

## Student Handout #1 – Invitation Letter from BES Scientist

Dear <name of student “company” or research team>:

The Baltimore Ecosystem Studies would like to know more about the soil in your community. We are particularly interested in earthworms and whether different habitats affect how many earthworms live in those habitats. For example, we would like to know earthworm populations for grassy, leafy, shady, garden, and forest habitats.

My colleagues and I have been studying soil and earthworms in Baltimore since 1999 because soil is so important to living things, and earthworms have a big impact on the soil. Our questions are:

1. What species of earthworms live in the city and where are they found?
2. What effect do they have on the soils of city parks, lawns, forests and other areas?

The more we understand about the soils in Baltimore, the better we can keep the soil and plants that grow in it healthy.

To increase the data on earthworms in Baltimore, we would appreciate it if you could use the techniques that we use in our research. Once you become earthworm experts in one area near your school, you can help us predict how many earthworms we might find in other places.

I hope you will accept this request. Please let me know when you are ready to make a presentation of your findings.

Thank you, and good luck with your research!

Sincerely,

Dr. Katalin Szlavecz  
Dept. of Earth and Planetary Sciences  
The Johns Hopkins University

**Getting to Know Earthworms**

Part I: What do you already know?

1. Draw an earthworm from memory in the space below.

2. Label the head and tail.

3. Write a description for each question, based on what you already know or have read about earthworms.

a. How does an earthworm move?

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b. What does an earthworm eat?

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c. How does the earthworm affect the soil?

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d. How does the earthworm affect other organisms (soil organisms, city animals, humans)?

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4. Write two questions you have about earthworms that could be answered by observation or measurement:

1.

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2.

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Part II: What can you observe?

1. Put on gloves when handling soil and earthworms.
2. Carefully empty the container of soil onto the plate. Do not touch the worm yet.
3. Without touching your worm, observe its behavior on the plate using the hand lens.
  - a. Draw a picture of the earthworm in the space below.

b. Label the head and tail and any other parts.

c. How can you tell which end is the head and which is the tail?

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d. How does the earthworm move?

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4. Use a dropper to moisten the worm and gently rub the soil off, if needed. Try to find the red **blood vessels** and brown **digestive tract** running the length of the worm's body. Make sure you can see the **segments** of the worm's body. Try to find tiny **bristles** on the sides of the worm. Mature worms also have a lighter-colored band around the body called the **clitellum**. Add these parts to your drawing, and label them.

5. Turn the worm over. Is there a difference between the top and bottom of the worm? How can you tell?

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6. List 5 things you could measure about this worm.

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| 1. |
| 2. |
| 3. |
| 4. |
| 5. |

Part III: Mini-Experiment: How long does it take an earthworm to burrow?

1. Place the earthworm on the surface of loose soil in a container.
2. Start a stopwatch. Stop the watch when the worm has completely disappeared beneath the soil. Record time.
3. Retrieve the worm by gently emptying the container into your hand and replacing the soil.
4. Repeat b and c two more times.
5. Share your results with at least one other group's results, and copy the data from at least one other group.
6. Calculate the average (mean) time it took each worm to burrow. (Reminder: to calculate the mean, first **add** all values in the data set and then **divide** the sum by the number of values.)

Burrowing Time (Seconds) for Two Worms

|                      | Time Trial 1 | Time Trial 2 | Time Trial 3 | Average (Mean) |
|----------------------|--------------|--------------|--------------|----------------|
| Our worm             |              |              |              |                |
| Another group's worm |              |              |              |                |

What did you discover about your worm?

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|--|
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Are your worm's results different from other worms in the class?  
Explain.

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What other earthworm characteristics could you test?

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## Investigations in Urban Soils: Earthworm Populations

### Earthworm Background for Students

Have you every looked under your feet? You have probably noticed some things that aren't very pretty, like dead leaves, dirt, and dog droppings. Where does all the stuff on the ground go?

It may sound strange, but most of what falls to the ground makes great food - for a soil **organism**. Thousands of different animals live in the soil under your feet. Most are too small to see without a microscope. Others are larger, like centipedes, pillbugs, and earthworms. All of these creatures live in the top layer of soil and many eat dead plants and animals for food (e.g. centipedes are carnivores). These creatures along with the microorganisms **decompose** the dead material, recycling it as food for plants.

**Earthworms** can have a big impact on the soil and the plants and animals that live in the soil. Earthworms eat almost non-stop. They eat fallen leaves, dead roots and wood but in every bite they usually get soil, seeds, and other things from the surface of the ground. The soil helps the earthworm's stomach grind up the organic material, and it all comes out the other end as droppings. Scientists call earthworm droppings **castings**. Castings look like dark, crumbly soil. Smaller soil animals love to eat them, and they are full of **nutrients** that help plants grow.

Earthworms **burrow** side to side and up and down in the soil. As they burrow, they eat. By doing so, earthworms mix the soil and create holes that let air and water into the soil. Air and water are needed by plant roots. Find a patch of ground that people have packed down by walking over it. You will see that that plants don't grow in hard, packed soil. So if you like plants growing in your neighborhood, then you should like soil and earthworms too!

Watch an earthworm carefully. You will see that it has a front end and a back end. Besides that, you will probably not see anything else familiar. An earthworm's body is made of many **segments** that make it look like a stack of Cheerios. Earthworms have no eyes because they live under the soil where there is no light. They have no legs; instead, they use their muscles to stretch forward. Tiny **bristles** on their sides grab the soil as they pull themselves through. Earthworms secrete a layer of **mucus** over their entire bodies. Mucus keeps them moist and helps them slide through the soil.

A mature earthworm will have a smooth section near the middle of its body called the **clitellum**. The clitellum makes a mucous sac where eggs are fertilized. The sac gradually slides off one end of the earthworm and protects the earthworm eggs until they hatch. Scientists use other features of earthworms to tell one kind from another, but these take a lot of practice and a microscope to recognize.

# The Amazing Earthworm!

Part I: Where In the World?

Earthworms are found

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Earthworms are related to

- \_\_\_\_\_
- \_\_\_\_\_

Part II: The Lovely Earthworm

Earthworm \_\_\_\_\_ are:

- usually \_\_\_\_\_ long, but can \_\_\_\_\_ to \_\_\_\_\_ their normal length
- \_\_\_\_\_: this lets them \_\_\_\_\_ and \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Earthworms \_\_\_\_\_ have:

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Earthworms \_\_\_\_\_ have:

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_ on each \_\_\_\_\_ that grab soil as they pull the body through

- \_\_\_\_\_
- \_\_\_\_\_
- five \_\_\_\_\_

Part III: It's a Dirty Job, But...

Earthworms affect the \_\_\_\_\_ by

- pulling fallen \_\_\_\_\_, dead roots, and other things \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- making \_\_\_\_\_ for \_\_\_\_\_ and \_\_\_\_\_ to stay in the soil, rather than \_\_\_\_\_

\_\_\_\_\_ like earthworms (mostly):

- \_\_\_\_\_
- \_\_\_\_\_
- earthworms can also harm plants by eating their \_\_\_\_\_ and eating so many leaves that sprouts are \_\_\_\_\_.

Other \_\_\_\_\_ like earthworms:

- \_\_\_\_\_
- birds, \_\_\_\_\_, shrews, \_\_\_\_\_, and lizards eat earthworms!

Part IV: Making More Earthworms

Each earthworm is both male and female

\_\_\_\_\_ earthworms have a \_\_\_\_\_

- this makes a sac of \_\_\_\_\_ where eggs are fertilized
- \_\_\_\_\_

From egg to adult:

- \_\_\_\_\_
- \_\_\_\_\_

# The Amazing Earthworm!

Part I: Where In the World?

Earthworms are found

- all around the \_\_\_\_\_
- in all kinds of \_\_\_\_\_ (except very \_\_\_\_\_ soil)
- in \_\_\_\_\_, \_\_\_\_\_, or \_\_\_\_\_

Earthworms are related to

- \_\_\_\_\_
- \_\_\_\_\_

Part II: The Lovely Earthworm

Earthworm \_\_\_\_\_ are:

- usually 1 - 12 inches long, but can \_\_\_\_\_ to twice their normal length
- \_\_\_\_\_: this lets them \_\_\_\_\_ and \_\_\_\_\_
- pink, brown, reddish, or \_\_\_\_\_
- protected by a layer of \_\_\_\_\_

Earthworms \_\_\_\_\_ have:

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

Earthworms \_\_\_\_\_ have:

- \_\_\_\_\_-sensitive heads
- cells all over their bodies that detect \_\_\_\_\_ and \_\_\_\_\_
- \_\_\_\_\_ on each segment that grab soil as they pull the body through
- a soft \_\_\_\_\_ that sweeps food into the mouth
- \_\_\_\_\_ that absorbs oxygen

- five \_\_\_\_\_

### Part III: It's a Dirty Job, But...

Earthworms affect the \_\_\_\_\_ by

- pulling fallen \_\_\_\_\_, dead roots, and other things \_\_\_\_\_
- \_\_\_\_\_ the dead stuff into \_\_\_\_\_
- \_\_\_\_\_ soil by bringing \_\_\_\_\_ to the surface
- making \_\_\_\_\_ for \_\_\_\_\_ and \_\_\_\_\_ to stay in the soil, rather than \_\_\_\_\_

\_\_\_\_\_ like earthworms (mostly):

- earthworm castings contain \_\_\_\_\_ that fertilize plants
- earthworm \_\_\_\_\_ allow air and water to reach \_\_\_\_\_
- earthworms can also harm plants by eating their \_\_\_\_\_ and eating so many leaves that sprouts are \_\_\_\_\_.

Other \_\_\_\_\_ like earthworms:

- tiny soil \_\_\_\_\_ feed on earthworm castings
- birds, \_\_\_\_\_, shrews, \_\_\_\_\_, and lizards eat earthworms!

### Part IV: Making More Earthworms

Each earthworm is both male and female

\_\_\_\_\_ earthworms have a \_\_\_\_\_

- this makes a sac of \_\_\_\_\_ where eggs are fertilized
- the sac slides off into the soil and \_\_\_\_\_ the eggs until they hatch

From egg to adult:

- some worms take a year to become \_\_\_\_\_
- earthworms may live for 10 years

**Student Handout #6 – Earthworm Sampling Protocol**

***DRAFT EARTHWORM PROTOCOL – MUSTARD SAMPLING***

|                  |   |
|------------------|---|
| <b>Source</b>    | Katalin Szlavecz, Dept. of Earth and Planetary Sciences, The Johns Hopkins University; Rich Pouyat, USDA Forest Service, and the Baltimore Ecosystem Studies Soil Ecology Group   |
| <b>Materials</b> | <ul style="list-style-type: none"><li><input type="checkbox"/> 1/2 cup mustard powder</li><li><input type="checkbox"/> 2 gallons of water</li><li><input type="checkbox"/> bucket or containers for carrying water</li><li><input type="checkbox"/> smaller container for scooping slurry</li><li><input type="checkbox"/> 50x50 cm pvc square</li><li><input type="checkbox"/> gloves</li><li><input type="checkbox"/> small container of dechlorinated water with water-tight lid</li><li><input type="checkbox"/> sturdy scissors</li></ul>  |
| <b>Procedure</b> | <ol style="list-style-type: none"><li>1. Mix the mustard powder and water thoroughly in the bucket.</li><li>2. Place the pvc square on the ground.</li><li>3. Carefully clear any loose soil or leaves from inside the square, collecting any worms that are on the surface.</li><li>4. Place these worms in the container of water.</li><li>5. Count the worms as you go.</li><li>6. Use scissors to clear away tall grass or weeds.</li><li>7. Slowly pour the mustard slurry over the 50x50cm area, scoop by scoop. Wait for worms to appear.</li><li>8. Place all worms in the container of water, adding to your count.</li><li>9. Continue until all the mustard slurry has been used.</li><li>10. Worms will survive for a few hours in the water.</li></ol> |

**Student Handout #7 – Earthworm Sampling Data Sheet**

**Earthworm Data Sheet**

Team Members: \_\_\_\_\_

**General Information:**

|          | Habitat #1 | Habitat #2 | Habitat #3 | Habitat #4 | Habitat #5 |
|----------|------------|------------|------------|------------|------------|
| location |            |            |            |            |            |
| date     |            |            |            |            |            |
| time     |            |            |            |            |            |

**Habitat** (check all that apply):

|                                | Habitat #1 | Habitat #2 | Habitat #3 | Habitat #4 | Habitat #5 |
|--------------------------------|------------|------------|------------|------------|------------|
| lawn                           |            |            |            |            |            |
| shrub area                     |            |            |            |            |            |
| tree area                      |            |            |            |            |            |
| garden bed                     |            |            |            |            |            |
| slope                          |            |            |            |            |            |
| bare ground                    |            |            |            |            |            |
| forest                         |            |            |            |            |            |
| stream bank<br>(distance from) |            |            |            |            |            |

**Ground cover variables** (check all that apply):

|                 | Habitat #1 | Habitat #2 | Habitat #3 | Habitat #4 | Habitat #5 |
|-----------------|------------|------------|------------|------------|------------|
| dense grass     |            |            |            |            |            |
| sparse grass    |            |            |            |            |            |
| weeds           |            |            |            |            |            |
| wood chips      |            |            |            |            |            |
| leaf mulch      |            |            |            |            |            |
| fallen leaves   |            |            |            |            |            |
| bare ground     |            |            |            |            |            |
| other, explain: |            |            |            |            |            |

**Soil variables** (check or complete all that apply):

|                 | Habitat #1 | Habitat #2 | Habitat #3 | Habitat #4 | Habitat #5 |
|-----------------|------------|------------|------------|------------|------------|
| packed, hard    |            |            |            |            |            |
| loose, crumbly  |            |            |            |            |            |
| color           |            |            |            |            |            |
| soil temp. (°C) |            |            |            |            |            |
| soil moisture   |            |            |            |            |            |
| other, explain: |            |            |            |            |            |

**Other variables** (check or complete all that apply):

|                                   | Habitat #1 | Habitat #2 | Habitat #3 | Habitat #4 | Habitat #5 |
|-----------------------------------|------------|------------|------------|------------|------------|
| light reading                     |            |            |            |            |            |
| shaded                            |            |            |            |            |            |
| air temp. (°C)                    |            |            |            |            |            |
| birds, other worm-eaters observed |            |            |            |            |            |
| other soil invertebrates observed |            |            |            |            |            |
| other, explain:                   |            |            |            |            |            |

**Worm count** (tally the worms as you collect them:  $\text{||||}$ )

|                          | Habitat #1 | Habitat #2 | Habitat #3 | Habitat #4 | Habitat #5 |
|--------------------------|------------|------------|------------|------------|------------|
| number of all worms      |            |            |            |            |            |
| number of juvenile worms |            |            |            |            |            |

- Juvenile worms do not have a clitellum – that light-colored band around the middle.
- Shaded boxes require a measurement. Get the data from your teacher or the designated measurer.

# Earthworm Essay Contest

Instead of a full report, all students must write an essay that summarizes our project. First prize: \$40. Next 10 best: \$20.\*\*

Make sure you have a *Class Data* sheet with our short data table before you begin your essay.

The title should be, Earthworm Population Investigation Summary

| Requirement  | Complete and scientifically correct | Incomplete or incorrect | Incomplete and incorrect | Missing |
|--|-------------------------------------|-------------------------|--------------------------|---------|
| Describe how and where we looked for earthworms.   | 5                                   | 4                       | 3                        | 0       |
| Summarize the results: tell where we found the most earthworms and what factors seemed to make that habitat good for earthworms. | 5                                   | 4                       | 3                        | 0       |
| Explain how scientists in Baltimore, like Dr. Szlavecz, could use the information we have gathered.                              | 5                                   | 4                       | 3                        | 0       |
| Topic sentence, closing sentence, complete sentences, no un-needed sentences.  | 5                                   | 4                       | 3                        | 0       |

Total Score: \_\_\_\_\_ / 20

\*\*This is a project grade for all science students.

\*\*No prizes will be awarded for essays that earn a score less than 16 out of 20 points.

## Science Experiment Report Checklist

30 Points

**Do your best work!**  
**The best reports will be read by Dr. Szlavec.**

Directions:

1. Use the checklist to write a report of the earthworm investigation.
2. If an item in the checklist is *italicized*, copy the exact words and just fill in the blanks.
3. Otherwise, write complete sentences to answer the prompt.
4. Place a check in each box as you complete the item.
5. Use the headings provided to divide your report into sections (e.g., *Investigation Summary, Background, Materials...*).
6. If any part of the checklist confuses you, give it your best effort, but also highlight it so you remember to ask me next class.
7. You may be asked to write a second draft.
8. Work alone.

**Investigation Summary (5 points, 1 point per item)**

- By doing this experiment, we were trying to answer the question, “What effect.....”*
- I hypothesized that, if.....*
- The manipulated variable in this experiment was \_\_\_\_\_, because....*
- The responding variable in this experiment was \_\_\_\_\_, because....*
- We kept everything else the same. In other words, we controlled the .....*

**Background (3 points)**

- Provide at least three facts that you read or learned about earthworms during class. Use your notes.
- Include a neat, labeled sketch.

**Materials (1 point)**

- List of ALL the materials the experiment used.

## Procedure (2 points)

- Write a numbered list of every step in OUR process.
- Attach the earthworm sampling directions from the scientists.

## Results (4 points, 1 points per item)

- \_\_\_\_\_ had the most earthworms (\_\_\_\_\_per square meter) and \_\_\_\_\_ had the least (\_\_\_\_\_per square meter).
- \_\_\_\_\_ had the highest soil temperature (\_\_\_ C) and \_\_\_\_\_ the lowest soil temperature (\_\_\_ C).
- \_\_\_\_\_ had the highest soil moisture (\_\_\_ on a scale of 1 - 10) and \_\_\_\_\_ the lowest soil moisture (\_\_\_ on a scale of 1 - 10).
- \_\_\_\_\_ had the most light (\_\_\_ on a scale of 1 - 10) and \_\_\_\_\_ had the least light (\_\_\_ on a scale of 1 - 10).

## Data Table(s) (6 points, 2 points per item)

- You must include the combined table that contains the average values for all factors for all four habitats (this table is provided by Ms. Harvey)
- Use that data to make a bar graph of Habitat and Average Number of Worms.
- Use the data to make one additional graph that you think is meaningful.

## Conclusions (12 points – 2 points per item)

- What habitats in our area seem to have the most earthworms? Did your hypothesis predict the way things turned out, or were you surprised?
  - What measurable environmental factors (soil temp, light, moisture) did and did not seem to have an effect on the number of earthworms in a habitat, and how do you know?
  - What observable factors (soil hardness, fallen leaves, etc.) seemed to have an effect on the number of earthworms in a habitat, and how do you know?
  - Summarize what you figured out from the results: **describe** the kind of habitats in our area that seem to have the most earthworms, based on our results. Include all factors that did have an effect on earthworm populations in our investigation.
  - How do our results compare to results from BES?
  - Based on our results, think of two other places in our area that we could have collected earthworms, and predict how many earthworms we would find there and why.
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## Style/Format (2 points, 1/2 point per item)

- Did you use proper grammar, usage, and complete sentences?
- Did you check for correct spelling, punctuation, and capitalization?
- Did you write the title for each section of the paper (Investigation Summary, Materials, Procedures, Results, Conclusions)?
- Did you use small, neat handwriting or 12-point double-space font?