The Young Scientist Program
http://ysp.wustl.edu
Washington University School of Medicine

Insect Biology

Introduction

Our earth is covered with a plethora of living organisms that interact together and the environment within an ecosystem. For an ecosystem to survive, you need continual cycling of nutrients and a balance of organisms within each trophic level.

Living organisms have all 8 characteristics:

1) ____

2) ____

3) ____

4) ____

5) ____

6) ____

7) ____

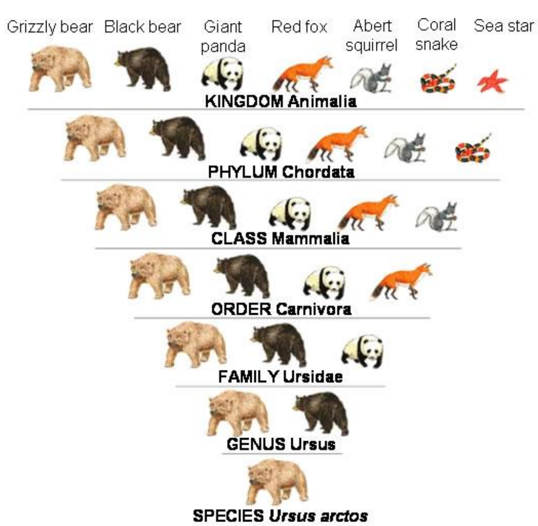
8) ____

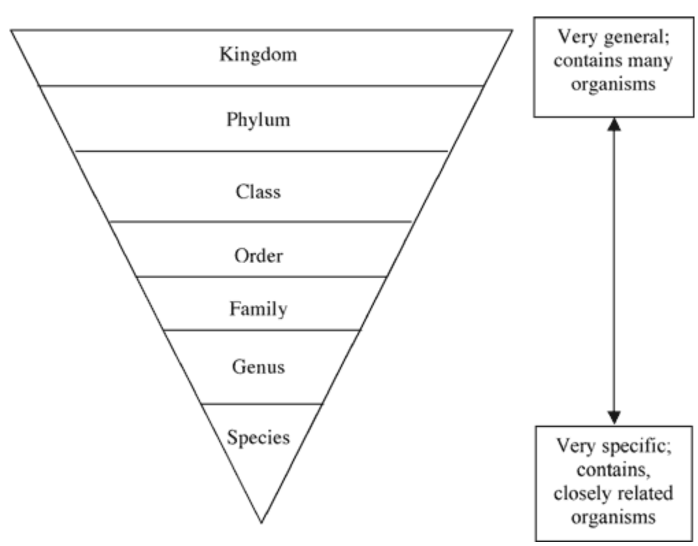
To classify these living organisms, Carolus (Carl) Linnaeus developed a **taxonomic** (taxis means arrangement and nomos means method) system in the middle of the eighteenth century based on physical characteristics of the organism and genetics. Each group is comprised of similar organisms and called a **taxon** (pl. taxa) which is subdivided into other groups.

The taxonomic scheme is _________ → ____________ → ___________ → __________ →

___________ → ___________ → ____________.

The best way to remembering the levels is: **K**ings **P**lay **C**hess **O**n **F**at **G**reen **S**tools.





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The first taxon is Domain which encompasses three distinct groups: Archaea, Bacteria and Eukarya.

_____________ are prokaryotic cells and have membranes composed of branched hydrocarbon chains attached to glycerol by ether linkages. The cell walls have no peptidoglycan. Archaea often live in extreme environments.

_____________ are prokaryotic cells and have membranes composed of unbranched fatty acid chains attached to glycerol by ester linkages. The cell walls contain peptidoglycan.

______________ are eukaryotic cells and have membranes composed of unbranched fatty acid chains attached to glycerol by ester linkages. Those that have cell walls contains no peptidoglycan.

The **Eukarya** domain is subdivided into 4 Kingdoms: Protista, Fungi, Plantae an Animalia.

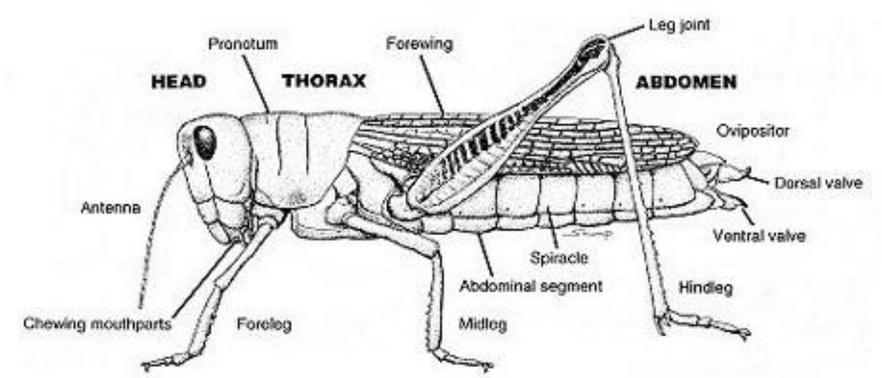
____________ are simple, predominately unicellular eukaryotic organism.

____________ are unicellular organisms composed of eukaryotic cells that have cell walls. The cells have cell walls but are not organized into tissues. The cells have cell walls but not organized into tissues. They do not carry out photosynthesis and obtain nutrients through absorption.

____________ are multicellular organisms composed of eukaryotic cells. The cells are organized into tissues and have cell walls. They obtain nutrients by photosynthesis and absorption.

____________ are multicellular organisms composed of eukaryotic cells. The cells are organized into tissues and lack cell walls. They do not carry out photosynthesis and obtain nutrients primarily by ingestion.

Within the Animalia kingdom, we will explore insects which is estimated to have around 925,000 species. Insects are animals with exoskeletons which are in the **Phylum Arthropoda** and the **Class Insecta**. Organisms are clumped into Insecta due to these classifications: 1) segmented bodies and jointed legs 2) 3 major body sections: head, thorax and abdomen 3) 6 legs 4) 2 antennae. Within the class Insecta, we have about 24 common orders which are outlined in the next sheet.



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Insects have three different **life cycles/metamorphoses** (change in form/habits of an animal during normal development):

- ________________ – no metamorphosis; the young resembles the adult, except smaller
- ________________ – incomplete metamorphosis; egg → nymph → adult
- ________________ – complete metamorphosis; egg → larva → pupa → adult

Insects have an **"open" circulatory system** meaning that they lack a complex network of veins and arteries to transport blood throughout the body. Instead, insect blood (**hemolymph**) flows "freely" throughout the body cavity (**hemocoel**). Insects have a multi-chambered "heart" (**dorsal blood vessel**).

Insects do have a ___________________________ but they do not breathe in the same way humans do. Air enters their bodies through external openings called **spiracles** which are connected to **tracheae** which supply the tissues with air. Insects can either respire passively or actively.

The last taxon is **species** which is a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding. For a species to survive, they have to be able to reproduce and adapt to changing environments. There are 4 factors which effect the size of a local population: 1) **Births** (B) – how many offspring are born 2) **Immigration** (I) – how many individuals migrate to the local population 3) **Emigration** (E) – how many individuals leave the local population 4) **Deaths** (D) – how many individuals die. The population size at a given time can be written as $N_{t=1} = N_t + B + I - D - E$. Species are placed on the **endangered** list if the population size is negative and continues to decline due to breeding success rates. Species on the endangered list have a high probability of going **extinct,** which means there are no living members of that species. For example, the Caribbean Monk Seal Nasal Mite, *Halarachne americana,* went extinct when its host the Caribbean Monk Seal went extinct less than 100 years ago.

There are many ways insects can avoid extinction and one is by **adapting** to their environment. One classic example is of the **peppered moth**, made famous by the British scientist, Bernard Kettlewell. Peppered moths have 2 common varieties: **dark-colored** and **light-colored**. Kettlewell knew that dark-colored moths were more common in polluted *industrial* areas than in rural areas. Light-colored moths, however, were more common in *rural* areas. He hypothesized that dark moths were best suited to the polluted environment because they were able to blend in better to the darkened vegetation and avoid predators. By contrast, he thought that these dark moths were more likely to be seen by predators in the clean, rural environment. To investigate, Kettlewell released a mixed group of light and dark-colored moths into each of these areas. He observed that light moths indeed survived best in the rural area and dark moths in the polluted area. Kettlewell had demonstrated **natural selection** in action!

Here are some other insects that have really amazing adaptations:

- The African desert locust (in the order Orthoptera – *Schistocera gregaria*) is able to fly at 21mph.

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- The Monarch butterfly (in the order Lepidoptera – *Danaus plexippus*) is able to migrate up to 2,485 miles in 75 days. Air travel from California to North Carolina is 2,240 miles!
- The *Titanus giganteus* is the largest insect (in the order Coleoptera) which is 16.7 cm.
- The *Phobaeticus serratipes* is the longest insect (in the order Phasmatodea) which is 555 cm.
- The *Lasius niger* is the longest lived adult (in the order Hymenoptera). The queen can live up to 28.7 years.
- The *Rhopalosiphum prunifolia* is the shortest lived insect (in the order Hemiptera). The aphid can only live from 4.7 days from egg to adult.
- The Hawain *Laupala* crickets are the fastest evolving insects (in the order Orthoptera). The crickets are able to produce 4.17 species per 1 million year.
- The Atlas moth has the largest wings (in the order Lepidoptera)

In this activity we are going to learn to use a **dichotomous key** to identify insects. A dichotomous key is a tool that scientists use to help identify a specimen. In science, we use many helping aids to organize and easily retrieve information. The dichotomous key allows for the scientist to ask a series of questions with yes or no answers. Each question should be phrased so that the answer will be either a yes or no. First, we will spend some time creating a dichotomous key using fictitious organisms. Then we will move over to classifying real insects using an established dichotomous key.

Materials

- Dissecting Scopes
- Hand-held magnifying glasses
- Loupes
- Pens/Pencils

Safety

Please be careful when handling the insects. We want to preserve them so they can be used by other groups.

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Protocol

1) Closely examine the new species. What characteristics do you think will be important in classifying these critters? Start with this one:

Number of eyes	

1. ______________

1) Use characteristics of your choice to create your own dichotomous key. Remember: dichotomous keys always provide 2 options at each branch!

2) Create a key for each of the 10 species.

3) Provide a name for your critters in the space below.

4) After that is done, now try and identify the real insects in front of you using the key provided.

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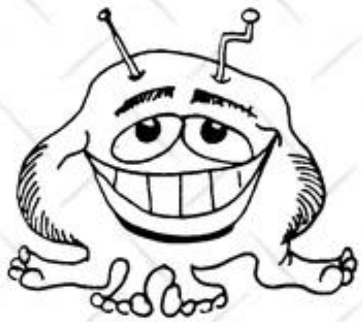
1. ________________

2. ________________

3. ________________

5. ________________



4. ________________

7. ________________

8. ________________

6. ________________

9. ________________

10. ________________

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Insect Identification		
Order Name (nickname)	**Metamorphosis**	**Characteristics**
Blattodea (Roaches)	Simple	flattened oval bodies, long laid back antennae, wings (almost never used)
Isoptera (Termites)	Simple	small, soft-bodies, usually pale-colored, antennae generally short and thread- or bead-like
Dermaptera (Earwigs)	Simple	slender flattened bodies, large pincers at end
Mallophaga (Chewing lice)	Simple	bristly body, toothed mandibles, small compound eyes, abdomen more wide or as wide as head
Orthoptera (Grasshoppers & crickets)	Simple	usually 2 pairs of wings, antennae many-segmented, cerci present, has ovipositor, FW is long, narrow, and many veined
Plecoptera (Stoneflies)	Simple	4 membranous wings, elongate, flattened, cerci present, long antennae, mouthparts chewing
Odanata (Dragonflies & damselflies)	Simple	two pairs of elongate membranous wings, compound eyes large, abdomen long and slender, antennae very short
Ephemeroptera (Mayflies)	Simple	distinguished easily by their two large, triangular wings
Thysanura (Bristletails)	Simple	spindle shaped, flat bodies with 3 long, bristly tail like appendages
Diplura (same)	Simple	1-segmented tarsi, chewing mouthparts, 2 cerci on head
Collembola (Springtails)	Simple	wingless, long bodies, 4-6 abdominal segments, multicolored, tube protrudes from abdomen, microscopic
Protura (Telsontails)	Simple	conical head, piercing mouthparts, lacks eyes and wingless, 12 segments in abdomen, .6-1.5mm
Homoptera (cicadas and more)	Simple	beak short and rising at back of head (different from Hemiptera), wings held rooflike over body, tarsi 1- to 3-segmented, antennae sometimes short and bristlike or sometimes long and threadlike
Anoplura (Sucking lice)	Simple	flattened and wingless, sucking mouthparts, abdomen thiner than head
Thysanoptera (Thrips)	Simple	slender bodies, short antennae, short legs, feathery wings
Hemiptera (True bugs)	Simple	FW (front wing) thickened at base and membranous at tip, HW (hind) shorter than FW, wings held flat on body, tips of FW overlap, mouthparts sucking, antennae of 5 or fewer segments (long and conspicuous or short and concealed)
Neuroptera (dobsonflies, lacewings, antlions)	Complete	FW and HW almost same size, four membranous wings, wings held rooflike over body at rest, wings with many veins, antennae long, cerci absent, mouthparts chewing
Hymonoptera (Bees, Ants, Wasps, and more)	Complete	wings are sometimes present, FW a little larger than HW, antennae usually fairly long
Coleoptera (beetles)	Complete	FW horny or leathery, FWs meet in straight line on back, HW membranous and are usually longer than FW, wings rarely absent or reduced, antennae usually with 11 segments (sometimes with 8-10), antennae variable in form
Mecoptera	Complete	slender, soft bodies; long legs and elongated, snout like heads

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(Scorpianflies)		
Trichoptera (Caddisflies)	Complete	shaped or colored like certain moths, antennae long and threadlike, antennae usually long as body or longer, HW a little shorter than FW
Lepidoptera (Moths & Butterflies)	Complete	4 membranous wings, usually have proboscis in form of coiled tupe, wings covererd in scales
Diptera (True flies)	Complete	one pair of membranous wings (you can identify them instantly from this), have knoblike projections called haltares
Siphonaptera (Fleas)	Complete	laterally flattened abdomens, tough skin, enlarged coxae, mouthparts with 3 piercing stylets for blood sucking

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Discussion Questions

1) Throughout this exercise, what was the most difficult to do and why?
2) Do you think this would also be difficult for real-world scientists? Why or why not?
3) Name the key features that distinguishes insects from other arthropods.
4) Why do you think there so many insects?
5) Are two individuals from the same species if they are not able to mate and produce offspring?
6) What is the difference between no metamorphosis and complete metamorphosis?
7) If you have an increase of emigration and death in the population, what would you have to increase to keep the population alive?