Classification Unit

Classification Concepts (Classification Introduction)
A Teaching Approach That Works
by Larry Flammer

I taught using an excellent textbook (BSCS blue). To open the year (after a quick pre-test Survey on the Nature of Science), I started with selected ENSI lessons on the Nature of Science, and used parts of Chapter 1. Chapter 2 introduced the Nature of Life, using the cell as the basic unit of life, along with a brief look at selected unicellular organisms, with engaging microscope work. This was followed with Chapter 3 - The Variety of Life - showing the great diversity of life, in color pictures, then proceeded to introduce basic taxonomy as our means to bring order to our study of life. My presentation was built on that background.

Diversity - Overview of the living world: If your text offers a pictorial presentation of the typical members of each kingdom, most animal phyla (or divisions in plants), and even classes, preferably with taxa (classification levels and names) indicated, and the defining features for each taxon, take a little time (1-3 class periods) to walk through it, asking students to suggest a few other members of each category if they can. Also, this is a good opportunity to display any actual members of each taxon you can with preserved and/or (wherever possible) living representatives in your classroom, and obtained outside and locally (e.g., borrowed from local museum or university). This is mainly to reinforce any earlier experience with groupings of organisms, and to transition into the formalities of taxonomy (see below). In addition, at various times during the course, for each of the species used or mentioned in those units, I would have my students figure out its kingdom, phylum and class (or division and class of plants, e.g., monocots and dicots in the angiosperms), along with the key features of that group. The overall purpose here is NOT rote memorization of the detailed taxonomy for each species, rather it's just to get familiar with the typical examples for the major groups, and hearing/seeing their taxonomic names. Sometimes it's fun, and helpful to show a good an engaging video or three of some selected groups with unusual characteristics that students probably haven't experienced, like the diversity of fungi, algae, and other protists. Also molluscs, arthropods, cnidarians, and echinoderms.

At some point, probably fairly early in your unit (see below), have your students do the "Nuts & Bolts" lesson from the ENSI site. I consider this lesson probably one of the more critical ones on the site - for getting the true nature and value of classification right. There are several misconceptions about classification, and this lesson should help to repair those misconceptions. You may want to do one or two of the other classification lessons, as well, although most deal with cladistics and how classification reflects evolution, so you may want to do them within your evolution unit. See the Index of Evolution lessons.

Classification Outline
(See bare outline to post on PowerPoint or overhead)

A. Classification - What is it? Putting things into groups - an engaging introduction -
JUNK BOXES: I had shoe boxes of "junk" - mostly various electronic components, pieces of paper, twigs, Al foil, old pencils, nuts, bolts, etc., roughly the same mix in each box - one box per team of students (2-4 per team). Students were asked to "put the stuff into groups" or to “organize the stuff” with no further hints. After about 5-10 minutes doing that, I asked who had the fewest groups (they were called "lumpers") and who had the most groups ("splitters"), showing how subjective this was. Then I asked each group why they grouped as they did (criteria). This usually fell into a few categories: 1) appearance/shape/structure/composition, 2) function or purpose, and 3) source (mineral, or living organism). This was an excellent opportunity to focus on the fact that criteria can vary, depending on why we are categorizing, or who is doing the categorizing. Next you can ask “Which grouping method was best?” Gather a few answers, but guide a response toward “It depends - at least partly - on the purpose of the person(s) doing the grouping. You can also ask if anyone found a few items that just didn't fit into just one of their groups; usually you will have at least a few, (especially if you included some
items that were a mix of organic and inorganic components e.g., pencils with erasers.). Here you can mention that we also find some organisms that don't seem to fit into just a single category, so we will be looking for a way to effectively explain that [evolution, as it turns out, but no need to mention that, yet].

IMPORTANT QUESTION TO ASK: Is Biological Classification like classifying junk? NO! Here is where you can do the Nuts & Bolts lesson to show how the classification of organisms is very different from classifying junk (or fasteners, or furniture, etc.)

B. Why Classify Life? To make studies of organisms more efficient, and easier to communicate to others. It also helps us to see that all life forms are biologically related to different degrees (seen in the nested hierarchy of biological classification).

C. Brief History: Easy and dramatic:
1. Draw a big circle on the board, and label it "The Entire Living World".
2. Then draw a straight line down the middle --> 2 groups (labeled "plants" on left and "animals" on right) - the earliest "system."
3. Then draw an angled line from the center out to about 8 o'clock, and another out to about 4 o'clock (to look like a “Peace” sign), and erase the lower half of the vertical line (to 6 o'clock) --> 3 groups (labeled plants, animals, and protists at the bottom, comprised of mostly of fungi, algae, bacteria and former unicellular members of plants and animals).
4. Then re-draw the erased line, so you have 4 groups (4th group with monera (bacteria), labeled just to left of the midline taken from the protists).
5. Finally, draw a line from the center to about 5 o'clock , inserting "fungi" between protista and monera. Or modify this, depending on how many kingdoms are used in your text, or students are expected to learn for state standards.

From here, hand out (or display) the History of Change chart, showing how groupings have changed over time. If you like, you may want to add the 6-kingdom system, separating out the Archaea from the Bacteria in the Moneran kingdom. Then I would go to the 3-Domain system, showing where most of the original groups of organisms fit into the Eukarya, while the bacteria are split into the Eubacteria and the Archaea - and explain why they are so placed. After all of this, you should point out the system that you will be using in your class, and the reason for this (used by your text, or expected in your state standards). But they should know that they may encounter one of the other systems - or even a newer system - in biology classes later on, probably for similar reasons.

The point to emphasize here is how science is dynamic, changing its concepts and "knowledge" as new information is discovered and leads to such changes, hopefully bringing scientific knowledge ever closer to the conditions in the real world: in this case, a classification that reflects real, biological, (evolutionary) relationships. See Classification History for more details. Also, see Biological Classification online.

VIDEOS: At various points during the unit, you might show a few videos about various groups of intriguing organisms, partly to show great diversity, partly to show some amazing strategies for survival, and partly to show examples of groups of organisms that were probably unfamiliar to your students. In our chapter 2, I had already shown a film on bacteria (which they also saw alive in living hay infusions and other materials). I also showed the video Fungi: The Rotten World Around Us, and some videos from the Life on Earth series, especially part 2 (Building Bodies, with molluscs, echinoderms, worms and crustaceans). I would use whatever you have access to, and is interesting and informative about a sampling of organisms within some particular groups that are beyond the usual zoo/aquarium types that they may already know about. It's also helpful if you can have a variety of organisms living in your classroom, various plants - especially some strange plants, like algae, duck weed, Elodea, carnivorous plants, and a Bryophyllum (Kalanchoe) plant (constantly sprouts baby plants from saw-tooth leaf edges), and some unusual animals, e.g. crayfish, guppies,
African Clawed Frog (if legal in your state). Along the way, I tried to focus on several "difficult to classify" creatures, with big labeled pictures of Euglena, platypus, lungfish, Tiktaalik, Archaeopteryx (yep, be sure that they spend some time on some extinct creatures), Peripatus, etc. They will be reviewed at the end of the unit, providing a rationale and a segue to my intro to evolution.

HOMEWORK: Their homework assignments were usually to make progress on my BOQ (Biology Objective Questions) for the chapter. I have included one here for our chapter 3, plus a key (BOQ Key). I found that this helped to structure the reading of each chapter and to integrate with labs, films, demos and emphases that I presented. You might want to consider doing something like this with your text and/or your curriculum. Each day, I would have posted the item numbers in their BOQ that they should finish by the next day, usually coinciding with our day-to-day topics. Near the end of the unit, I would collect their papers and spot check their responses to certain key items, grade their papers (as homework - 5 points possible), then return them, along with the key for them to look over IN CLASS to check their own answers, and we would discuss any items of concern. This makes a very good review tool before the unit test. (I number the keys, and make sure that all are returned when we are finished, so they aren’t passed on to future classes.)

D. Universal System (KPCOFGS) introduced. I had printed MY "credentials" with each of my "names" on a different 8x30 cm poster board “card”, all attached together with tape so they fan-folded into a single compact rectangular package (about 30 cm wide). At some magic moment, I stood on a tall ladder, opened my lab coat and let my "credentials" come flowing (and unfolding - out) - down to the floor. Then I dramatically read them out aloud: k. ANIMAL - p. CHORDATE - sub-p. VERTEBRATE - c. MAMMAL - o. PRIMATE - f. HOMINID - g. Homo - s. Homo sapiens - Flammer, Larry. Always impressive (if applause is any measure!)

You might want to try a contest for the cleverest mnemonic phrase for memorizing the sequence KPCOFGS - share one or two of your favorites, then ask them to try their hands at being creative. See the Kings Play Chess file.

SPECIES: I made a strong point about the biological species concept - and the proper (and improper) ways to write the species name of an organism (underlined or italics, only first letter of genus is capitalized - see Species Definition for use on PowerPoint or overhead). Along with this, you might point out that there are actually several different ways to define a species, but we are using the biological definition. Furthermore, students should realize that it’s often not easy to distinguish whether two slightly different organisms belong to one species (perhaps as members of two varieties, cultivars, races, breeds, or sub-species) or are actually in two different species - especially if all we have are single specimens - or fossils - where we can't see if they can mate and produce fertile offspring. This difficulty can be troublesome for traditional ideas that species were specially created and are fixed, but is not surprising if species can evolve. See excellent online resources that discuss the species concept (see end of this page).

HIERARCHY: Also very important: the concept of hierarchy - best illustrated by bringing in a couple of HUGE packing boxes (kingdom level), inside which you find 2-3 slightly smaller big boxes (phylum level), inside one of which you find 2-3 slightly smaller boxes (class level), etc. I had a little fuse box with multicolored corn kernels inside for the genus and species levels (different colors of corn for different sub-species/varieties). The real trick is finding an out-of-the-way place to store the two big boxes (you could get by with one big box - as just one kingdom).

As an activity for working with the boxes-within-boxes hierarchy concept of classification, I developed my Primate Classification assignment, which would work well here. You should point out that the members of each group have more characteristics in common as you go down the outline-type hierarchy.

TREE-THINKING: At some point, perhaps in your Introduction to Evolution unit, students should see how the taxonomic hierarchy which structures Linnaean classification corresponds to a phylogenetic tree. For a link
to a useful diagram to show this, see our pages at Microevolution to Macroevolution and Classification. There is also an excellent resource for this at Phylogenies & Tree-Thinking. A common misconception related to this is the assumption that our ancestors are only our lineal ancestors - our parents - grandparents - great grandparents, etc. In reality, our combined ancestry includes our lateral ancestors, too (aunts, uncles, great aunts, great uncles, etc.). See the useful Ancestry Cartoon activity to help make this point, and also showing how this relates to evolutionary ancestry.

E. HARD TO CLASSIFY: Finally, bring up those "hard to classify" creatures "discovered" during the unit and during your survey of the diversity of life. Ask "Why don't these critters fit clearly into single groups, like most other critters do?" To help you transition from this into your intro to evolution unit, take a look at my Evolution Solution article. As a matter of fact, my primary motive for doing classification like this is to show how evolution provides the best testable explanation for these problematic species that don't fit easily into single groups.

F. CLASSIFYING vs IDENTIFYING vs KEYING OUT
Many teachers like to have their students make and/or use a key to identify particular organisms or objects as part of their classification unit. However, students often come away confusing three distinctly different processes: Classifying, Identifying, and Keying Out; they aren't the same, and this should be clearly pointed out.

Classification is the subdividing of the living world into defensible categories.
Identifying is figuring out which category a particular organism belongs to in that classification scheme.
Keying is a specific way to facilitate the identification process for a particular group of organisms in a particular region (for which the key was prepared). Typically, such a key is a dichotomous hierarchy of decisions about whether the individual has or doesn't have particular features. These features are usually just handy for field identification, and are not necessarily diagnostic for the particular taxon for which it's used. Identification can also be done using pictures of the organisms and/or their particular features.

G. ASSESSMENT: I have also attached a copy of one of my quizzes that you might find helpful.

H. CLASSIFICATION LESSONS ON THE ENSI SITE
Classification, Hierarchy, Relationships INDEX
* Making Cladograms
* Molecular Biology & Phylogeny (cytochrome-c lab)
* Why Cladistics?
* What, If Anything, Is A Zebra?
* Cladistics Is a Zip...Baggie
* Nuts & Bolts: Is Classification Arbitrary?
* Tutorial: Investigating Evolutionary Questions Using Online Molecular Databases
* What did T. rex taste like? (UCMP lesson/tutorial)
* Primate Classification

I. ONLINE INFORMATION for SPECIES CONCEPT:
Understanding Evolution - Berkeley: Biological Species Concept
http://evolution.berkeley.edu/evosite/evo101/VA1BioSpeciesConcept.shtml
TalkOrigins: Observed Instances of Speciation - discusses different species definitions
http://www.talkorigins.org/faqs/faq-speciation.html