IE Unit Plan: Mosses

Course: Biology 11
Unit: Plant Biology
Topic: Mosses and their close relatives (Bryophytes)
Number of Lessons: 4
Topic covered previously: Algae (aquatic, plantlike organisms)---4 lessons
Next topic to be covered: Ferns (the first Tracheophytes)---4 lessons

Background to the lessons/students: The students are enrolled in Grade 11 in a Canadian high school based in Nanjing, China where they are taught the BC curriculum. Most of them are 16 or 17 years old so the Imaginative Education (IE) framework that I have chosen to employ is the Philosophic Framework. I have also incorporated aspects of the Mythic and Romantic Frameworks wherever it was deemed appropriate.

The most powerful underlying idea or theory in this topic: The fossil record suggests that the first plantlike organisms (algae) arose in water about 500 to 600 million years ago. Some of these algae eventually evolved to live out of the water, at least part of the time. From these algae there eventually evolved (about 300 million years ago) two separate groups of land (i.e., terrestrial) plants: Bryophytes and Tracheophytes. The adaptations that allowed aquatic organisms to survive in dry land environments were not simple and form the crux of the evolutionary story of plants. Mosses and ferns are important "intermediates" in the evolutionary history of plants that exemplify some of the key adaptations to life on land. Indeed, the major theme I have chosen to follow for the plants unit (including this mosses mini-unit) is that the evolutionary story of plants can be represented by "adaptations to life on land" which the different types of plants exhibit. The invasion (through evolution) of terrestrial environments by once aquatic organisms will be the main underlying idea in this mini-unit.

An alternative: Plants are very diverse. For the sake of organizing the vast array of plant (and other) species, scientists have separated plants into groups using a logical, hierarchical system of taxonomy. The plant kingdom is divided into five phyla; three of them have already been discussed and include different forms of algae (Chlorophyta, Phaeophyta, and Rhodophyta). The two remaining phyla are Bryophyta (mosses and relatives) and Tracheophyta (vascular plants---by far the most diverse). Although plants are incredibly diverse, they also exhibit a certain degree of unity, as evidenced by their being placed in the same kingdom. So as we study the various differences found between species, we will always keep in mind the key characteristics that unify all plants (eukaryotes; mostly multicellular; photosynthetic autotrophs; cellulose in cell walls; starch for storage; alternation of generations, etc).

Content that exposes the scheme or theory most vividly: At the beginning of the plants unit I incorporated an aspect of the Romantic Framework in organizing a "Plant Extremes" trivia game. Students really enjoyed this and became emotionally engaged with the various fascinating and incredible plant facts that were elucidated (e.g., the biggest fruit ever produced, and yes it's a fruit, is a pumpkin which weighed in at over

1400 lbs; the most massive living thing is a Giant Sequoia tree in California which weighs more than 15 blue whales and has a trunk diameter at its base of 11m!). In order to first engage students with the topic of mosses specifically I will mention some of the fascinating facts about this group of unappreciated plants and use an eye-catching title:

"And You Thought Mosses Were Boring"

- Liverworts (wort from the Old English word for plant, wyrt; liver because they resemble the lobes of the human liver), close relatives of mosses, were the first land plants.
- Mosses and liverworts are found on all seven continents, including Antarctica
- Mosses are generally small (usually no more than a few cm in height) but the tallest species is found in New Zealand and can reach 50 cm!
- Sphagnum mosses (peat moss) can absorb from 16 to 26 times as much water as their dry weight. For example, one pound of dry sphagnum can weigh up to 26 pounds after being soaked in water! This amazing trait has led to the widespread use of sphagnum in gardens as a soil additive.
- Sphagnum's amazing ability to absorb a lot of moisture, coupled with its mild antiseptic properties, led to its widespread use as a surgical dressing during WWI.
- Mosses were used extensively in the 18th century to stuff pillows and mattresses.
- Many bird species use mosses to line their nests and thus spread the distribution of various moss species.
- Moss gardens were developed in Zen gardens in Japan thousands of years ago and are still maintained today as a major tourist attraction.

Having now caught the attention of the students and engaged them in thinking about mosses, I will use the analogy of the frog (an incorporation of the Mythic Framework) and ask students: How are frogs similar to mosses? Students will work in pairs to write down the various similarities (both need to live near water; both can be seen as part water, part land organisms; both are usually green, etc.) and then we will discuss these similarities as a class. We will develop the metaphor of mosses as the "amphibians of the plant world."

After using these proverbial "hooks" I will show students some living examples of moss plants, and let them observe the mosses and feel them with their own hands. I will then show students the algae that they have previously observed. How are these two types of organisms different? Students will eventually be led to discuss the increasing complexity of the mosses as opposed to the algae and how this represents an evolutionary continuum of adaptations to life on land.

Students then brainstorm the various challenges faced by land plants that do not affect aquatic plants. Since I have alluded to these in the section on algae, students should already be aware of some of the key challenges (cells above ground need water to be supplied to them; parts of the plant that make food need to be supported in the air so that they receive sunlight; water and nutrients moved upward, while food, or products of photosynthesis, moved downward; respiration, or gas exchange, must occur without the

excessive loss of water; reproduction must occur in areas where sperm cannot swim; zygotes and embryos in danger of drying out, etc). Of course, mosses are still a kind of "intermediate" form such that they need to be in moist environments and require water for reproduction to occur.

Content that will present a strong meta-narrative of the topic: I will then focus in on the key characteristics of mosses, providing lecture notes to students, and comparing and contrasting mosses with algae. Mosses (and ferns, which will be the next topic) can be seen as an "intermediate" step in the evolutionary history of plants between water plants and land plants. Alluding back to our frog analogy, we can refer to them as the "amphibians" of the plant world. The key similarities with algae that will be stressed are that both types of organisms are non-vascular, both lack true leaves, stems, and roots, both exhibit similar stages in their life cycles (students must learn the stages of the moss life cycle), and both need to be close to water. The key differences are that mosses live on land in shady habitats, need to be relatively small and often crowd together, have root-like structures that slowly conduct water (rhizoids), have leaf-like structures that don't conduct water but can trap it, and have a waxy cuticle on their outer surface.

These differences are all key adaptations that moss ancestors have developed over millions of years to be able to live on land, something algae simply cannot do for any extended period of time. We will discuss how another family of organisms (Tracheophytes) has adapted to such a dry, and in many ways "hostile" environment, in later lessons. Students should be able to compare and contrast the life cycles of mosses and ferns, which provide a succinct summary to the different evolutionary paths followed by Bryophytes (haploid gametophyte dominant) and Tracheophytes (diploid sporophyte dominant). We can then compare the similarities and differences in the adaptations exhibited by these two groups of land plants, and thus illustrate the increased complexity that accompanied the movement of plants from water to land near water, and later to land that is relatively "dry."

In addition to focusing on the incorporation of mosses into the evolutionary story of plants in general, I must also include features of mosses that are important to the other themes I am developing in this course. The ecological role of mosses will be discussed (habitat for many small creatures; involved in first stages in rebuilding soil, as a part of the succession process, etc) as well as the way mosses are used for human benefit (soil conditioners, peat, etc).

Main anomalies to the meta-narrative: Evolutionary theory represents a foundation on which the rest of biological science is built. Most people now accept as fact that evolution has occurred, that is, species have changed over time. *How* this change has occurred is not completely certain and various theories have been provided. We have already completed the evolution unit in this course and students are familiar with evolutionary theory. The evolutionary story of plants is a part of the evolutionary theory that suggests that all organisms are related to each other through evolution and more recent species have descended from ancient ones. Students will be asked to recall the key concepts in evolutionary theory and reanalyze its application to the various kingdoms we have

already discussed (Monera, Protista, Fungi, and now Plantae). We will also touch on some Kingdom Animalia examples that will provide more relevance and hopefully interest, considering our own place within this kingdom.

But nobody can claim for certain that the evolutionary story scientists have outlined for plants is what actually happened. Students will be asked to come up with potential anomalies to the theory presented thus far. For example, how can we be certain that algae were present before land plants considering the paucity and discontinuity of the fossil record in the plant world? Are the characteristics exhibited by mosses actually adaptations to life on land or do they serve some other purpose? Are these separations of plant groups valid considering they are based on such vague distinctions such as "possessing leaves" versus "possessing leaf-like structures", or "roots that conduct water" versus "root-like structures that slowly conduct water"? Later in the plants unit, students will also consider the plausibility of the currently predominant theory that mosses evolved separately from the higher plants and do not represent an intermediate form between algae and ferns.

Indicate the alternative theories or meta-narratives that will be used: Having rehashed evolutionary theory and its anomalies, students will be asked to come up with alternative explanations or time frames as to how plants have come to occupy most habitats on earth. For example, students may be skeptical about the time periods suggested for the evolution of the different groups and suggest that perhaps mosses evolved before some forms of algae and the evolutionary story is actually the reverse, namely adaptation of algae from a land plant ancestor to life in water. Or perhaps some students may support the creationist arguments that oppose the ideas of evolutionary theory. The creationism versus evolution debate is a highly controversial one in many schools today and it would be prudent to analyze both sides of the argument. At the very least, from a scientific perspective, analyzing this debate will clarify for students the many assumptions which evolutionary theory is based on. Since we have discussed the general beliefs of both creationists and evolutionists in some detail during the evolution unit, the lesson can involve a mock "town hall meeting" debate, with students choosing a side and coming up with logical arguments to support their particular perspective.

List areas in which students' sense of agency can be engaged and encouraged: As I discussed previously, I include the ecological significance of all the living things studied in this course, and mosses will be no exception. Students will be able to see that these small and seemingly insignificant plants are in fact very significant in a variety of moist land environments and as pioneer species. Environmental awareness is fostered through this stress on the ecological interrelationships of all living things with the hope that students will understand the importance of sustaining the delicate ecological balance on our planet. Once students are able to grasp the significance of organisms such as algae (50-75% of all photosynthesis done by algae!) and mosses to sustaining life itself, they are more likely to base their future actions on the ethical imperative of providing a sustainable future for subsequent generations of all living things.

The economic importance of mosses to humans will also be analyzed so that students are aware of human activities that are directly related to this group of organisms. For example, sphagnum moss, which decomposes into peat moss over time, is used extensively by gardeners to help the soil retain water and to decrease soil pH. Other types of mosses have been used for medicinal purposes (Native Americans used them to treat burns and bruises), still others ("peat") have been used as a fuel much like coal, and sphagnum moss is also burned by brewers with the smoke produced giving Scotch whisky that "smoky" flavor.

What concluding activity will help to both support and show problems with students' theories, ideas, meta-narratives, ideologies, etc.: An activity which seems useful here is to compare and contrast the evolutionary stories for the different living things we have considered so far in the course (bacteria, protists, fungi, plants, some animals). Are their analogies to the "adaptations to life on land" pattern in the other kingdoms of living things? There definitely are in the animal kingdom (e.g., amphibians, reptiles) but not so much in the other kingdoms, an observation that can be elaborated on. Students also reconsider whether evolutionary theory itself is the only possible explanation for species change over time.

Furthermore, students can revisit some of the details learned during the evolution unit and discuss the contradictions and uncertainties that exist in terms of how scientists believe evolution occurs (Punctuated Equilibria Model versus Gradualism). Which of the ideas is most consistent with the evolutionary story of plants as pertaining to the evolution of mosses from algae ancestors? After covering other topics (ferns, gymnosperms, angiosperms) we will ask these same questions all over again. How have our ideas changed throughout this unit? How have ideas changed regarding this topic throughout human history? Can we be certain about what we believe now? These are the kinds of questions that will be asked of students to plant the seeds of Ironic understanding.

Forms of evaluation: Since these students are ESL students, a major hindrance to learning this material is first understanding the vocabulary terms involved. Therefore, I will continue with my weekly vocabulary quizzes and give a "mosses vocabulary" quiz in the third lesson. Since there will be significant discussion of how the evolution of plants ties into evolutionary theory as a whole, students will be asked to write a short essay on how they believe early land plants (and specifically mosses) evolved. In these essays I will be looking for evidence that students have understood the essence of evolutionary theory, have comprehended that it is just a theory and not an undeniable truth, and have elaborated on the theory in light of the anomalies we came up with as a class. Students must also answer comprehension questions during and after each lesson to show me that they have understood the material. There will also be a quiz at the end of this mini-unit which will test students' understanding of the moss life cycle.

At the end of the Plants Unit there will be a unit test which will test students' knowledge of the various plant groups (including mosses), as well as their ability to understand and apply related evolutionary and ecological principles. During the next mini-unit, which will involve ferns, students will perform a lab which will allow them to observe first-

hand the key differences between ferns and mosses, and mainly the fact that of these two plant groups, only ferns possess true stems, roots, and leaves. Following the mini-unit on ferns students will also work in pairs on an “Adaptations to Life on Land” poster which should summarize the major evolutionary advances observed in plants as they moved from water to land.