ADVANCED ECOLOGY

Zoo 573

3 (2+1)

Lecture 1

Objective of the Course

- ***To provide basic concepts of population and community ecology of both terrestrial and aquatic animals***

Course Outline

- *Characteristics of aquatic and terrestrial animal populations*
  - *Natality rate,*
  - *Mortality rate,*
  - *Density,*
  - *Age distribution*
- *Population growth*
- *Effect of abiotic factors (aquatic & terrestrial) on*
  - *Population growth*
  - *Spacies intra- and inter-relationships*
- *Population cycles*
- *Community changes*
- *Desert animal communities*

Course evaluation

- Term presentations = 15%
- Practical = 20%
- Midterm Exam = 20%
- Home works = 5%
- Final Exam = 40%

Biome

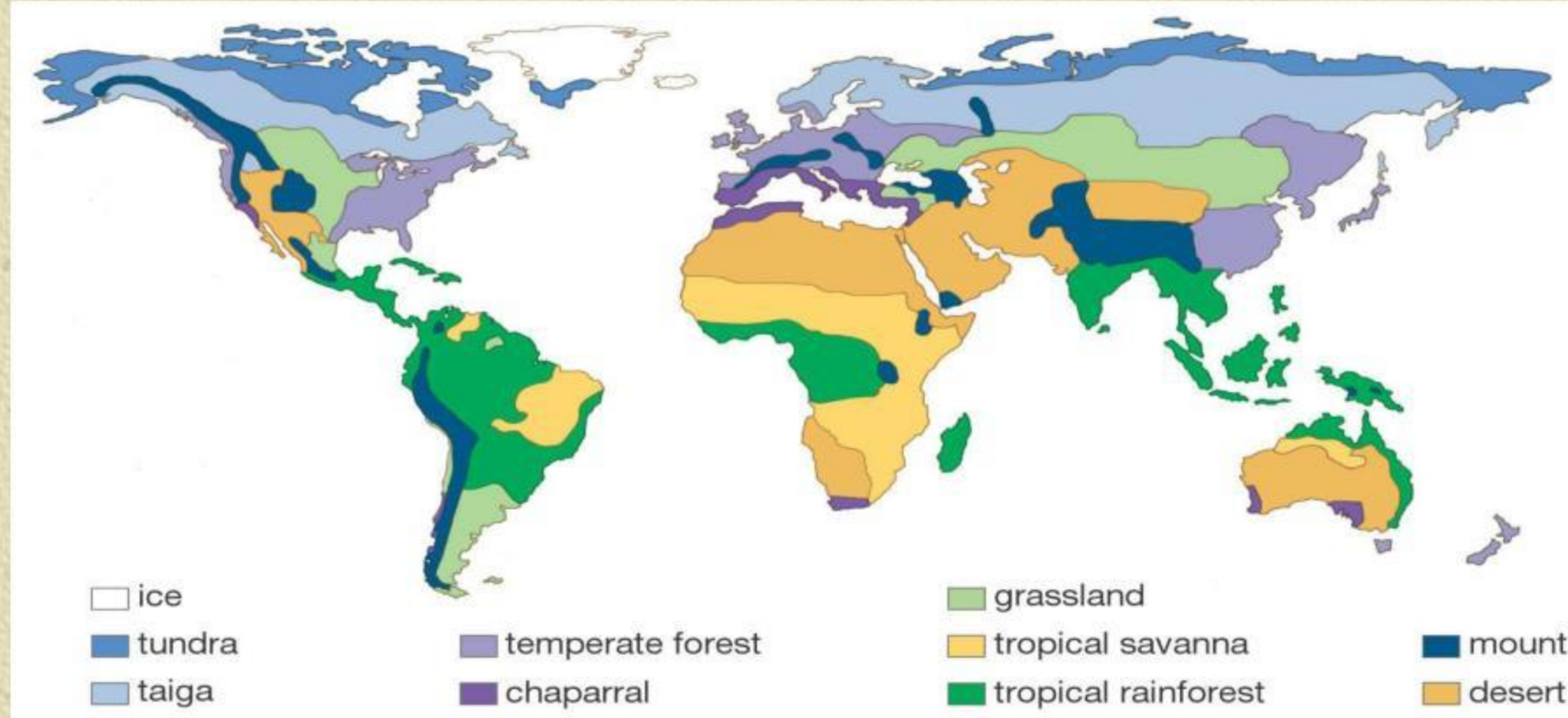
- An area made up of a distinct combination of plants and animals.
- Biomes are made up of the groups of ecosystems found on earth.
- Biomes are terrestrial or aquatic in nature.

Terrestrial and aquatic ecosystems

- It is not easy to compare terrestrial and aquatic systems because there is such a large variety of these environments. It is possible to recognize in the terrestrial part of the biosphere a small number of units with distinctive vegetation and climate, each with a complex of communities of large extent. These units are known as biomes and six major biomes are usually recognized, namely the:

- Tundra,
- Taiga (coniferous forests),
- Deciduous Forests,
- Grasslands,
- Tropical Rain Forests,
- Deserts.

TERRESTRIAL BIOMES



1. **Tundra** = "treeless plain" • Flat terrain with low shrubs, grasses, sedge, mosses, lichens; low biodiversity • One-fourth of Earth's terrestrial surface • Present in northernmost latitudes (≥ 60° N) • Desert-like rainfall (30-50 cm or 12-20 in per year)

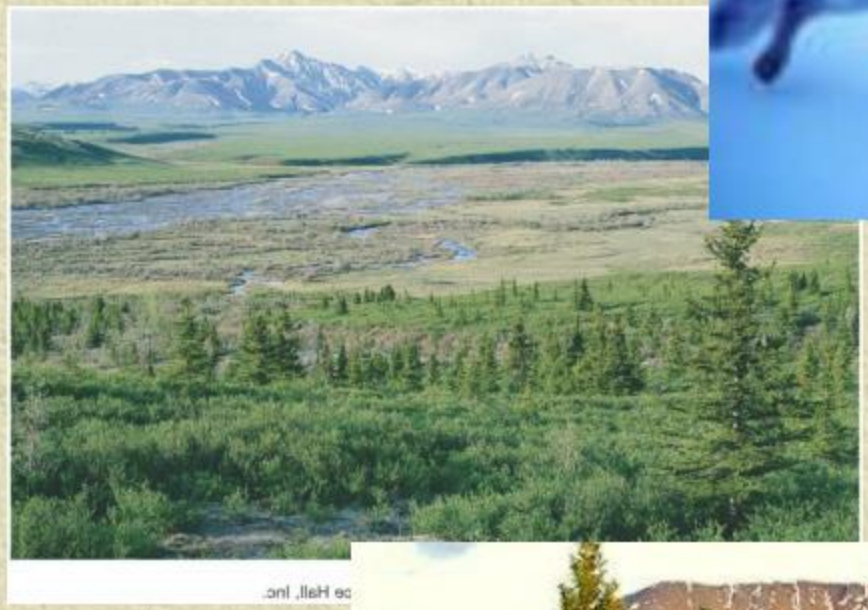
Permafrost – condition of permanent frozen soil beginning ~ 1 meter (m) below surface and extending down to 500 m • Water can not drain •

Plants produce in short 50-day season •

Year-round: Arctic lemmings, hares, foxes • Summer migratory animals seeking food • No reptiles or amphibians

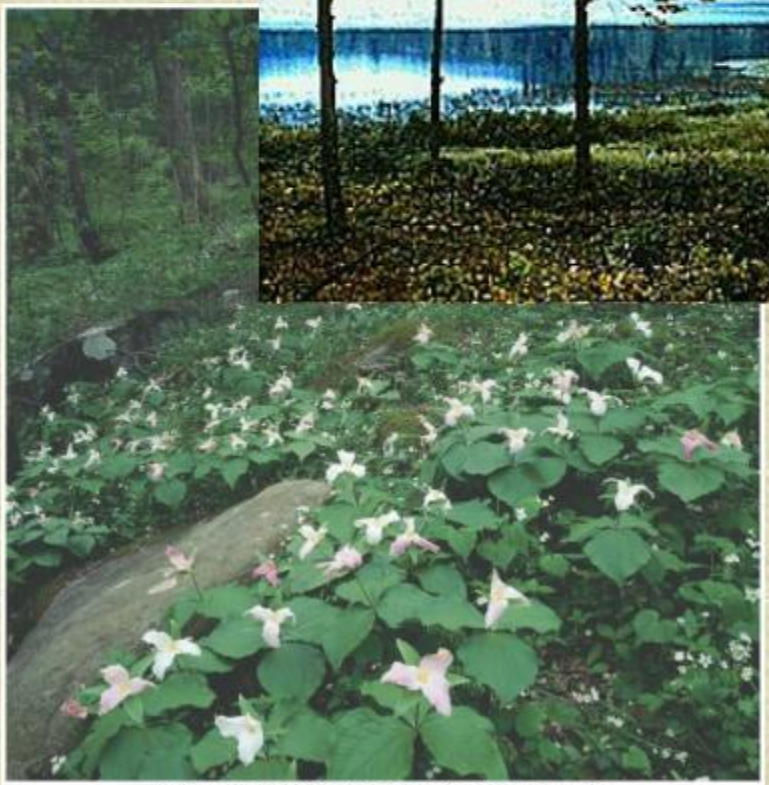
Tundra

Taiga



2. Taiga • Also known– covered with coniferous trees such as firs, pines, spruces, and cedars (dominant vegetation) – located south of tundra • Largest biome on Earth; low biodiversity • Winters: very cold and snowy • Summers: warm, rainy, and humid • Large mammals, fur-bearing animals • Very few reptiles and amphibians.

Temperate Deciduous Forest



3. Temperate Deciduous Forest • Majority of eastern US, as well as continental western Europe and east Asia • Deciduous trees (with seasonal leaf loss) including maples, beeches, oaks, and hickories, as well as understory of woody shrubs and vines and herbaceous plants • Much precipitation (3-8x that of tundra) • Milder winters, warm to hot summers • Great variety of animals, including reptiles and amphibian

Temperate Grassland

4. Temperate Grassland • Areas of predominantly tall, mixed, or short grasses sandwiched between temperate deciduous forests and deserts • Annual precipitation of 25-100 cm • Extremely fertile soil (US Midwest farms) • Natural grasslands destroyed for agriculture; very little left in world • Short grass prairie – crops and cattle

Savanna • Subtype of grassland: tropical grassland in Southern Hemisphere (Africa, South America, and Australia) • Seasonal drought, warm climate, dotted with stands of trees, and home to typical large mammals (e.g. in Africa, elephants, giraffes, zebras, lions, spring boks, cape buffalo, etc.)

Desert

6. Desert – area receiving < 25 cm annual precipitation; evaporation > precipitation • Deserts may be cold, temperate, or hot • Flora and fauna specialized to survive with little water – collect and conserve • Soils poor because lack of water = very little biomass, or net productivity, low organics = inability to hold water • Concentration of inorganic salts high.

Tropical Rainforest

7.Tropical Rainforests: Large warm equatorial areas, abundant annual precipitation (200-450 cm and even to 1000 cm for some) with high biomass productivity and biodiversity • 7% of Earth's land mass under massive destruction; can not be replaced • Poor, acidic soil: plants uptake quickly-decomposed organic nutrients.

Aquatic Ecosystems

- Marine
  - Intertidal Areas
  - Coral Reefs
  - Estuaries – fresh water from streams and rivers spills into oceans
  - Sargasso Sea (middle of Atlantic Ocean – floating rafts of algae called sargassum)
  - Polar Ice – Arctic Ocean and ocean around Antarctica

- Freshwater
  - Stream and River; Pond and Lake
- Wetland
  - Marshes and Swamps

1. Marine Ecosystems Photic zone = surface to 100 m down; photosynthesis occurs Saltwater oceans cover ¾ of Earth's surface.

Intertidal Zone: the place where the ocean meets the land; area is exposed to the air for part of the day; sea grasses, periwinkle snails, and herons are common in intertidal mudflat; sea stars and anemones live on rocky shores; clams, crabs, snails, and conchs are common on sandy beaches •

Neritic Zone: Ocean floor starts to slope downward as you move away from shore; water is warm and receives a lot of sunlight; plankton and seaweeds common; sea turtles, dolphins, corals, sponges, and colorful fishes dominate – CORAL REEFS!

• Oceanic Zone: Sea floor drops sharply; contains deep water of open ocean; many unusual animals are adapted to this zone, such as whales, squids, fishes that glow, sharks, etc.
• Benthic Zone: Ocean floor; deepest parts do not get any sunlight and are very cold; animals, such as fishes, worms, sea urchins, and crabs, have special adaptations to the deep, dark water

ESTUARY - • Coastal point of contact between freshwater and saltwater; mix = “brackish” water • Constant mixing stirs up nutrients for photosynthesizers; animal life abundant • As productive as tropical rainforests and coral reefs • Concerns: • Although protected, human pollution and encroachment threaten health of estuaries

Abundance of life is generally greater: • Nearer coast (intertidal zone) due to stirring action of waves and nearer surface from light • In polar regions rather than tropical regions (abundant food – plankton - for large organisms) • In tropical coral reefs along shallow coastlines

2.Freshwater Ecosystems Inland freshwater streams, ponds, and lakes cover 2.1% of Earth's surface.
Littoral Zone - area of water closest to edge of lake or pond; cattails, rushes, algae, water lilies; small animals, snails, insects, clams, worms, frogs, salamanders, turtles, fish, and snakes

Open-Water Zone – the zone of a pond or lake that extends from the littoral zone and that is only as deep as light can reach – bass, lake trout, and other fishes.

Deep-Water Zone – the zone of a lake or pond below the open-water zone, where no light reaches – carp, catfish, worms, crustaceans, fungi, and bacteria

WETLANDS

‘Wetlands’ means those areas that are covered or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wetlands generally include **swamps, marshes, bogs, and similar areas.**

Similarities between Terrestrial and Aquatic systems

- In both terrestrial and aquatic environments the ecosystems include communities made up of a *variety of species*.
- Within both terrestrial and aquatic communities there are populations at the *different trophic levels*.
- A great deal of *mutual interdependence exists between species in both terrestrial and aquatic environments.*
- In undisturbed terrestrial and aquatic ecosystems *equilibrium is reached*, i.e. very few major changes are observed over a period of time.
- In both ecosystems *stratification (vertical zonation)* occurs.

Differences between Terrestrial and Aquatic systems

- Because aquatic environments are so rich in nutrients *they support more life* than equivalent terrestrial ecosystems. The small drifting photosynthetic organisms of the oceans, referred to collectively as phytoplankton are regarded as the major photosynthesizers, or *primary producers*, of the earth.

- Aquatic environments are *much more stable* than terrestrial environments, with smaller fluctuations in temperature and other variables.

- Aquatic organisms are *seldom exposed to desiccation* while terrestrial organisms are often exposed to desiccation and are usually relatively resistant to drying out.

- *Oxygen* (because there is very much less present) is sometimes a limiting factor an aquatic habitats but this is seldom the case in terrestrial habitats.

- *Light* can be a limiting factor in some aquatic habitats, but in most terrestrial environments there is hardly ever a shortage of light.

- Terrestrial animals are influenced *far more by gravity*, while water supports aquatic organisms.

What are communities?

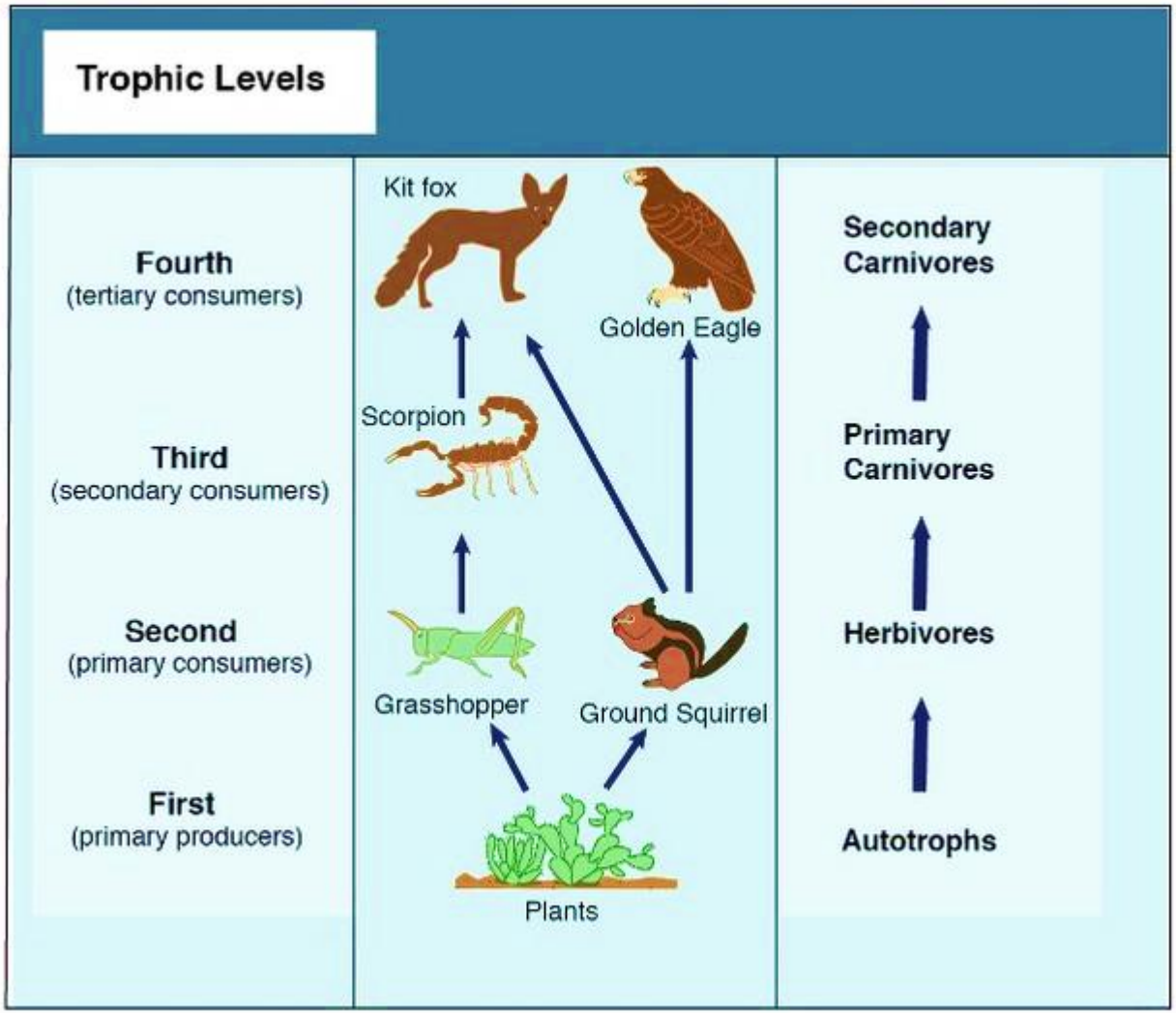
- What are ecological communities?

- A community is a collection of populations of all the organisms which occur together in a given place and time. Community ecology is the study of the interactions between these organisms, and the interactions between the organisms and their environment.

- Communities can be found in the water and on the land
- Interaction does occur between these two types of communities
- This interaction can be good, for example some aquatic animals such as alligators can live on both the land and in the water
- Sometimes though, the interaction can be bad. For example, water runoff can erode from the terrestrial community into the aquatic community. This excess soil is considered pollution

Feeding Relationships in Nature

Food chain and Food web is an important conceptual tool for illustrating the feeding relationships among species within a community, revealing species interactions and community structure, and understanding the dynamics of energy transfer in an ecosystem.


Trophic Levels
Fourth
(tertiary consumers)
Third
(secondary consumers)
Second
(primary consumers)
First
(primary producers)
Kit fox
Golden Eagle
Scorpion
Grasshopper
Ground Squirrel
Plants
Secondary Carnivores
Primary Carnivores
Herbivores
Autotrophs

Energy Flow in Ecosystems

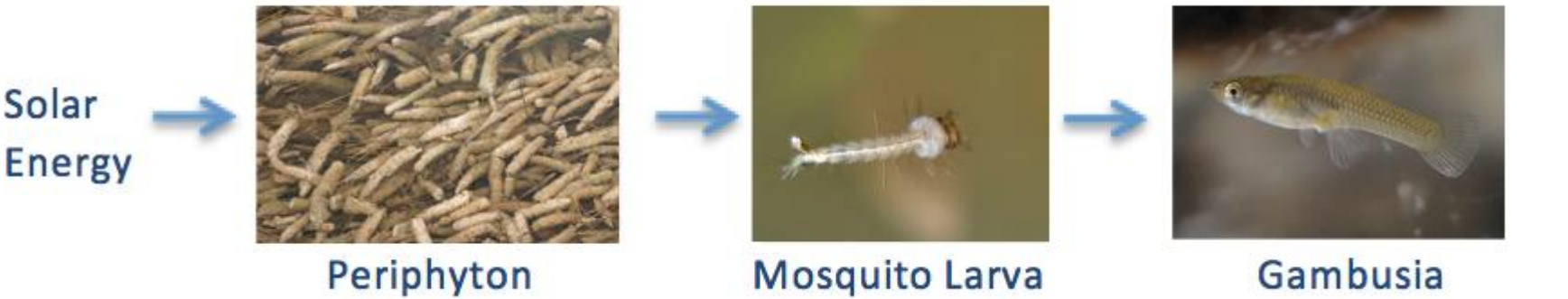
In every ecosystem, organisms are linked through feeding relationships. There are a great many feeding relationships in any ecosystem, but energy always flows from primary producers to various consumers.

These feeding relationships are represented by food chains and food webs.

A food chain is a sequence in which organisms transfer energy by eating and being eaten.

There are two types of food chains: the grazing food chain, beginning with autotrophs, and the detrital food chain, beginning with dead organic matter .

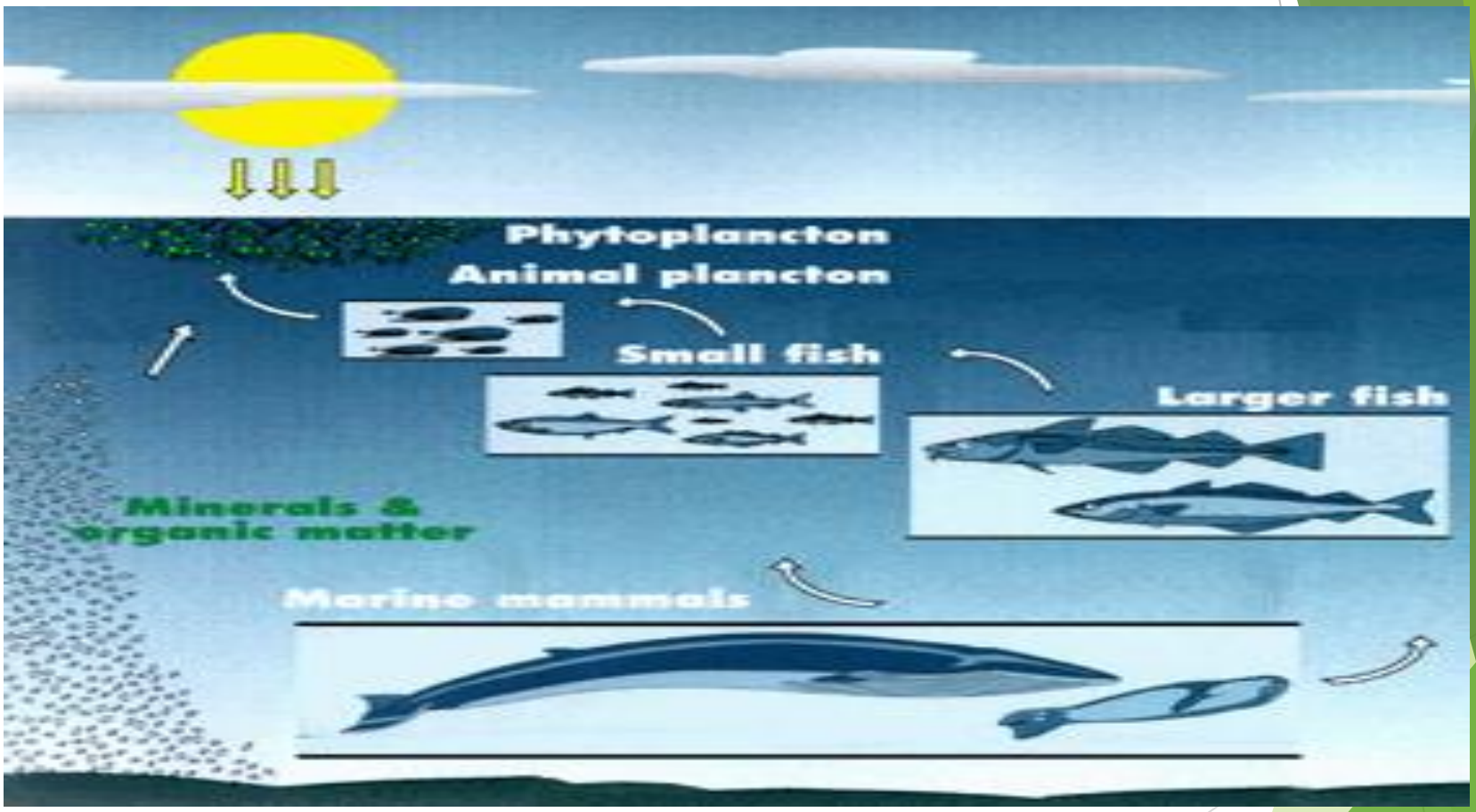
- **In a grazing food chain,** energy and nutrients move from plants to the herbivores consuming them, and to the carnivores or omnivores preying upon the herbivores.
- **In a detrital food chain**, dead organic matter of plants and animals is broken down by decomposers, e.g., bacteria and fungi, and moves to detritivores and then carnivores.



Notice that the arrows point in the direction of the energy flow. The point of the arrow goes to who is doing the eating.

In most ecosystems, feeding relationships are much more complicated than the relationships shown in a food chain. The network of feeding interactions is called a **food web.**

Food Chain


Phytoplancton
Animal plancton
Small fish
Larger fish
Minerals &
organic matter
Marine mammals

Food Web

- A food web is the interconnection of food chains within a community.
- Within a food web, animals are grouped according to the types of food they consume.
- These groups include herbivores, carnivores, and omnivores

Applications of Food Webs

1. Food webs are constructed to describe species interactions (direct relationships).

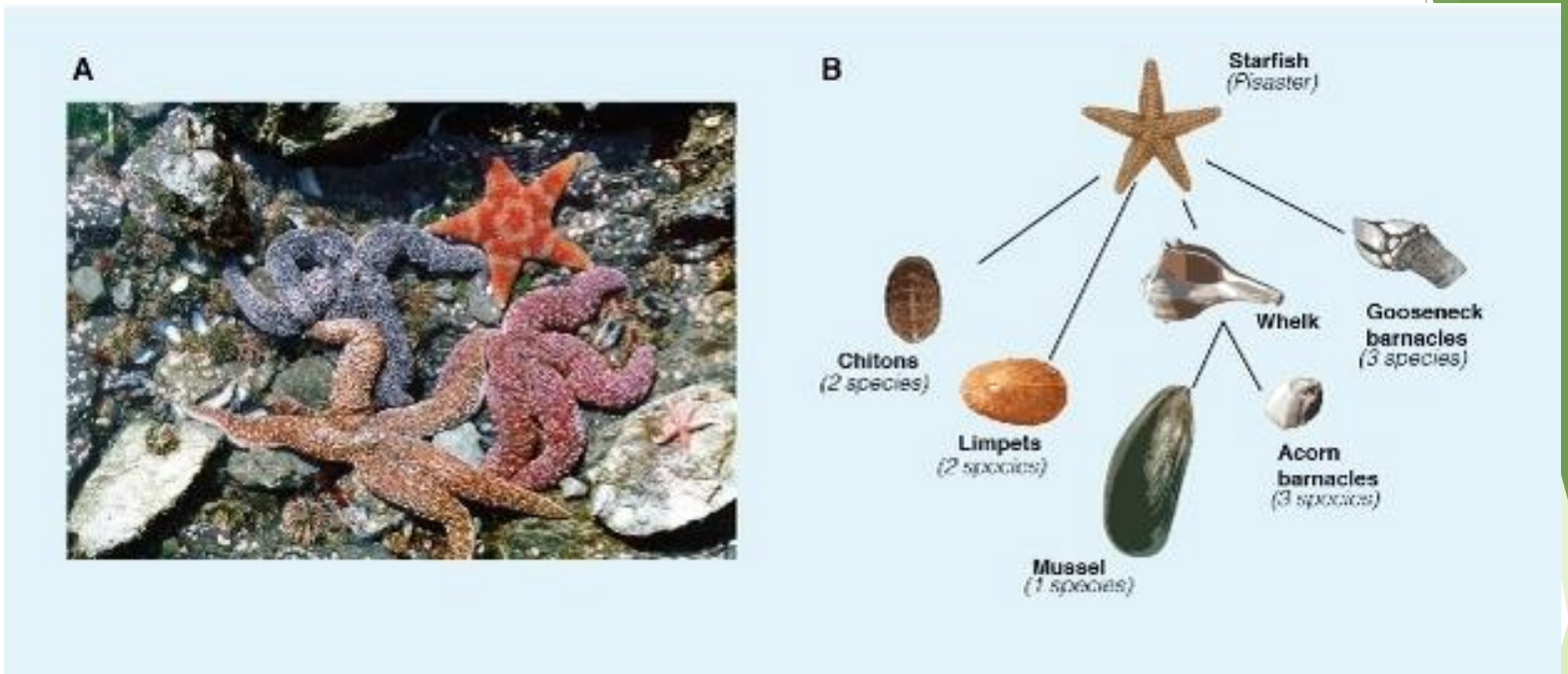
The fundamental purpose of food webs is to describe feeding relationship among species in a community. Food webs can be constructed to describe the species interactions. All species in the food webs can be distinguished into basal species (autotrophs, such as plants), intermediate species (herbivores and intermediate level carnivores, such as grasshopper and scorpion) or top predators (high level carnivores such as fox).

2. Food webs can be used to illustrate indirect interactions among species.

Indirect interaction occurs when two species do not interact with each other directly, but influenced by a third species. Species can influence one another in many different ways. One example is the keystone predation are demonstrated by Robert Paine in an experiment conducted in the rocky intertidal zone. This study showed that predation can influence the competition among species in a food web. The intertidal zone is home to a variety of mussels, barnacles, limpets, and chitons (Paine 1969). All these invertebrate herbivores are preyed upon by the predator starfish *Pisaster* (Figure 3). Starfish was relatively uncommon in the intertidal zone, and considered less important in the community.

When Paine manually removed the starfish from experimental plots while leaving other areas undisturbed as control plots, he found that the number of prey species in the experimental plots dropped from 15 at the beginning of the experiment to 8 (a loss of 7 species) two years after the starfish removal while the total of prey species remained the same in the control plots. He reasoned that in the absence of the predator starfish, several of the mussel and barnacle species (that were superior competitors) excluded the other species and reduced overall diversity in the community.

Predation by starfish reduced the abundance of mussel and opened up space for other species to colonize and persist. This type of indirect interaction is called keystone predation.

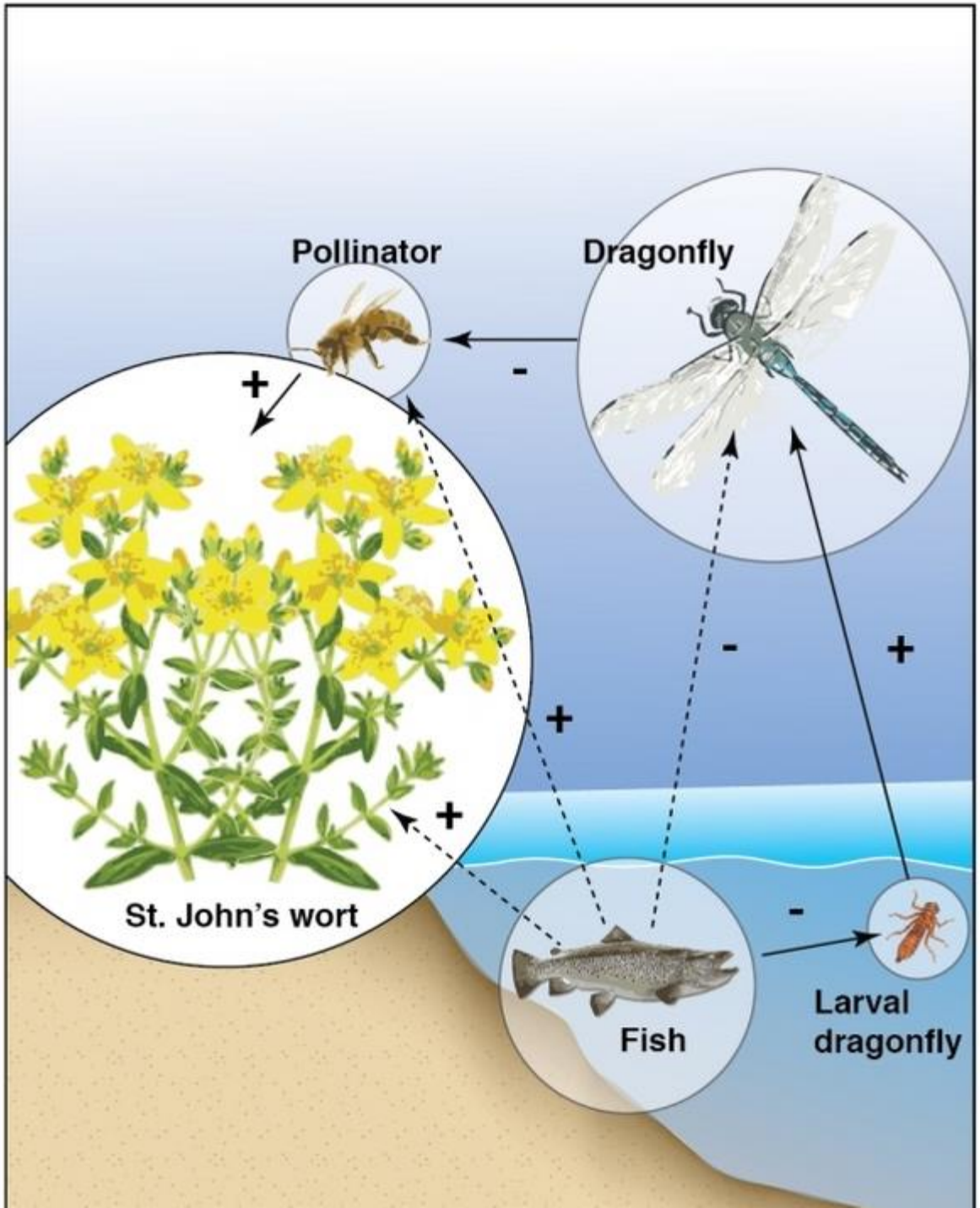


a) The rocky intertidal zone of the Pacific Northwest coast is inhabited by a variety of species including starfish, barnacles, limpets, chitons, and mussels. (b) A food web of this community shows that the starfish preys on a variety of invertebrate species. Removal of starfish from this community reduced the diversity of prey species due to increased competition.

Another interesting study demonstrated indirect interactions among species in both aquatic and terrestrial ecosystems.

In a study conducted near Gainesville, Florida, Knight and her colleagues (2009) investigated the effects of fish in ponds on plant seeds production. They measured and compared abundances of both larval and adult dragonfly in and around four ponds that had been stocked with fish and four ponds that lacked fish (Knight et al. 2009).

They found that ponds with fish produce fewer larval and adult dragonflies than ponds without fish, as fish prey on larval dragonflies. As dragonfly population decreases, the populations of their prey, including bees, flies, and butterflies, decrease. These prey species are pollinators of the plants. Therefore, flowers in the vicinity of ponds without fish receive fewer pollinator visits than flowers close to ponds stocked with fish. Since the production of seeds is pollen-limited, fewer pollinator visits result in lower seeds production. This study demonstrates, via a complex trophic cascade, that adding fish to a pond improves the reproductive success of a plant on land



An interaction food web shows that fish have indirect effects on the populations of several species in and around ponds.

The solid arrows represent direct effects, and the dashed arrows indirect effects; the nature of the effect is indicated by + or -. Fish have indirect effects, through a trophic cascade, on several terrestrial species: dragonfly adults (-), pollinators (+), and plants (+)