

The Development of an Environmental Literacy Learning Progression: Biological Diversity in Environmental Systems

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ENVIRONMENTAL LITERACY

Biological Diversity within Environmental Literacy

Environmental science literacy is the capacity to understand and participate in evidence-based discussions of the effects of human actions on environmental systems, and the feedback from those systems on human societies.

"By changing global climate, expanding and intensifying land uses, polluting, introducing exotic species, and over-harvesting biological resources, human activities have accelerated extinction rates massively. The biotic consequences of these factors . . . are apparent in progressive degradation of ecosystem services upon which humans rely."

Kerr et al., Science, vol 316, 2007, p1581.

The **decisions** that citizens make with respect to the **intersection between society and biodiversity** are wide-ranging, and include actions in roles such as:

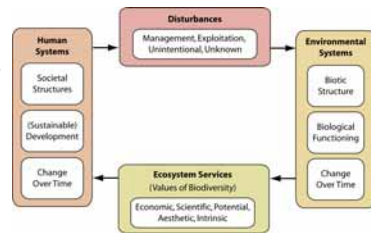
- **Consumers** – e.g. decisions about the provenance of one's food.
- **Voters** – e.g. for land use policies such as ANWR or for biofuels.
- **Workers** – e.g. decisions relating to commuting.
- **Volunteers** – e.g. at farmers markets or conservation societies.
- **Advocates** – e.g. for local issues, such as the preservation of natural areas.
- **Learners** – e.g. as viewers of nature documentaries.



A quick browse through recent covers of TIME magazine shows headlines such as "Forget Organic, Eat Local" and others relating agriculture and biodiversity with climate change and pollution; illustrating how the intersection between environmental science and society has entered the forefront of everyday life.

The Upper Anchor

To the right is the (modified) LTER loop diagram, with the upper anchor being largely situated in the environmental systems box, but organized in such a way as to allow students to connect the arrows. The loop diagram illustrates the connections between human systems and environmental systems as 1) human actions that have environmental impact, and 2) human societies' utilization of ecosystem services.



A Framework for the Environmental Systems portion of the loop:

1. Principles: Tracing Information across a hierarchy of systems.

2. Processes

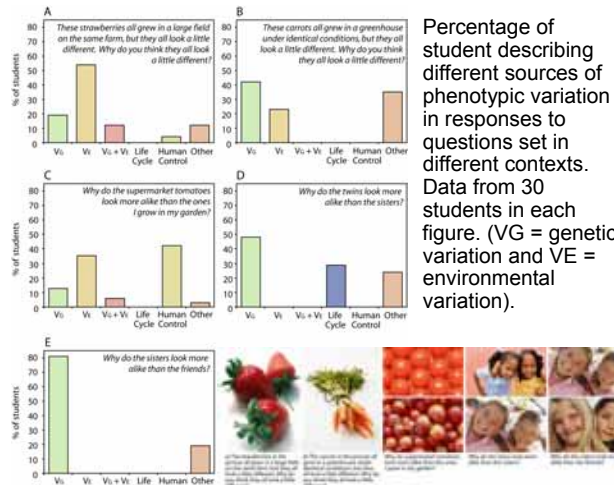
	Processes within Populations	Processes within Communities
Processes that create biodiversity	Mutation, sexual recombination.	Colonization by new species.
Processes that sustain biodiversity	Life cycles, reproduction.	Relationships between populations.
Processes that reduce biodiversity	Natural selection, human selection.	Natural succession, Human management.

- ### 3. Change over Time:
- In natural systems, these changes include evolutionary changes and ecological succession. In coupled natural and human systems, they become:
- **Reduction of genetic diversity in populations and species.**
 - **Reduction of species diversity in communities** (including extinction).

Levels in Student Reasoning

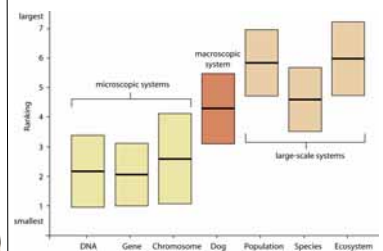
Level	Structure of Systems	Tracing Information	Change over Time
	If a scientist wanted to measure the diversity of species in a given area, what types of data might she collect?	a) The strawberries in the picture all grew in a large field on the same farm, but they all look a little different. Why do you think they all look a little different? b) The carrots in the picture all grew in a greenhouse under identical conditions, but they all look a little different. Why do you think they all look a little different?	Farmers often use pesticides to help prevent insects from eating their crops. Over time, the insects slowly become resistant to these pesticides, and so the farmers have to use different pesticides to protect their crops. Tell a story about how the insects become resistant to the pesticides.
Level 5	Different species of organisms; Population of each species; Total number of organisms; Percentages of each species. (SSD)	a) The strawberries look different because when they pollinate or reproduce they are coming from different parents and are given different genes. Also things such as minerals and water will also affect them. b) They all look a little different because they were given different DNA codes. Just like kids are not the same even from the same parents. (NED)	When the crops are sprayed some bugs are killed but some may live and when the living mate they will give their kids genes to help them survive through the pesticides so the bugs adapt to the pesticides and because the bugs reproduce fast and don't live long it doesn't take long for them to adapt to the pesticides. (NED)
Level 4	# of each animal; # of types of animals; how many predator and prey animals are in the area. (WMM)	a) Because they probably came from different parts of the field where conditions might be different like water type and amount, crowded or not, how much sunlight, and the soil difference. And combinations of the conditions. b) Their genetics. (HAP)	As the bugs live in and around these pesticides, their immunity to it becomes stronger, and this immunity becomes stronger as they pass them down to their young in genes. (EET)
Level 3	The different kinds of living things in an area. The most has the most diverse population. (CJW)	a) They all look a little different because they may not have had the same nutrients or sun in certain parts of the field. b) The light in the greenhouse wasn't reaching everywhere. (CEM)	The insects eventually become immune to the pesticides because when one insect takes it in, then they reproduce there is already pesticides in the offspring so they are used to it and the pesticide doesn't really affect them. (EAT)
Level 2	Narrative descriptions of systems at the macroscopic scale	a) The light could have been different, some could have had more sunlight than others. b) Maybe they were different kinds of carrots. (KAV)	Their bodies try to fight off the pesticides. Once they figure out how to fight them it's easy for them to fight so the pesticides no longer work. (EDE)
Level 1	Anthropomorphic and natural tendency narratives	a) All plants are different. No two are the same. It's impossible to have two of the same plants. b) Like I said above. No two "carrots" can look the same! (SS)	Insects become resistant by they get used to the smell and taste and eventually it doesn't bother the insects. (KKC)

Assessment Data



Percentage of student describing different sources of phenotypic variation in responses to questions set in different contexts. Data from 30 students in each figure. (VG = genetic variation and VE = environmental variation).

Put the following items in the boxes below, going from the smallest to the largest. **Population, Gene, Species, DNA, Ecosystem, Dog, Chromosome**



Mean student rankings of each system (black bar) plus and minus two standard deviations (colored blocks).

Center for Curriculum Materials in Science (CCMS)

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