Friday 27 January 2006, 7th class meeting
(Miller Chapters 2, 3, 4; Leopold)

Environmental Biology (ECOL 206)
U. Arizona, spring 2006
Kevin Bonine, Ph.D.
Alice Boyle, Kristen Potter, Graduate TAs

1. Thank Kathy Gerst
2. Energy, Ecosystems, Cycles
3. Ishmael for lab this week, mostly outside next week
4. ECOL 206 Website for handouts and assignments (bring small notebook and 3-ring binder to lab)
5. Read Dillard excerpt available on course website (for Wednesday)

EVOLUTION: A Series of Seven Lectures Exploring our World and Ourselves

Location: Center for Creative Photography Auditorium, 1010 North Olive Road
Parking is available in the Park Avenue Garage

Time: All lectures begin at 7:00 pm

All the sciences, from astronomy to biology, have worked together to discover the processes that create the current state of our universe, our world and ourselves. These evolutionary processes define the origin of the atoms that make up all matter, the origin of stars and planets, and the development of life itself.

The University of Arizona College of Science is proud to present these seven lectures. Each will illustrate this vision of evolution and demonstrate how we know that evolution represents reality.

Tuesday, February 21. Biological Evolution: What It Is and What It Isn’t (Joanna Masel, Assistant Professor, EEB)
Tuesday, March 7. Cosmic Evolution: From Big Bang to Biology (Chris Impey, Distinguished Professor, Astronomy)
Tuesday, March 21. Earth Evolution: The Formation of Our Planet (Joaquín Ruiz, Dean of COS and Professor, Geosciences)
Tuesday, March 28. Social Evolution: Cooperation and Conflict From Molecules to Society (Rick Michod, Professor, EEB)
Tuesday, April 11. Animal Evolution: Recycling Ancient Genes For New Uses (Lisa Nagy, Associate Professor, MCRB)
Tuesday, April 18. Human Evolution: Tracking Our Origins with DNA (Michael Hammer, Research Scientist, ARL/EEB)
Tuesday, April 25. Disease Evolution: The Example of HIV (Michael Worobey, Assistant Professor, EEB)

Call 520.621.4090 or go to cos.arizona.edu for more information.

Current Environmental Events

Energy Transfer

- Photosynthesis (Producers vs. Consumers)
  \[ \text{CO}_2 + \text{H}_2\text{O} + \text{energy} \rightarrow \text{Glucose} + \text{O}_2 \]  
  \[ \text{(sun)} \]  
  \[ \text{(C}_6\text{H}_{12}\text{O}_6) \]  

- Aerobic Respiration (Producers and Consumers)
  \[ \text{Glucose} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{energy} \]  
  \[ \text{(C}_6\text{H}_{12}\text{O}_6) \]  
  \[ \text{(ATP)} \]
Primary Productivity (kcal per m² per year)

Humans use >27% earth’s NPP

Some Laws

- Law of Conservation of Matter
  all atoms conserved
  there is no “away”

- First Law of Thermodynamics:
  energy neither created or destroyed, but may be converted from one form to another

- Second Law of Thermodynamics:
  when energy changed from one form to another, some of the useful energy degraded to low quality, dispersed, less useful energy (usually lost as heat)

Ecosystem Cycles

Decomposers

~10%
(soil formation takes ~15-1000 years)

Soil Organisms

**Rhizobium spp.**

- Nitrogen is a limiting factor in soil
- Atmosphere comprises 78% nitrogen
- Atmospheric nitrogen (N₂) very stable
- Only prokaryotes (not eukaryotes) reduce N₂
- Efficient nitrogen-fixing systems couple the energy intensive chemical reduction of molecular nitrogen to photosynthesis.

Mutualism between eukaryote and prokaryote:
- Plant provides source of energy and an ecological niche for the bacterium, which in return synthesises ammonia for the host plant.

At the global scale, the Rhizobium-legume symbiosis provides a quantity of fixed nitrogen equivalent to that produced by the entire chemical fertilizer industry.

Roots of soybean and alfalfa plants, with symbiotic Rhizobium bacteria, help keep soils healthy and fertile.

Applications for clean up of contaminated soils:
- Toxic chemicals like TNT or toluene (ingredient in fuel and dyes).

Genetic engineering?

**Soil Types...**

Life on Earth:

1. Energy flow
2. Cycling of Elements
3. Gravity
Please form six groups and take about 5 minutes to put your cycle on the board.

Feel free to use your text book.

Then explain it to the rest of the class.

1. Rock
2. Phosphorus
3. Carbon
4. Water
5. Oxygen*
6. Energy*

Biogeochemical Cycles:

Nutrient atoms, ions, compounds needed for life cycle between abiotic and biotic.

- Water
- Oxygen
- Carbon
- Phosphorus
- Nitrogen
- etc.

Carbon Cycling

- Photosynthesis (Producers vs. Consumers)
  \[ \text{CO}_2 + \text{H}_2\text{O} + \text{energy} \rightarrow \text{Glucose} + \text{O}_2 \] (sun) \( (\text{C}_6\text{H}_{12}\text{O}_6) \)

- Aerobic Respiration (Producers and Consumers)
  \[ \text{Glucose} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{energy} \] \( (\text{C}_6\text{H}_{12}\text{O}_6) \) (ATP)
Carbon Cycle (Marine)  
Figure 2.25  Miller, 2003

Carbon Cycle (Terrestrial)  
Figure 2.25  Miller, 2003

Water Cycle  
Figure 2.24  Miller, 2003

1. Rock
2. Phosphorus
3. Carbon
4. Water
5. Oxygen* (how related to Carbon cycle? where limited?)
6. Energy* (→one-way→)

Aldo Leopold 1949  
A Sand County Almanac  
Thinking Like A Mountain

- Mountain
- Deer
- Wolf
- Carrying Capacity
- Time
- Human hubris

Leopold

Thinking like a mountain
"a mountain lives in mortal fear of its deer"

"trimming the herd to fit the range"

Scale in both space and time
Aldo Leopold Land Ethic

- **social evolution** (social disapproval for wrong actions)

- human as plain member and citizen, not ruler

- Conquerer self-defeating because falsely thinks s/he understands how the system works and can control it

Evolution of rights...

- monarchs
- white males
- "all men"
- humanity
- sentient beings
- nature

“A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise”

Aldo Leopold

“Whether you will or not
You are a King, Tristram, for you are one
Of the time-tested few that leave the world,
When they are gone, not the same place it was.
Mark what you leave.”

As quoted in Leopold, 1949
p. 261 (The Land Ethic)