ZOOLOGY

THE STUDY OF ANIMALS

I Evolution: The theory that through a very slow, on-going process a living form of organism can change its morphological and physiological characteristics; "descent with modifications".

A. Charles Darwin (1809-1882) credited as being first to present the idea of evolution. It was his trip aboard the "Beagle" (1830-1836) that he collected samples from the Galapagos Islands and used as evidence for the theory of Natural Selection; in 1859 he wrote *The Origin of Species*.
B. **Natural Selection**: The process by which life forms, having traits that enable them to adapt to the environment, survive in greater numbers. Example: Peppered moth (*Biston betularia*). The peppered moth can be black or white. Before the English industrial revolution (~1740), only about 1% of moths were black and the rest white. The barks of the trees, where they spent most of their time, were covered with white lichen, providing a perfect camouflage. With the coal burning furnaces of the industrial revolution, the soot and fumes caused the lichen to die and the dark colored bark of the trees became camouflage for the dark moths instead. Within a few years, 90% of the peppered moths were black, the black color being selected for survival.
C. Evidences for natural selection:
    1. Paleontology: The study of fossil records, which are millions of years old, help to explain origins and historical relationships between modern and ancient organisms. (Example: *Eohippus*, a small, fossil, four-toed horse to *Equus,* the large, modern single-toed horse).
    2. Environmental clues
        a. A member of a species inhabiting the far north may tend to have shorter appendages (Allen's Rule), denser fur and a larger size (Bergmann's Rule) than its counterpart in warmer climates.
        b. The giraffe neck extended in response to an unexploited food source, the savannah treetops. Thus, later generations were taller.
    3. Anatomical clues
        a. Organs: fish have a 2-chambered heart; most reptiles a 3-chambered heart; birds and mammals a 4-chambered heart.
        b. Bony structures: *Eohippus* had four toes; the modern horse one toe.
D. **Genetic Diversity** results in some individuals developing traits that allow them to survive a specific change better than other individuals. Those that survive pass "successful" genes to offspring.
    1. Gene pool is affected by the environment (**evolutionary adaptations**). You will get shifts in makeup of populations. An example is the evolution of insecticide resistance in insects. Over the years chemical insecticides have been used to kill insects that harm crops or carry disease. The insecticides kill off all or most of the susceptible insects but a few rare individuals have beneficial mutations survive and reproduce. This differential survival changes the structure of the population.

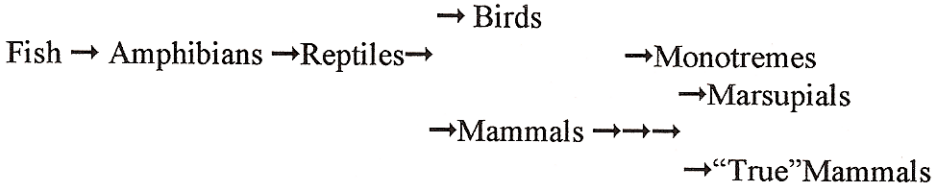
a. For evolution to occur, there must be variation among individuals in the trait under consideration. **Genetic Variability**.
b. The trait must be heritable – genetically determined and passed on to offspring.
c. The trait must increase fitness – the reproductive success of the individuals that have the trait.
d. The relative fitness of the different genotypes depends on the environment. If the environment changes, the trait may no longer be beneficial.

2. **Genetic drift**. Random mutations in genes contribute to genetic diversity. Most likely to occur in small populations as a result of happenstance, not of differences in fitness. For example, if a forest fire kills most of the individuals of a population, the few survivors may happen to display a different frequency in their genetic characteristics than the ancestral population. After a few generations, the new population may differ from the ancestral population.

E. **Sexual Reproduction** is one of the reasons why animals have been so successful in exploiting diverse ecological niches. Sexual reproduction creates a population that is a collection of distinct genotypes–a genetic diversity that is the raw material upon which natural selection acts.

F. **Extinction** is a natural part of evolution as some species succeed and others do not. Mass extinctions tend to follow major catastrophic events such as volcanic eruptions, meteor impact or climate change. Man has caused extinctions through a variety of means from hunting to habitat destruction to climate change. The major causes of loss of species include: (mnemonic – **HIPPO**)
- **H**abitat loss
- **I**ntroduction of nonnative species
- **P**opulation growth
- **P**ollution
- **O**ver-consumption or over harvesting

G. Evolutionary development is generally from less complex to more complex and specialized.
1. Protozoa, single-celled animals, to multicellular life, Mollusca, Arthropoda.
2. Vertebrate evolution:



II Taxonomy

A. Classification of plants and animals, begun by Carl Linnaeus (1707-1778).
1. Over one million living species names in the animal kingdom.
2. Fossils (extinct species) are also included in the system.

B. **Binomial nomenclature** allowed scientists from across world to discuss same animal (or plant) that might be called by different common names in each region

C. Methods of classification based on:
1. **Morphology** – form and structure, comparative anatomy
2. **Phylogenetic Analysis -** study evolutionary relationships to classify and order animals

3. **Phenetic Analysis -** use statistics based on number of similar attributes of each species to classify and group animals.
4. **DNA:** Uses modern DNA techniques to establish relationships among current animals, as well as evolutionary relationships.

D. Categories of plants and animals are subdivided into smaller and smaller, more closely related groups. (Mnemonic: **K**ings **P**lay **C**hess **O**n **F**ine **G**old **S**ets)
1. Kingdom
    a. Broadest category
    b. Five major Kingdoms (see above)
2. Phylum
    a. Most primitive – Protozoa; most advanced – Chordata.
    b. Plural – Phyla
3. Sub-phylum (example: Vertebrata)
4. Class
    a. Names ending in "-a" in most cases.
    b. Vertebrate classes: Amphibia, Reptilia, Mammalia, Aves, and 3 fish classes (Agnatha, Chondrichthyes, and Osteichthyes)
5. Order (examples: Primates, Carnivora)
6. Family
    a. Names ending in "idea" – a rule with no exception.
    b. Examples: Ursidae (bears), Felidae (cats)
7. Genus
    a. Names always capitalized, and underlined or in italics.
    b. Example *Homo*
8. Species – similar organisms able to interbreed in the wild
    a. Names never capitalized, but are underlined or in italics.
    b. Example: *H. sapiens*
9. Sub-species
    a. As with the species subdivision, not capitalized, but underlined or in italics.
    b. Example: *Gorilla gorilla gorilla*

E. Examples of taxonomical classifications

	Human	**Amur Tiger**	**Dungeness Crab**	**CA Poppy**
Kingdom	Animalia	Animalia	Animalia	Plantae
Phylum*	Chordata	Chordata	Chordata	Magnoliophyta
Sub-phylum	Vertebrata	Vertebrata	Crustacea	
Class	Mammalia	Mammalia	Malacostraca	Magnoliopsida
Order	Primate	Carnivora	Decapoda	Ranunculales
Family	Hominidae	Felidae	Candridae	Papaveraceae
Genus	*Homo*	*Panthera*	*Cancer*	*Eschscholzia*
Species	*H. sapiens*	*P. tigris*	*C. magister*	*E. californica*
Sub-species	*H. s. sapiens*	*P. t. altaica*		

- "Division" is used in plant and fungi classification and is equivalent to the rank of phylum

III Five Major Kingdoms

A. **Monera** (bacteria)
B. **Protista** (single-cellular plant-like and animal-like organisms)
C. Fungi
D. Planta

1. Takes in carbon dioxide and releases oxygen
2. Food producer
3. Generally immobile

E. **Animalia**
1. Takes in oxygen and releases carbon dioxide
2. Primary and secondary food consumers
3. Generally mobile
4. Three categories of Animals today
    a. Protozoa (unicellular eukaryotic organisms – cell has a nucleus)
    b. Invertebrates
    c. Vertebrates

Animalia Kingdom: Vertebrates vs Invertebrates

I. **Invertebrates:** Animals without backbones - jellyfish, octopi, mollusks, worms, arthropods (insects, spiders, crabs, scorpions, crustaceans, etc.). They may have an internal or external skeleton of some sort. There are far more invertebrate species than there are vertebrate species.

Of the invertebrates, the **arthropods** represent the largest group. They comprise the most successful animal group on the planet in terms of species and habitat diversity. (For more detail see the **Arthropod Study Guide**)

- All arthropods have exoskeletons, which are periodically shed because they do not grow. They provide armored protection and a support structure for the body. Arthropods have segmented bodies and six or more jointed legs.
- Arthropods have existed on Earth far longer than mammals
    - They can be traced back 500-550 million years
    - Insects date from 345-395 million yrs. (modern insects from 225-250 million yrs.)
    - Mammals and flowering plants date from 54 -65 million years

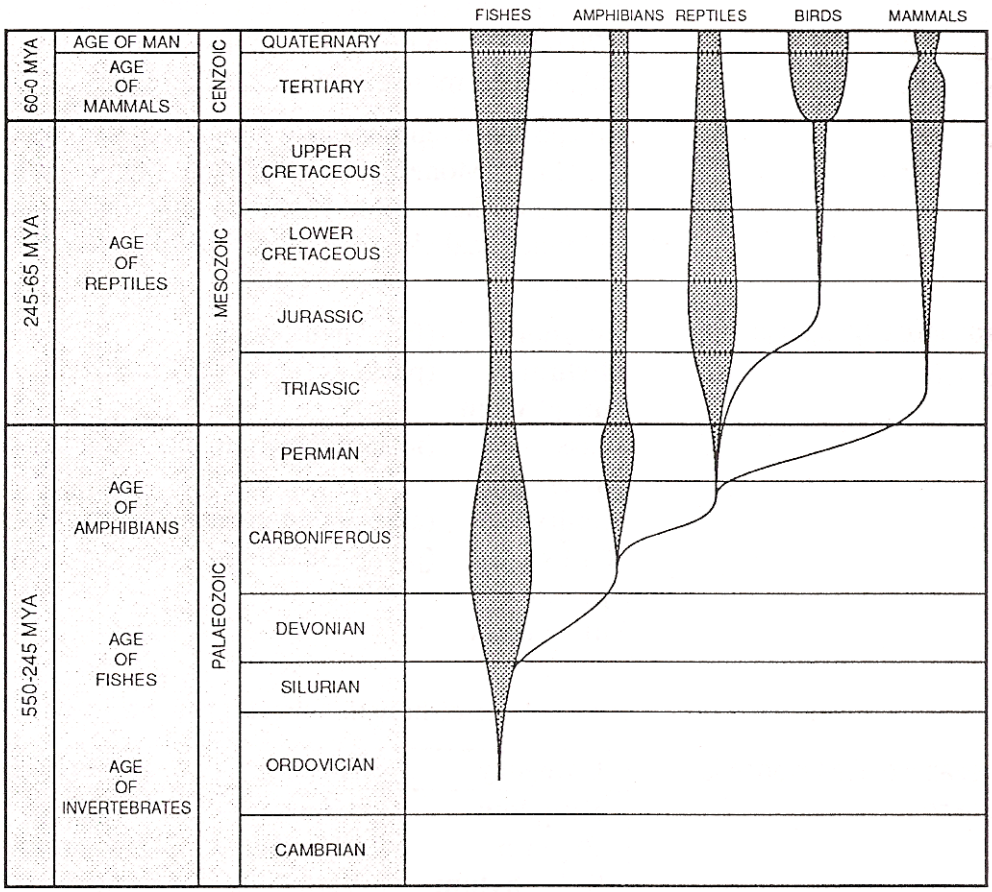
The largest class of arthropods is the **insects.**

- Insects comprise over 90% of all the animal species on the planet, but only 10% of them are considered pests. It is estimated that ants and termites account for 20% of all animal mass in the world (10% each). There are over 500,000 species of beetles alone.
- All insects have:
    - 3 body parts: head, thorax and abdomen
    - Six jointed legs
    - Two antennae
    - An exoskeleton
    - Most, but not all have wings and can fly
- Insects are vital to the natural world because they:
    - Are responsible for pollinating over 80% of all flowering plants
    - Play a major role in the decomposition of organic matter. They eat more plant material than any other animal.
    - Play vital roles in food webs and food chains
    - Are vital to soil aeration

- Can survive in many diverse and often harsh or severe climates

II. **VERTEBRATES:** Animals with backbones or spinal columns – fish, amphibians, reptiles, birds and mammals.

The Development Of Major Animal Classes



Fish compromise the earliest of the vertebrates (See **Fish Study Guide**). Features or characteristics include:

- **Ectothermic** (an organism who regulates its body temperature largely by exchanging heat with its surroundings; having body temperature that varies with the environment)
- Aquatic
- Have gills
- Reproduce either by laying eggs or live birth
- Have scales

Tetrapods (bony vertebrates with four limbs or limb-like appendages) developed from these primitive fishes. Tetrapods first grew limbs and left the water for land, finally giving rise to the modern **amphibians**, including salamanders and newts, frogs and toads and caecilians (limbless amphibians that resemble snakes) (See **Amphibian Study Guide**). Amphibians developed around 370 million years ago.

There have been dramatic declines in the populations of various amphibians all over the world in the past 10-20 years. It is thought that amphibians serve as a good indicator of the over all

environmental health of the planet or the environmental health of individual habitats. Features or characteristics include:

- Ectothermic
- Permeable skin to oxygen and water; respiration occurs through skin membranes, gills and lungs. Naked skin lacking hair, feathers, and surface scales.
- Three-chambered heart
- Most need fresh water source to lay eggs
- They are the only four-limbed vertebrates that go through two life stages or metamorphosis (**metamorphosis**: a change in the form and often habits of an animal during normal development after the embryonic stage. i.e. in amphibians the changing of a tadpole into a frog.)

Reptiles are vertebrates that evolved from advanced amphibians from 320-310 million years ago and became adapted to living on dry land (See **Reptiles Study Guide**). The development of the amniotic egg allowed organisms to lay eggs on land rather than in water as amphibians do.

The four orders of reptiles include:

- Lizards (See **Lizard Study Guide**) and snakes (See **Snake Study Guide**)
- Crocodiles, gavials, caimans and alligators (See **Crocodilian Study Guide**)
- Turtles, terrapins and tortoises (See **Turtle/Tortoise Study Guide**)
- Tuataras (found only in New Zealand)

Reptile characteristics include:

- Ectothermic
- Water tight skin covered in scales
- Cloaca (posterior opening for both bodily excretions and reproduction)
- First animals to develop amniotic eggs

Aves or Birds (see **Bird Study Guide**)
Modern birds trace their descent back to lizard-like reptiles about 160 million years ago and have much in common with modern reptiles. This was most likely a small Theropod dinosaur. Birds show many unique adaptations, mostly aiding flight. Other Bird characteristics include:

- Feathers (developed from modified scales)
- Scales on legs
- Four-chambered heart
- Lay eggs
- Endothermic - warm blooded; very high metabolic rate
- Pneumatized (filled with air spaces) bones to reduce weight for flight

Mammals (See **Mammal Study Guide**)
The early ancestors of mammals diverged from reptile-like amniotes more than 200 million years ago. Modern mammals can be divided into three broad categories. The primitive egg-laying mammals were the first group to diverge followed by the marsupials. The placental mammals followed.

1. **Egg laying** (platypus and echidna)
    - Born from soft-shelled eggs
    - Nourished by mother through many glands on abdomen

2. **Marsupial** (koala, kangaroo, opossum, etc.)
    - Young born in a very undeveloped state
    - Carried and fed from mammary glands in the mother's pouch.
3. **Placental** (majority of mammals)
    - Fetus derives nutrition from the mother through the placenta
    - Born either precocial or altricial
        - **precocial**: capable of a high degree of independent activity from birth (i.e. an antelope, zebra or giraffe)
        - **altricial**: the condition in which an animal is born underdeveloped and helpless requiring care during growth and development (i.e. an eagle, gorilla, or bear)
    - Fed by milk from mammary glands of the mother after birth.

Mammals are divided into 21 scientific orders. Mammalian characteristics include:

- Hair, sometimes in very small amounts: fur, quills, wool, bristles and whiskers; whales have a few bristles around the mouth at birth
- **Endothermic** or internally controlled constant body temperatures (note that there exceptions such as bats, echidna and mole rats that cannot maintain a constant body temperature and animals such as bears that drop their body temperature during hibernation).
- Four-chambered hearts.
- The jaw is a single bone
- Mammary glands (functioning only in females during time of lactation). Nurse young
- Live birth

(REV 2013)

ZOOGEOGRAPHY

Biogeography: The branch of biology that deals with the geographical distribution of plants and animals.

Zoogeography: The branch of biogeography concerned with the geographic distribution of animals and especially the study of the relationship between animal forms and species and the regions in which they live.

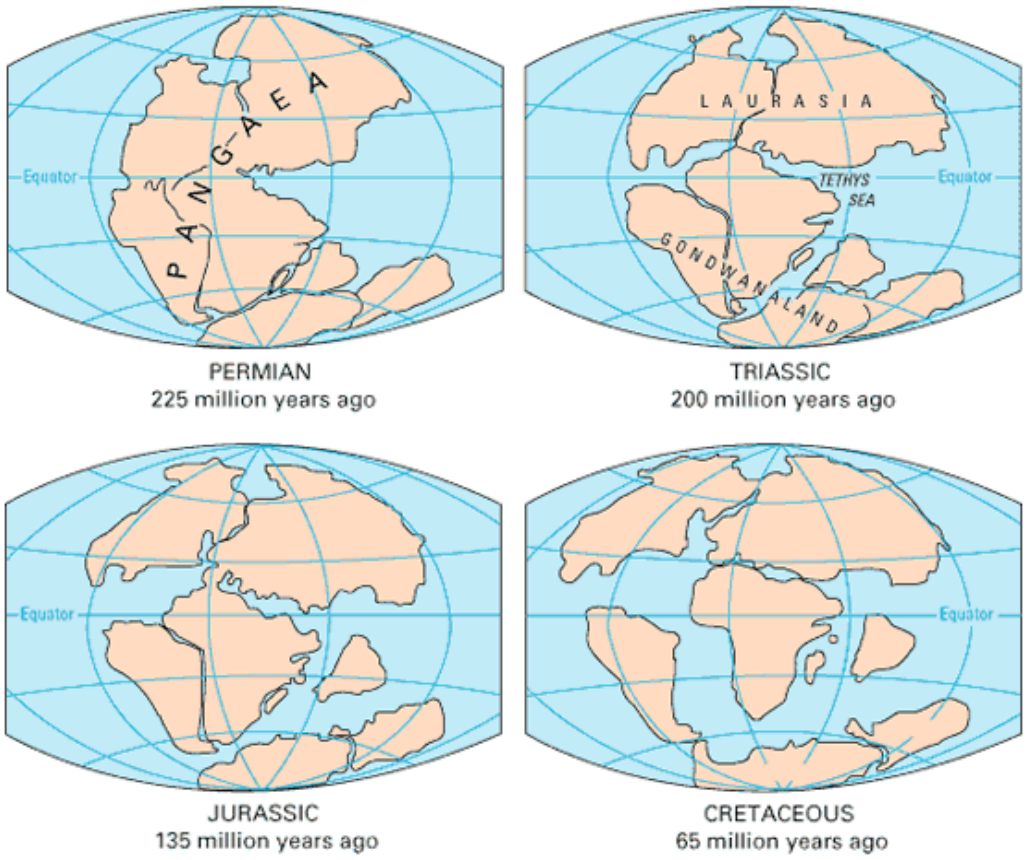
Early in the development of biology it was noted that each species of organism tended to occur only in a limited part of the world, where it was native, or "endemic". This observation raised the question of why taxa (species and groups of species) were confined to certain geographic areas.

One obvious answer is that, because areas differ in climate and ecology, species survive only in areas that meet their climatic and ecological requirements. This explanation of endemism proved insufficient, for biologists soon learned that 1) organisms transported to certain areas where they are not endemic often survive and even prosper and 2) widely separated areas generally house different taxa, no matter how similar the climate and ecology of those areas.

Taxa are endemic in certain areas today for one of two possible reasons: 1) because their ancestors originally occurred there and their descendants survive there until the present day or 2) because their ancestors originally occurred somewhere else, and later they (or their descendants) dispersed into new areas where descendants survived to the present day. These two reasons characterize two types of historical explanations, called "vicariance" and "dispersal" respectively. In the vicariance explanation, an ancestral population is divided into subpopulations when a barrier appears that they cannot cross. In time, the two separated subpopulations evolve into different taxa. In the dispersal explanation, the range of the ancestral population is limited by a barrier, and the newer population remains isolated from the old area. The newer group eventually evolves into a different taxon. For the dispersal explanation, an important factor is the means of dispersal of a particular group. Elephants wander, birds fly, fishes swim and fern spores are blown by the wind.

There was a time during the Wallacean period, which lasted about 100 years (1860-1960), when it was believed that, through natural selection, dominant species of plants and animals arose in small centers of origin, from which they spread and diversified over the earth. The Wallacean explanation was based on the theory that the major geographic features of the earth – the continents and ocean basins – had been stable during the evolution and dispersal of recent life. The Wallacean period ended in the 1960"s when geophysical studies of the sea floor showed that continents and ocean basins are not permanent features of geography. The new evidence confirms and revives the theory of continental drift developed early in this century. According to its classic version, this theory states that all continents were once united into a single landmass, Pangaea. About 180 million years ago, Pangaea split into a northern supercontinent, Laurasia, and a southern supercontinent, Gondwanaland. Laurasia included what is now North America, Europe and Asia (except for the Indian subcontinent). Gondwanaland included what is now South America, Antarctica, Australia, Africa, India, and possibly other parts of southern Asia. Subsequently, both Laurasia and Gondwanaland fragmented, producing the modern continental arrangement.

CONTINENTAL DRIFT

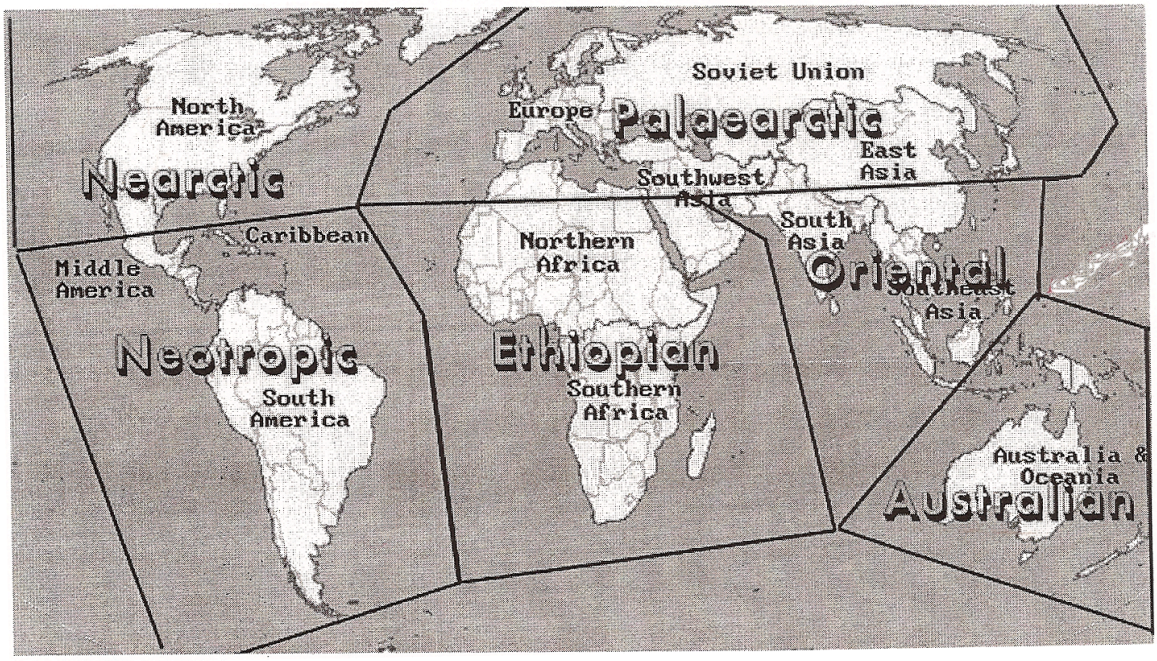


Alfred Wegener's **continental drift theory** was modernized in the 1960's to explain why the continents moved. The **plate tectonics theory** states the reason for continental movement, is due to the free flowing liquids underneath in the mantle. The earth's crust is not a solid shell; it is broken up into huge, thick plates that drift atop the soft, underlying mantle. The plates are moving at a speed that has been estimated at 1 to 10 cm per year. The movement of the plates explains the cause of earthquakes, volcanic eruptions, and mountain range formation as well as the movement of the continents, mid-ocean ridges, and oceanic trenches. Most of the Earth's seismic activity (volcanoes and earthquakes) occurs at the plate boundaries as they interact.

The six zoogeographical realms of today are the **Nearctic**, **Neotropic**, **Ethiopian**, **Palaearctic**, **Oriental** and **Australian** (see figure page 9). Each region possesses distinctive and uniform taxonomic groups and each, to a greater or lesser extent, shares some families between the regions.

The Nearctic and Palaeartic regions share fauna – caribou, wolf, hare, bison, and deer. The Neotropical, isolated until 15 million ears ago, has varied and distinctive fauna. The Ethiopian region has the most varied vertebrate fauna and is second only to the Neotropic in endemics. The oriental has the fewest endemics of the tropical regions, but is rich in primate species. The Australian region (Australia, Tasmania, New Guinea) has been separated from other land masses for millions of years. Its marsupials have become diverse and have evolved ways of life similar to those of placental mammals.

ZOOGEOGRAPHICAL REALMS OF TODAY



Oceanic and Antarctic Realms are sometimes considered as separate.

Sources:
Biography Gareth Nelson and Norman Platnick.
Docent Training lecture notes on biogeography, January 1989

ECOLOGY

Ecologists look at nature from many different angles and they organize the things they learn in a variety of ways, but their basic unit of study is the ecosystem.

An ecosystem consists of all the living and nonliving things that make up a particular environment; i.e., a pond, a forest, a desert or a mangrove swamp. The concept is important, not just because it is a convenient way of arranging data, but because it represents a panoramic, holistic approach to thinking about nature and the interdependence of all matter.

Scientists frequently describe the interactions within an ecosystem in terms of exchanges of energy and nutrients. Plants derive energy from the sun and nutrients from the earth; they in turn supply both to the animals – microorganisms as well as larger grazing species that feed on them. As the plant-eating animals are themselves eaten by carnivorous ones, **food chains** and **food webs** are formed.

Ultimately, of course, the animals at the ends of the food chains – whether buzzards, whales, or people – also die. When they do, their bodies are returned to the ecosystem, where they decompose for the benefit of future generations of plants and animals. The cycle is completed and a new one begins; it is immortality of a sort.

No ecosystem is entirely isolated. Through what are called transition zones, grasslands merge into forests, and saltwater swamps gradually become land. The ecosystems themselves often

are divided into zones. Typically, **zonation** reflects differences in altitude, temperature, water supply, salinity, and other similar factors. Red mangroves tend to grow around the low tide mark in a swamp, black mangroves at the normal high tide mark, and white mangroves at the still higher tide level that is reached during equinoxes. The animals in each zone usually vary as a result of the differences in vegetation.

Most ecosystems are fragile; their characters tend to change with time, as one group, or **community**, of plants and animals gives way to another. This is called **succession**. Such changes normally take place in a slow, orderly fashion as plants and, to a lesser extent, animals respond to – and modify – their environments. Mangroves gradually help build new land, only to be replaced by buttonwoods; an inland pond may gradually silt up, become a marsh, then a meadow, and finally a forest. The last stable step in such a progression is called the **climax community**.

Of course the normal process of succession may be interrupted at any point. A hurricane can wash away new land overnight causing a mangrove community to revert to an earlier stage in the sequence. And people interfere in endless ways. Organic pollution of a pond can cause a temporary explosion of plant and animal life, which may deplete the ecosystem's oxygen supply, finally killing everything in the pond. Dams and dikes may later regular fluctuations of water levels necessary for the maintenance of freshwater marshes such as the Everglades as well as saltwater mangrove communities.

The destruction of just one link in the web of life may have profound consequences. For example, when prairie dogs are poisoned, the birds that feed on their carcasses also die, leaving insects and small rodents without natural predators. These prey populations then swell, making them far greater pests than the prairie dogs ever were.
Ecosystems might suffer less damage if would-be tinkerers remembered that the term derives from the Greek oikos, meaning "house", or "home", and treated the various ecosystems accordingly. **Ecology**, of course, has the same root. It relates as "the study, or science of the home". Patterned after economy, **ecology** actually is just another way of saying "home management" or more mundanely, "housekeeping".

Ecosystems come in all sizes – from laboratory culture (microcosm) to the zone in space, extending millions of miles around the sun and other stars, in which life can exist (the **ecosphere**). Ultimately, all ecosystems are interlinked. Together they constitute our home. We have no other.

Reprinted from ANIMAL KINGDOM (Oct/Nov '83), an article written by Hugh Rawson

SOME BASIC ECOLOGICAL CONCEPTS

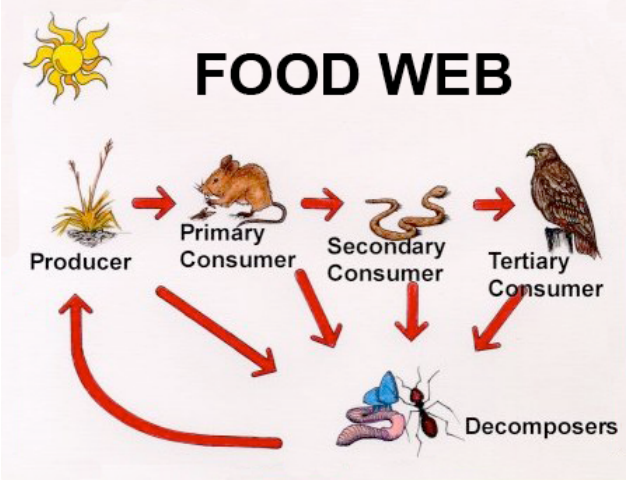
The living world is based on complex relationships among plants, animals, and the places they inhabit. ***Ecology*** is the study of these relationships. By studying ecology we begin to see how living things depend on each other and on their habitat for survival.

An ***ecosystem*** is the assemblage of interacting living things in an area, together with their environment. Different kinds of ecosystems are called ***biomes***. Tropical rainforest and desert are two examples of biomes.

The ***environment*** in which a living thing exists is made up of both non-living parts (**abiotic** - air, water, rocks and minerals, sunlight) and living parts (**biotic** - bacteria, plants, protists, animals, etc.). Living things are constantly exchanging chemical substances with the world around them. These substances move in continuous ***cycles*** between the living and nonliving worlds. Some of the cycles are the nutrient cycle, water cycle, nitrogen cycle, and carbon cycle. **Biomass** is the collective mass of all living things.

In the living world, every form of life is food for another and almost all life on earth depends on energy from the sun. Plants use sunlight, together with water, carbon dioxide gas from the air, and chemicals from the soil or water to make their own food; they are called ***producers*** (or autotrophs). They form the first ***trophic level*** of a ***food chain***. Living things that cannot make their own food (e.g. animals) are called ***consumers*** (heterotrophs). ***Decomposers*** break down organic material such as dead plants and animals so that the constituent compounds can be returned to the soil. This transfer of energy through the trophic levels is called ***energy flow***.

Food chains describe the transfer of energy through producer, herbivore, predator and decomposer in an ecosystem. Food chains interconnect to form ***food webs***. Energy is used up in metabolic processes or in movement, so only about 10% of the energy an animal receives is available for the next **trophic level**. That is why each level supports fewer individuals than the one before (e.g. lots of grasshoppers, fewer grasshopper-eating sparrows and even fewer sparrow- eating hawks), and also why food chains rarely contain more than five steps.



An ecological ***community*** is a collection of living things that are found in the same area or ***habitat***. A habitat is the specific environment in which any given organism or any given population lives. Within a given habitat may be several ***microhabitats***. For example, in a forest habitat, microhabitats include the canopy of the trees, the forest floor, and a rotting log. Some species are so specialized that they live in just one microhabitat; others are more "generalists" and use the entire habitat.

In a simple community, there may be just a few species, but in a complex community, there can be many hundreds or thousands of species. Each species occupies a unique niche. A ***niche*** refers to a living thing's role or “job" in its environment; it is the specific role a particular organism

plays in the community. An animal's niche is defined by factors such as its habitat, what it eats, when it is active, its predators, and its tolerance to environmental factors such as temperature and humidity. An organism has an ecological niche, which is distinct from its physical habitat.

No two species can occupy exactly the same niche. This is the principle of ***competitive exclusion***. Species may share the same habitat, but their roles (or jobs) are different. If two species are competing for the same niche, the one that is best adapted to the range of conditions present will survive by having the higher birth rate and/or lower death rate.

Niches are created from the partitioning of resources. In natural situations, species that might compete have evolved ways to reduce competition and divide resources. They may use the habitat at different times of day (***temporal separation***) or use different parts of the habitat (***spatial separation***). ***Competition for resources*** affects the number of individuals in a particular species and the total number of species that can coexist in a given habitat.

Each species has a ***pattern of distribution*** related to the range of environmental conditions (e.g. light, temperature, humidity, etc.) and food sources to which it is adapted. Surrounding the species' habitat are the areas where the species cannot survive (or reproduce) because the environmental conditions exceed the tolerance limits of the species. Organisms with tolerance of a wide range of conditions generally have a wide distribution (e.g. puma) whereas those with a narrow range have a more restricted distribution (e.g. snow leopard). This idea of limiting factors is one reason why species -- except humans! -- don't expand their ranges all across the earth.

(10/01)

NOTES ON HABITAT AND ENVIRONMENT*

1. **Explain the meaning of the term "food chain" or food web.**
   A food chain is a concept that can be diagrammed to depict the food relationships among plants, plant eaters and animal eaters. A food chain may consist of only a plant and an animal population that east it.

   For example: wheat ⟶ crickets ⟶ frogs ⟶ raccoon

   A food web is made up of two or more interconnected food chains and more accurately describes the complex relationships in the natural world than does a simple food chain. [See example on previous pg - pg 8]

2. **Be able to describe a typical food chain from any biome.**

3. **Explain what is meant by the general principle of biology, which states that no two species can occupy the same ecological niche in a particular region.**
   This **competitive exclusion** principle states that two or more resource limited species, which have an identical pattern of resource use cannot coexist in a stable environment. One species will be better adapted to the range of conditions present and will out-compete or eliminate the others.

4. **What is ecology?**

Ecology is the study of the interrelationships among organisms and between organisms, and between them and all aspects, living and non-living, of their environment.

5. **What is a biome?**
   A **biome** is a biological subdivision that reflects the ecological and physiognomical character of the vegetation. One variety of landscapes, each biome has a characteristic type of vegetation growing in response to regional climatic conditions and each is inhabited by characteristic sets of animals. Biomes are the largest geographical biotic communities convenient to recognize.

6. **What are the major types of biomes?**
   Tundra; **forests** (temperate deciduous forests, Northern coniferous forests, tropical dry forests, cloud forests, tropical rain forests; **grasslands** (temperate grasslands, tropical savannahs); and **deserts** are the major types or terrestrial biomes. The other major biome is the aquatic biome (freshwater and marine). It is important to remember that biomes do not have definitive edges. Patterns of land and sea, of winds and ocean currents, blur the boundaries. Within mountain systems, the zones all come together. Permanent snowfields may be within a few miles of tropical forests; one side of a ridge may be a desert and the other covered with rich vegetation.

7. **What is climate?**
   The basic ingredients of weather and climate are temperature, moisture and light. Weather is the day-to-day changes in these factors; climate is the general region or geographical pattern.

8. **Why are tropical forests said to provide the most favorable climate for life on land?**
   They provide continuous warmth, easy availability of water, abundant light; hence, a year-round growing season.

9. **What animals at the San Francisco Zoo come from tropical forests?**
   Monkeys and apes, coatimundi, tapir, mandrill, various insects, poison dart frogs, turtles, spectacled bear, lemur, aye-aye etc.

10. **What are some of the special adaptations of animals that live in grassland?**
    Burrowing (small animals)
    Sheer toughness and bulk (rhino, elephant, hippo)
    Speed (predatory and prey: the fastest land animals live in open country (i.e. cheetah, patas monkey)

11. **What animals come from grasslands?**
    Zebra, giraffe, hippo, kangaroos, wallaroo, lion, crowned crane, African elephant, Marabou stork African wild dog, warthogs, etc.

12. **What are the characteristics of a desert?**
    - Dryness (arbitrarily set at less than 10 inches of rainfall per year)
    - Life is limited by the scarcity of water
    - Vegetation widely scattered and not forming a general covering for the soil
    - Temperature drops rapidly at night
    - Plants and animals must have adaptations to make the most of what water there is
    - Bright clear skies

- Hot sun (in **most** cases, technically, Antarctica is a cold desert because of the lack of usable water

13. What are the characteristics of the deciduous forests of temperate zones?

Since the regional temperature differences within the North Temperate Zone and the South Temperate Zone may be considerably modified by the geographical features of the continents and oceans, it is difficult to talk about characteristics general to all. For example, California, part of the Chilean coast, the area around the Mediterranean, and southwest Australia are sometimes grouped together as a single "Mediterranean biome". Temperate zones are generally characterized by definite changes of season. The primary landscape type of the North Temperate Zone is the deciduous forest. These forests provide a home for these San Francisco Zoo animals: deer, raccoon, Siberian tiger, grizzly bear, pheasant, owls, bobcat etc.

14. **What are the characteristics of the taiga?**
    - The trees are conifers (fir, spruce, pine), which means they are green all year around with stiff needles instead of broad leaves
    - The ground is covered with a mat of slowly decaying needles
    - Lakes, ponds and bogs are numerous in many regions
    - Winters are longer and colder than in temperate zones
    - Large herbivores (deer, moose, elk, caribou) and wolf, sable, ermine, wolverine, bear and numerous rodents

15. What are the characteristics of the tundra?

Arctic – land surrounding a polar sea
- Subsoil permanently frozen ("permafrost")
- Precipitation and evaporation low
- Vegetation includes a considerable variety of grasses and lichen, ponds and bogs may form in summer

Antarctic
- Seas surrounding the isolated southern continent
- Only two kinds of seed found, so vegetation can hardly be said to exist
- Some bare ground areas but very harsh and cold
- True land vertebrates absent (penguins and seals depend on the sea)
- Very few invertebrates – insects, arachnids, etc.

16. What animals are found in the tundra?

Polar bear, waterfowl, reindeer/caribou, snowy owls, musk ox, elk, arctic fox, weasel, snowshoe rabbit, etc.

17. What about island life?

Islands differ greatly according to their size, location, structure and climate. It is vest to study the islands individually for details about their animal life. The islands species of birds or mammals include: Australia (kangaroos, koala), New Guinea (crowned pigeon), Sri Lanka (peafowl, Asian elephant), Palawan (peacock, pheasant), Falklands (Magellanic penguins), Sumatra (orangutan, siamang), Kodiak (Kodiak bear), Tasmania (Bennett's wallaby), Madagascar (lemurs, aye-aye, tomato frog, day gecko)

18. What is meant by environment?

A living thing's environment is everything in its surroundings. Weather, climate, rainfall, water pathways, wind, soil, insolation (Insolation = amount of sunlight), human additions (pollution), engineering, and altitude. The environment is the combination of all external factors that affect and influence the growth, development and reproduction of organisms.

19. What is a habitat?

The general description (not specific geographic location) of where an organism normally lives. Oceanic, estuarine, riparian, desert, savanna, scrub forest, tundra, etc. (may be very specific)

20. What is an animal's niche?

Niche refers to the role or function of an animal in its environment (predator, prey, scavenger, etc.) Usually more specific e.g., zebra grazes tall dry grass, gnu fresh tender. Maybe a "snake-eating snake", or two different desert mice eat same things – day vs night.

* Extracted from ANIMAL WORLDS by Marston Bates

Principal Biomes with their Dominant Growth Forms and some Representative Species

Biome	Dominant Growth Form	Representative Plants (mostly Northern Hemisphere)
Aquatic Systems		
Open oceans	Plankton, floating algae	Diatoms, plankton (dinofiagellates, etc,)
Estuaries & shores	Multicellular algae, grasses	Seaweeds, eelgrass, marsh grass
Lakes & streams	Algae, mosses, higher plants	Plankton algae, filamentous algae, duck weed, water lilies,
Swamps, marshes, bogs	Algae, rushes, etc.	pondweed, water hyacinth Cattails, water plantains, pipeworts, rushes, sedges, sphagnum moss, tamarack, baldcypress, mangrove
Forests		Many species of evergreen, broad leaved trees (unfamiliar to us),
Tropical rain forests	Trees, broad leaved evergreen	vines, epiphytes (orchids, bromeliads, ferns)
Tropical seasonal forests	Trees, both evergreen and	Mahogany, rubber tree, papaya, coconut palm
Temperate rain forests	deciduous Trees, evergreen	Large coniferous species (Douglas fir, Sitka spruce, coast redwood, western hemlock, white cedar)
Temperate deciduous	Trees, broad leaved deciduous	Maples, beech, oak, hickory, ash, basswood chestnut, elm, sycamore
Temperate evergreen		Pines, Douglas fir, spruce, fir
Boreal coniferous (taiga)	Trees, needleleaved Trees, needleleaved	Evergreen conifers (spruce, fir, pine), blueberry, oxalis
Reduced Forests		
Scrublands, chaparral	Shrubs, sclerophyll, evergreen	Live oak, deerbrush, manzanita, buckbrush, chamise
Thorn woodlands	Spinose trees and large shrubs	Acacia, large shrubs
Temperate woodlands	Small evergreen or deciduous trees, grass or shrubs	Pinyon pine, juniper, evergreen, oak
Grasslands		
Tropical savanna	Grass (and trees)	Tall grasses, thorny trees, sedges
Temperate grasslands	Grass	Bluestem, Indian grass, grama g'rass, buffalo grass, bluebunch, wheat grass
Tundras		
Arctic	Diverse small plants	Lichens, mosses, dwarf shrubs, grass, sedges, forbs
Alpine	Small herbs (grasslike)	Sedges, grasses, forbs, lichens
Deserts		
Tropical warm	Shrubs, succulents	Spinose shrubs, tall cacti, euphorbias
Temperate warm	Shrubs, succulents	Creosote bush, ocotillo, cacti, Joshua tree, century plant, bur sage (in USA)
Temperate cold	Shrubs	Sagebrush, saltbush, shadscale, winterfat, greasewood (in USA)

(10/01)

Adaptations

Animals live in a variety of unique environments. Through natural selection, animals have modified, over time, both their behavioral and physical characteristics to better equip themselves for survival in their environments. As environments change, animals must adjust to survive. Animals have characteristics that work for their environment, but not always what works best.

No two species can occupy exactly the same niche. This is the principle of ***competitive exclusion***. Species may share the same habitat, but their roles are different. If two species are competing for the same niche, the one that is best adapted to the range of conditions present will survive by having the higher birth rate and/or lower death rate. In natural situations, species that might compete have evolved ways to reduce competition and divide resources. The species that is not the better adapted will die out or must adapt to a new niche.

A subset of organisms within a species can get isolated from the rest of their species and through adaptations, this subset can develop into a new species all together. **Speciation** is the evolutionary process by which new biological species arise. It is the formation of new species as a result of geographic, physiological, anatomical, or behavioral factors that prevent previously interbreeding populations from breeding with each other. A species is a group of organisms that can interbreed in nature to produce a fertile offspring. For example, the isolation of populations results in development of different gene pools and resultant different traits. Islands and continents separated over time show distinct differences within and among species as a result. Shift of continents over time results in distinctly different types of animals/plants on various continents and islands.

Isolating mechanisms that may prevent breeding between species:

- **Geographic isolation**: Species occur in different areas, and are often separated by barriers. Madagascar's lemurs were isolated from evolutionary changes of the world and radiated into the large island's many niches without much competition or predation.
- **Ecological isolation**: Species occupy different habitats. They do not encounter individuals of other species with different ecological preferences. The lion and tiger overlapped in India until 150 years ago, but the lion lived in open grassland and the tiger in forest. Consequently, the two species did not hybridize in nature.
- **Temporal isolation**: Species breed at different times. This may be different times of the day or different seasons. In North America, five frog species of the genus *Rana* differ in the time of their peak breeding activity.
- **Behavioral isolation**: Species engage in distinct courtship and mating rituals. Individuals of different species may meet, but one does not recognize any sexual cues that may be given.
- **Mechanical isolation**: Interbreeding is prevented by structural or molecular blockage of the formation of the zygote. Mechanisms include the inability of the sperm to bind to the egg in animals, or the female reproductive organ of a plant preventing the wrong pollinator from landing.

Adaptive Radiation is the evolution from one kind of organism to several divergent forms, each specialized to fit a distinct and diverse way of life. Adaptive radiations often occur as a result of an organism arising in an environment with unoccupied niches, such as a newly formed lake or isolated island chain. The colonizing population may diversify rapidly to take advantage of all possible niches. Adaptive radiations commonly follow mass extinctions. An example of this is the replacement of the non-avian dinosaurs with mammals.

Comparable selective forces, act on animals and plants in similar habitats but different parts of the world, often cause totally un-related species to assume a similar appearance. This process is convergent evolution. **Convergent Evolution** is the independent development of similar structures in organisms that are not directly related; often found in organisms living in similar environments. The prairie dogs in the United States can be seen as the equivalent to the Southern African meerkat; they live in similar habitats and they are both burrowing mammals, living together in a tight knit social group.

Why Should Animals Adapt?

- **Feeding**: pressure from predator/prey interactions and competition for limited food sources have led to the evolution of many adaptations.
- **Defense**: protect themselves and their young from predators, pests and weather.
- **Locomotion**: they must be able to move throughout their habitat.
- **Reproduction/perpetuation of species**: must recognize their own species, attract a mate and raise young.

Types of Adaptations

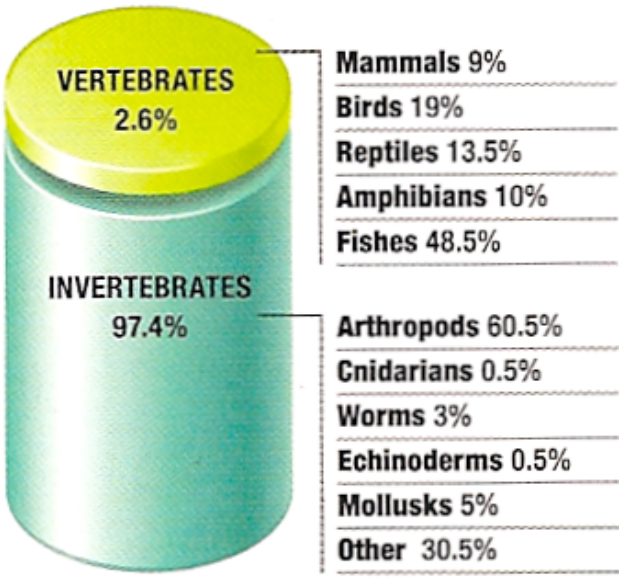
- **External Physical Features**
  - Color: color or patterns can be used as camouflage or for identification.
  - Size: an animal's size or shape enables it to reach food, keep cool or warm, or be streamlined in wind or water.
  - Features: specific parts, like eyes, hands, tongues, ears or toes, can serve a special purpose, how an animal moves, large paws of predators, large snouts for good sense of smell, large ears for hearing, large eyes for seeing, etc.
- **Internal Physiological Adaptations**
  - Light skeleton for flying, large lungs or heart, multiple stomachs to ease digestion, tolerate higher body temps to reduce water loss, specialized kidneys, delayed implantation, etc.
- **Behavioral Adaptations**
  - Social behaviors (living in groups or alone), vocalizations, nocturnal, grooming, facial or body gestures, maternal care, rolling in mud to protect skin from sun and insects, dominance, territorial, etc.

Biodiversity

Biodiversity is the diversity of living things. It is the degree of variation of life forms within a given species, ecosystem, biome, or an entire planet. The extent of biodiversity is a measure of the health of an ecosystem.

There are three kinds of biodiversity. To preserve diversity, you need to preserve all three.

- **Species diversity** – the number or variety of species
- **Genetic diversity** – the genetic makeup of a species, a term that describes the tendency of genetic characteristics to vary; the variety of genes and diversity within a species.



SPECIES DIVERSITY

- **Ecosystem diversity** – the variety of habitats, living communities and ecological processes in the living world. Ecosystem diversity includes both biotic (living) and abiotic (non-living) components, which makes it different from both genetic and species diversity.

Why is biodiversity important?

- Interdependence of species.
- Disease effects individuals differently so may not kill everyone due to genetic diversity. Zoos try to maintain genetic diversity due to this concept of disease.
- Genetic disorders
- "Natural Selection". Species respond to changes in their environment.

Biodiversity "**hot spots**" – biographic regions with a significant amount of biodiversity that is under threat from humans. If you save where biodiversity is greatest, then you save most of the species.

There is a great diversity in the Tropical Rainforest with over 1/2 of all plant and animal species. It is the richest and most diverse biome on earth. This is an area of low seasonality and resources are relatively stable. Food availability and reproduction seasons are not limited to short periods of time as they are in a more temperate environment. Plants and animals can afford to specialize.

With high species diversity in the rain forest, an area might have only one or two individual of a particular species. Wind pollination would not be successful. Dominant trees in the rainforest are flowering with their pollination predominantly done by animals. Many species of plants have brightly colored flowers that are easy to see in dim light and scents tend to be strong that insects and birds find the flowers quickly. **Co-evolution** is the simultaneous evolution of adaptations in two or more populations interacting so closely that each is a strong selective force on the other. There are many cases of co-evolution found in the tropical rainforests such as the hummingbird beak shape and the shape of the flowers.

ANIMAL BEHAVIOR

Darwinian concept of fitness: leaving the most offspring. "Survival of the fittest" really means long-term perpetuation of a species or a lineage.

Innate vs. **learned**

Some behaviors are "innate" or inborn, and some are learned. Examples of learned and innate behaviors:

- Parenting in gorillas (mostly learned). Gorillas live in social groups, female gorillas are exposed to babies and to parenting before they become parents themselves.
- Salmon returning to their spawning grounds (innate)
- Whooping cranes following their annual migration route (learned) Why this would not be a disadvantage - Young bird would not under natural circumstances make its first trip alone.
- Song of the brown-headed cowbird. Note that the cowbird is a nest parasite, i.e., lays its eggs in other birds' nests. Young cannot learn the species-specific song from a parent because the parents that raise them are a different species. Song is completely innate. Other birds learn their song from their male parent. Whether a song is learned or innate in birds varies from species to species. Concept of template so that bird that hears the song of many birds (as is typical in nature still learns only the song of its species.)
- Courtship, nest building, incubation and parenting in doves (innate).

Not only the behavior itself, but also whether it is genetically programmed (innate) or learned is an adaptation.

One of the complications in interpreting animal behavior is that animal senses differ from our own. Concept of the "Umvelt" (the animal's sensory world).

- Orientation and navigation
  - Homing in pigeons. Use direction of sun (But keep in mind they must have a sense of time to do so!) under cloudy skies they use earth's magnetic field.
  - Navigation in migratory birds. Even in cages, birds orient in direction of migration. Birds that migrate in daylight orient with respect to sunlight and birds that migrate at night use the stars. Clock-shifting birds "rotates" their internal compass.
- Sharks and electroreceptors (ampullae of Lorenzini)
- Honeybees and other insects see ultraviolet. Patterns in flowers.
- Pythons, rattlesnakes have heat-sensing (infrared) pits.

Reproductive strategies: male vs. female

Differential investment in gametes results in common patterns of greater maternal behavior and greater selectiveness in females. Male patterns include Male-male competition:

- Showiness. The peacock's tail. How could it evolve if it makes it harder for the male to escape predators? Advantage in reproduction outweighs disadvantage in survival
- Horns in male antelope and antlers in male deer. How can you tell that these are not important for defense? Females often don't have them, and in the case of deer antlers, males don't have them all the time.
- Voice in male toads but not in females.
- Sometimes what looks like "rape" is the female attracting competition for her suitor so that she will in the end mate with the strongest male. Elephant seal mating. This does not have to be a conscious strategy on the part of the female. But the females that

struggle have babies that are sired by the biggest and strongest males. Good example of importance of not attributing human standards to animal behavior.
- Infanticide. How could killing babies be adaptive? The Bruce effect in which exposure of a female to an unknown male results in pregnancy disruption in mammals.
- Shared, equal investment. Magellanic and other penguins pair for life, share duties equally.

Why live in groups?

- Living in groups. Herds of hoofed animals on Serengeti. The resources are rich and cannot be defended, thus territoriality would be neither practical nor necessary. Advantages of living in herd include vigilance against predators and the “dilution effect"-in a large group you are less likely to be singled out by a predator. Disadvantages - parasites, competition for resources.
- Apparently "altruistic” behaviors.
    - Reciprocity - Grooming in primates. "I scratch your back and you scratch mine." Cheaters are recognized and eventually shunned.
    - Cooperative hunting Harris hawks. Flexibility demonstrates that it is an adaptive response to environment
    - Kin selection. Marmosets, acorn woodpeckers, bees, raise siblings instead of their own offspring at some point in their lives. Lionesses in a pride are closely related. Nurse each others' young and hunt for group.

Why not live in groups?

- Territoriality. Resources are limited and can be defended from other individuals or groups. Predators are often solitary. Social predators are well known but not as prevalent as solitary.

Avoid **anthropomorphism** (attribution of human qualities to nonhumans)!
When observing animals describe actions, not apparent function. Objectively describe what you see, not what you think they are trying to accomplish. E.g., "running approach with head forward" not "trying to frighten." Interpretation is likely to be incorrect. Examples: Inactive animals look "sad ". Grinning at chimpanzees - grinning is seen as a threat in many primates. Happy grin in chimps does not expose teeth.

Docent class outline January 2006

SOCIAL GROUPINGS

Did you know??? According to Noah, all animals go in twos, but in reality there are several basic social units. Usually the social grouping has something to do with the needs created by sharing: sharing the task of killing a large prey, sharing the task of defending the group against predators, sharing body heat to keep warm at night, sharing out different duties that can be performed at the same ~e, sharing the food that has been obtained by special members of the group, and so on. Some of the classifications are:

1. **Solitary**: The adult males and females live alone and meet only in the breeding season. After courtship and copulation, they split up again and have no further relations until the next season. The female deals with the young without the help of the male, or in certain cases the male rears the young without the help of the female. The solitary adults may wander over vaguely defined home ranges, or they may restrict themselves to clearly defined and defended territories.
2. **Pair**: Wherever the parental duties are too much for one parent, the male and female form a strong attachment for one another and live together as a bonded pair. Nesting fish, as well as over 90% of the birds, form pairs that share the parental duties equally.
3. **Family**: This is merely an extension of the pair. When the young arrive they often remain with the parents until they are fully, or nearly fully, grown. During the later stages of their development to adulthood they frequently move about with their parents and, at this stage, create a larger grouping. Occasionally, there may be overlapping litters, with older offspring remaining while new babies are being cared for. In such cases, the extended family begins to 1ook quite complex, but it is still essentially based upon the original pair. When young do become fully adult they are driven away or wander off on their own to form separate pairs.
4. **Harem**: A typical mammalian grouping consists of one dominant male and a harem of females. The size of the harem varies from species to species. The harem system requires, of course, that a large number of males are unlucky in the breeding season and must remain on the fringe of the reproductive groups. There they may become solitary or may form into bachelor groups. When the harem-masters become too old or too sick, new overlords will emerge from the strongest in the bachelor groups and will take over the females. Inherent in this type of social system is a marked sexual dimorphism, with males usually much bigger than females, a result of the fierce inter-male competition for dominance. Some harems are permanent, while others dissolve at the end of the breeding season. When this happens, the individuals may disperse or they may stay together in new groupings.
5. **Matriarchy**: By a small shift in the balance of power between the genders, the harem system can be converted into a matriarchy. In this type of grouping, the females stay together at the center of society, with the males on the outside. Instead of the dominant males moving in and taking over the females during the breeding period, they are simply allowed in for mating only and then driven out again.
6. **Oligarchy**: This is a more complex social grouping where power is invested in an elite gang of dominant males. Young adult males are driven out of this group and form separate bachelor parties that must bide their time until they can steal young females and set up an oligarchy of their own. The advantage of this arrangement is that it provides and efficient means of defense against predators. They also can help one another to defeat an attack by rival males, or an overly dominant female. This arrangement requires a certain amount of restraint and cooperation on the part of the dominant males, but it clearly has compensatory advantages. It is employed by a wide range of species, wIth slight

variations. In some cases, there is a strong peck-order operating within the group of males, and sometimes also within the group of females.

7. **Arena**: Some species have developed an all-male grouping of a special kind. In various bird species, the males all cluster together in the breeding season on a special patch of ground called a lek or arena. There each displays as vividly as he can. The females visit the arena and select the male of their choice, mate with him and then leave to rear the young on their own.
8. **Hierarchy**: A social hierarchy, peck-order, or social dominance grouping consists of individuals that are ranked according to their status. Since territorial individuals are dominant in their own area but subordinates in other areas, hierarchically grouped individuals have the same status wherever they go. Their rank is determined not by place but by person. This arrangement can become part of a reproductive group, but it is also frequently seen in non-breeding groups, where a hierarchy develops in relation to food sources.
9. **Aggregation**: In non-breeding groups the size of the gathering can swell and swell, especially during migration. There, when animals are on the move, there is little social structure, merely a mass of advancing animals.
10. **Caste System**: These are extremely complex social organizations in which there are different classes of individuals, providing an efficient division of labor.

Animalwatching, Docent Doings - Feb. 1992

RHYTHMIC ACTIVITIES

Many of the activities of an organism occur in more or less rhythmic patterns during the life of an individual organism. Some, such as food gathering, rest, sanitation, and, in higher animals, play usually occur every day. Others, such as the avoidance of major environment changes and reproduction, are seasonal in distribution.

Activity that occurs during the daylight hours is **diurnal** activity, at night is **nocturnal** activity, and twilight (either dawn or dusk) is **crepuscular** activity. Some animals appear to be **arrhythmic** in relation to the daily cycle of light and darkness. Many activities appear to follow some rhythmic pattern, lasting 24 hours, that is controlled by some internal mechanism. Such activities are termed **circadian** (circa, about; dies, day) **rhythms**. Many activities are related to longer periods, such as the seasons of the year. Such seasonal activities in longer-lived animals may include reproduction, hibernation, aestivation, and migration. These various aspects of activity are considered in more detail in the following sections.

Many of the rhythmic activities of animals appear to be under the control of some unlearned mechanism (often called the **biological clock** that is synchronized with some external environmental factor. The basic controlling mechanism is still poorly understood. Many biologists are convinced that the “clock” is some innate, perhaps subcellular, metabolic mechanism that ‘keeps time” internally (endogenous clock) and is reset by environmental factors. Others are just as equally convinced that there is no internal clock and that some external mental factors (perhaps cosmic radiation) controls the basic metabolic rhythm, while other environmental factors (such as light or darkness) only modify the basic rhythm (exogenous clock). In any case, kangaroo rats, hamsters and flying squirrels maintain circadian activity cycles in total darkness, ad these cycles may not be a 24 hour duration. Many marine animals, especially along the seashore, display a tidal rhythm, some being active during high tide (oysters and clams open their shells at such times), others during low tide (fiddler crabs are active and undergo a color change during periods of low tide).

In addition to the circadian, rhythms of longer duration are known. Lunar rhythms and seasonal rhythms are well known.

HIBERNATION AND ESTIVATION

During adverse environmental conditions, many organisms become inactive. When the inactive period occurs during the winter months, it is called **hibernation**, and when in summer, it is called **aestivation**.

Hibernation is a characteristic of temperate zone animals during periods of relatively low temperature and physiologically inaccessible water (snow and ice). Both the time of beginning and the duration of hibernation are variable. Some animals enter hibernation in early fall, long before extreme cold weather arrives. Many different environmental stimuli appear to be involved in its onset. Cooler temperatures of late summer and early fall appear to initiate hibernation in many species. The absence of proper types of food (green plants for ground hogs or a large number of flying insects for bats) or the lack of proper moisture content in foods appear to be the effective stimuli for some species.

Even in the presence of cold and food shortages, certain animals apparently do not enter hibernation if they have not yet stored enough fat to survive the winter. Adult jumping mice become obese and enter hibernation earlier than do the young of the year. Other factors, such as carbon dioxide concentration in the den and hormone concentrations in the body, may play some role in the process. Changing relative lengths of the daylight and dark may control hormonal activity within the animal.

Many physiological changes occur during hibernation. The metabolic rate is greatly reduced as evidenced by lowered body temperature, lowered respiratory rates, lowered rate of circulation of body fluids, reduction in rate of digestive enzyme production, and all other measurable aspects of metabolism. Before hibernation, animals retreat to protected places where temperatures do not go below freezing and relative humidity remains constant.

Brumation is a term used for the hibernation-like state that ectothermic animals utilize during very cold weather. This dormancy is similar to hibernation. Reptiles can go for months without food but during brumation, they often need to wake up to drink water and return to "sleep". Brumation is triggered by lack of heat and the decrease in the hours of daylight in winter.

Aestivation is dormancy during dry, hot periods of the summer months in temperate and tropical regions. During such periods, water is usually physically inaccessible. During aestivation, animals retreat to holes in the ground or other protected places where temperatures are not extreme and relative humidity remains high. (i.e., lung fish or Kalahari burrowing frog)

(rev 01/00)

ENDANGERED SPECIES

Following are terms as they are defined in the **Red Data Book**. This publication consists of a constantly updated list of animals in jeopardy and give their status, distribution, population, habitat, as well as conservation measures taken and those proposed. Published by the International Union for the Conservation of Nature and Natural Resource (**IUCN**), this book is an important tool in wildlife management.

I. **Endangered**
Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

II. **Vulnerable**
Taxa believed likely to move into the endangered category in the near future if the causal factors continue operating. Included are taxa of which most or all the populations are **decreasing** because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously **depleted** and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are **under threat** from serious adverse factors throughout their range.

III. **Rare**
Taxa with small world populations that are not at present endangered or vulnerable, but are at risk. These taxa are usually localized **within** restricted geographical areas or habitats or are thinly scattered over a more extensive range.

IV. **Out of danger**
Taxa formerly included in one of the above categories, but which are now considered relatively secure because effective conservation measures have been taken or the previous threat to their survival has been removed.

V. **Indeterminate**
Taxa that are suspected of belonging to one of the first three categories but for which insufficient information is currently available.

In practice, endangered and vulnerable categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is to justify their transfer to another category.

CAUSES OF ENDANGERMENT

I. Natural causes (climatic changes, storms, volcanic eruptions or evolution)
II. Human-related causes
   A. Direct predation – hunting for food or sport
   B. Direct predation for body parts (usually illegal), which are used for decoration or for presumed medicinal value. (i.e. rhino horn, ivory, seal skin, etc.)

C. Killing animals considered to be vermin. (i.e. predator animals thought to kill livestock – coyotes, eagles and snakes)
D. Habitat destruction (forest clearing, dam building, commercial and residential construction)
E. Side effects of poisons and pesticides
F. Introduction of domestic animal species in area where they have not been before (predation by these animals on native species and/or competition for the same food)

ACTION BEING TAKEN TO REVERSE THE TREND TOWARD EXTINCTION

I. International treaties ratified by the USA and thus governing our actions
   A. Convention on International Trade in Endangered Species of Wild Fauna and Flora (**CITES**), drawn up originally in 1973, ratified and in effect as of 1975. Now signed by over 70 countries (as of Dec. 1982). Operates by listing appropriate species in one of three Appendices, as follows, with comments on restriction in trade:
      1. **Appendix I:** All species threatened with extinction, which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to further endanger their survival and must only be authorized in exceptional circumstances. Examples: all species of Genus *Lemur*, the lion-tailed macaque, orangutan, gorilla, gray whale, tiger, leopard, snow leopard, jaguar, cheetah, northern elephant seal, and Asian elephant. Note that this list does not necessarily correspond exactly with the IUCN list of "Endangered" (E).
      2. **Appendix II**: All species which although not necessarily now threatened by extinction may become so unless trade in specimens is subject to strict regulation in order to avoid utilization incompatible with their survival, or other species of related and similar forms which might be confused with the susceptible species and make possible trade in the first-mentioned types. Examples: the Barbary ape, chimpanzee, polar bear, lesser panda, serval, Brazilian tapir, black rhinoceros, golden eagle, all crowned pigeons of Genus *Goura*, and the great Indian hornbill. This list does not necessarily correspond exactly with the IUCN list "Vulnerable" (V).
      3. **Appendix III**: All species which any signatory party (country) identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the cooperation of other countries. This list may include species, which in other countries are not even considered vulnerable and thus are not otherwise on any list for protection, but in some country of their origin are deemed to be in need of protection from unrestricted trade.
   B. Migratory Bird Treaty with Canada and Mexico – codified for compliance by the Migratory Bird Treaty of 1981. Relates to hunting controls and seasons for the waterfowl that migrate seasonally from one country to another. This is over and above the protection of endangered species such as the very scarce whooping crane (*Grus Americana*) which summers in Canada and winters in Texas in a special reserve. Like CITES, this treaty is enforced by USA Federal Regulations which are administered by the U.S. Department of the Interior (USDI). Any other country, which may be a party to such a treaty, will of course enforce it by its own laws on its own territory.
   C. Fur Seal Treat of 1911, 1957**,** etc. The USA, Canada, USSR and Japan agree to a limit to the catch of northern fur seal. Also administered by the USDI.
II. Federal Laws (USA) and Departments responsible for enforcement. (Partial List)

A. Lacey Act of 1900: governs importation of injurious species. Administered by the USDI (Department of the Interior).
B. Endangered Species Act of 1973 (principal amendments added in 1978, 1982, 1988, 2004 and 2009): governs trade in all life forms contemplated by CITES and other agreements to which the USA adheres. The provisions of this Act are administered by both the Department of the Interior and the Department of Commerce, depending on the species in question (USDI & USC).
C. Marine Mammal Protection Act of 1972: discussed elsewhere in this Notebook (Pinniped Study Guide). Administered by the Department of Commerce, depending on the species in question (USDI & USDC).
D. Migratory Bird Treaty Act of 1981: administered by USDI.
E. Bald Eagle Protection Act of 1940: administered by USDI.
F. Animal Welfare Act of 1970: establishes federal controls over treatment and care of animals in interstate and foreign commerce. Administered by the Department of Agriculture (USDA).
G. Fur Seal Act of 1966: administered by USDI.
H. Various other animal and plant quarantine acts: administered by USDA.
I. Various federal laws governing importation of such animal groups as dogs and rats, psittacines (parrots, etc.), turtles, monkeys and invertebrates: administered by the Department of Health and Human Services (USDHHS).

SIGNIFICANCE OF INTRICATE LEGAL CONTROLS INDICATED ABOVE TO ZOO OPERATIONS

The intricate system of laws and regulations suggested above (many of them being interconnected) requires that zoos and other legitimate institutions wishing to import, maintain, or dispose of almost any kind of animal must first obtain a bewildering variety of permits from the various federal, state and local authorities. This process can easily extend into a lengthy sequence of requests and reports extending over a period of many months before the actual transfer or other action can be accomplished. As a Docent, you are not expected to be familiar with all of these details, but you should appreciate the fact that they do govern most of the transactions entered into by our Zoo, often frustratingly slowly.

SPECIES SURVIVAL PLAN

By Mark Rich, Director, Mesker Park Zoo

In most of the world's wild places, populations of wild animals are declining. Thousands of creatures will be lost during the next decades, forever. Because of trends now far advanced, these losses are no longer avoidable. Among the threatened and endangered are not only creatures whose plight has been widely publicized at home (such as America's whooping crane, California condor and black-footed ferret), but also far more species from abroad – and they may mean even more to human society. The tiger, Asiatic elephant and gorilla are all endangered. Almost all of these are dying as a result of human increase and the development of wild lands for man's use.

Specifically, the Species Survival Plan (**SSP**) seeks to strengthen and coordinate captive breeding programs so that zoos can help the worldwide effort to preserve vanishing species in five ways:

1. By reinforcing natural populations, which may have been reduced by catastrophe or disease or which may be so small that they are no longer viable genetically or demographically.
2. By providing animals for repopulation of original habitats when that proves practical.
3. By serving as refuges for species destined for extinction in nature.
4. By maintaining repositories of germ plasm in addition to populations of wild animals.
5. By conduction research and developing more successful techniques of animal husbandry in support not only of captive propagation but also of the care of faltering populations of wild animals in nature.

THE STATUS OF ZOO PROPAGATION PROGRAMS

About on –sixth of all types of mammals and one-twelfth of all the world's species of birds have been bred in zoos during the past two years. Most encouragingly, the zoo profession has established an International Species Inventory System (**ISIS**) and entered into the task of propagating diminishing wild animals with an almost unparalleled spirit of cooperation.

In recent years, rare animals as valuable as gorillas, Indian rhinos, Bali mynahs and Chinese alligators have been transferred from zoo to zoo almost entirely without reference to financial gain or loss. They have been moved only to enhance the chances of propagation for the welfare of the species concerned. Enormously enhanced breeding results are one outcome. Another is a dawning recognition of the need for intensive research and careful coordination. The SSP is a specific response to these needs and a strategic approach to the selection of a few species, which zoos may reasonably sustain for many generations. Also recommended will be the number of institutions over which the species should be distributed.

The SSP strategy is a commitment to:

1. Analyze each species demographically to determine patterns and potentials of survivorships and fertilities and, hence, of change.
2. Provide for the population's rapid expansion to, and stabilization at, the proposed carrying capacity with an age and sex structure that will optimize genetically effective size and demographic stability. This will normally entail both the removal of animals from certain age and sex classes as well as regulation of reproduction.
3. Analyze each species genetically through genealogical as well as electrophoretic and karyotypic studies to assess the diversity and distribution of the gene pool.
4. Maximize the preservation of genetic diversity in the species.
5. Provide for the collection and preservation of as much germ plasm as possible.

The American Association of Zoological Parks and Aquariums' Species Survival Plan seeks not only to stimulate further in-zoo research on critical problems in reproductive physiology, genetics, sociobiology and animal medicine, but also to expand these efforts by fostering joint projects amount the zoos themselves.

Reprinted from ANIMAL WORLD. Adapted from the **AAZPA SPECIES SURVIVAL PLAN** (REV 01/00)

Environmental Sustainability

Environmental sustainability is the capacity to endure; it is how biological systems remain diverse and productive over time. Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their needs. Healthy ecosystems and environments are necessary to the survival and flourishing of humans and other organisms.

Why buy locally? There are numerous reasons why buying locally grown food is both rewarding and delicious, including enjoying the taste of fresh food, improved health and nutrition, environmental stewardship, support for family farms and rural communities and ensuring animal welfare. In the US, the average produce travels nearly 1,500 miles between where it is grown to your table. About 40% of our fruit is produced overseas.

Sustainable agriculture is a way of growing food that is healthy for both consumers and animals, does not harm the environment, is humane for workers, respects animals, provides a fair wage to the farmer, and supports and enhances rural communities.

What is Seafood Watch?

The Monterey Bay Aquarium Seafood Watch program helps consumers and businesses make choices for healthy oceans. Our recommendations indicate which seafood items are "Best Choices," "Good Alternatives," and which ones you should "Avoid."

Nearly 85% of the world's fisheries are fished to capacity, or overfished. Our seafood choices have the power to make this situation worse, or improve it. Seafood Watch recommendations don't hinge on any single issue. Instead, they consider the fishery, habitat, species, management, and a host of other factors that affect each species. In this way, Seafood Watch offers a complete vision of sustainability.

From: Monterey Bay Aquarium Seafood Watch Program, *montereybayaquarium.org*

See **Zoo History Study Guide** (pg 8 - 11) **and Conservation Corner Study Guide** for information on SF Zoo's conservation efforts.

Zoological Specialties

A. **Taxonomy**: study of classifications and relationships
B. **Ornithology**: study of birds
C. **Mammology**: study of mammals
D. **Ichthyology**: study of fish
E. **Herpetology**: study of reptiles and amphibians
F. **Paleontology**: study of evolution as evidenced in the fossil record to support the taxonomist
G. **Ecology**: study of the interaction of plants and animals with the environment
H. **Ethology**: study of the behavior of animals
I. **Zoogeography**: the study of animals and their geographical distribution
J. **Entomology**: the study of arthropods.

ABBREVIATIONS, CONVERSIONS AND FACT SHEET DATA

Animal Code: By Sex
1.1.1. = 1 male, 1 female, 1 unknown

Abbreviations:

HRL = Head-rump length
TL = Tail length
L = Length (total)
SH = Shoulder Height (at withers of quadruped)
BH = Body Height (if highest point not at withers)
wt = weight
M = Male
F = Female

Metric Conversions:

1 m = 100 cm = 39.37 in
1 kg = 1000 gm = 2.2 lb
1 in = 2.54 cm
1 lb = 454 gm

Temperature Conversions:

C = 5/9 (F – 32)
F = 9/5 C + 32

Land Measurement Conversions (Approximate):

1 sq mi = 259 hectare (ha)
1 ha = 2.5 acre (ac)
1 sq km = 100 ha

(Rev 1998)

Common Definitions

WORD	DEFINITION		WORD	DEFINITION		WORD	DEFINITION
Cathemeral	Irregular bursts of activity throughout 24 hour periods		**Carnivorous**	Eats mainly animals		**Appendix I**	Threatened with extinction, trade permitted only in exceptional circumstances, i.e. lemurs
Crepuscular	Active at dawn and dusk		**Folivorous**	Eats stems & leaves		**Appendix II**	Not necessarily threatened, but trade must be controlled, i.e. Nile hippopotamus
Diurnal	Active during the day		**Frugivorous**	Eats mostly fruit		**Appendix III**	Protected in one country, ask other CITES partners for assistance in controlling trade.
Nocturnal	Active during the night		**Herbivorous**	Eats anything green (i.e. plants of any kind)		**CITES**	Convention on International Trade in Endangered Species of Wild Fauna and Flora; see Appendices I, II, III
Grazer	type of feeding where the herbivore eats on grasses or other low vegetation		**Omnivorous**	Eats anything		**IUCN**	International Union for Conservation of Nature and Natural Resources
Browser	Type of feeding where the herbivore consumes leaves, shoots, & fruits from plants, selectively						