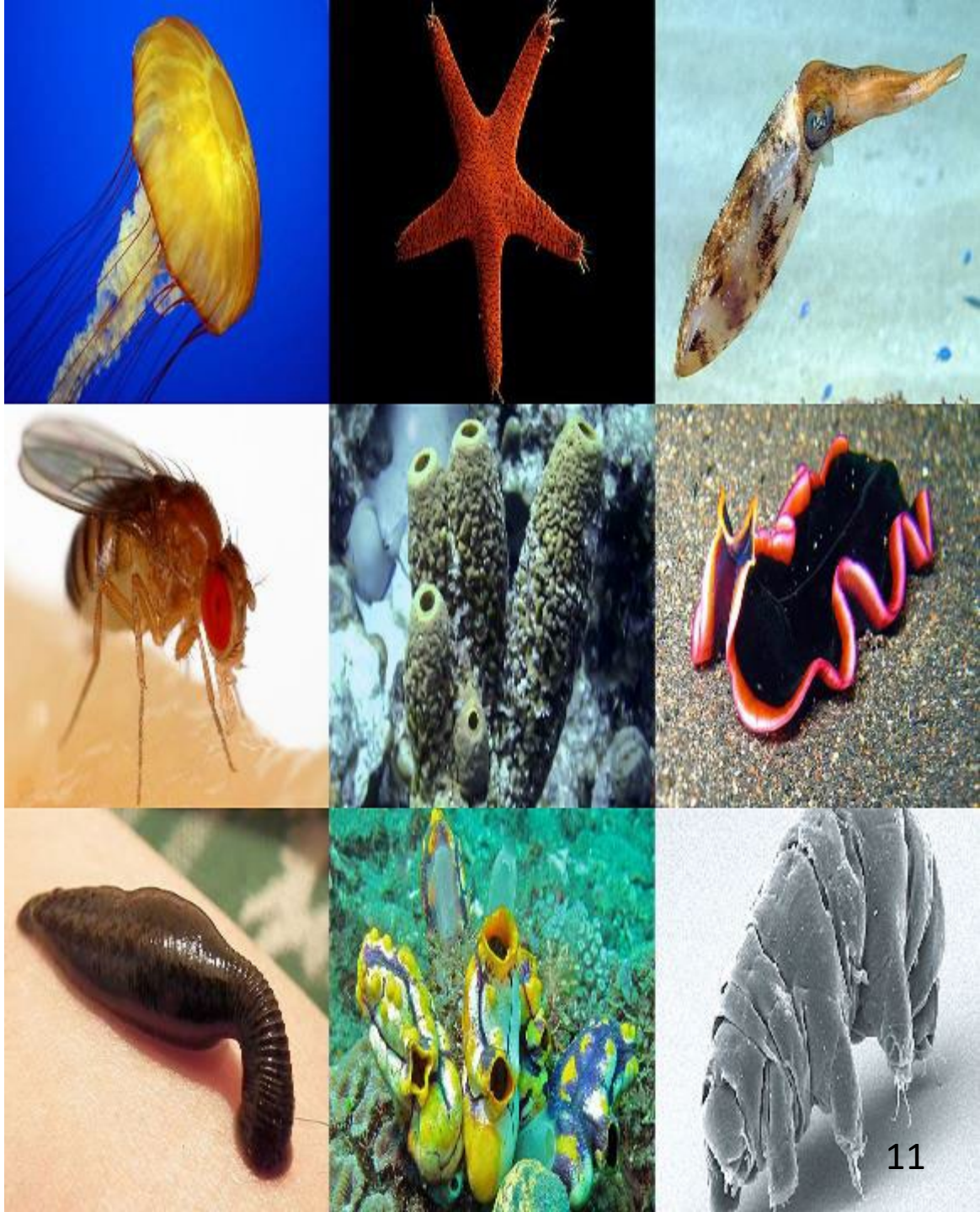
Vertebrates are all animals, including humans, that have an internal backbone and skeleton. This includes:

- Reptiles, amphibians, fish, birds and mammals.

Invertebrates

Invertebrates are all animals that have *no* backbone or internal skeleton. This includes:

- Insects, spiders, squids, shellfish and worms.
- Many have hard exoskeletons, outer shells, like those of insects and crustaceans.
- Others have fluid-filled, hydrostatic skeletons, like worms and jellyfish.



Scientists classify all of the Animal Kingdom's vertebrates and invertebrates into categories called ***Phylum***

***Phylum* means a direct line of descent within a group. The plural form of phylum is *phyla*.**

- Members of the same phylum can be very different and have only basic similarities.
- However, all organisms in the same phylum are believed to have *a common evolutionary ancestry*.

There are over 30 categories of phylum for living animal life.

- Most of the diversity of animal life is found in **nine** major groups of phylum.

Video: Nine Major Animal Phyla

Watch this **video** on the nine major phyla of animal life.

- As you watch, record the names of the phyla that have **invertebrates** you might find in a garden. List animal examples.
- Identify the phylum in which all vertebrates are classified.

Phyla in the Garden Video Notes

Phylum:	Phylum:	Phylum:	Phylum:	Phylum:
Example(s)	Example(s)	Example(s)	Example(s)	Example(s)

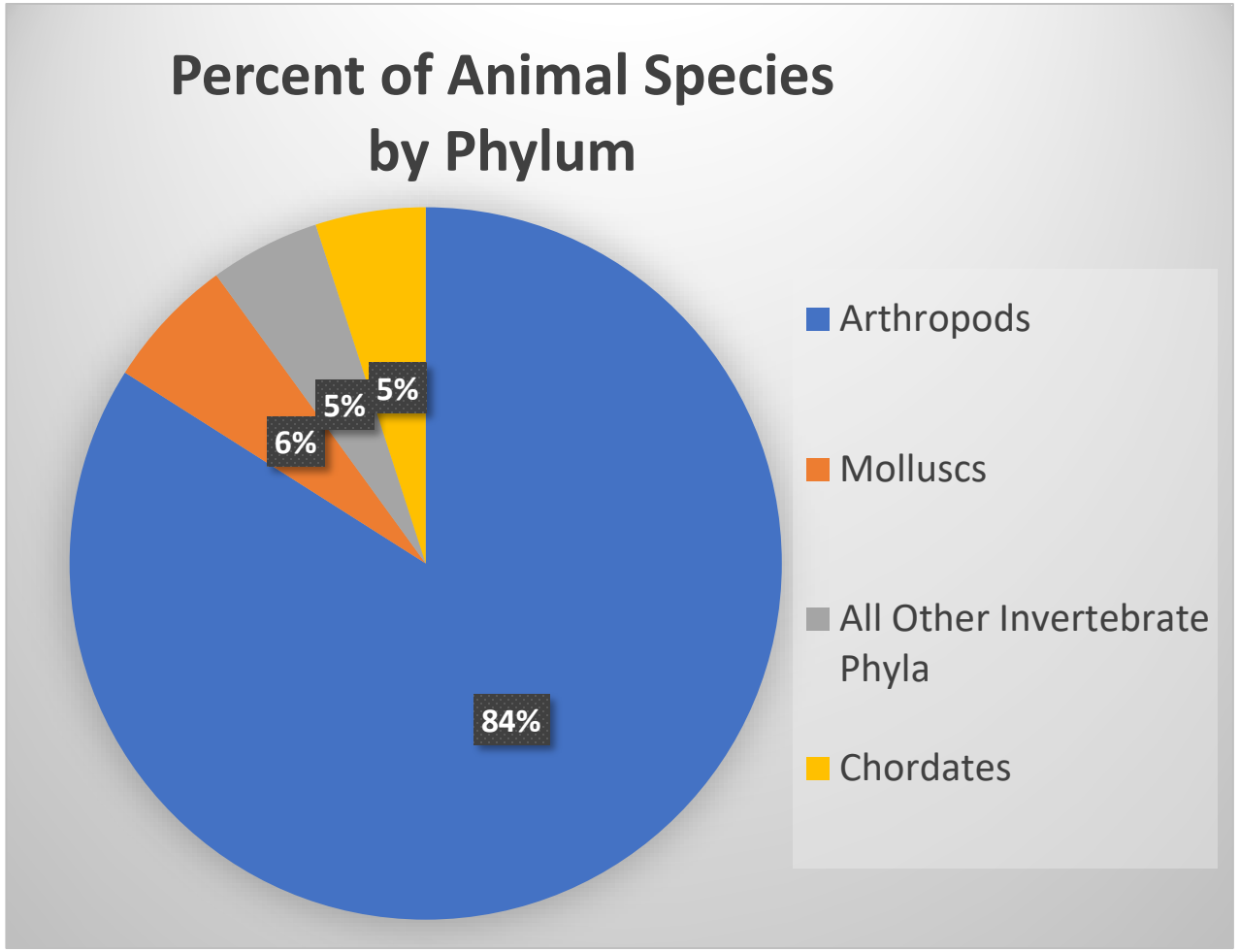
All vertebrates are classified into the _____phylum.

Phyla in the Garden Video Notes

Phylum:	Phylum:	Phylum:	Phylum:	Phylum:
Example(s)	Example(s)	Example(s)	Example(s)	Example(s)

All vertebrates are classified into the _____phylum.

Putting the Animal Kingdom into Perspective



- **All vertebrates** have been classified into the Chordate phylum. There are also two invertebrates that share some *structure* characteristics of vertebrates, so they have been grouped into this phylum. This means vertebrates represent ***less than 5%*** of all life in the animal kingdom.
- **All other invertebrates** have been classified into over 30 phyla. So, invertebrates represent ***over 95%*** of all life in the animal kingdom.

➢ ***Study the circle graph.***

What invertebrate phylum has the largest percent of all animal life?

Check For Understanding

- Complete the sentence: Scientists primarily group living things based on their evolutionary relationships and their _____.
- What criteria do scientists use to classify an animal as an invertebrate?
- What does phylum mean?
- From your *9 Major Phyla* video notes, name a phylum and an animal you could find in a garden.
- Invertebrates makeup what percent of all animal life?
- What is the largest animal phylum?

Photo Credit: Joseph Berger, Bugwood.org

Phenomena in the Garden:

Observing for invertebrate phyla

Supplies: Magnifying glass and/or camera, recording sheet, pencil.

Location: Work in small groups. Each group picks part of a larger location to investigate. These are small habitats called *microhabitats*. Use the recording sheet to write a brief description of the habitat. Examples: Dry grass; damp soil; wet leaves; rotting log; wood pile; tree; shaded rocks, flower or vegetable garden bed.

- ✓ **Carefully observe** for animals in this microhabitat. You may want to turn over rocks, leaves or logs to look for animals.
- ✓ **Record the type and number of each animal observed**. If you cannot identify it, write down a description, make a drawing, and/or take a picture. Include its phylum.
- ✓ **Record your observations about each type animal**. Describe what it looks like, exactly where you saw it, and what it was doing.
- ✓ **Compile results as a class.** Hold onto these results as you will be doing a 2nd observation following Lesson 2 to gather additional phyla data and compare results.

Phyla Observation #1

Location: **Date:**

Microhabitat-Describe the location	Animal	Notes	Phylum

Class-wide Results of Phyla Observations

Location: **Date:**

Microhabitat-Describe the location	Animal(s)	Notes	Phylum

Develop a Model To Describe the Phenomena

Revise or draw a new model to reflect what you have learned about the various animals that live in a garden and how they are classified by scientists.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing animal classification.

Extend Your Learning

Featured Phylum: Nematoda

Some species of the Nematoda phylum live in the soil. These nematodes are so small they can only be seen under a microscope.

Watch the video and answer these questions:

- How many nematodes live in one square meter of fertile growing soil?
- How do nematodes help maintain the ecosystem?

➢ Update your phyla video notes and your model to reflect what you have learned.

➢ Interested in learning more? Click on Nematodes in Antarctica and scroll down to the video.

A Closer Look at the Largest Animal Phylum

Lesson Two

Arthropods: *Kings of the Animal Kingdom!*

The arthropod phylum has the largest number of invertebrates and represents an estimated 84% of *all* animal life.

- Arthropod is the Greek word for joint-legged. In addition to jointed legs, all arthropods have:
  - ✓ bendable feet
  - ✓ segmented body sections
  - ✓ an exoskeleton (outer skeleton) made of a hard cuticle covering called chiton.

Video: Arthropod Characteristics

Watch this video to learn more about the characteristics of arthropods.

- As you watch the video answer the following questions:

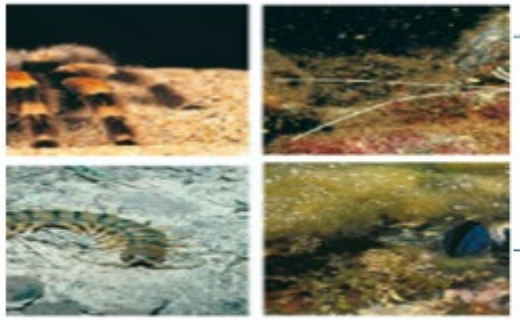
➢ What makes arthropods unique?

➢ How many categories or subphyla are there?

A Closer Look at the Subphyla of Arthropods

Kingdom

Phylum



Subphylum

Subphyla

- Chelicerata: Means front appendages of pincers or fangs. Includes spiders, mites and scorpions.
- Crustacea: Means hard shell and aquatic. Includes crabs, lobsters and isopods.
- Hexapoda: Means six legs. All insects.
- Myriapoda: Means many legs. Includes millipedes and centipedes.

Insects (Hexapods) are the largest group or subphylum of animals in the Arthropod Phylum

Insects comprise an estimated 75% of all arthropods.

- They are also the largest group of animals on Earth!
- Over one million species or types of insects are known to exist, and the final count may be much greater.
  - Scientists believe insects were the first animals to fly. In 2008, researchers discovered a full-body impression of a primitive flying insect estimated to be a 300-million-year-old specimen.

Beetles are the largest group of insects

Beetles make-up about 40% of all insects.

- Most beetles fly. However, their wings are different from other flying insects. The front wings have hard protective covers. The back wings are used for flying. They are thin and are kept under the front wings when at rest.
- Different beetles eat different things. These include plants, decaying plant matter, animals that may be dead or alive, and animal feces.

Video: Baby, You're An Arthropod!

Check For Understanding

- Why are arthropods called the kings of the animal kingdom?
- What does the word arthropod mean?
- Describe another characteristic shared by all animals in this phylum.
- How many categories or subphyla are in the arthropod phylum?
- Name a category or subphylum of arthropods.
- In what subphylum are insects classified?
- Insects represent what percent of all arthropods?
- Beetles represent what percent of all insects?
- Name something beetles eat.

Phenomena in the Garden:

Observing for invertebrate phyla

Supplies: Magnifying glass and/or camera, recording sheet, pencil.

Location: Return to the **same microhabitat** you observed in Lesson 1. Use the recording sheet to write a brief description of the habitat-*including any changes you have observed*. (Examples include moisture-level, plants, debris, etc. **Carefully observe** for animals in this microhabitat.

Record the type and number of each animal observed. If you cannot identify it, write down a description, make a drawing, and/or take a picture. Record its phylum. *If it belongs to the arthropod phylum, include its subphylum*.

- ✓ **Record your observations about each type animal**. Describe what it looks like, exactly where you saw it, and what it was doing.
- ✓ **Compile results as a class.** Compare these results to your first observation results. Were there increases observed in some phyla and decreases in other phyla? Hold onto this data for a follow-up activity in Lesson 3.

Phyla Observation #2

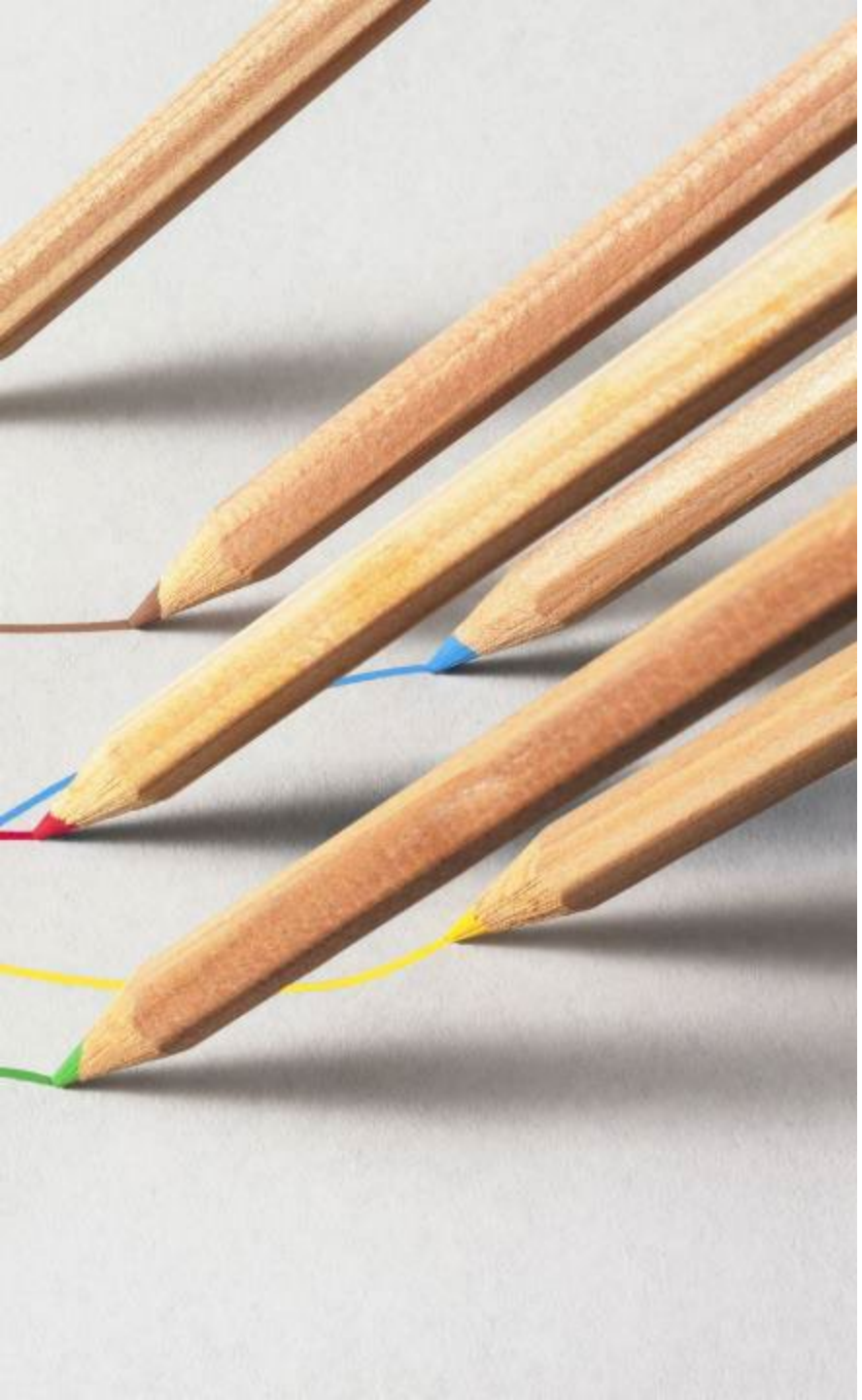
Location: **Date:**

Microhabitat-Describe the location	Animal	Notes	Phylum & *Subphylum if it is an Arthropod*

Class-wide Results of Phyla Observation #2

Location: **Date:**

Microhabitats-Describe the location	Animal(s)	Notes	Phyla/Phylum



Develop a Model To Describe the Phenomena

Revise or draw a new model to reflect what you have learned about various animals that live in a garden and how they are classified by scientists.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing animal classification.

Extend Your Learning
Featured Arthropod: Armadillidium vulgare

Did you find any "pill bugs" in your garden phyla searches?

Watch the video and answer these questions:

- *What category or subphylum of arthropods are pill bugs?*
- *Where will you find pill bugs?*

➢ Interested in learning more? Click on: Featured Creature

Subphyla Hexapoda's Role in Ecosystems

Lesson Three

Ecosystem Basics

An ecosystem consists of both living things called *biotic* and non-living things called *abiotic* that function together.

Reflect on your phyla in a microhabitat observations:

- What was an example of a **biotic** factor in the microhabitat?
- What was an example of an **abiotic** factor in the microhabitat?

Ecosystem Basics *Continued*

An ecosystem must provide *everything*, both biotic and abiotic, that its inhabitants need to live and reproduce.

- sunlight
- food
- water
- air
- nutrients
- a place to live or grow
- others of their own species

Video: What if Insects Disappeared From the Planet?

Are insects a critical component of an ecosystem?

As you watch this video answer the following questions:

- What percent of insects are beneficial to an ecosystem?
- What is one example of how insects are important to an ecosystem?

How do insects impact an ecosystem?

Every factor in an ecosystem depends on every other factor either directly or indirectly.

Insects have a direct beneficial impact on ecosystems by providing:

- Pollination
- Control of pests
- Decomposing organic matter
- Serving as the base of food webs

How do we p**rotect** beneficial Insects, while c**ontrolling** insects and other pests that are causing damage?

Scientists recommend using a system called Integrated Pest Management (IPM).

- The word integrated is defined as *combined.*
- **IPM** is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage using a *combination* of:
  - identification and monitoring
  - biological control
  - cultural control
  - mechanical and physical controls
  - chemical controls

IPM: Ongoing Identification and Monitoring of Plants

Accurately identify the insect and if it is a problem.

- Learn what serve as "host" plants that attract certain insects and other invertebrates.
- Learn how to identify the insects and other invertebrates at all their life stages.

Monitor plants frequently for both beneficials and pests.

- This will help you catch pest infestations early.

Remember, about 90% of all insects are beneficial

Begin by *building a knowledge base* of these insects and other beneficial invertebrates commonly found in gardens.

- A useful resource is the UCIPM *Meet the Beneficials* poster which provides identification information.

IPM: Biological Control works with nature

Being able to identify the "beneficials" means you know which invertebrates to leave alone, allowing them to do the work of controlling pests in the garden.

- Beneficials will help keep invertebrate pest damage to a minimal level.
- The presence of beneficials is also an indicator to **not use broad-spectrum pesticides** in a garden.

➢ *Broad-spectrum means it will kill a wide range of insects **including** beneficials.*

Biological Control also means learning to identify pests and the type of damage they cause

Pests represent about 10% of all insects and some other invertebrates. Gardeners need to know how to identify these pests in order to make informed decisions about how to control plant damage.

- These damaging pests are often plant specific. UCIPM provides identification information on the pests found on fruits and vegetables.

➢ This information is available at the following link: https://ipm.ucanr.edu/agriculture/#gsc.tab=0

➢ It is also available using this QR code.

IPM: Cultural Control

Cultural control means to manage the growing conditions with gardening practices that *discourage pest invasions*. This includes:

- Good garden sanitation: Removing debris and infested plant material.
- Proper watering and fertilizing so that plants are not stressed or weakened.
- Growing plants that are identified as pest and/or disease resistant.
- Companion planting of plants with other plants that deter insects.

IPM: Mechanical and Physical Controls

Mechanical and physical controls may kill a pest directly, block the pest out of the growing zone, or make the environment unsuitable for it. Methods include:

- Removing pests from plants by hand or spraying with water.
- Using barriers and traps to protect plants from pests.

IPM: Chemical Control

Chemical control means using pesticides. This approach is taken only after the other control methods have been proven ineffective.

Children under the age of 18 should not handle or be exposed to the use of any type of pesticide including those labeled organic.

- Be sure that your pest problem is serious enough to warrant a pesticide treatment.
- Always use the least toxic, yet effective, materials available and use them in ways that reduce impact on humans and protect the environment.

➢ For further guidance on chemical control and IPM in general refer to: UCIPM Pesticides-Safe and Effective Use in the Home and Landscape and watch the video.

Video: IPM Basics

Becoming familiar with the five components of Integrated Pest Management is a first step. Implementing the five components of IPM takes time and practice.

Watch the video to see an example of how this is done.

- Following the video, be prepared to describe how one of the five components of IPM was *implemented* in the garden:
  - identification and monitoring
  - biological control
  - cultural control
  - mechanical and physical control
  - chemical control

Check For Understanding

- What does an ecosystem consist of?
- What percent of insects are beneficial?
- Give an example of how insects impact the ecosystem.
- Why do scientists recommend that gardeners use integrated pest management (IPM)?
- How do gardeners practice biological control?
- What is cultural control?
- Give an example of a mechanical or physical control method.
- When should use of a chemical control be considered?
- How old does someone need to be to handle or be exposed to a chemical control?

Photo: Kimberly Steinman

Phenomena in the Garden:

How many beneficial invertebrates are in your microhabitats?

As a class or in small groups, analyze the results of your *Class-Wide Observation #2* data to determine which invertebrates observed in the microhabitats were beneficial.

- Refer to the IPM Meet the Beneficials Poster to aid in the identification of beneficials.
- Refer to the IPM Insects, Mites, Mollusks, Nematodes to aid in the identification of pests.
- Complete the table by categorizing each invertebrate into one of the three categories: Beneficial/Pest/Need More Information.

➢ **Which category had the most invertebrates?**

- Reflect on the results: Where were most of these invertebrates located? Hypothesize why they were in these locations.

Beneficial Invertebrates	Pest Invertebrates	*More Info Needed* Invertebrates

Develop a Model To Describe the Phenomena

Draw a final model that reflects what you have learned about various animals that live in a garden and how they are classified by scientists.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing animal classification.

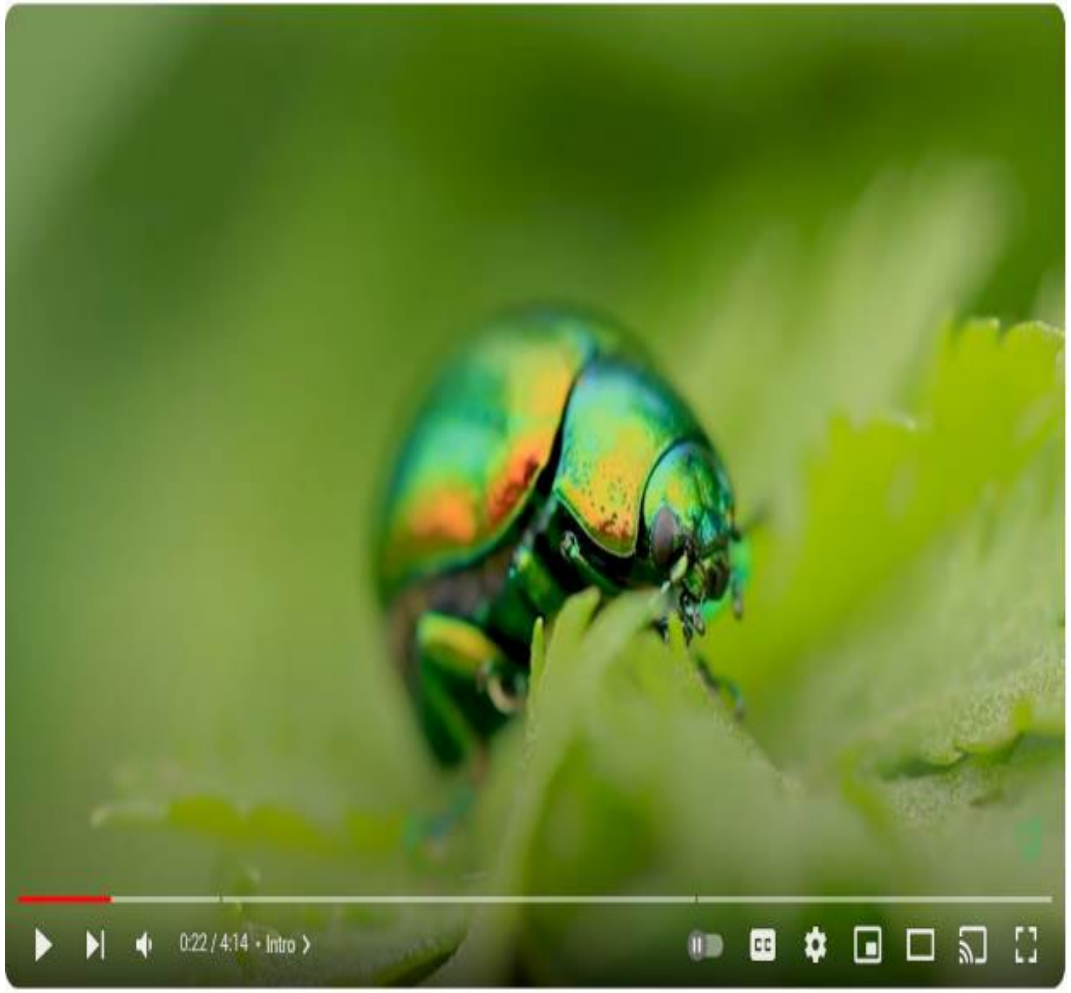
Extend Your Understanding:
The Importance of Host Plants

Many beneficial insects rely on certain plants to survive. These are called host plants.

- Watch this video about the Tansy Beetle and learn about its host plant.
- Fortunately, most beneficial insects use a wider selection of host plants. Review the list of beneficial insects and their host plants.

Is there a beneficial insect you would like to attract or see more of in your garden?

➢ Develop a list of host plants that could be grown in your garden to attract this insect.



Teachers: Please Provide Your Input!

Master Gardeners would appreciate your feedback on this lesson. The survey is anonymous but does require a Gmail account to access.

➢Please click on the link to complete a brief survey.

MG Lesson Survey

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program

Next Generation Science Standards

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS4.A: Evidence of Common Ancestry and Diversity
The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)

Next Generation Science Standards

Science and Engineering Practices:

- Develop and use a model to describe phenomena. (MS-ESS2-1),(MS-ESS2-6)
- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Crosscutting Concepts:

- Small changes in one part of a system might cause large changes in another part. (MSLS2-4),(MS-LS2-5)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

Career Technical Standards

AgriScience Pathway

C12.0 Students understand fundamental pest management:

- C12.1 Understand the major classifications of pests (e.g., insects, weeds, disease, vertebrate pests).
- C12.3 Understand the major principles, advantages, and disadvantages of integrated pest management.

Ornamental Horticultural Pathway

F4.0 Develop and implement a plan for basic integrated pest management.

- F4.1 Read and interpret pesticide labels and understand safe pesticide management practices.
- F4.3 Identify common horticultural pests and diseases and methods of controlling them.

Resources

- Chelicerata: Lucid Central
- Citizen's Guide to Pest Control and Pesticide Safety; Environmental Protection Agency, March 2005
- Companion Planting PDF: Cornell University Extension, Chemung County
- Ecosystem: Encyclopedic Entry; National Geographic
- Expectations: Rodrigo B. Salvador, Barbara M.Tomatani, Katrin L. O'Donnel; Daniel C. Cavalerri, Joao V.Tomatani, Rhian A. Salmon, Julia Casper; Frontiers in Environmental Science, March 9, 2021
- Featured Creature: Department of Entomology and Nematology; University of Florida
- Finding Phyla: Science Projects; Science Buddies

Resources *Continued*

- How do we divide the animal kingdom? Museum of Natural History Learning Zone; University of Oxford
- Invertebrate Identification Guide: imperial.uk.ac
- Invertebrates: Pictures and Facts: National Geographic Kids
- Invertebrates are ignored by conservationists, policymakers and the public: Smithsonian Insider; Animals, Science & Nature, September 1, 2011
- Kids.kiddle.co/Kiddle
- Keystone Species: National Geographic Education
- California Master Gardener Handbook: Insects, Chapter 7; Richard H. Molinar; 2015
- Museum of Natural History Learning Zone: Oxford University
- Phylum Arthropoda: Exploring Our Fluid Earth; University of Hawaii at Manoa

Resources *Continued*

- Plants for Bugs: Do insects prefer native plants? A study into the garden plant origin preferences of invertebrates:Royal Horticultural Society
- Species Profiles: At Risk Invertebrates: Xerces Society for Invertebrate Conservation
- The Link Between Invertebrate and Bird Health: How to Help In Your Own Front Yard; Posted by Nicole Becich, DVM, AAV Conservation Committee Co-Chair; Monday, November 22, 2021; Association of Avian Veterans
- The Unseen World Of Invertebrates: Maya Spanabel, Butterfly Pavillion; Ledgemont Leader, March 11, 2023
- There are 57 Billion Nematodes for Every Human on Earth:Todd Hollingshead; BYU News; July 25, 2019
- The Unseen World Of Invertebrates: Maya Spanabel, Butterfly Pavillion; Ledgemont Leader, March 11, 2023

Resources *Continued*

- There are 57 Billion Nematodes for Every Human on Earth:Todd Hollingshead; BYU News; July 25, 2019
- What are Arthropods? Buz Wilson; Australian Museum; May 14, 2021
- What are Insects and Why Do We Need Them? Insect Biodiverity Center; Penn State; Huck Institute of the Life Sciences
- University of California IPM Program Resources:
  - Invertebrate Pests
  - Is it Safe? UCIPM PowerPoint
  - Pesticides: Safe and Effective Use in the Home and Landscape
  - UCIPM Statewide Pest Integrated Management Program
  - What Is Integrated Pest Management?

Resources Continued

- **Images**: Creative Commons, Stock; UCIPM; Wikipedia; Wisconsin Horticulture
- **Videos:** BBC Studios; MooMoo Math &Science; Science Up!; Root Shoot Soils; What If?; University of Maryland Extension; Eco Sapien

Master Gardeners

The University of California Cooperative Extension (UCCE) Master Gardener Program (MGP) is an educational program designed to teach and effectively extend information to address home gardening and non-commercial horticulture needs in California.

UCCE is the outreach arm of UC's division of Agriculture and Natural Resources (ANR). Master Gardener volunteers (MG volunteers) promote the application of basic environmentally appropriate horticultural practices through UCCE-organized educational programs that transfer research-based knowledge and information.

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program

Gardening Questions?

- Email or Call the UCCE Master Gardeners of Riverside County
- Email Helpline
  - anrmgriverside@ucanr.edu
- Telephone Helpline
  - 951-683-6491, ext. 232 or 231
- Riverside Master Gardeners Website

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