Did you enjoy Planet Earth? I sure did!

OK, now the real lecture . . .

Communities and Ecosystems.
Let's get some more definitions down.

* From before... population - a group of organisms of one species occupying a geographic location at the same time, such that they can potentially interbreed.

* And another variation of... community - a group of interacting populations that inhabit the same region (habitat).

* Biotic - living organisms, versus abiotic.

* Ecosystem - includes all the biotic plus abiotic, or nonliving, components of a defined area.
Habitat – the physical location where members of a population typically live.

This one’s new . . .

Niche – total of all the resources a species exploits for its survival, growth, and reproduction. Therefore, . . .

Habitat is a subset of niche.

There can be many niches in an ecosystem.
Even a rotting, fallen tree branch can be an ecosystem containing a rich community of microbes, fungi, insect larvae, worms, mosses, lichens, algae . . . .
Coevolution

Some connections between species are so strong they result in coevolution.

This is the phenomenon where genetic change in one species selects for subsequent change in the genome of another species.

We’ve already talked about some examples of this, e.g. that between a specific pollinator and a specific plant, and even endosymbiosis is a type of coevolution.

We also saw it with that special spider and the Pitcher plant in Planet Earth.

And the Red Queen arms race relationship between parasites and hosts that may have contributed to the evolution of sex is another example.

http://en.wikipedia.org/wiki/Coevolution
Competition, not the human sports sort.

- Competition occurs when two or more species each need some limited resource.
- The competitive exclusion principle states that two species cannot coexist indefinitely in the same niche. Something’s gotta give.
- Species that acquires more resources will replace the less successful species.
- We saw this in the example in *Planet Earth* when the tree fell down and all sorts of plants competed for the limited sunlight that could now reach the forest floor, and also with all the monkeys competing for figs in the canopy.
A striking example often cited concerns barnacles.

When *Balanus* is absent, *Chthamalus* grows everywhere. But when *Balanus* is present, they outcompete *Chthamalus* in the moister habitat; however, the other species does just fine in the slightly drier upper intertidal zone.
However, . . .

* Species with similar needs can (and do) coexist in communities.
* We saw this with the monkeys in the jungle as well. They were a great example of . . .
* Resource partitioning – multiple species use the same resource in a slightly different way or at a different time, yet all in the same place.
* A well known classic example are Warblers in a mature coniferous forest.
* Birds of each species feed in different ways and on different parts of the tree.
Here’s the Warbler example. Each bird has a different preference for its primary feeding zone.
Symbiosis – one species living in or on another

- Again, you’ve seen many of these already!
- Mutualistic – both partners benefit. For example . . .
  - Cow and cellulose-digesting microbes in their gut.
- Commensalism – one species benefits, the other is not significantly affected. An example, about half of adults . . .
  - Have tiny mites in their eyebrow/lash hair follicles.
- Parasitism – one species benefits at the expense of another. For example . . .
  - The Cordyceps fungi that attacks the ants in the rain forest from the Planet Earth film we watched. And, a familiar example here . . .
  - Mistletoe on pecan trees taps into the host’s plant vascular system to extract vital water and nutrients.
Here's a summary.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutualism</td>
<td>Both partners benefit</td>
<td>Algae in coral animals; mycorrhizal fungi in plant roots</td>
</tr>
<tr>
<td>Commensalism</td>
<td>One partner benefits with no effect on the other</td>
<td>Moss plants on tree bark</td>
</tr>
<tr>
<td>Parasitism</td>
<td>One partner benefits to the detriment of the other</td>
<td>Tick on a deer; tapeworm in a human (see chapters 18, 19, 21, and 22 for many examples of disease-causing organisms)</td>
</tr>
</tbody>
</table>

And don’t forget the original – endosymbiosis!
Predators eat prey, ya think!

- Predation exerts a strong selective pressure on prey to avoid being eaten, again, no duh . . . 
- So special adaptations have evolved, e.g. . . .
- Speed like a gazelle or hummingbird;
- Camouflage like a stick insect or sea horse;
- Warning colors like ‘fake’ monarchs; and . . .
- Weapons and structural defenses.
- Predators have to defeat prey defenses, so it becomes an arms race. Like the . . .
- Red Queen from Alice in Wonderland!

Sunday, April 8, 2012
Great camo' man...
This tree frog ‘warns’ it potential predators not to mess with it with brilliant coloration. The frog has really bad toxins in its skin.
These aren’t ants at all – they’re a type of spider that looks like it’ll sting you.
Communities change over time.

- This is succession – the gradual change in a community’s species composition through time.
- It occurs as competing organisms, especially plants, respond to and modify the physical environment. And it...
- May lead to a climax community – where the community remains fairly constant.
- Primary succession – occurs in an area where no community previously existed, e.g. after an extremely severe forest fire or as recent glacial retreat exposes soil.
- Pioneer species are the first to colonize.
Here's a diagram of primary succession in New England.

<table>
<thead>
<tr>
<th>Pioneer stages</th>
<th>Intermediate stages</th>
<th>Climax community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare rock</td>
<td>Lichens</td>
<td>Oaks, hickories, black walnuts, maples, tulip poplars, beeches</td>
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<tr>
<td>Lichens</td>
<td>Mosses</td>
<td>Grasses</td>
</tr>
<tr>
<td>Herbs, weeds</td>
<td>Shrubs</td>
<td>Pines, hickories, immature oaks</td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td>Oaks, hickories, black walnuts, maples, tulip poplars, beeches</td>
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</table>

Time (hundreds of years)
Succession can also be...

* Secondary succession – this occurs where a community is disturbed but not completely destroyed; it has some soil and life remaining.

* For instance, after most forest fires, or in an abandoned farm field, or after a really bad storm surge from a hurricane, or even like what happened in the film we watched last time when that tree fell down.

* In all succession the pioneer species tend to be r-selected (remember - Type III survivorship, many offspring).

* These pioneer species often alter the physical conditions in ways that allow other species to subsequently become established. And . . .

* Climax community members tend to be K-selected.
Energy input:

* All ecosystems share two properties:

1. No matter what, they all rely on a continuous supply of external energy.
2. Plus, nutrient cycles continuously recycle the atoms that make up every object in any ecosystem.

* We’ll talk about energy input first.
* It all comes down to food chains – a series of organisms that successively eat each other.
Food chains are comprised of organisms of different trophic levels. Most start with autotrophs using light energy (but remember the thermal vent ecosystem).
Trophic level – an organism’s position in the food chain.

- Primary producers are autotrophs. They ... 
- Directly or indirectly provide energy for all other organisms in any food chain anywhere on earth.
- Consumers are heterotrophs. They ...
- Obtain energy from producers or other consumers.
- Herbivores are primary consumers.
- Carnivores are secondary or tertiary consumers.
- Decomposers break down detritus (dead stuff and poop).
- A food web is a network of interconnected food chains.
Different parts of the earth have different food webs – here’s Antarctica’s.
Here’s one published in 1923 from an island near Norway.
And here's a nice one on the temperate zone soil food web.

Primary productivity varies widely.

* Wetlands and tropical rain forests have the highest primary productivity levels.
* Deserts have the lowest (but some are higher than others; and some very, very cold places are deserts too, even though we usually don't think of this).
* Gross primary productivity – the total amount of energy trapped or “fixed” by all of the autotrophs in an ecosystem.
* Net primary productivity – the amount of energy available for consumers to eat (the rest of the energy is lost as heat or used to generate ATP within the primary producers).
Consumers cannot digest every bit of food they eat, and they also lose energy to heat.

* Only between 2% to 30% of the total available energy in all the organic molecules of an organism that is eaten is actually transferred from one trophic level to the next.

* The “10% rule” is a convenient estimate, but efficiencies vary widely depending on what is being eaten, and on whether the eater is an ectotherm or endotherm.

* Eventually all is lost to heat, which is unrecoverable. This is why all ecosystems need a continual input of energy (usually the sun)!
Ecology energy pyramids...

* Represent each trophic level as a block whose size is directly proportional to the energy stored in new tissues per unit time.

* They help to explain why food chains (not webs) rarely extend beyond four levels.

* This also explains why the world’s largest animals have always been herbivores.

* The lower humans eat on the food chain, the more people we can feed in the world.
Here's an example showing how humans can make a big impact.
Biomagnification is where...

- A chemical becomes more concentrated in organisms at successively higher trophic levels.
- It happens with chemicals that have at least the following two characteristics:
  1. They need to be fat soluble (animals eliminate water-soluble chemicals in their urine). And...
  2. They cannot be readily degraded.
- For example, DDT was previously extensively used to kill insects, particularly mosquitoes. It was banned in 1971 in U.S. after documenting that...
- It caused cancer, and a thinning in bird eggshells.
DDT concentration in an organism's tissues is biomagnified up the food chain.
Chemical cycles – we talked about these in reference to Bacteria and Archaea. Let’s return to them now.

Biogeochemical cycles – interactions of organisms and their environment continuously recycle elements.

All cycles have four steps in common:

1. Autotrophs take up (fix) inorganic molecules from the environment and incorporate it into organic forms.
2. Heterotrophs eat the autotrophs, such that the elements become parts of the heterotroph.
3. This works all the way up the food web of an ecosystem.
4. And eventually, decomposers release the elements back to the environment in their inorganic form.
The sun's heat evaporates water.
Water vapor condenses and falls back to the earth.
Underground water supplies are also involved.
And organisms respire and transpire.
Autotrophs use CO₂ to synthesize organic molecules.

Cellular respiration releases CO₂.

Dead organisms and excrement return organic carbon to the soil.

Nitrogen is an essential component of proteins, nucleic acids, etc.

The atmosphere is 78% $N_2$ gas but most organisms can’t use this form. Much of life . . .

Relies on nitrogen-fixing bacteria to convert $N_2$ to ammonia ($NH_3$).

Plants take up ammonium ($NH_4^+$) and nitrates ($NO_3^-$).

Nitrification – bacteria convert ammonia to nitrites ($NO_2^-$) and then to nitrates ($NO_3^-$).

Denitrification – bacteria return nitrogen to the atmosphere as $N_2$. 
And, among others, the phosphorus cycle

- Phosphorus occurs in nucleic acids, ATP, and membrane phospholipids.
- It is also a major component of the extracellular matrix of bones and teeth.
- The inorganic portion of the cycle occurs mostly in sediments and rocks (not in the atmosphere).
- Geological sources release phosphate ions ($PO_4^{3-}$).
- Autotrophs take up some, most returns to bodies of water to deposit in sediments.
Next time . . .

* Biomes, the niches of life, . . .
* And the entire biosphere — Gaia!
* Then the Ecology section Exam after that.