inTruST Learning Scenario

Title: Investigating Mealworms: Thinking and Working Like Scientists

Pictures:








Link to YouTube video:

https://youtu.be/q5kkVmxoFlA

Research Questions/Tasks

Short Description (max. 500 words)

This project focuses on researching mealworms (*Tenebrio molitor*) through independent scientific inquiry. Students explored the behavior, structure, and development of mealworms by designing and conducting their own experiments.

A material box provided different tools and environmental options, allowing students to investigate how factors such as light, temperature, moisture, food, and substrate influence mealworm behavior. Students developed their own research questions, formulated hypotheses, and carried out controlled experiments to test them.

In addition to behavioral studies, the project also included biological observations. Using optical tools such as a binocular microscope and a digital microscope, students examined the physical structure of mealworms in detail. They observed body segments, movement mechanisms, and other visible characteristics.

Another important aspect of the project was understanding the life cycle of mealworms. Students learned about complete metamorphosis, including the stages from larva (mealworm) to pupa and finally to the adult beetle. They also classified mealworms within the animal kingdom, identifying them as insects and describing their key features.

Data collection played a central role in the project. Students recorded their observations systematically and analyzed the results using basic statistical methods. They created tables, diagrams, and graphs to visualize patterns and interpret their findings.

Finally, students evaluated their experiments by reflecting on the reliability of their methods, possible sources of error, and the validity of their conclusions. The project not only provided insights into the biology and behavior of mealworms but also helped students develop essential scientific skills such as observation, experimentation, data analysis, and critical thinking.

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Information about the Implementation

Students' age: 12/13 Students' language: German

Number of lessons: 5 Duration of one lesson: 50 minutes

For which subject(s) is the activity usable?

Physics ☐ Chemistry ☐ Biology ☒ Science ☒ Maths ☐

Art ☐ Technology & Design ☐ Other:

Level of Inquiry (see information in the Appendix):

0 - Confirmatory ☐ 1 - Structured ☐ 2 - Guided ☐ 3 - Open ☒

Select the Science and Engineering Practices that are the focus of the designed unit:
(Detailed information on the practices can be found here (Next Generation Science Standards).)

1		Asking questions and defining problems	☒
2		Developing and using models	☐
3		Planning and carrying out investigations	☒
4		Analysing and interpreting data	☒
5		Using mathematics and computational thinking	☒
6		Constructing explanations and designing solutions	☒
7		Engaging in argument from evidence	☒
8		Obtaining, evaluating and communicating information	☒

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Information about the Learning Szenario

Which topic of the curriculum is covered?
This unit covers topics in **Biology**, particularly:

- Characteristics of living organisms
- Invertebrates (insects)
- Structure and function of organisms
- Life cycles and metamorphosis
- Behavior of animals in response to environmental factors
- Introduction to scientific inquiry and experimentation

Description of the learning objectives?
Students will:

- Develop an understanding of mealworms as living organisms and classify them as insects
- Describe the basic body structure and life cycle (metamorphosis) of mealworms
- Investigate how environmental factors influence animal behavior
- Plan and conduct simple scientific experiments independently
- Formulate research questions and hypotheses
- Collect, record, and analyze data using basic statistical methods
- Present results using tables, diagrams, or graphs
- Reflect on their findings and evaluate their experimental methods
- Demonstrate responsible and ethical handling of living organisms

Materials and other resources

Which resources and materials (hardware, software) are needed?



- ✓ Live mealworms (larvae, possibly pupae & beetles)
- ✓ Magnifying glass / hand lens
- ✓ Balance / scale for weighing
- ✓ Substrate & food (oats, fruits, protein powder, onions etc.)- Keeping the mealworms healthy during the activity
- ✓ Tweezers (Safe handling of worms without injury)
- ✓ various fragrances (essential oils) and cotton wool
- ✓ Digital microscope (USB or tablet-connected)
- ✓ Stereo microscope / binocular (dissecting microscope)
- ✓ Ruler / measuring tape
- ✓ Toothpicks
- ✓ Small containers / Petri dishes (Keeping worms separated for observation)
- ✓ Light source / flashlight (Testing light sensitivity)
- ✓ Graph paper / notebooks / Cardboard tube (Recording data and making diagrams)
- ✓ Spreadsheet software (Excel, Google Sheets, Numbers)
- ✓ Presentation / drawing software (PowerPoint, Keynote, Google Slides, or drawing apps)

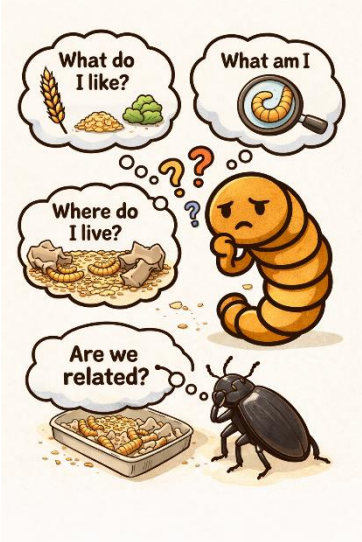
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Previous knowledge of the students

Before starting the station activities, pupils should already:
Know basic characteristics of animals (that there are different groups such as mammals, birds, insects, etc.).
Be familiar with the idea of body parts (head, legs, wings, etc.) and be able to label simple diagrams.
Understand simple life cycles (for example butterfly, frog, or plant seed to plant) so that metamorphosis is not completely new.
Have basic measuring and recording skills (use of ruler, counting, making simple tables).
Have basic safety and care rules for handling living creatures in the classroom (gentle handling, washing hands afterwards).
Be able to work in small groups and follow written or pictorial instructions at a station.

Description of the lesson plan (simplified version for teachers)

This item describes the topics addressed during the unit of learning, its educational purposes and how to carry out the lessons in more detail.
This unit of learning focuses on exploring mealworms (*Tenebrio molitor*) through inquiry-based and hands-on activities. It combines biological knowledge with scientific skills such as observation, experimentation, and data analysis.



1. Introduction and Preparation Lesson - 1/2 lesson(s)

The unit begins with an introductory lesson that prepares students to take on the role of young scientists and conduct their own investigations. Guided by the question **"What can we observe about animals?"**, the class explores what they might investigate about a living organism.

Key areas include:

→ Behavior
→ Body structure
→ Daily activities and habitat
→ Senses
→ Growth and development, including the life cycle

Students are encouraged to think like young scientists by generating their own ideas and developing possible research questions. Alongside this, they learn that working with living animals comes with ethical responsibilities. Before beginning their investigations, the class discusses the following guidelines, which emphasize careful handling, minimizing stress, and taking responsibility for the animals' care and well-being throughout the project.

Ethical Guidelines for Working with Living Animals

- **Respect living animals.** Mealworms are living creatures and must be treated gently and with care.
- **Observe before handling.** Whenever possible, observe animals in their habitat. Handle them only when necessary and under teacher supervision.
- **Provide appropriate care.** Ensure suitable housing, food, moisture, ventilation, and temperature throughout all stages of the life cycle.
- **Plan safe investigations.** Students discuss their ideas with the teacher before beginning. Investigations must not involve injury, food deprivation, harmful substances, or extreme conditions.

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- **Allow animals to move freely.** Never squeeze, shake, drop, or force an animal to respond. During choice investigations, allow it to move away from a stimulus.
- **Keep observations brief.** Return animals promptly to their habitat and stop an investigation if there is any concern about their well-being.
- **Practice good hygiene.** Wash hands after handling animals or their habitat, and keep food and drinks away from the investigation area.
- **Plan for continued care.** Arrange care during weekends and holidays and after the unit ends. Classroom-reared mealworms and beetles should not be released outdoors.

Before each investigation, students ask: **"Can we answer our question while keeping the animals safe and well cared for?"**

The teacher explains how the project will be assessed, and students are given a sheet with the evaluation criteria.

2. Experimental Phase (Main Focus) - min. 2 lessons

The main part of the unit consists of student-led experiments conducted in the classroom. Using a provided material box, students design and carry out their own investigations on mealworms. They test environmental factors such as light, temperature, moisture, food, and surfaces, or focus on biological observations.
Students work independently or in small groups to:

- Formulate hypotheses
- Plan and conduct experiments (what Materials do I need, what instruments do I use,...)
- Observe and document results
- Collect and organize data

Additionally, students have the opportunity to take mealworms home. This allows for extended observation, including studying long-term behavior and the process of metamorphosis. Students can raise and care for the mealworms, gaining deeper insights into their development and needs.

Students use a worksheet as a template to help them plan their experiments and document their observations and results.

3. Presentation and Reflection - 2 lessons

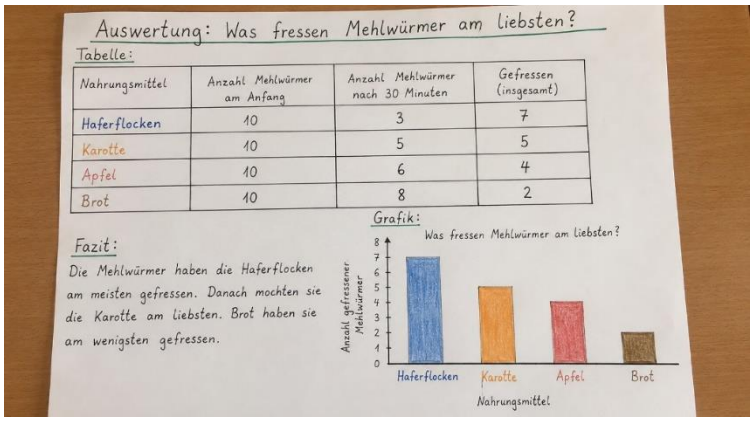
In the final phase, students present their experiments and findings to the class. They use tables, diagrams, or visual aids to explain their results and conclusions.
This phase also includes reflection, where students:

- Evaluate their experimental methods
- Discuss sources of error
- Compare results with their hypotheses
- Reflect on what they learned about scientific research and living organisms

Students were free to choose how to present their findings, for example through a digital presentation, a poster, a drawing, or another format of their choice.
Attached are some examples of students' work.



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Auswertung: Was fressen Mehlwürmer am liebsten?

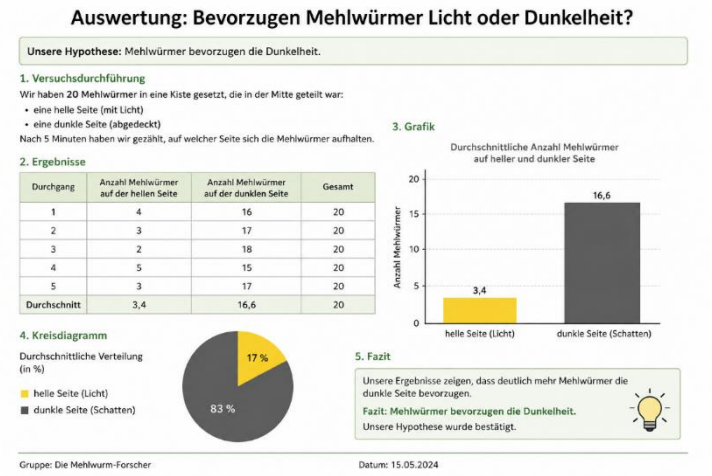
Tabelle:

Nahrungsmittel	Anzahl Mehlwürmer am Anfang	Anzahl Mehlwürmer nach 30 Minuten	Gefressen (insgesamt)
Haferflocken	10	3	7
Karotte	10	5	5
Apfel	10	6	4
Brot	10	8	2

Fazit:

Die Mehlwürmer haben die Haferflocken am meisten gefressen. Danach mochten sie die Karotte am liebsten. Brot haben sie am wenigsten gefressen.

Grafik:



Auswertung: Bevorzugen Mehlwürmer Licht oder Dunkelheit?

Unsere Hypothese: Mehlwürmer bevorzugen die Dunkelheit.

1. Versuchsdurchführung

Wir haben **20 Mehlwürmer** in eine Kiste gesetzt, die in der Mitte geteilt war:

- eine helle Seite (mit Licht)
- eine dunkle Seite (abgedeckt)

Nach 5 Minuten haben wir gezählt, auf welcher Seite sich die Mehlwürmer aufhalten.

2. Ergebnisse

Durchgang	Anzahl Mehlwürmer auf der hellen Seite	Anzahl Mehlwürmer auf der dunklen Seite	Gesamt
1	4	16	20
2	3	17	20
3	2	18	20
4	5	15	20
5	3	17	20
Durchschnitt	3,4	16,6	20

3. Grafik

4. Kreisdiagramm

Durchschnittliche Verteilung (in %)

5. Fazit

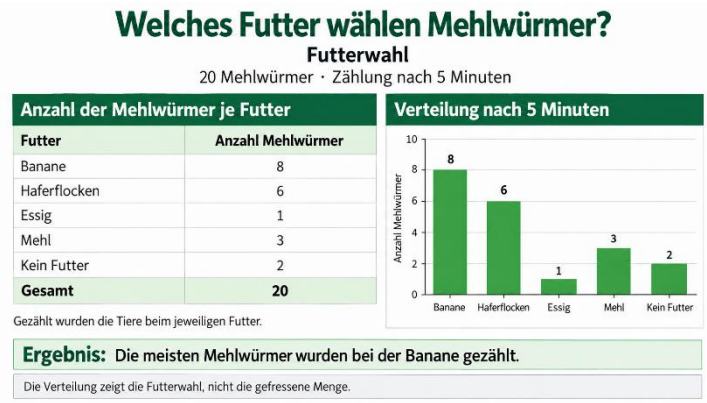
Unsere Ergebnisse zeigen, dass deutlich mehr Mehlwürmer die dunkle Seite bevorzugen.

Fazit: Mehlwürmer bevorzugen die Dunkelheit.

Unsere Hypothese wurde bestätigt.

Gruppe: Die Mehlwurm-Forscher

Datum: 15.05.2024



Welches Futter wählen Mehlwürmer?

Futterwahl

20 Mehlwürmer · Zählung nach 5 Minuten

Anzahl der Mehlwürmer je Futter

Futter	Anzahl Mehlwürmer
Banane	8
Haferflocken	6
Essig	1
Mehl	3
Kein Futter	2
Gesamt	**20**

Gezählt wurden die Tiere beim jeweiligen Futter.

Verteilung nach 5 Minuten

Ergebnis: Die meisten Mehlwürmer wurden bei der Banane gezählt.

Die Verteilung zeigt die Futterwahl, nicht die gefressene Menge.

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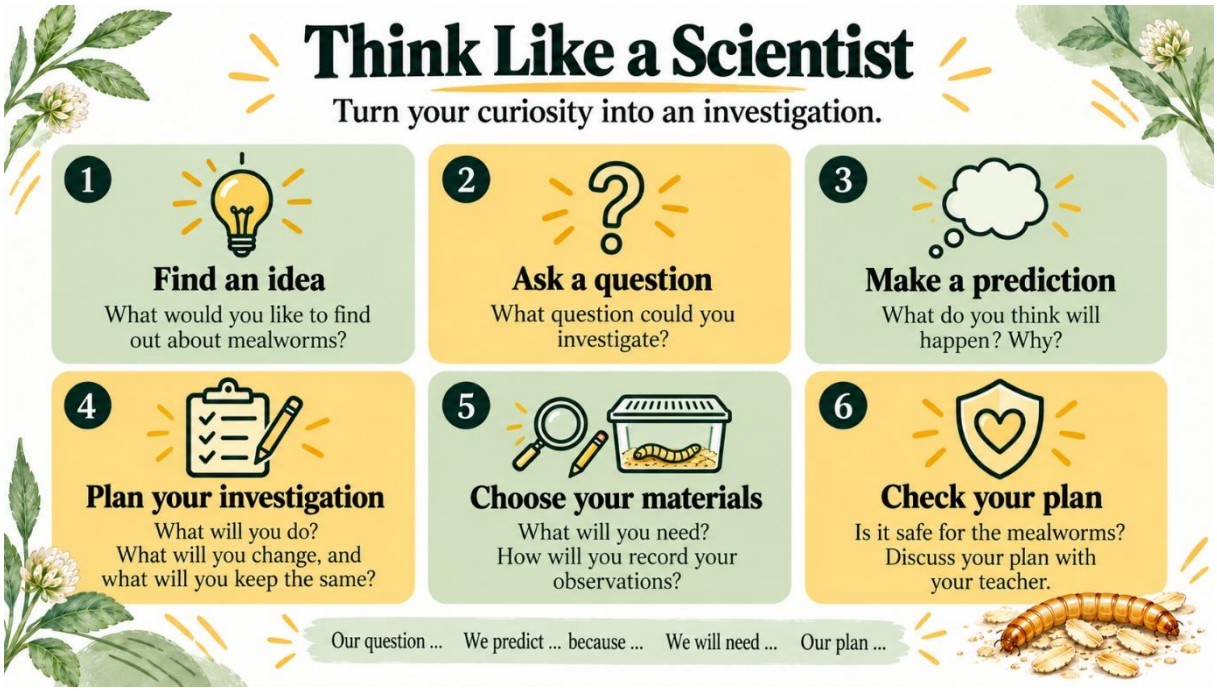
PowerPoint Slides for Lesson 1





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Research Task: Investigating Mealworms

1. Research Question

What do we want to find out about mealworms?



2. Assumption (Hypothesis)

What do we think will happen?

3. Materials

4. Experimental Plan and Procedure

What do we observe/measure?
What did we do? What do we change?

5. Results

Observations, table or sketch:

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6. Evaluation

What do our results mean?

7. Reflection

What went well? What would we do differently? How do we make sure it is fair?

Additional

New question or idea for improvement:



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Assessment – Investigating Mealworms

Category	3 Points	2 Points	1 Point	0 Points	My Points
Research Question & Planning	clear, testable question and meaningful plan	understandable, partly appropriate	unclear question or hardly any plan	no idea	
Procedure	careful, structured, fair test	mostly correct, minor mistakes	unsystematic or inaccurate	not carried out	
Results & Evaluation	results clear + good explanation	results present, explanation partial	few or unclear results	no results / no evaluation	
Collaboration & Work Behavior	active, respectful, works independently	mostly involved	little active	disrupts or does not participate	

Total Points: _____ / 12

Feedback:



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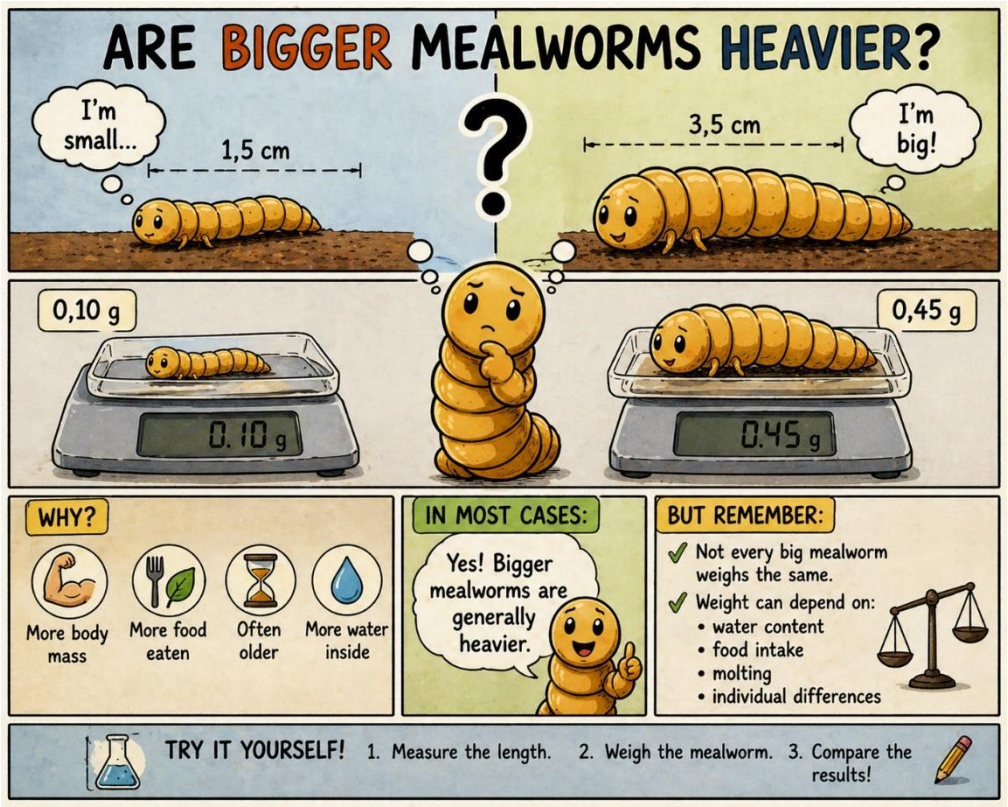
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IDEA CARDS

The idea cards provided inspiration for students who had difficulty developing their own experiment or who wanted to conduct an additional investigation









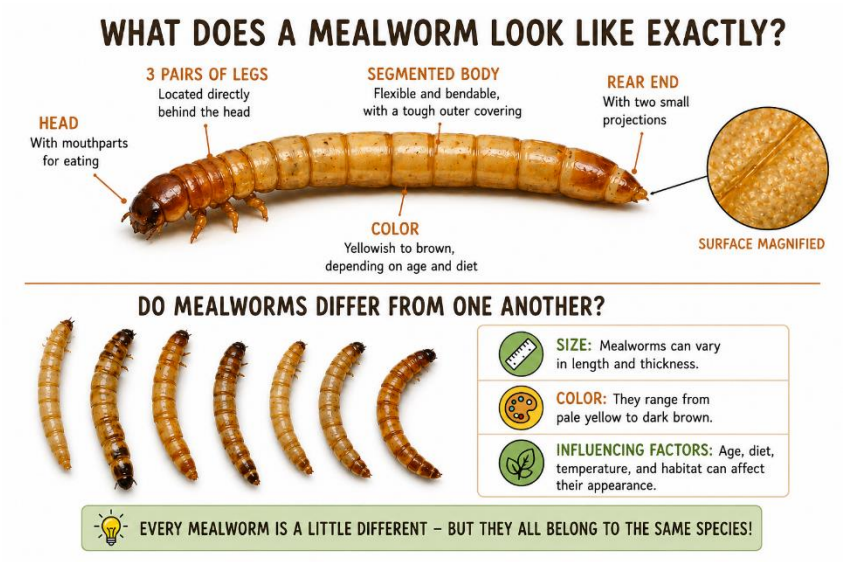






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Guiding Questions

Behaviour

- Do mealworms move faster or slower?
- How do they react to touch?
- Do they have favorite places?

Environment

- Do they prefer light or darkness?
- Do they prefer warm or cold temperatures?
- What happens in moist or dry conditions?

Food

- What do they prefer to eat? (oats, carrot, apple, etc.)
- Do they eat at the same time?

Body

- Are larger mealworms heavier?
- Do all mealworms have the same number of body segments?

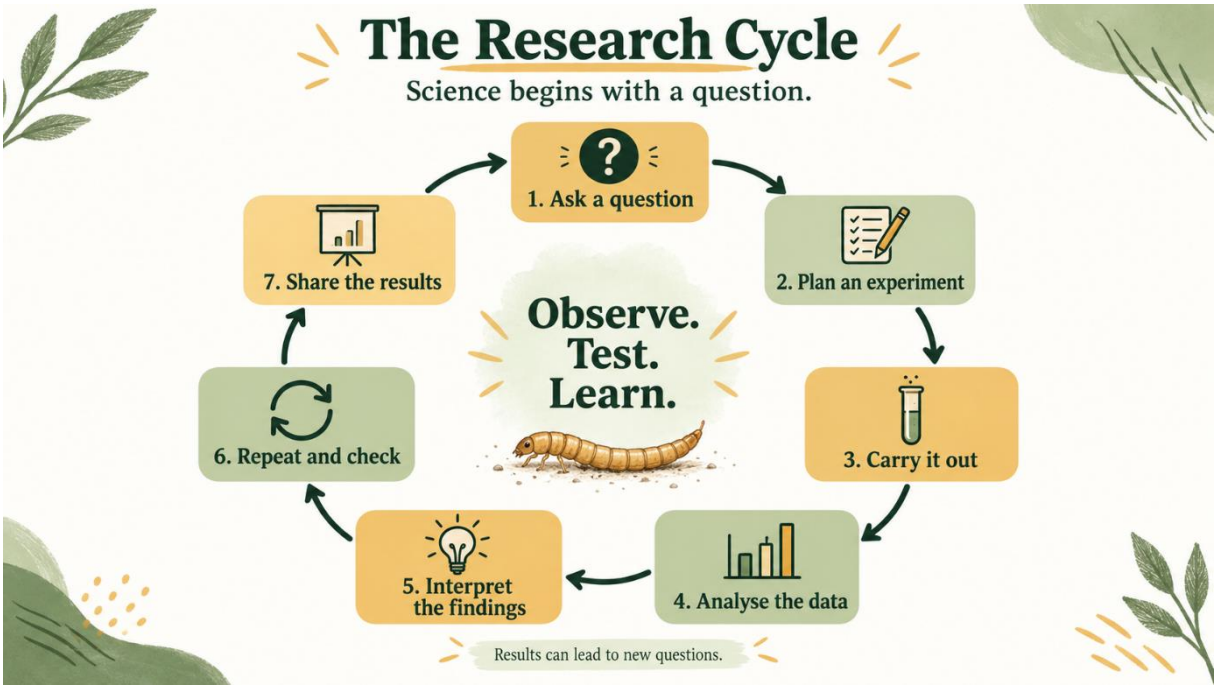
Development

- How can you recognize different stages of development?
- Does their behavior change depending on the stage of development?

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Power Point Slide for Lesson 3



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Appendix

Level of Inquiry

Refer to the table below for information about the level of inquiry according to Orosz et al. (2023). Select the relevant level of inquiry for your unit in your template above. Please note that, as discussed during LTT2, you can adjust the responsibilities assigned to students and teachers at Levels 1 and 2 if you wish.

Level of Inquiry	Problem/ Question	Procedures	Interpretation of Results	Purpose & Requirements
Level 0 – Confirmatory Inquiry	Teacher	Teacher	Teacher	Students reproduce the results
Level 1 – Structured Inquiry	Teacher	Teacher	Students	Practising simple inquiry skills (e.g., observation, measurement, data interpretation, discussion of results, documentation) or introducing students to IBL
Level 2 – Guided Inquiry	Teacher	Students	Students	Opportunity for cooperative learning, room for creativity, development of skills and abilities (above + formulation of hypotheses, designing the experiment)
Level 3 – Open Inquiry	Students	Students	Students	Greatest level of freedom; demands advanced inquiry skills, reasoning ability and creativity, and high level of responsibility

Science and Engineering Practices

As a framework for designing the learning units, this project used the science and engineering practices according to the Next Generation Science Standards (NGSS). Detailed descriptions of each practice can be found in the Appendix F of the NGSS:
https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

Literature

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states. Appendix F: Science and engineering practices in the NGSS.* National Academies Press. https://www.nextgenscience.org/

Orosz, G., Németh, V., Kovács, L., Somogyi, Z., & Korom, E. (2023). Guided inquiry-based learning in secondary-school chemistry classes: A case study. *Chemistry Education Research and Practice*, *24*(1), 50–70. https://doi.org/10.1039/D2RP00110A

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