Objectives

After you have completed this unit you should know for each order:

- its common name, order name, and meaning of the order name
- its development or metamorphosis
- 3-4 facts regarding its life history and/or economic importance
- its wing type, leg types and mouth adaptations

Question

How do you... tell the difference... between a beetle and a bee?

Introduction

Bees and Beetles
- Six legs
- Exoskeleton
- Two antennae
- Four wings

Classification Review

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Class</th>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecta</td>
<td>Coleoptera</td>
<td>Scarabaeidae</td>
<td>Dung Beetle</td>
<td>Scarabaeus</td>
<td>Sauricus</td>
</tr>
<tr>
<td>Insecta</td>
<td>Hymenoptera</td>
<td>Apidae</td>
<td>Honey Bee</td>
<td>Apis</td>
<td>mellifera</td>
</tr>
</tbody>
</table>

Classification Review Diagram
Review Terms

These terms will help you throughout the unit and on your lab projects.

1. **Anamorphic**: Development in some parainsects where abdominal segments are added during the molting process.
2. **Ametabolous**: An insect that undergoes slight or no metamorphosis. The young look just like the adult. They also keep molting even after becoming an adult, something the other kinds of insects don’t do.
3. **Hemimetabolous**: An insect that undergoes incomplete metamorphosis. The young look very similar to the adult.
4. **Holometabolous**: An insect that undergoes complete metamorphosis. This type of metamorphosis includes the egg stage, larval stage, pupal stage and adult stage.
5. **Apterygote**: An insect that doesn’t have wings.
6. **Paleopterous**: Insects having wings, but the wings cannot fold back over the insect’s abdomen.
7. **Pterygote**: This term refers to all winged insects.
8. **Neoptera**: Having wings, but the wings have a flexon, or hinge, that allows the wing to be folded back over the abdomen.
9. **Exopterygote**: Insects with wings that develop from structures called wing pads located on the outside of the growing insect.
10. **Endopterygote**: Insects with wings that develop from internal wing pads present in the larva.

Review Terms: Answers

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**Hexapoda**

All six-legged arthropods, hexapods, were once classified in the Class Insecta. After some debate, some scientists group hexapods into three classes, Parainsecta, Entognatha, and Insecta and some scientists split them into four classes, Protura, Collembola, Diplura and Insecta. Each of the classification schemes are based on certain similarities between the groups. We will take a look at two cladograms that show the differing opinions of how these organisms should be classified.

*Note: Because the parainsects are so closely related to the insects, we still consider them insects in the non-technical sense of the term and encourage you to include them in your insect collection.*
Objectives Recap

- 28 insect orders.

You will learn about each of the more common orders in the lecture and readings and will complete the chart on your study guide.

1. its common name
2. its development, or metamorphosis
3. 2-3 facts regarding its life history and/or economic importance
4. any special adaptations of mouthparts, legs, or wings
5. the meaning of the order name

Insect Taxonomy

- 28 insect orders.

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Class Parainsecta: Order Protura

- Eyeless
- Lack antennae
- Small (<2mm)
- Anamorphic development
- Enlarged forelegs (sensory organs)
- Lack tentoria and cerci
- 5 segmented legs
- Nymphs begin with nine segments, but an adult have twelve
- Feed on fungi and vegetable matter
called coneheads

Notice the meaning of the order name in the top right corner.

Proturan Walking Video

Proturan Defensive Posture Video

Class Parainsecta: Order Collembola

Springtails can tuck their tail (furcula) underneath and snap it back out, "springing" them off of the ground.

- Anamorphic development
- 1 pair of antennae
- No compound eyes
- Soil dwelling arthropod
- Scavenger
- Collophore (for water management – once thought to have glue – thus the name)
- Furcula – jumping organ

Fill out the table on your study guide under the heading "Insect Orders."
Class Entognatha: Order Diplura

Entognathans are a group that have enclosed mandibles.

- soil arthropods
- Predators feeding on mites, insects, collembolans, etc.
- 700+ described species
- eyeless
- 1 pair of antennae
- Sclerotized forceps on the abdominal tip (cerci)
- 0.5-50mm
- 10 body segments
- Continued molting

Notice that the ending -ura means tail.

Class Insecta: Subclass Apterogota

Order Archaeognatha

- Bristletails
- Mostly nocturnal
- 350 known species
- Common in leaf litter
- Scavengers/herbivores: feed on algae, lichens and vegetation
- Wingless
- Primitive jaw arrangement
- Continual molting (ametabolous)
- Female picks up sperm packet for each egg clutch
- Cerci shorter than medial caudal filament

Watch Dr. Yanoviak from the University of Arkansas Little Rock as he describes the unique gliding behavior of this primitive insect.

http://www.youtube.com/watch?v=tsNZtVfWUOk&feature=related

Class Insecta: Subclass Apterogota

Order Zygentoma (Thysanura)

- include silverfish and firebrats
- ametabolous development
  - some species live more than 6 years and can molt more than 60 times.
- wingless
- covered in silver scales
- compound eyes
- three caudal filaments
- Indirect fertilization
- males leave sperm packets
- occasional invaders of homes
- prefer moist environments

We are now entering the division of the winged insects. Notice that the name often ends in -ptera which means wing.

Note: a naiad is an aquatic nymph of a hemimetabolous insect.

Class Insecta: Subclass Pterygota

Order Ephemeroptera (Mayflies)

- Aquatic
- Herbivores
- Indicators of water quality
- Naiads have gills and caudal filaments
- Subimago stage
  - only insects to molt once they have wings
- Triangular wings
- Adults (imago) emerge, mate, lay eggs, and expire
- Vestigial mouthparts as adults (do not feed)

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Class Insecta: Subclass Pterygota

Order Odonata (Damsel'flies, Dragonflies)

The gills on the damselfly larvae are articulated and easily break off when the animal is disturbed.

Can you tell which is which? Remember, the damselfly naiad has external gills.
Order Odonata (Damselflies, Dragonflies) (continued)

- Toothed ones
- Damselfly
- Dragonfly
- Compound eyes

Neopteran Phylogeny

Gullen and Cranston, 2010, Figure 7.2

- Odonata
- Plecoptera
- Dermaptera
- Embioptera
- Neuroptera
- Zoraptera
- Orthoptera
- Phasmatodea
- Grylloblattodea
- Mantophasmatodea
- Mantodea
- Blattodea (cockroaches)
- Blattaria (butterflies)

Order Plecoptera: (stoneflies)

- Hemimetabolous
- Filiform antennae
- Flat appearance
- Require clean, moving water

- Folded wing
- The adults emerge at the same time and live for only a few weeks.

Infraclass Neoptera: Division Exopterygota

- Wing pads
- Predatory hemipterans
- Note: These wing pads are an indication that the insect has not developed into the adult stage. This is a tip you can use while you are out collecting your insects.

Order Dermaptera (earwigs)

- Hemimetabolous
- Beaded antennae
- Short elytra with fan-shaped flight wings
- Nocturnal
- Scavengers
- Pincer-like cerci
- Females protect eggs and young (sub-social)

Myth: Earwigs were once thought to enter the ear and burrow into the skin of sleeping individuals.

Order Embioptera (webspinners)

- Front legs with silk producing glands
- Hemimetabolous
- Filiform antennae
- Adult males are winged
- Found under tree bark
- Herbivores
- Build tunnels of silk
- Enlarged hind legs to move backwards
- Live in groups
Zoraptera (angel insects)

- Rare and not well understood
- Some are winged
- Small >4mm
- Moniliform antennae
- Found in rotting wood or in sawdust

Order Orthoptera (grasshoppers, crickets, katydids)

You can tell that you have now entered the section of neopterous insects. As you can see, the wings are folded on top of each other over the abdomen and are not held out to the side or straight back.

Order Phasmatodea (Walking sticks)

- Hemimetabolous
- Chewing mouthparts
- Eggs are dropped to the ground from the trees
- Long slender antennae
- Reduced (brachypterous) wings
- Defensive secretion from thorax
- Can regenerate legs
- Longest insects representative

From the Greek “phasm” or phantom

Florida two-lined walking stick

Grylloblattodea (Rockcrawlers)

- Found on mountaintops and in caves at low temperatures
- Hemimetabolous
- Filiform antennae
- Only 25 species worldwide
- Slow development (7 years per generation)

Cricket cockroach

Order Mantophasmatodea (Heel Walkers or Gladiators)

This is an order that is only found in Africa.

Why then should we mention it?

This order, thought to be extinct, was recently found living in South and Eastern Africa. Species in this hemimetabolous order are still being named and described. The media blitzed this discovery of such a strange critter.

Greek for Mantid and Phantom

For more information, read the Gladators article from Scientific American.

Order Mantodea (Praying Mantids)

Mantis is the Greek word for Mantids

- Hemimetabolous
- Chewing mouthparts
- Triangular head
- Compound eyes
- Raptorial front legs
- Predaceous
- Long pronotum that allows the head to turn

Mantis egg case
Order Blattodea (Cockroaches and Termites)

- Hemimetabolous
- Dorso-ventrally flattened
- Filiform antennae
- Cursorial legs
- Chewing mouthparts

Blatta is the Greek word for cockroach

Termites are also known as white ants. They are the only hemimetabolous insect with true social behavior. These insects have a caste system that includes workers, soldiers, and reproductives. The worker is the bread winner of the family. They are nearly blind and they forage for food by building tunnels to protect themselves. The workers are charged with protecting the colony. They have a larger head than the common workers and large strong mandibles. Termite colonies consist of both males and females and the king remains with the queen in the colony.

Note: Believe it or not, termites are closely related to cockroaches.

Order Psocodea (Lice)

Two groups:
- Bark and book lice (formally Psocoptera) – scavengers that feed on fungi, lichens, insect eggs, and organic debris
- Parasitic lice (chewing and sucking lice) (formally Phthiraptera) – ectoparasites that feed on blood, skin, hair, and feathers.

Lice are wingless parasites of birds and mammals. These lice are pretty host specific and may be limited to feeding on a specific species. Lice are ectoparasites and need to remain close to the host. Therefore, they attach their eggs, or nits, to the hair or feathers of the host.

Order Thysanoptera (Thrips)

Some thrips are common pests of plants. They inject their mouthparts and suck the plant juices of the buds, flowers or fruits of the plant causing damage to these structures. Some species are predaceous and feed on mites. Adults can be winged or wingless. The wings are thin and are covered with a fringe of hairs. Thrips are hemimetabolous, but they may have a pseudo pupal stage with a silken cocoon. This puzzles scientists and may be an instance of convergent evolution.

NOTE: The term “thrips” is used both as the singular and plural form!

Order Hemiptera (True Bugs)

- Hemimetabolous development
- Piercing-sucking mouthparts
- Half-wings
- Scutellum
- Defensive secretions
- Predators, herbivores, and parasites

Hemiptera – (continued)

Homopterans differ from hemipterans by uniformity of their wings and the origin of their piercing-sucking mouthparts. Homopteran forewings have a uniform texture unlike the half-wings of their hemipteran brothers and the winged homopterans hold their wings in a tent shape over their bodies. The proboscis is opistognathous meaning that it is on the ventral posterior margin of the head capsule. The proboscis, or beak, is smaller in homopterans and they use this beak to suck out juices from vascular plants.
The digestive system of most homopterans has a filtering system. This allows the insect to ingest large amounts of sap and then excrete the excess water and sugars. Ants appreciate this meal of honeydew and provide protection to the insects in exchange for this sweet meal. Many homopterans, like aphids and leaf hoppers, are important carriers of plant diseases. Others are beneficial, like the lace scale that produces shellac and the cochineal scale that produces red dye.

**Order Neuroptera (Lacewings, Antlions, etc.)**

- Holometabolous
- Beneficial predators
- Weak fliers

Note: Orders similar to the neuropterans include Megaloptera, and Raphidioptera.


**Mecoptera, Strepsiptera, and Raphidioptera**

- Mecoptera – scorpionflies and hangingflies
  - predators, scorpion-like tail is harmless
- Strepsiptera – twisted-wing parasites
  - parasites of insects, only have hind wings
- Raphidioptera – snakeflies
  - predaceous, found in Europe, Asia and the Western US.

**Order Coleoptera (Beetles)**

- Coleoptera is the largest order of insects (about 40% of all known animals).
- These guys are holometabolous and the larvae are referred to as grubs.
Order Diptera (True Flies)
- Dipters are the true flies.
- Holometabolous development
- 2 functional wings
- Hindwings as halteres
- Various mouthparts
- Larvae called maggots

If you notice the names, you will see that if the word fly is separated, then it is a Dipteran. If it is attached, it is not. Example: House fly or Butterfly

Order Siphonaptera (fleas)
- Hematophagous with piercing-sucking mouthparts
- Laterally flattened (secondarily wingless)
- Holometabolous
- Can transmit disease
- Saltorial hind legs
- 2400 species with ¾ affiliated with rodents

Oriental Rat Flea: Plague vector
The bubonic plague was the most common form of the Black Death. The mortality was close to 100% (even today there is no treatment). Symptoms are a high fever and skin turning deep shades of purple due to disseminated intravascular coagulation. Yes, all from a flea bite.

Order Trichoptera (Caddisflies)
- Holometabolous
- Filiform antennae
- Hairy wings
- Wings held roof-like
- Aquatic immatures
- Case makers

Order Lepidoptera (Butterflies and Moths)
- Lepidoptera is the second largest order of insects behind Coleoptera.
- Lepidopterans are holometabolous and the larvae are known as caterpillars.
- While it appears that caterpillars have many legs, there are only three true pair and 2-8 pair of fleshy prolegs.
- Most caterpillars are herbivorous and many can cause substantial damage to crops, trees, or ornamental plants.
- Some caterpillars can sting because they are covered with urticating hairs.
- Adult leps are well known for their scaled wings.
- The adult butterflies and moths feed by a siphoning tube that is coiled for storage.

Moth and Butterfly differences
- Moths
  - the antennae taper to a point
  - they are thick bodied
  - the wings lay against the abdomen at rest
- Butterflies
  - the antennae end in a club
  - the body is more delicate
  - the wings are held upright or out to the side at rest

Order Hymenoptera (bees, ants, and wasps)
- Holometabolous
- Mandibulate mouthparts
  - (some, like bees have modifications where their mouth is shaped like a tongue to lap nectar from flowers).
- Four wings that are joined together (fore and hind) by tiny hooks called hamuli.
- Some wasps are herbivores and form galls.
- Others are tiny and are parasites of other insects.
- Many bees and wasps are important pollinators.
- Ants are common pests around homes.
- Hymenopteran females develop from fertilized eggs and males develop from unfertilized eggs.
Insect orders are grouped according to whether or not they are ametabolous, hemimetabolous or holometabolous.
You will also see that the insect orders are grouped according to the absence or presence of wings.
Additional groupings concern whether or not the wing has a flexen, i.e. apterygote, paleopterous or neopterous.
The orders are also grouped according to how the wings develop.
If the wings develop from structures on the outside of the body the insect is called an exopterygote.
If the wings develop from internal wing pads, the insect is called an endopterygote.

Be sure you know which orders go with each classification.

Your mind is probably spinning with all the terms and the characteristics of each order.
Do you know the difference between a bee and a beetle yet?
How many wings does a fly have?
During an upcoming lab or in your own collection, you should be able to look at specimens and the differences will become clearer to you.

Now that you know the order characteristics, you will be an expert in no time.

Note: To review the order characteristics and check your chart from the study guide, you may refer to http://entnemdept.ufl.edu/choate/insect_orders.htm.