## Classifying Living Organisms <br> (Ages 9-11)

Authors: Éric Nicol along with Anne Pichavant, Guillaume Lecointre, Nelly Baccala, Marie-Laure Bonnet, Christophe Lefèvre
Summary: Suggested pedagogical cues for producing, based on a small sample, a tree illustrating the ties between living organisms.

Target Concepts: Evolution of living organisms

## Preamble

By giving the children a collection of species to classify, the teacher will be able to convey a number of important conceptual abilities to the children, the first of which is classifying according to what organisms have, as opposed to what they do not have, what they do, where they live, what their use is, or any assumptions as to what they are. In so doing, he will eliminate all utilitarian classifications ("seafood"), anthropocentric ("invertebrate") and ecological ones ("burrowers", "fish") from an approach that aims to be scientific.

## Opening Questions

Being familiar with a living organism means, first and foremost, being able to answer the question, "what are its characteristics?", before moving to questions like, "how does it work?" Answering the question, "what are its characteristics?" means, in order, (1) understanding what composes an organism and what it has in common with others, (2) where it comes from and (3) where it fits in the classification. The last two questions can be answered thanks to the first. In other words, it is impossible to define, group living beings and discuss their origin without taking the time to look at what they have concretely. It would make no sense to put them in the same group based on what they do not have: what they do not have can by no means distinguish them and would not be able to testify to their origin. To substantiate this approach with the child, the following starting point can be used: knowing one another means, in part, knowing what one is made of and where one comes from. A child can be asked to attempt to describe a classmate by stating what he does not have, then make groups of classmates based on what they do not have. The results can subsequently be compared with those achieved when classmates are described and put together in groups based on what they have. Very quickly, it can be concluded that the second approach can be meaningful, while the first is not.
The objectives are, over the course of several sessions:

- to describe the species: establish the level of description and bring out the anatomical vocabulary;
- distinguish, classify, sort and order;
- bring out classification criteria to, ultimately, classify on the basis of what living organisms have;
- trigger debate where the observations made and confirmed fact are compared;
- identify organisms that fit together;
- bring out the underlying causality in what they share;
- draw a tree using the combinations;
- classify extraneous species, including fossils, in the already-established classification.

2

## 1. Observe and Describe

The first stage is the observation/description stage. For children who are not very familiar with living organisms, begin by describing animals and plants based on photos, in order to bring out the concept of descriptive assertions, then, ultimately, move toward abstraction. This is because a picture of an animal can be viewed for what it is as an individual, or as a representative of an already-assimilated taxon. For example, a robin can be seen as something unknown with a red breast, or as a bird. In description what animals may have, it can be stated that a specific cat is orange, while another is holding a skein of wool. To move toward abstraction, once those descriptions have been made, attempts can be made to sort the generalisable attributes from those resulting from specific situations, by:

- limiting size effects,
- limiting colours by using black-and-white pictures or drawings,
- distinguishing between what is specific to the animals' physical structure and that which is contingent to the photograph.

Show more pictures of individuals from a given species so that the children are later able to perceive what is specific to a species, then remove any repeat images. Ultimately, once size, colour and situation are removed from the picture, the children will be ready to describe species at the appropriate level and broach anatomical vocabulary (head, eyes, wings, hair, feathers, legs, feet, fins, antennae, etc.). The following step is to repeat the same exercise on a sample population of pre-set size, to be classified by the children.
Comment: this session will be radically different if based on an actual sample of species collected in nature. However, the objectives are the same.

## 2. Distinguish, sort, classify, order

A collection of species (figure 1: a cloth moth, two butterflies, a ladybug, a cockchafer, a beetle, a spotted-gar, a John Dory fish, a man, a rabbit, a cat, a bat, a pigeon and a chicken) is shown in the form of photocopied drawings on coloured paper. The students are asked, in small groups, to sort, classify or order the species, according to the colour of their paper: those with pink paper will be asked to sort, those with blue paper will have to classify, and those with white paper will have to order. With scissors and glue, each group will reorganise the drawings based on what they have to do. Immediately, the concept of criteria will emerge. The sorting criteria will include "has hair" or not, "lives on the farm" or not. The specimen will be ordered from large to small, or from most attractive to most unattractive.

The results are handed in and all posted. You will note that the three groups will have gotten mixed up: some will have sorted, thinking they were classifying, while others will have ordered thinking they were classifying, and vice versa, etc. The worksheets can then be handed out again, in three categories:
-those who sorted:
The species are sorted according to the presence/absence of one or more criteria. For instance, there are the species with hair (cat, bat, rabbit, man) and those that do not (the others). This activity is used in the guides to determining species, but are by no means a classification.

- those who ordered:

The same criterion is used consistently. For instance, the species were ordered from largest to smallest, or from "nicest" to "meanest".

- those that classified:

The groups are designed based on what the species have (rather than what they do not have) and the attributes are referred to as classification characteristics. The characteristics are varied and fit together. For example, amongst those with four legs, there is a sub-group with hair (in which case it is said that the characteristics are naturally ordered). Sets of species that fit together may emerge.


## 3. Classification: Criteria and Characteristics

Once the sorting and ordering have been completed the actual classification can begin. Initially, the teacher will let the classification criteria emerge, to ultimately recommend to the class that it should classify only on the basis of what the animals have.
If the classification criteria are left to emerge, this will yield a mix of heterogeneous criteria. Animals will be classified together because:

- they do the same thing ("they fly", or "they eat meat"),
- they live in the same place ("they live on the farm"),
- they are (apparently) this or that ("they are insects"),
- they serve the same purpose ("they can be eaten"),
- they are not this or that ("they do not have vertebrae" or "they do not have legs"),
- they have this or that ("they have six legs").

The teacher can let all of the criteria come out, then sort through them with the students.
If the objective is to reach a classification in relation with the organisms' evolutionary history, the teacher will have to tell the students to only classify according to what the animals have (the last of the six criteria above).
The natural tendency will be to only put together disjointed, non-inclusive sets. The second instruction can be to encourage the young classifiers to focus above all on creating sets that fit together. This boils down to prioritising the characteristics: all of the species with hair already had four legs, etc. One way of getting the children started without explicitly asking them to fit the groups together is to ask the classifiers what the animals all have. For example, they all have a head. On the head characteristic, the most inclusive group will emerge. The other groups will necessarily fit into the first.

As far as materials are concerned, the same sheets of paper will need to be cut up, and the children will have to paste the animals into the groups created. In each group, the children will discuss amongst them as to what the animals have. This discussion will lead them to look at the pictures and compare what they know about the
species. Each group of children will produce sets with specific characteristics. For example, the rabbit-cat-manbat group will combine the hair and nipple characteristics. Each group of children will be asked to draw the sets (in circles, of different colours, if necessary) and to write the characteristics next to the set. Creating set on the basis of multiple characteristics is encouraged.
If necessary, this will lead the children to rephrase their characteristics when they choose an inappropriate characteristic, and bring them back to the anatomical aspects (meaning what the animals have). For example:

- Inappropriate ("we don't say"): I am putting them together because they swim (I am classifying based on what they do);
- Appropriate ("we say"): I am putting them together because they have fins (based on anatomy);
- Inappropriate ("we don't say"): I am putting them together because they are mammals (I classify based on what they appear to be);
- Appropriate ("we say"): I am putting them together because they have nipples (based on anatomy).

At a later stage, all of the characteristics of all groups in the classroom will be read out, commented on as a group and posted on the board. For the teacher, the enlarged animal pictures can have been cut out in advance on construction paper and posted on the board using poster putty.
The sets are reassembled using all of the characteristics determined and validated by the class (figure 2).

## The characteristics are:

- (cockchafer, beetle, lady bug): elytra (wing-case).
- (butterfly 1, butterfly 2 , cloth moth): four wings.

The two previous sets: six legs, antennae, external skeleton.
Pigeon, chicken: feathers.
Cat, man, rabbit, bat: nipples, hair.
The previous set, plus the pigeon and the chicken: four legs.
John Dory, spotted-gar: ray-finned.
The two aforementioned sets: internal skeleton.
All: head, eyes.
Possibly:
Pigeon, chicken and bat: wings.
The places where the groups fit together are clear.

## Note 1:

The bat poses a problem. The children will quickly be thrown off by the fact that the bat has hair and nipples, like the cat, but also wings like the pigeon and chicken. Three options: either the bat is removed from the sample at the outset, or it is suggested that it be classified immediately, as shown here; or it is brought in once the session is over, so as to show the complicated issues only at a later stage. When one of the latter two options is taken, the position assigned to the bat needs to be explained. The rationale used will be based on the concept of parsimony. The class has selected two characteristics for placing the bat with the cat, man and rabbit, while only one characteristic ties it to the bird. It will therefore be placed with the animals for which the largest number of characteristics can be listed.


Four wings - Antennae, six legs, external skeleton - elytra ( or wing-case) - ray-finned - internal skeleton -feathers-four legs - ears, nipples, hair - eyes, head

## Note 2:

In an initial version of the sample, there was only one bird: the pigeon. The fact that the bird is the only species representing feathers is not a problem as such, and it can be deemed that it is a set on its own. If this is a problem, just add a chicken to the sample, as suggested here.

## Note 3:

The basic point of the session is to keep from classifying the animals on the basis of what they are not. Experience shows that, naturally and even without being specifically instructed not to do so, children do not classify on the basis of what animals are not. Closed groups with no scientific value, like "invertebrate" or "agnates" are "cultural pollutants" that are a problem more for adults than for the children.

## 4. Underlying Causality (the classification says something about the world)

The class can be asked why the species have things in common. The responses are:

- Because God made them that way (if the occasion arises, a definition can be given as to what is specific to scientific assertion).
- Because they are in the same environment.
- Because they make babies.
- Because they are part of the same family.
- Because they are cousins.
- Because they come from the same mother's stomach, but the mother lived in prehistoric times?

The children can be stirred to recall that their family's history, as it unfolded over a very long time, is known as genealogy. The term can, in fact, come from the class. What does genealogy entail? Ancestors.
Why are the things they have in common with another species? Because they inherited it from their ancestors, and more specifically, from shared ancestors.
As soon as the term "genealogy" is let loose, the children naturally talk about trees. Some children even say that species change. Behind the sets that fit together, there are animals changing over the course of their genealogy.

Once the key words "ancestors, "cousins", "genealogy", "transformation" or "evolution", or even "tree" have come out, all of the ingredients are there to explain that, what they have in common (and which others do not have) comes from the fact that inherited the factors from ancestors that are only common to them (meaning they are not the ancestors of other species). For example, the six-legged species come down from an animal that was the ancestor of the June beetle, ladybug, beetle, two butterflies and mite, but is not the ancestor of the others (cat, rabbit, etc.), otherwise the others would also have six legs.


## 5. From Classification to the Tree

A number of sets closely fit together depict a tree seen from above. Each set is a branch. The more inclusive the set, the deeper the corresponding branch. Two sets at the same hierarchical level are brother groups (figure 3). A series of sets, when projected into the third dimension, becomes a tree.

## From a practical standpoint:

1. either the teacher should be left to draw the tree behind the sets.
2. or a mobile shall be used.
3. or a session should be specifically planned so that the children can draw the tree themselves. In that event, a different colour should be used for each set and the corresponding branch will help visually sort through the branches. The student who drew the right tree can be asked to explain his approach, then check that no information was lost in moving from the sets to the tree.
4. or the tree for the sets drawn on the board should be displayed immediately, leaving the children to place the animals at the ends of the branches themselves, in line with the sets, an exercise that necessarily requires their understanding the link between the branches and the sets. The characteristics can then be placed on the tree branches (figure 4). There, it shall be clear that the trees and bats learned to fly twice, each on their own.

## 6. Placing a new species in the classification

It can be suggested that a mammoth be placed in the final tree. The children just have to check its attributes (characteristics) and place it accordingly: it has a head, an internal skeleton, four legs, nipples and hair. What they can see here is that the fossil will not be placed at a knot in the tree, but at the tip of a branch, like currently-living animals.


## 7. Learning New Words

The aim here is not to teach the children the exact scientific terms, but to ensure that they are capable of defining animal groups put together in the classroom:

- head, eyes: animals (or metazoans).
- six legs, antennae, external skeleton: insects.
- four wings: butterflies.
- wing case: beetles.
- internal skeleton: vertebrae.
- ray-finned: ray-finned fish (or actinopterygians).
- Four legs: four-legged animals (or tetrapods).
- Feathers: birds.
- Nipples, hair: mammals.


## 8. Conclusions and Precautionary Measures

This session helped reach a number of objectives:

- Phylogenetic classification was discussed without specific mention being made of it;
- The closed anthropocentric groups were eliminated (invertebrate, agnatha, etc.);
- An approach to classification, moving from observation to classification, was taken, rather than the opposite approach, based on pre-conceptions - when purported knowledge is projected on a perception of the living world, to confirm an often-reassuring by phylogenetically-faulty mental classification;
- it was asserted that a classification states something about the world (transformation over the course of genealogy) and the metaphor of the tree contribute to this;
- the results yielded were compatible with what science produces today.

Tens of different sessions can be invented on this model, depending on the collection of species to be classified. Species can be collected on the seaside, in the forest, along pond sides, etc., and a session of this kind designed with a limited number of samples. However, the main difficulties, for the teacher, will come from striking the right balance between the similarities due to evolutionary convergences, those that are too broadly shared amongst living organisms to serve as a uniting factor in the sample being considered, and those that testify to a true relation. In other words, the risk is that the approach can be successful and well-understood in class, all the while leading a phylogenetically-faulty classification. For instructional reasons, the balance is struck upstream, when the species to be classified are selected. Preparing such a session requires a great deal of advance documentary work: the collections of species to be classified need to be checked, to balance out the difficulties resulting from assertions that are potentially contradictory, and check that those most likely to emerge from the class are actually characteristics that will lead to a phylogenetic classification.

