Introduction

This past summer, using FX Palo Alto's ENJI software, I designed a multi-channel interface that illustrates the interconnect nature of the biological and physical world.

The students will use either a computer lab or in-class laptop computers to access the software.

This lesson is designed to help students understand the interconnectdness of the biological and physical word. The students will make observations, record their observations in a "field notebook," describe how the organisms in the forest are dependant on each other and the physical surroundings, taxonomic classification, and energy flow.

The software will be used in conjunction with the ecology unit covered as part of my AP Biology course at Ann Sobrato High School. I anticipate using three or four days to allow students to fully explore the ecosystem.

Evaluation will be through a written field notebook an the normal quiz / exam structure incorporated into the course.

Philosophical Background

One of the principle questions that faced biology as a young science (1800's) was that of the nature of species. Not so much in terms of definition, indeed the biological definition of species depends very much on the particular organism under scrutiny, but in the fixity of species, that is, were species somehow created and remain unchanging through time, or are they dynamic and plastic entities that respond to the influence of their surroundings through both time and space.

Charles Darwin is largely credited, along with Alfred R. Wallace, with providing a plausible mechanism for organisms to respond to their environment (as species) and make adjustments as the environment changes. That mechanism is called natural selection.

In the 1900's, especially after the 1950's, biology shifted from a cataloging approach (although that task is still very much unfinished) to one of examining the interactions among different organisms and organisms with their environments. This endeavor is called ecology.

Ecology then is study of interactions, of relationships. Those interactions occur at many organizational levels simultaneously. At any given instant in any biologically active region on Earth, interactions happen from the sub-atomic to the planetary level, and beyond. In ecology, for the most part we can restrict our focus from the chemical to the global, but none the less, that still includes a vast, almost intangible quantity of potential data.

The chemical / atomic level of interactions include:

- photosynthesis
- respiration
- chemical cycles

The cellular level of interactions include:

- membrane transport
- reproduction
- genetics

The organisml level of interactions include:

- feeding hierarchies
- reproduction
- acclimatization
- evolutionary change

The environmental level of interactions include:

- biogeochemical cycles
- temporal cycles
- global level fluctuations and changes

Of course, all of these levels have components and influences both on and from all of the other levels in one way or another and with different magnitudes. For example, the biogeochemical (the term alone tells the story) cycles really occur at all levels. Carbon, CO_2 as a gaseous component of the atmosphere, can be studied at the global level, its fluctuations and movements (shifts through space and time) related to changes (both cause and effect) occurring within the biotic portion of an ecosystem. The movement of the carbon can be followed (via feeding hierarchies, i.e. autotrophs and heterotrophs) through the organismal level as well; but of course, carbon can not be studied this way without looking at least photosynthesis, respiration, and protein synthesis. That naturally requires examination of the compounds formed and required by these processes, i.e. carbohydrates, proteins, nucleic acids, and so on. From here we quickly learn about covalent bonds, hydrogen bonds, ions, electrons…

Ideally, students would study all of these levels observing a balance between field and laboratory work; observing and measuring data, analyzing those data, modeling and predicting scenarios, and evaluating practice. A multichannel computer interface would be an indispensable tool for achieving this goal.

I think the most significant and powerful aspect of biology / ecology education is a unification of the levels, understanding of their interdependency and interconnectedness as a basis for understanding our species position in and influence on the biosphere.

Practice

The basic ecological concepts involving material cycling and energy flow, abiotic and biotic interactions, food webs, reproductive strategies, etc., are already familiar to the students from conventional class-room instruction and activities. The multichannel interface allows students to layer these concepts simultaneously providing them opportunity and help in perceiving the interacting nature of these phenomena.

Using the “notebook” allows / encourages students to record their observations and questions as well as the answers to those questions as the student continues her / his investigations.

In addition the instructor has access to the notebooks for assessment and feedback through the local network.

The interface allows a student to explore a community and witness some of the interactions occurring “behind the scenes”

By exploring the primary image with a cursor students will find several types of interactions;

“mouse-over” sounds or text messages provide clues for further exploration.

The Interface and its development

Physical location of
Tikal

opening_scene

This is the opening scene, what the student first sees upon entering the program. The image is from Tikal, the Mayan ruins in the Peten region of Guatemala.

Green text are heading appropriate to those columns

Yellow text are terms appropriate to those columns arranged in a hierarchal list from top to bottom.

There is a “hotspot” on the *Sabal mayarun* palm tree lead from “opening_scene” to “scene_one”

Simultaneous hierarchical events

I identified six “hierarchies that were incorporated originally in my conceptualization

structural
material
energy flow
ecological
taxonomic
genetic

I arranged these so that the individual (human) level
Is maintained at the same relative position in terms of size and then allowed the larger and smaller (or, more and less inclusive) categories to take up parallel and adjacent positions in a tabular form

structural	**materials**	**energy flow**	**ecological**	**taxonomic**	**genetic**
		sun			
	geological	atmosphere	biosphere	life on earth	
			ecosystem	kingdom	species
				phylum	
				class	
			community	order	population
				family	
				genus	
individual	biological	individual	individual	species	individual
cell		cell			cell
organelle		chloroplast			
pathways		photosystems			
molecule	chemical	atp			DNA

This chart serves as the conceptual starting point for the multi-channel structure of “Tikal.” The hierarchical position of the student within the ecosystem is monitored in this format.

The concepts within ecology can be arranged in various hierarchal patterns.

I used this idea along with one involving these hierarchies occurring in a simultaneous and parallel nature as a foundation of my project.

My approach was to attempt to show parallel hierarchies occurrence and hopefully, some degree of their interaction.

How it looks in the classroom

1) demonstration / exploration

Initially students will need guidance with the interface. There is a definite pattern to the layout of the screen; each channel does not necessarily display the same "type" of information.

2) task / assignment

3) field project (application)

4) presentation / modeling

Definition of ecology from wilkipidia

The interactions can be mentioned and explained but require time and thought to "see"

Normally shown through graphs like predator / prey relationships

Introduce the idea that the natural world can be viewed with a "layered" structure defined by size regimes (and inclusiveness according to human classification schemes) starting with molecular…

Powers of 10

Then the "organismal" level, the place where we live out our daily lives, most of us anyway…

The level where the interactions from previous levels

These are "levels" bigger than we are, not yet in Tikal

There are alternative ways that life can be "organized"

This was the most important concept that I developed this summer

This is pretty much what I used to conceive Tikal

This, the interactions, is where the most room for growth lies

On to examples of hierarchies

These came out of my first thoughts and power point work

It seemed natural that the interaction of the students with the program begin at the “human” level.

This chart is very close to the first ones that I used in the power point version of the presentation that I developed initially. In the ENJI version, several of the categories were left out, mostly due to the desire to reduce the amount of text based information.

Most of the creatures are not obvious from our casual human perspective

Power point was useful for me since I had a reasonable familiarity with the program. It was fairly easy to work out some of the basic concepts there.

Flash seemed too have too steep an initial learning curve and it made more sense to get on with ENJI

1st impression

I like the look of the screen… let specific channel do specific job

Hot spots work well, lots of potential with hot spots in video

I found that once there were a few similar looking images placed into the basket that some sort of “sub-directory” structure would have been very helpful

Continue with oxygen, who eats who etc…

Also continue to ecological hierarchy

California State Content Standards for Ecology

6 Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:

a Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

b Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

c Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.

d Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

e Students know a vital part of an ecosystem is the stability of its producers and decomposers.

f Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.

g * Students know how to distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.