CLASSIFICATION AND BIODIVERSITY

Overview

This unit aims to connect biodiversity to the larger idea of why and how we classify objects in general by leading students through the various processes involved in creating, using and updating classification trees. After introducing students to the basic process of classification, the tasks focus on biodiversity through drawing, observing and finally classifying. These tasks are contextualized with historical (and current) examples where scientists use information obtained through observations of organisms to make and refine existing biological classification trees.

Minimum time required: Minimum 3 sessions of 40 minutes

Type of learning unit: Indoor/Classroom

Outline

Task 1 (20 min)

In this task, students are introduced to classification using objects in their geometry box. A sample classification tree is provided to the students. The students make their own classification tree by identifying the similarities and differences of these objects. Students can begin to explore the process of creating classification trees and their utility.

Task 2 (20 min)

This task uses a historical context of scientific illustrators to introduce students to the process of observation and drawing organisms. Students are then given instructions to draw 6 organisms using the basic shapes. This task aims to help students notice features they can use to classify the organism.

Task 3 (20 min)

Students recognize and tabulate features for each organism. Using the information they gather during the drawing process and by identifying similarities and differences, students create a classification tree.

Task 4: (20 min)

Students challenge their classification tree with new information: (a) a new feature for existing organisms and (b) new organisms. Students explore how this new information might alter their classification tree.

Task 5: (40 min)

This is an optional extension task where students can observe organisms in their natural environment and try to classify them.

Learning objectives

1. Understanding the significance of observation and drawing to study organisms
2. Recognizing the process of creating, using and updating basic biological classification
3. Analysing and organising information through classification

Links to the curriculum

Class 8	Class 9	Class 10
Chapter 7: Conservation of Plants and Animals	Chapter 5: The Fundamental Unit of Life	Chapter 9: Heredity
	Chapter 6: Tissues	Chapter 15: Our Environment

Introduction

Biologists study different plants, animals and other organisms around us and make classification trees based on their observed features. Biological classification has multiple purposes. Classification makes the study of biodiversity easier by ensuring that newly found organisms are assigned to appropriate groups. Based on what we know about other organisms in that group, we can predict the characteristics of these newly discovered organisms. These classification trees often also give us clues to how evolution might have occurred over millions of years!

But classification is a concept not just limited to biology. We all often organise objects into groups based on similarities and differences in their properties. You may have recently organized or classified everyday objects around without even realizing it.

For example, maybe you recently were looking in your cupboard for clothes to wear. How are the clothes arranged in the cupboard? The clothes might be organized based on their utility (daily wear / special occasions/school) or based on what weather they are for (summer/monsoon/winter) or based on whose clothes they are (yours / your parents / your siblings). These sorts of organization of clothes make it easier to find what you want.

Can you think of any place (other than clothes in the cupboard) where you use classification?

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In the task below, we will classify objects we commonly find in our geometry boxes.

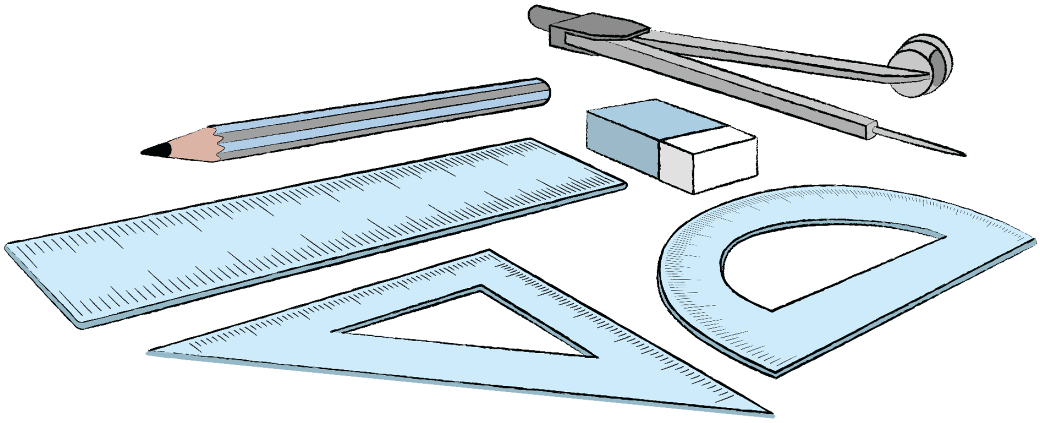
Materials required:

Paper / Pen / Pencil,

Geometry box

Task 1: Make a classification tree

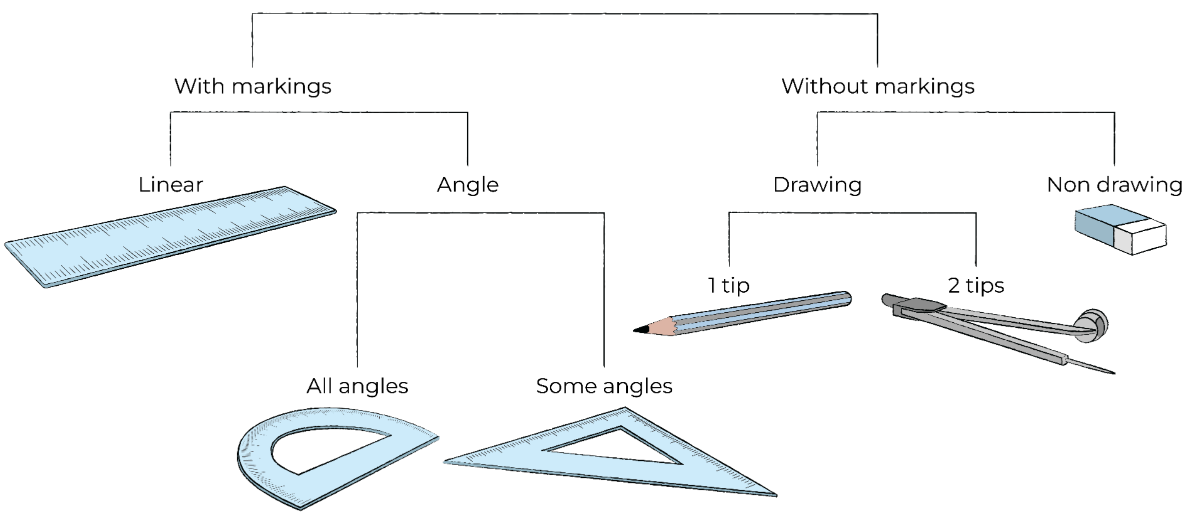
Find the following objects from your geometry box:
Pencil, Ruler, Set square, Eraser, Protractor, Compass



> This is a suggested list of items to classify.
>
> Here is a more comprehensive set of materials that are found in student geometry boxes:
>
> Ruler, Protractor, Eraser, Sets square (45-45-90), Sharpener, Sets square (30-60-90), Divider, Compass, Pen, Pencil, Colour pencil.
>
> You may choose a slightly different set of objects if you like. You can also choose a larger set of objects which may lead to more involved discussions.

To classify objects, observe them carefully and identify differences and similarities between them. You might notice that two objects share some properties but differ in other properties. For example, a common feature of the scale, set square and protractor have markings. However, they measure different things. Then, you can choose a property to divide the objects you have into groups. Whatever property you choose, note that each object should fit into *one and only one group*. You can continue this process within each group to further organize objects.

For example, here is one possible classification of these objects:



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So here, objects are first divided into groups based on the property of markings: scale, protractor and set square have markings while pencil, compass and eraser are without markings.

Within the group of objects with markings, we choose to divide them into subgroups based on the property of what they measure: scale measures linear objects and protractor and set square measures angles.

> This tree is provided as a sample for students to study.
>
> You might want to discuss a few important properties of this tree:
>
> (i) All 6 objects are included in the classification tree
>
> (ii) At each division, each object fits into *one and only one* group. However, a group can have more than one object.
>
> (iii) The classification tree is hierarchical, i.e., an object in a sub-group has to fulfil the properties of the group from which it arose. For example, a pencil has 1 tip AND is used for drawing AND is a non-measuring object.

Can you try to draw a different classification tree with the same objects?

> To get different trees, you can encourage students to use a different property for the first division.
>
> Note that even with the same set of objects, students may come up with different classification trees as a result of the properties and the order of divisions they choose.
>
> There is no “correct” property to use and no “correct” tree. This task is for students to start exploring how classification is carried out. The discussion can focus on how/why students chose features or order of divisions.

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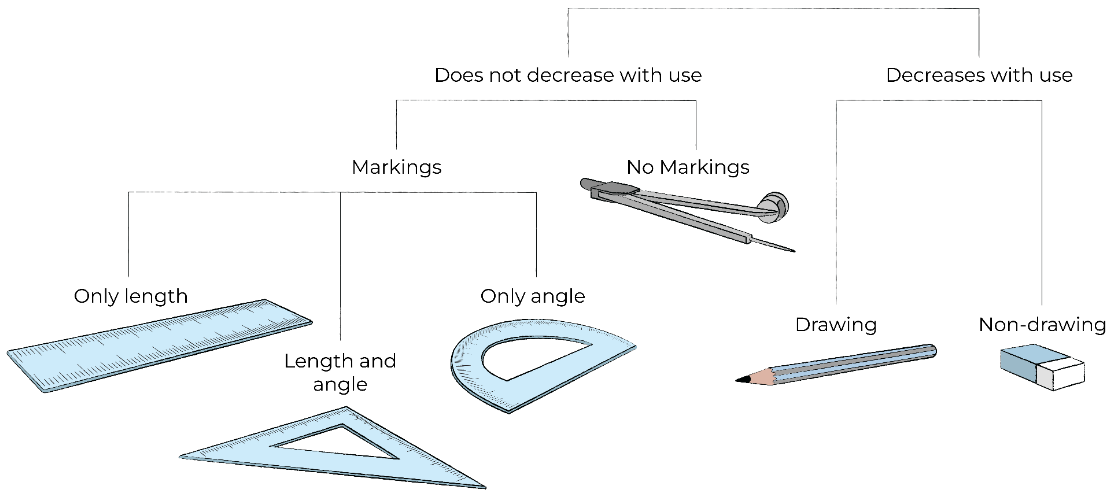
In fact, some of the objects might fit into different groups. For example:

(i) Set square: measuring angle vs length

(ii) Compass: writing vs. measuring

Here is one possible tree. If you like, you can provide just the feature for the first division of this tree to students and ask them to continue making the tree.



In what ways do you think the classification tree provided is useful? In what ways do you think your classification tree is helpful?

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The students will come up with various classification trees using different properties. You can ask students why they chose one property over another. You can use examples of classification trees from different students to discuss how some trees might have the same properties for divisions but are ordered differently.

You can also discuss how we can go about creating a common or standard classification tree for geometry box objects: i.e. how do we decide which tree is “better” and why? For example, should we try to divide objects based on similar shared properties or should we use unique properties to separate objects from the rest? How do the number of properties and the order in which we use them affect a tree?

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Task 2: Draw some organisms

Biodiversity comes from two words: biology and diversity. Biological diversity is the variety of living organisms found on earth. Each of these organisms differ in the shape, size, color, body parts, habitat, behaviour etc. This diversity has evolved over millions of years since life first originated on earth. Biological classification can help us understand how this process occurred.

Just like for the objects in your compass box, classification of biological organisms is based on differences and similarities of organisms. One way to classify organisms is externally visible features , i.e. the shape, number and type of body parts. To study this, early naturalists and biologists used to observe and make detailed drawings of organisms.

Maria Sibylla Merian (1647–1717) was a Dutch[1] scientific illustrator[2]. As a young student, Maria collected insects. She went on to travel to Suriname[3] to observe and make detailed drawings of the biodiversity there. Her work mainly focused on insects, their life cycle and their plant hosts.

The earliest biological classifications were based on detailed drawings by scientific illustrators like Maria. In fact, years after her expeditions, Carl Linnaeus in the 1730s, used Maria's drawings to describe and identify about one hundred new species!

[1] Dutch: person from the Netherlands

[2] Scientific illustrator: Someone who creates detailed, accurate visual depictions of living organisms or natural phenomena. Historically, scientific illustrations were detailed drawings made by hand by directly observing the collected sample or specimen, which often became the sole source of scientific information on that specimen.

[3] Suriname: a country in South America

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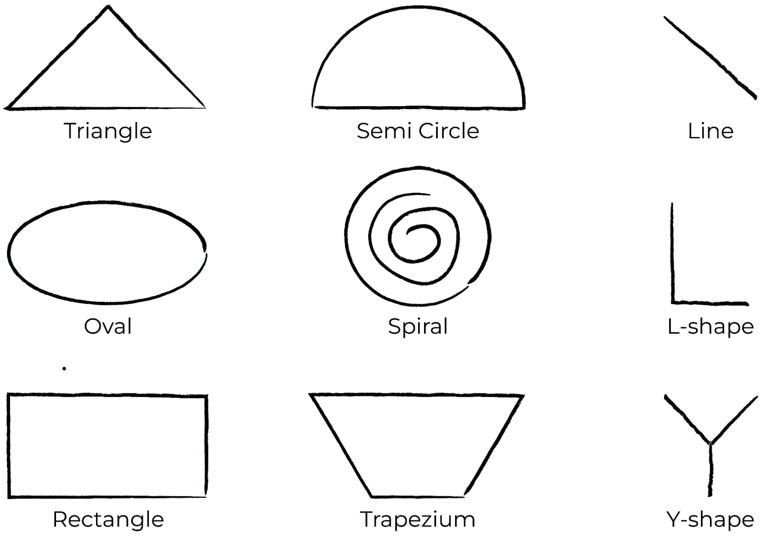
So, let us also draw and classify some organisms! For our drawings, we are going to use these simple shapes:



Here are instructions below to draw some organisms:

Organism 1

1. Draw 3 non-overlapping ovals, in increasing order of size, attached to each other at the narrow ends. The smallest oval shape represents the **head**. The middle oval represents the **thorax** and the last oval represents the **abdomen**.
2. Draw 3 L-shapes on each side of the thorax. These represent **legs**.
3. Draw 2 straight long lines from the head pointing away from the rest of the body. These represent **antennae**.
4. Draw a line starting from the point between the head and the thorax and ending at the end of the abdomen. Draw two semi-circles, one on either side of this line. These semi-circles represent **wings**.

Organism 2

1. Draw a semi-circle. This represents the **head**.
2. Draw a long rectangle, using the flat side of the semi-circle as the shorter side of

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the rectangle. Divide the rectangle into smaller rectangles using straight lines perpendicular to the longer side of the rectangle. The long rectangle represents the **trunk**.

3. For each smaller rectangle, draw 2 L-shapes on each side. These represent **legs**.
4. Draw 2 straight short lines from the head pointing away from the rest of the body. These represent **antennae**.

Organism 3

1. Draw a long thin oval. This is the **body**.
2. Divide the oval into many parts using lines perpendicular to the longer sides of the oval.
3. Shade one of the rectangles near (but not at) one end of the oval. This is the clitellum.

Organism 4

1. Draw 3 non-overlapping ovals in increasing order of size, attached to each other on the narrow end. The smallest oval shape represents the **head**. The middle oval represents the **thorax** and the last oval represents the **abdomen**.
2. Draw 3 L-shapes on the thorax on each side. These represent **legs**.
3. Draw two lines from the head pointing away from the rest of the body. These represent **antennae**.

Organism 5

1. Draw a long oval. This oval contains the **foot**. One end of this oval contains the **head**.
2. Draw a spiral on top of the oval away from the head. This is the outer covering (or shell) that contains the **body organs**.

3. Draw 2 short lines and 2 long lines on the head pointing away from the rest of the body. These represent **antennae**.

Organism 6

1. Draw a trapezium (a quadrilateral with two parallel but unequal sides). This represents the **abdomen**.
2. Draw a triangle, with the longer parallel side of the trapezium as the base pointing away from the trapezium. (And not overlapping with the trapezium) . This triangle represents the **cephalothorax**: a fusion of the head and the thorax.
3. Draw 3 L-shapes on either side of the abdomen, close to the cephalothorax. These represent the **legs**.
4. Draw 2 L-shapes, one on either side of the cephalothorax, close to the abdomen. These also represent **legs**.
5. Draw large 2 Y-shapes, one on either side of the cephalothorax, towards the middle. These represent **modified legs**, also called appendages or pincers.
6. Draw two small lines near the tip of the cephalothorax pointing away from the rest of the body. These represent the **antennae**.

Can you guess which animals you have drawn?

Organism 1: ____________________________

Organism 2: ____________________________

Organism 3: ____________________________

Organism 4: ____________________________

Organism 5: ____________________________

Organism 6: ____________________________

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These drawings are roughly meant to correspond to the following organisms:

Organism 1: cockroach (or fly)

Organism 2: millipede

Organism 3: earthworm

Organism 4: ant

Organism 5: snail

Organism 6: crab

Note: refer to the teacher notes after Task 3 for drawings of the six organisms. These are just exemplar drawings – students might draw each organism slightly differently (or in different orientations). Students can proceed to the table of features as long as they have incorporated the features from the instructions.

The exact identification of the organism is not important. Other guesses/names for these organisms might also be used for the following discussions. The discussion is easier if everyone can agree what to call each organism.

Task 3: Organize information and make a classification tree

Let us organise the information we have about these animals into a table. Here is a table to help you organize information. Look at the instructions and your drawings of the organisms to fill in the table. A few of the features have been added to help you.

Table of features								
No.	**Organism**	**No. body parts**	**Body parts**	**No. of Antennae**	**No. of wings**	**No. of legs**		
1	Organism 1 ____________	3 parts	Head, thorax, abdomen	1 pair	1 pair	3 pairs		
2	Organism 2 ____________		Head, trunk			many		
3	Organism 3 ____________	1 part	Body not divided					
4	Organism 4 ____________		Head, thorax, abdomen					
5	Organism 5 Snail		Head, body organs (in shell), foot			1 muscular foot		
6	Organism 6 ____________		Cephalothorax, abdomen	1 pair				
7								
8								

(Note: The last two columns and last few rows can be left empty for now. They will be used later).

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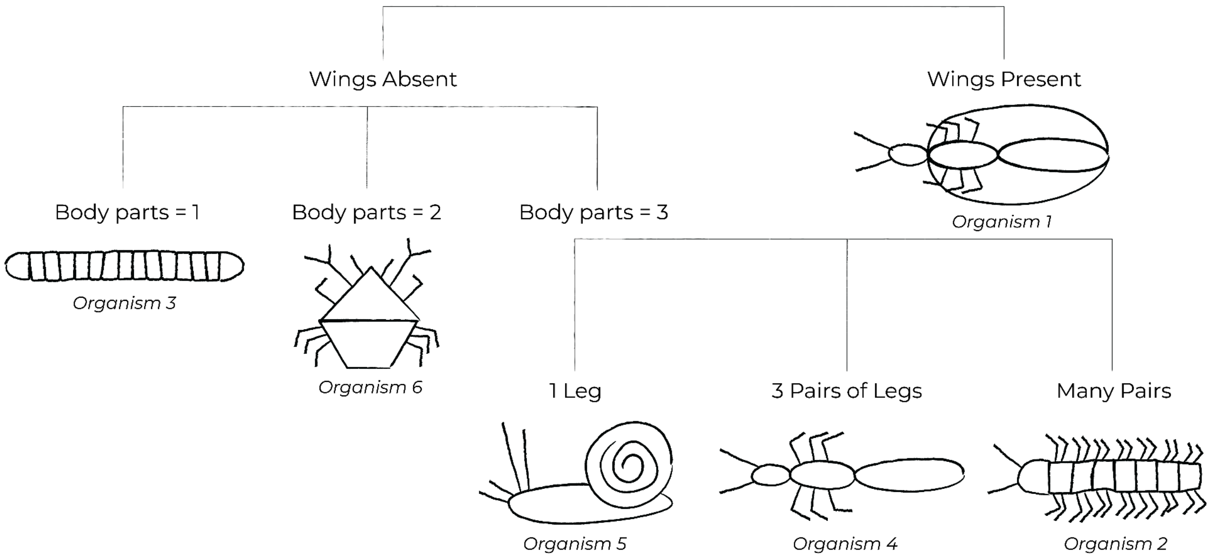
> You can start by asking students to attempt a classification tree using just the drawings. They might find it challenging to incorporate all the different features. A discussion around this may help students understand why the organisation of the information into a table of features might make the classification easier.
>
> Note that this table of features is often called a “character table” and this type of table is used by scientists to identify differences and similarities for classification.
>
> One version of the table is provided at the end of this version. There might be some differences in how students fill out the table. Again, we encourage students to discuss why / how the features might be different

Using only the features from this table, draw a classification tree of the organisms. You can choose any division feature to start the classification tree but remember that each organism, at each division, should fit into exactly one branch.

What are the features you used as divisions in your tree?

Remember, each organism can be in one, and only one, division at each stage. Your classmates might have drawn a different tree even with the same information. More information about the organisms might help us understand which tree is better.

Here is a possible classification tree.



Different students may choose different features to start the classification tree. Other students might use the same features but in a different order. Students are encouraged to draw different trees and start to discuss which they think is "better" and why.

Task 4: Challenge your classification tree

a) New information

Many years of observation and research reveal information about organisms that might not have been directly observable. For example, many animals are 'segmented', i.e. consisting of many repeated parts or 'segments'. Some of the organisms we have drawn are segmented. Sometimes these segments are easily identifiable like in the many parts of a centipede and sometimes not so visible, like the internal parts of a cockroach. Other animals like the snail are not segmented.

Organism 1 – segmented

Organism 2 – segmented

Organism 3 – segmented

Organism 4 – segmented

Organism 5 – not segmented

Organism 6 – segmented

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In a new column for "segmented", fill in this new information in your table of features.

Now, let us see how this new information looks on our classification tree.

Circle all of the animals that are segmented. Are all the animals that are segmented in one group or are they spread across groups?

> Task 4a introduces students to the situation where further scientific research can result in biological features that are beyond their physical appearances or external morphology. This new information can be used to update existing trees.

Draw a new classification tree that also includes segmentation as a feature.

What are the features you used as divisions in your tree?

How is your new tree different? In this new tree, are there other features that are split across groups?

Students can look at what are the different divisions in each of the trees and how organisms are split across them. In some cases, the same division might appear twice in the same tree. You can discuss how this might be possible. Or if there is a tree where this can be avoided.

Students can be encouraged to observe and tabulate other features of these organisms. You can then discuss how to add this feature to their classification tree. Students may also come up with features such as walking animals vs crawling animals, animals with shells and without shells and so on.

You can also use the example of the circulatory system: it can be 'open' (the blood is not enclosed in blood vessels) or 'closed' (the blood is enclosed within blood vessels). (Open circulatory system: Organisms 1, 2, 4, 5, 6. Closed circulatory system : 3.)

As students add features to their table, they can choose to draw more trees or stay with the ones they have already drawn.

Currently, biological classification trees are based not just on physical features but on many other features, most importantly DNA sequences. These sequences are used to make "phylogenetic trees" to understand how species evolve. These trees have divisions just like the trees you made, but use differences in DNA sequences as features. These types of classification trees can also be used to estimate when and how a species evolved. This is not an easy task: scientists often have many different trees based on the same DNA sequences and it is difficult to understand which one shows what might have actually happened evolutionarily.

You now have multiple trees that could represent your organisms. Select one of the trees you have drawn for the following tasks.

Are there other properties of this tree that you prefer and why? Which of your classification trees do you think is 'better' and why?

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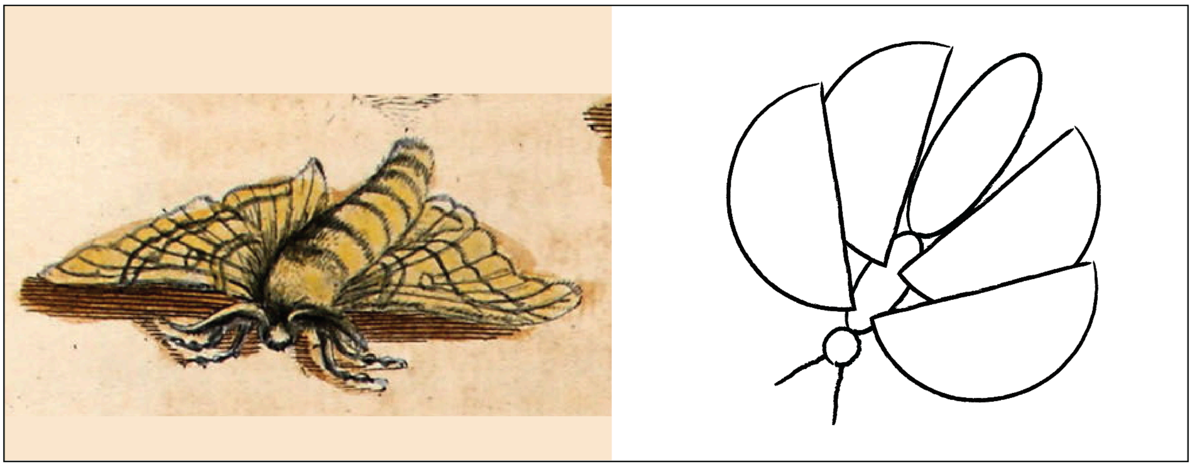
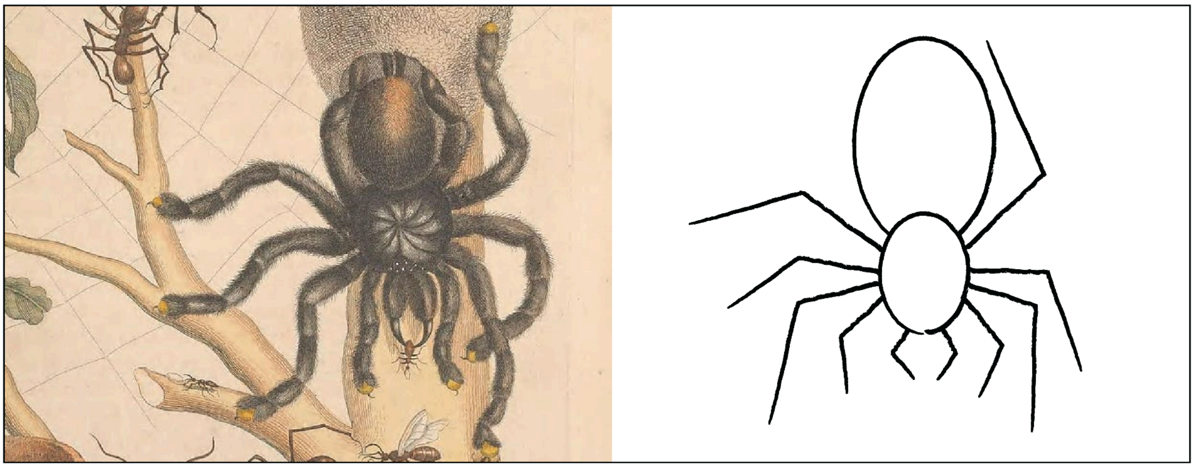
b) New animals

Maria was especially fond of the silkworms and observed and studied them in detail. Here is one of her scientific illustrations of the silkworm life cycle.



For now, let us focus on the adult form.

She also studied some spiders. Here is her drawing of a type of a big spider called a tarantula:



Look at Maria's drawings and the simplified versions to fill out the table of features.

Note that both the silk moth and spider are segmented.

Place these organisms in your classification tree.

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Did these animals fit easily in your classification tree? Did you have to make any changes / new divisions for these animals?

This Task 4b introduces students to the situation when new organisms are discovered and based on their features these organisms are placed in existing classification trees. Sometimes, existing classification schemes have to be modified to accommodate the new organism.

You can remind students of the classification levels of Kingdom, Phylum, Class, Order, Family, Genus, and Species and how new features or new organisms can change how organisms get classified at each level.

Maria made significant contributions to understanding biodiversity, ecology and classification. Long after Maria's death, a number of taxa and genera have been named after her, including recently, in 2018, a newly reported butterfly in South America: *Catasticta sibyllae*.

The Indian subcontinent is one of the most biologically diverse regions of the world. New organisms are being reported and studied all the time. For example, there is a purple frog found in the western ghats of India which was only studied, reported and named *Nasikabatrachus sahyadrensis* in 2003! This led to changes in how we understand the evolution of certain species of frogs. You can read more about it here:
https://www.saevus.in/the-purple-frog-living-in-the-shadow-of-the-dinosaurs/

A systematic understanding of such biodiversity and its classification is necessary for effective conservation efforts.

There are many more examples of new species from around the world that changed how classification trees are drawn. You can use these examples to motivate students to make their own observations in Task 5.

Here are two other examples of new species reported recently from India:

(i) Arunachal Pit viper

In 2019, a new species of snake, the Arunachal pit viper was reported by Ashok Captain from the forests of Arunachal Pradesh. This viper was named *Trimeresurus arunachalensis* and placed under a new genus Trimeresurus based on external and internal features as well as DNA analysis. Read more:
https://india.mongabay.com/2019/05/a-new-species-of-venomous-pit-viper-from-arunachal/

(ii) Parasitic plant

In 2022, a previously uncharacterised parasitic plant was reported by Lalji Singh from the Nicobar Islands. The plant was named *Septemeranthus nicobaricus*. In the case of the parasitic plant, a new Genus had to be created called Septemeranthus to account for its features.

Task 5: Observing organisms in soil

Precautions

- Wash your hands (before and) after this exercise.
- Observe insects from a safe distance: DO NOT touch them with your hands! Do not try to poke them with sticks etc either.
- Observe insects in their natural habitat: DO NOT remove them from where they are.

Please make sure students follow the required safety precautions throughout this activity.

Where to find insects to observe?

soil: under a stone
soil: a few cm under the surface
trees: under the bark of the tree
trees: in branches
garden: around flowering plants
homes: near a light at night
homes: masala box/rice/grains/kitchen supplies

Choose one of these locations (or another of your choice):

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Students can choose to observe insects in any of these locations (or others) either individually or in groups.

Draw some insects

Observe the insects carefully.
Choose 4 insects and draw them using simple shapes (like you did in Task 2)

Do any of these insects look similar to the ones you have already drawn in Task 2?

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Classify your insects:

Add the organisms you have just drawn to new rows in your table of features from Task 3. Try to identify the same features: number of legs, antennae, body parts etc.

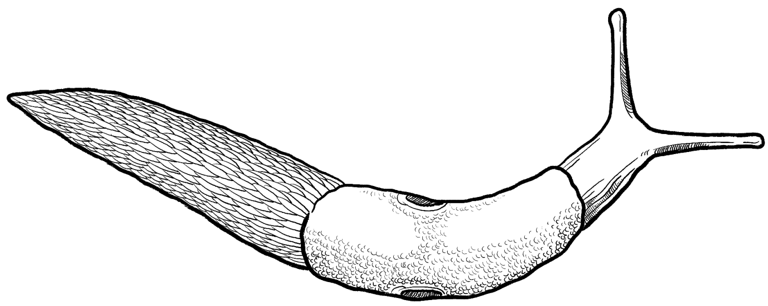
Are there any other features that you have noticed? You can add these as new columns to your table of features from Task 3.

Can you try to place these insects in your current classification tree? If you like, you can try drawing a different classification tree that includes your set of insects.

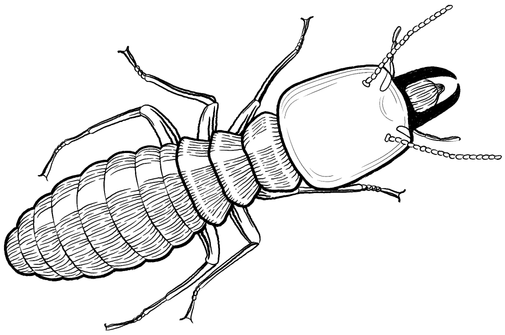
This exercise gives students an opportunity to explore diversity in their environment and observe real organisms and their features. Most features that we have used in Task 3 are easily identifiable. If you like, missing features can be added by looking up more information about these organisms.

Here are some of the organisms students might observe:

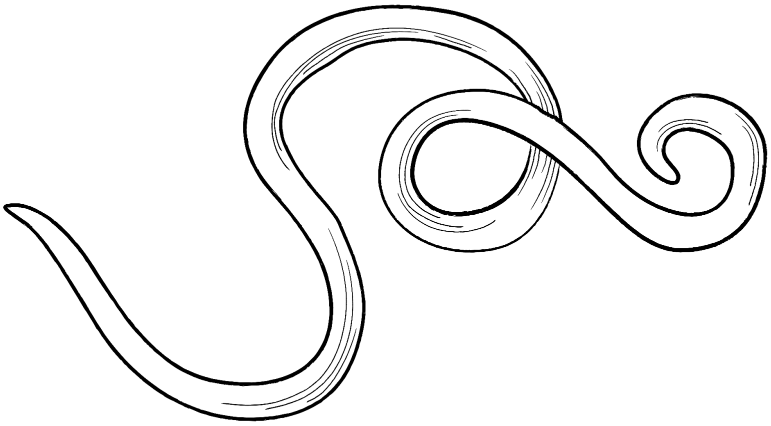
1. Land slug



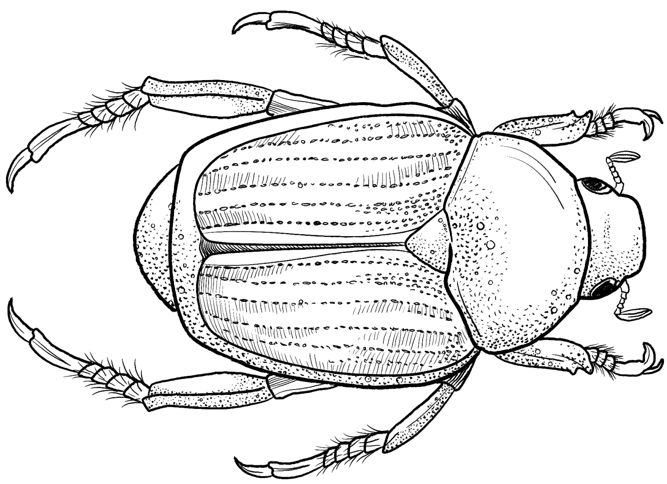
2. Termite



3. Roundworm



4. Beetle



5. Centipede

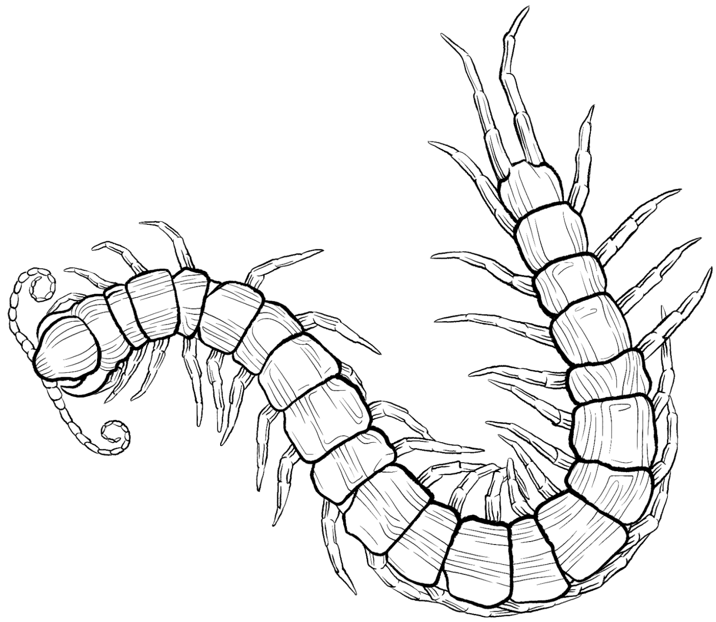


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Table of features									
No.	**Organism**	**No. body parts**	**Body parts**	**No. of Antennae**	**No. of wings**	**No. of legs**	**segmented**		
1	Organism 1 Cockroach	3 parts	Head, thorax, abdomen	1 pair	1 pair	3 pairs	Yes		
2	Organism 2 Millipede	2 parts	Head, trunk	1 pair	0	2n pairs[4]	Yes		
3	Organism 3 Earthworm	1 part	Body not divided	0	0	0	Yes		
4	Organism 4 Ant	3 parts	Head, thorax, abdomen	1 pair	0	3 pairs	Yes		
5	Organism 5[5] Snail	3 parts	Head, body organs (in shell), foot	2 pairs	0	1 muscular foot	No		
6	Organism 6 Crab	2 parts	Cephalothorax, abdomen	1 pair	0	5 pairs	Yes		
7	Silk Moth	3 parts	Head, thorax, abdomen	1 pair	2 pairs	3 pairs	Yes		
8	Tarantula (big spider)	2 parts	Cephalothorax, abdomen	0	0	4 pairs	Yes		
9	Centipede	2 parts	Head and trunk	1 pair	0	1n pairs	Yes		

[4] For organisms like the millipede, students might count the pairs of legs they have drawn or represent it as '2n' where n is the number of rectangles or say 'many'. All are acceptable responses.

[5] For the snail, some of the features on mere observation may be different from what is provided in the table here. For example, students may argue that the number of body parts should be only 2 or that the foot should not be counted as a leg

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Table of features									
No.	**Organism**	**No. body parts**	**Body parts**	**No. of Antennae**	**No. of wings**	**No. of legs**	**segmented**		
10	Beetle	3 parts	Head, thorax and abdomen	1 pair	1 pair	3 pairs	Yes		
11	Slug	3 parts	Head, body organs (in shell), foot	2 pairs	0	1 muscular foot	No		
12	Termite	3 parts	Head, thorax, abdomen	1 pair	0	3 pairs	Yes		
13	Roundworm	1	Body not divided	0	0	0	No		
14									
15									
16									
17									

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References:

1. Quillin K.,Thomas S. (2015). Drawing-to-Learn: A Framework for Using Drawings to Promote Model-Based Reasoning in Biology. CBE–Life Sciences Education Vol. 14, 1–16.
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3. Tree of life web project: http://tolweb.org/tree/
4. Gendron P. (2017). The Classification & Evolution of Caminalcules. The American Biology Teacher, Vol. 62, No. 8 (Oct., 2000), pp. 570-576.
5. The Great Indian Nature Trail with Uncle Bikky - Author and illustrator: Rohan Chakravarty and Essays by Bijal Vachharajani (Available with WWF – India: https://shop.wwfindia.org/books/the-great-indian-nature-trail-with-uncle-bikky.html
6. Scientific Illustration: https://www.fi.edu/blog/scientific-illustration-what-is-it
7. More about Maria Merian :
   https://www.theatlantic.com/science/archive/2016/01/the-woman-who-made-science-beautiful/424620/
   https://www.lannoo.be/sites/default/files/books/issuu/9789401433785.pdf
   https://www.researchgate.net/publication/256297016_Maria_Sibylla_Merian_The_first_ecologist/link/004635223822c0e3d3000000/download