Hemiptera

We now begin a series of lectures on the hemipteroid orders, which includes the Hemiptera (Heteroptera and Homoptera), Thysanoptera, Psocoptera, and Phthiraptera. This group of orders is sometimes referred to as the **Paraneoptera**.

In previous editions of your text book, the insects included in this order were placed in two large orders: the Hemiptera (or true bugs), and the Homoptera (the cicadas, treehoppers, leafhoppers, planthoppers, aphids, white flies, scales, etc.). Recent studies, however, have indicated that certain homopteran groups are more closely related to the hemipteran groups than they are to the rest of the Homoptera. Consequently, these two orders have now been combined into one very large order, the Hemiptera.

This order can then be divided into a number of suborders: the Heteroptera (true bugs), Coleorhyncha (primitive, rare family - the Pelordiidae - occurring in southern South America and Australia), the Auchenorrhyncha (cicadas, treehoppers, leafhoppers, and planthoppers), and the Sternorrhyncha (aphids, whiteflies, and scales). In the past, the Coleorrhyncha (Perlordiidae) has been treated as belonging to either order and may bridge the gap between the two. As mentioned above, recent evidence indicates that the Auchenorrhyncha may have a closer relationship with the Heteroptera (wing coupling device, etc.) than it does with the Sternorrhyncha.

The most recognizeable linking character is the sucking mouthparts, consisting of four piercing stylets (2 mandibular and 2 maxillary - differs from other sucking insects). The mouthparts in the Heteroptera arise from the anteroventral part of the head; those of the Auchenorrhyncha arise from the posteroventral part of the head; and those of the Sternorrhyncha, if present, arise from between the procoxae. Also, the winged Heteroptera usually have the basal half of the front wings hardened and leathery and the distal half membranous; the homopteran suborders have the front wings more uniformly textured, either somewhat thickened or entirely membranous. Also, there is a tendency for the wings to be held more flat over the backs in the Heteroptera, whereas the homopteran groups tend to hold their wings more rooflike over their backs.

We will take a look at the suborder Heteroptera first.

* Other references:
1. How to know the true bugs, by J. A. Slater and R. M. Baranowski, 1978.
2. Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States, edited by T. J. Henry and R. C. Froeschner, 1988.
3. True Bugs of the World (Hemiptera: Heteroptera), by R. T. Schuh and J. A. Slater, 1995.

The Heteroptera are referred to as the true bugs. Note that “bug” is written separate, for example stink bug as opposed to butterfly being written all as one word. The word Heteroptera means non-uniform wing (Hetero- = non-uniform; -ptera = wing), and refers to front wings being half and half.

Early on, it was realized that the Heteroptera could be divided into two basic groups, those that were terrestrial and those that were aquatic. These were named the **Geocorisae** and the **Hydrocorisae**, respectively. The Geocorisae had relatively elongate and distinct antennae, whereas the Hydrocorisae had very short inconspicuous antennae. At about this time, redundant categorical names were also proposed for the two groups, **Gymnocerata** and the **Cryptocerata**. It was then recognized that some of the Geocorisae were different, exhibiting a semi-aquatic habit; they collectively were then called the **Amphibocorisae**.

During the 1950's and 60's, it was realized that this 3 suborder classification did not adequately reflect phylogenetic relationships, and a new classification was developed. The Heteroptera was then divided into 7 groups, called infraorders. They are: 1) Enicocephalomorpha, 2) Dispsocoromorpha, 3) Nepomorpha (= Hydrocorisae), 4) Gerromorpha (= Amphibocorisae), 5) Leptopodomorpha, 6) Cimicomorpha, and 7) Pentatomomorpha. There are several present day workers who believe that the Aradidae should be split off into its own infraorder, the Aradomorpha.

Characters:

Head

* Antennae - In the Nepomorpha the antennae are shorter than the head and usually hidden in cavities beneath the eyes (text figs. 22-5A and 22-6A); in the remaining suborders including the terrestrial forms, they are usually longer than the head with 4 or 5 segments (disregarding the minute ring segments between larger segments and antenniferous tubercles which may appear to be segments but are not hinged to the head. Sometimes the antennae are thickened apically in which case they are called **clavate**; sometimes the segments are thickened in the middle and narrowed at the ends like a football, in which case they are called **spindle-shaped**.

* Eyes - compound eyes are nearly always well developed. The ocelli may or may not be present; if they are present there are usually two and they are usually situated between the compound eyes.

* Mouthparts (see fig. 2-17, p. 21 in text) - piercing-sucking type that arise from the ventral surface of the head, but usually near the anterior part of the head. The beak is segmented (usually with 3 or 4 segments). The outer segmented part of the beak is the **labium** and is in the form of a long tube with a groove in the ventral surface in which the four piercing stylets lie. The four piercing stylets are actually the two **mandibles** and the two **maxillae**. The maxillae fit together to form two channels, a food channel and a salivary channel. The stylets are actually completely encircled basally by the **labrum**. The **clypeus** is located just above the labrum. The outer labium does not actually pierce the plant or animal while feeding, but rather folds up while the inner stylets do the piercing and sucking.

* Bucculae - These are ridges on the ventral surface of the head, one on each side of the beak (figs. 2-17A and 22-1B, buc).

* Plates of the head - The surface of the head between the compound eyes is called the **vertex**. Often the anterior portion of the top of the head is divided into three longitudinal lobes. The middle lobe is called the **tylus** (sometimes called the clypeus) while the outer lobes, one on each side of the tylus, are called the **juga** (singular **jugum**) (sometimes called the paraclypei).

* **Trichobothria** - these are small sensory hairs. They are found on the head in some groups and on the legs or abdomen in other groups.

* Thorax:

* Pronotum - The lateral edge of the pronotum is either sharply ridged (called **margined**), or **rounded**. The posterolateral angles of the pronotum are called the **humeral angles**.

* Scutellum - This is the more or less triangular sclerite behind the pronotum. It may be very small or quite enlarged and rounded as in the Scutelleridae.

* Wings - As mentioned earlier, the forewings are thickened basally and membranous distally. The term for this kind of wing is **hemelytron** (plural - Hemelytra). With the forewing in the resting position the outer basal portion is called the **corium** and the inner portion next to the scutellum is called the **clavus**. The corium and clavus are separated by the **claval suture**. Sometimes the outer apical portion of the corium is set off by a suture, forming a small triangular shaped area called the **cuneus**. The apical membranous portion of the wing is called the **membrane**. In the descriptions and the key, there will be reference to **closed wing cells**; this refers to a portion of the membrane which is completely enclosed by wing veins, that is a wing cell that does not reach the wing margin. The hind wings are entirely

membranous; at rest the wings are held flat over the back with the membranous parts of the forewings overlapping each other. Also, within the Hemiptera some individuals are **apterous** (wingless) or **brachypterous**. "Brachy-" means short, so these have wings that are shorter than normal and often lack or nearly lack the apical membranous portions. Sometimes the surface of the forewings (and sometimes the rest of the dorsal surface) is in the form of a network of raised ridges forming numerous small cells like a network - this is called **reticulate** and is common in the Tingidae. This should not be confused the pattern found in the Aradidae and Phymatidae which is more like numerous raised bumps or tubercles which is called **granular**. In most groups, there is a wing-coupling device. Near the apex of the clavus along the anal margin of the front wing there is a set of opposable ridges. There is a corresponding fold in the costal margin of the hind wing which fits between the ridges.

* Scent glands - Most families of Hemiptera do have scent glands. They are very small or obsolete in some families. These scent glands give off defensive secretion when the insects are disturbed. The scent glands, in adults, are usually located on the ventral or lateral surface originating on the metapleura between the middle and hind legs.

* Legs - The legs may be thin or thickened and are often modified for the specialized habitat that the insect lives in (swimming type legs for aquatic families) or for the specialized diet of the insect. Predaceous families often have forelegs with the femora thickened and provided with numerous spines or teeth; this type of leg is called **raptorial** and is used to grasp prey. Different families will have different numbers of **tarsal segments**, but they will number from 1 to 3. When keying you will sometimes have to count the number of tarsal segments. This can be difficult, especially if the the tarsi are covered with hair; in this case look at the either from the side or from the bottom; often the tarsal segments are easier to count on the hind legs. The last tarsal segment usually ends with a pair of **tarsal claws**. These are usually apical, but in a couple of families, the Gerridae and the Veliidae, they are **anteapical**, or situated back from the apex. There is often a padlike structure situated at the base of each tarsal claw called **pulvilli** or a single pad or hair between the claws called an **arolium** (plural arolia). In dried specimens they are often shriveled.

I. Infraorder Enicocephalomorpha - at one time this infraorder was thought to be related to the Reduviidae, but it is different enough to warrant its own infraorder. It probably is the sister group to the rest of the suborder. There are two North American families in this infraorder - we will discuss one, the Enicocephalidae.

1. Enicocephalidae - Unique-headed (Enico = unique; -cephala = head) or gnat bugs (p. 294, fig. 22-17).

* Front wings entirely membranous - corium & membrane not differentiated. For this reason they are considered to be of rather primitive stock and probably form the sister group to the remaining hemipteran families.
* Rostrum is 4-segmented.
* No prosternal groove.
* Head is elongate, constricted behind eyes and at base, somewhat swollen between the two constrictions; the ocelli are located on the hind lobe.
* They have comb-like structures on their front tibiae that they use to clean debris off of their legs.
* They were at one time thought to be related to the Reduviidae, but in that group the beak is 3-segmented and there is a prosternal groove.
* This is a group of small (2-5mm) bugs which occur in leaf litter, in among soil particles, or sometimes on foliage or in flowers. They are predaceous on tiny invertebrates. The common name gnat bug refers to the habit many species exhibit of forming swarms at dusk or dawn prior to mating. It used to be thought that this was a small group, but a modern revision of New World species shows that there are quite a few genera and species.

II. Infraorder Dipsocoromorpha - no families from this suborder are required. These are very small (1-2mm) and rarely encountered bugs. They occur in leaf litter and detritus. They can be best collected by running Berlese samples and sometimes they will come to light. I have collected both Dipsocoridae and Schizopteridae.

III. Infraorder Nepomorpha - Aquatic bugs (a few are shore inhabiting). Antennae are shorter than the head and are usually concealed in grooves on underside of head. Aquatic except Gelastocoridae and Ochteridae inhabit moist margins of ponds and streams. Predaceous (except most Corixidae) on insects and small aquatic animals. Most Corixidae feed on algae and other small aquatic organisms which they scoop up with spatulate front tarsi; a few are predaceous. There are no trichobothria.

1. Nepidae - waterscorpions. (3 genera and 12 North American species)

* Figure 22-18 in text.
* No ocelli.
* **Long caudal breathing tube formed by cerci.**
* Legs - Front legs are raptorial: fore coxae are elongate with the femora and tibiae modified for grasping prey (fig. 22-2F in text). There are apical sense organs on fore tibiae which sense prey vibrations.
  - Tarsi are all one-segmented.
  - Middle and hind legs not modified for swimming.
* There are 2 basic body shapes: 1) long and stick like (*Ranatra* sp.) or shorter and broader (*Nepa* & *Curicta*). Only one species of *Ranatra* (*fusca*) is known to occur in our area, but a couple others may occur here; *Nepa apiculata* has been recorded from Mirror Pool. The two North American species of *Curicta* occur in the south or southwest.
* They can fly but rarely do.
* They can inflict a painful bite, but their beak is very short, so usually can handle without getting bit if you don't get your fingers near the head.
* They are usually found in still water areas where they cling to sticks and underwater vegetation and wait for insects or small animals to swim by as prey. They usually hang upside down with the long breathing tube just breaking the surface of the water.
* The female usually lays her eggs by inserting them into aquatic vegetation.

2. Belostomatidae - giant water bugs. (3 genera & 19 North American species)

* Figure 22-19 in text.
* No ocelli.
* Abdomen with <u>short</u> caudal filaments, sometimes called air straps (air siphons). These are not formed into a tube as in the Nepidae. They simply transfer air to the sub-hemelytral airstore by a channel formed by setae.
* Legs - Front legs are raptorial with the front femora enlarged and thickened (fig. 22-2B in text).
  - Hind legs are flattened & fringed with long hairs and are used as oars for swimming.
* Flattened elongate-oval in shape.
* Membrane in wings with distinct wing veins.
* These can be medium to quite large-sized (some in U.S. are up to 65mm in length and one species in South America can be over 100mm in length).
* Can secrete a foul-smelling liquid from anus.
* Fairly common in ponds and lakes; voracious predators feeding on other insects, snails, tadpoles, and will sometimes attack small fish, frogs, or birds. In some cases they can even be economically damaging in fish hatcheries.
* Can inflict a painful bite, but once again the beak is fairly short (fig. 22-5A in text).
* The large species in the genus *Lethocerus* (one species reported from North Dakota) are very difficult to catch in the wild because they are very good swimmers. They are, however, attracted to lights - some are commonly called electric light bugs.
* Some species (*Belostoma* and *Abedus*) have the unusual habit of the female laying her eggs on the back of the male which carries them about until they hatch. One species of *Belostoma* has been collected in North Dakota.

* Often used as food items for people (Mexico, common in Thailand).
* Often found with immature red water mites (Hydracarina) attached to their legs, wings, or abdomen.

3. Corixidae - water boatmen - largest family of this suborder. (17 genera & about 125 North American spp.)
* Figure 22-20 in text.
* No ocelli.
* Legs - Front tarsi one-segmented and modified into scoop-like structures (pala), usually fringed with setae used to strain microorganisms from the water (fig. 22-6B in text).
  - Front femur is involved in stridulation.
  - Hind legs long and oar-like.
* Dorsal surface usually relatively flat and often with fine transverse lines.
* Beak is unsegmented and conical in shape (fig. 22-6A in text).
* Wings often have transverse light and dark bars or bands.
* Strigil on abdominal tergite 6 in males is misnomer - holds female during mating or help maintain subelytral air stores.
* Occur in any body of freshwater (sometimes including puddles) & some in brackish waters.
* They usually feed on algae, in which they pierce individual cells with their short beaks; a few are predaceous on mosquito larvae, brine shrimp and other microorganisms.
* Like notonectids and pleids they have a physical gill.
* Some corixids stridulate by rubbing their fore-femur against the gena.
* Eggs laid on aquatic plants; one species attaches its eggs to back of crayfish.
* In Mexico, some people gather corixid eggs and the corixids themselves, dry them, and grind the masses into a kind of flour; also used for pet food. They are also an important part of the food chain.
* Adults overwinter under the ice and can sometimes even be seen swimming under the ice or in pockets in the ice.
* Readily come to lights.

4. Ochteridae (Not Required) - velvety shore bugs. (1 genus & 7 North American species) - replace the saldids in the tropics
* Ocelli present; eyes are somewhat bulging.
* Antennae somewhat longer, four-segmented.
* Legs
  - hind tarsi 3-segmented; front and middle tarsi 2-segmented (1st segment quite small).
  - front legs not modified for grasping prey.
* The beak is long reaching to hind legs.
* Size is only about 4-5mm in length.
* They inhabit mud or sand flats or among grass and weeds along margins of ponds and streams. Sometimes will come to lights.
* Predators on small insects.
* Eggs laid singly on sand grains or other small objects.
* Nymphs often cover themselves with sand for camouflage.
* Don't occur in our area - closest is records from Missouri and Nebraska. I have collected these along very small streams (less than a foot wide) in sandy, pebbly areas in Louisiana.

5. Gelastocoridae - toad bugs. (2 genera & 7 North American species)
* Figure 22-21 in text.
* Ocelli present (very difficult to see); eyes bulging (fig. 22-5B in text).
* Resemble small toads in appearance and hopping habit.
* Antennae short and concealed under head.
* Front and middle tarsi 1-segmented; hind-tarsi 3-segmented.
* Front legs are raptorial.
* Fore wings are immovably fused.

* On rocky and sandy shores of ponds and streams - riparian. Sometimes *Nerthra* are found far from water and can burrow into the soil.
* Prey on a variety of small insects by jumping on them and grasping them with front legs.
* Adults may be macropterous or brachypterous, neither fly.
* Eggs are laid in the sand.
* Only one common species throughout most of U.S.: *Gelastocoris oculatus*. Does not occur around here - closest is Missouri, Nebraska, and Wisconsin, although there is one old (1926) record from Manitoba.

6. Naucoridae - creeping water bugs. (5 genera & 22 North American species)
* Figure 22-22 in text.
* No ocelli.
* Ovate flattened bugs that resemble small belostomatids, but wing membrane lacks veins and abdomen lacks terminal filaments.
* Front legs are raptorial; front femora thickened (fig. 22-2D in text).
* Tarsi 2-segmented.
* Size - 9-13mm in length.
* In ponds, lakes, and slow moving water, usually near bottom.
* Can inflict a painful bite. Pant leg story?
* Prey on various aquatic insect larvae and mollusks.
* One species, *Ambrysus mormon*, has recently been collected at several sites in the southern and southwestern parts of North Dakota. The more common eastern U.S. species are in the genus *Pelocoris* (one species reported from MN and SD).

7. Notonectidae - backswimmers. (3 genera & about 35 North American species)
* Figure 22-23 in text.
* No ocelli.
* Keeled ventrally.
* wings held roof-like over back.
* Macropterous forms lack veins in the wing membranes.
* Forelegs are raptorial.
* Front tarsi are 2-segmented; hind tarsi lack claws.
* Hind legs are long and oar-like with a fringe of hairs.
* Wings lack transverse lines (in contrast with Corixidae).
* Males of many species stridulate by rubbing the front legs against the beak.
* Can give a painful bite.
* Respires via a physical gill - a bubble of air encloses the abdomen and acts as a semi-permeable membrane which keeps the oxygen concentration inside equal to that in the surrounding water.
* Some have hemoglobin, but not for respiration. Rather it helps maintain bouyancy.
* Occur in ponds and lakes, and often come to lights. Swim and rest upside down. May also be active during the winter.
*The three genera in North America are *Buenoa* (small, 5-9mm, slender, and antennae 3-segmented - one species has been collected in ND), *Notonecta* (larger, 8-17mm, stouter, and antennae 4-segmented - 4 species have been collected from ND), and *Martarega* (only one species known from Arizona - same characters as *Notonecta*).

8. Pleidae - pygmy backswimmers. (2 genera & 7 North American species)
* closely related to the Notonectidae and included in that family by some people. But hind legs not distinctly natatorial. They do swim upside down like the notonectids.
* No ocelli.
* Dorsal surface very convex; forewings are beetle-like.
* Size - very small - 1.6-2.3mm.
* Rostrum is present and 3-segmented.

* Fore-legs are not raptorial.
* Lacks keel on underside.
* Also respires via physical gill.
* Found in marshes and ponds with lots of aquatic vegetation where they feed on microorganisms. Will come to lights. Females insert the eggs into aquatic vegetation.
* *Neoplea striola* has been collected from Mirror Pool in southeastern ND, and from several other localities throughout the state.

IV. Gerromorpha - families of the Gerromorpha have 3 pairs of head trichobothria; antennae usually 4-segmented and are visible from above. They are semiaquatic or shore inhabiting.

1. Mesoveliidae - pond treaders, or water treaders. (1 genus, *Mesovelia*, & 3 North American species)
* Figure 22-24A in text.
* Small, 2-4mm. Green or yellowish green.
* Rostrum 3-segmented.
* Claws arise at the apex of the last tarsal segment.
* Membrane of hemelytra lacks veins and is more or less confluent with membranous clavus (fig. 22-4G in text).
* Ocelli present in winged forms, absent in wingless forms.
* Scutellum is visible in winged forms.
* Occur on floating vegetation and along pond margins where they feed on small microorganisms. Will come to lights. Some occur in forest litter or on moss near water; some in caves; some in intertidal marine habits.
* Insert eggs into plant tissue.
* Adults may be winged, brachypterous, or apterous; they can also break off their wings.
* Does occur in North Dakota. We have seen many specimens from Mirror Pool.

2. Hydrometridae - marsh treaders or water measurers. (1 genus, *Hydrometra*, & 7 North American species)
* Figure 22-25 in text.
* Size - about 8mm in length.
* Head as long or longer than thorax.
* Ocelli reduced or absent.
* Rostrum 4-segmented.
* Eyes conspicuously bulging laterally.
* Body linear, legs slender - appears like small walking stick.
* Adults may have or lack wings.
* Claws are apical.
* Occurs along marsh and pond edges where they prey on small insects and other invertebrates. Females lay stalked eggs on emergent vegetation. Come to lights.
* Should occur here, but has not officially been reported from ND. I believe I have seen specimens from Mirror Pool; has been reported from MN, SD, and Manitoba.

3. Hebridae - velvet water bugs. (2 genera and 15 North American species)
* Figure 22-24B in text.
* Small, less than 3mm.
* Antennae 4 (*Merragata*) or 5 segmented (*Hebrus*).
* Wing membrane with numerous, fine veins.
* Body has a **hydrofuge** covering of hairs. (water-repelling)
* Tarsi 2-segmented. Claws apical.
* Brachypterous and apterous forms.
* Rostrum 4-segmented.
* Ocelli present.

* Occur in vegetation at the waters edge; are predaceous; escapes predators by running on water surface. A few brackish species. Some can overwinter frozen in ice among sphagnum moss.
* I have collected these by 1) dipping moss, algae, aquatic vegetation, and placing in a white enamel pan, then waiting for awhile for the bugs to begin moving, and 2) by taking berlese samples from dried up pond areas.
* Not known from ND, but two species recorded from MN.

4. Veliidae - broad-shouldered water striders or riffle bugs. (3 genera & 33 North American species)
* Figure 22-26B in text.
* Size - 1.6-5.5mm in length.
* Tarsal claws ante-apical (fig. 22-3D in text). Tarsi 1 to 3-segmented.
* Middle pair of legs equi-distant from fore or hindlegs (except in *Rhagovelia*).
* Ocelli absent.
* Rostrum 4 segmented.
* To distinguish from Gerridae: With hind leg extended posteriorly the hind femur will not or only slightly surpass the posterior end of the abdomen.
* Also have a hydrofuge covering of hair.
* Adults are often apterous.
* Males are sometimes phoretic, riding on the backs of the females.
* Occur on just about any body of water including riffles (*Rhagovelia*) and quieter areas (*Microvelia* and *Paravelia*) where they are predaceous. There are also a few marine species and a few terrestrial species. Some are found in bromeliads and tree holes. Will come to lights.
* Some exhibit expansion skating - secrete a drop of liquid from rostrum, hits water, reduces surface tension and propels insect forward faster than it could with leg power.
* In *Rhagovelia* the hind tarsi are deeply cleft and provided with a large tuft of hairs which help facilitate movement over the water surface. We have collected a species of *Rhagovelia* from the Moorhead Science Center.

5. Gerridae - water striders. (7 genera and over 50 North American species)
* Figure 22-26A in text.
* Tarsal claws ante-apical. Tarsi 2-segmented.
* Mesothoracic legs arise closer to the metathoracic legs than to prothoracic legs.
* Ocelli usually present, but are very small.
* Rostrum 4-segmented.
* With hind legs extended posteriorly, the hind femur will extend much beyond the posterior apex of the abdomen.
* Adults may be macropterous, brachypterous, or apterous.
* Also have a hydrofuge covering of hairs.
* Ripple communication - prey location and communicate with each other.
* Occurs on lakes, ponds, or slow moving rivers where they are predaceous on small insects. There are marine forms (*Halobates*). They will come to lights.

6. Macroveliidae (Not Required) - very similar in appearance to veliids or mesoveliids; only two species reported in North America, but one has been reported from North Dakota - it is usually thought of being more western in distribution. It differs from the mesoveliids in having 6 closed cells in the wing membrane and the pronotum is produced back over the scutellum. They occur along the shores of small streams, etc.

V. Leptopodomorpha

1. Saldidae - shore bugs. (12 genera and about 70 North American species)
* Head trichobothria present.
* Antennae 4-segmented.

* Rostrum 3-segmented.
* Ocelli present.
* Tarsi 3-segmented.
* Membrane of hemelytra with 4 or 5 closed cells (fig. 22-4F in text).
* This group is evolutionarily important in that it has ties to both the semi-aquatic and terrestrial Hemiptera groups.
* Adults can run and jump rapidly. Occurs around bodies of water. Are predators and scavengers. Will come to lights.

VI. Cimicomorpha

* Antennae 4-segmented.
* Beak 4-segmented (exceptions: 3-segmented in Anthocoridae, Reduviidae, & Cimicidae).
* Mid- & hind tarsi 3-segmented (exceptions: Piesmatidae, Tingidae, & Phymatinae).
* Ocelli present (exceptions: Tingidae, most Miridae, & a few Reduviidae).
* Abdomen lacks trichobothria; also lacks trichobothria on head.

1. Tingidae - lace bugs. (23 genera & about 140 North American species)

* Figure 22-27 in text.
* small - 2-5mm.
* Wings with numerous closed cells (reticulate sculpturing) throughout - no division into corium, clavus, & membrane. This reticulate or lace sculpture is present only in the adults, the immatures are rather spiny. Some are brown and tear-drop shaped - the look very much like a grass seed.
* Ocelli absent.
* Pronotum with a caudal process covering scutellum.
* Tarsi 1 to 2-segmented.
* They feed on plants, usually from the underside of leaves. They can cause damage such as necrotic spots to leaf loss. They are also known to vector viral wilts.
* Eggs are laid on the underneath sides of leaves; nymphs are spiny.
* The lantana tingid has been imported into the Old World to combat lantana, an introduced weed there.
* Some live in ant nests. Some will come to lights.

2. Miridae - plant bugs or leaf bugs. (largest family of Hemiptera with 223 genera and 1750 North American species)

* Figures 22-1 and 22-28 in text.
* Small to medium in size (4-10mm).
* Wings with **cuneus** (figure 22-4A in text).
* Ocelli absent (except in the subfamily Isometopinae).
* Beak 4-segmented.
* Wing membrane usually with 1 or 2 closed cells at base (as opposed to Anthocorids which usually lack veins in the wing membrane; again look at figure 22-4A in text).
* Most are plant feeders, some are predaceous, some are scavengers.
* Some of the plant feeders can be serious pests (eg. tarnished plant bug on legumes, vegetables, and flowers; cotton fleahopper on cotton; garden flea hopper on many cultivated plants). Most will come to lights.
* Some nymphs have eversible rectum - adhesive - if becomes dislodged from host plant they evert this adhesive rectum which may stick to another part of the host plant.

3. Lyctocoridae (about 36 North American species)

* Until recently, this group (along with the Lasiochilidae) was included in the Anthocoridae. It shares with the Anthocoridae (and Lasiochilidae) the following characters: wings with a cuneus (also shared with Miridae), wing membranes lacking closed cells, veins in membrane few or lacking, rostrum 3-segmented, tarsi 3-segmented, ocelli present.

* scent gland orifice extends laterally and then narrowly curves anteriorly. Last two antennal segments much smaller in diameter than the first two segments.
* Common species is *Lyctocoris campestris*. Sometimes lives in nests of rodents, and to suck the blood of domestic animals and humans.
* None recorded from ND, but a couple species should occur here.

4. Anthocoridae - minute pirate bugs (about 43 North American species)
* Figure 22-30B in text.
* Size - small, 2-5mm in length.
* See above under Lyctocoridae for characters shared with that family and Lasiochilidae (see figure 22-4C for wing characters).
* Scent gland orifice extending nearly straight towards lateral margin of thoracic pleura; the last two antennal segments are about the same diameter as the first two segments.
* Brachypterous forms do occur.
* Predators of very small arthropods and their eggs & immatures; often found in litter and decaying plant material; also on plants and many other habits; often will come to lights.
* Some will "bite."
* Some members undergo **traumatic insemination** in mating where the male punctures and fertilizes the female through abdominal wall.
* Because of their predatory habits, many species have been transported for use in biocontrol projects (*Orius*).
* One species, *Orius tristicolor*, is known from ND, but others should be here also.

Note: Lasiochilidae - scent gland orifice extends laterally and then distal end curves somewhat posteriorly.

5. Cimicidae - bed bugs (8 genera & 15 North American species).
* Figure 22-30A in text.
* Wings are reduced to small pads - brachypterous.
* Rostrum 3-segmented.
* Tarsi 3-segmented.
* Dorso-ventrally flattened.
* Obligate parasites of birds and mammals.
* Eggs are laid in crevices; each of the 5 instars requires a blood meal; bugs are found on the host only when they are feeding.
* Reproduction is via **traumatic insemination**. Males pierce the cuticle of the female on the right posterior edge of the 4th abdominal sternum. This pouch-like area is called **Ribaga's organ**. The sperm migrates from here through the haemolymph to the ovaries.
* *Cimex lectularius* in the New World & *C. hemipterus* in the Old World are primarily parasites of man. Not usually important as disease vectors.

6. Polyctenidae (Not Required) - only two rare U.S. species. These are interesting in that they are ectoparasites of bats (common name is bat bugs). They lack ocelli, eyes, and wings.

7. Nabidae - damsel bugs (10 genera & 34 North American species).
* Figure 22-29 in text.
* Size - 3.5-11mm in length.
* Apex of tibia with a ventral pad of short hairs (figure 22-3B in text).
* Rostrum 4-segmented, first joint is very short and thick.
* Forelegs somewhat raptorial (figure 22-2E in text).
* Membrane of hemelytron with numerous marginal cells (figure 22-4E in text).
* Both Macropterous and brachypterous forms occur.
* Predaceous usually on aphids or other small arthropods.
* Several species have been studied for potential use as biocontrol agents.
* They are often confused with Lygaeidae. Compare wing venation and tarsal characters.

* Some of these have been found on spider webs - **kleptoparasites**.

8. Reduviidae - assassin bugs, ambush bugs, and thread-legged bugs (49 genera & 160 North American species).
* Figure 22-31 in text.
* Rostrum 3-segmented & bowed out (does not lie flat against body) - tip fits into grooved area on prosternum (figure 22-7B in text).
* Antennae usually 4-segmented.
* Forelegs raptorial (figures 22-2A, C in text).
* Most species have the abdomen somewhat flattened & broadly rounded.
* Some species stridulate by rubbing apex of beak on prosternal groove.
* Predaceous on insects or facultative parasites on mammals.
* Immatures of some groups cover themselves with debris for camouflage.
* The wheel bug has a cog-like crest on the prothorax (*Arilus cristatus*).
* Kissing bugs (*Triatoma* spp., subfamily **Triatominae**) so named for their habit of biting humans around the mouth area (bite is painless). These are also sometimes called blood-sucking cone-noses. These transmit some diseases such as Chagas' disease. Chagas' disease does occur in the feral population in the southern United States, but fortunately, the species of *Triatoma* we have do not usually bite humans.
* *Rhodnius prolixus* has been used extensively in insect physiology experiments.
* Some members of the subfamily **Emesinae** are called thread-legged bugs and resemble walking sticks or hydrometrids. Some of these are kleptoparasites around the webs of spiders, some feed on the spiders themselves.
* Another subfamily appears to be obligate predators on millipedes.
* Members of the subfamily **Phymatinae** are called ambush bugs. These are sometimes given full family status. In these the last antennal segment is swollen, the front femur is greatly swollen, and they often lie in awaiting on flowers where they "ambush" their prey.

VII. Pentatmomorpha

1. Aradidae - flat bugs. (10 genera & 123 North American species).
* Figure 22-32 in text.
* Relatively small (3-11mm); dark brown to black; body surface usually somewhat granular.
* Antennae 4-segmented.
* Rostrum usually 4-segmented (only 2 or 3-segments visible in some species); they have very long maxillary stylets which are retracted into the head when not feeding.
* Tarsi 2-segmented.
* No ocelli.
* Body strongly dorso-ventrally flattened; wings not reaching apex of abdomen.
* They feed on fungi often (but not always) under the bark of dead trees (mycetophagous). Some will come to lights. Some are found in the nests of birds and rodents.
* Some feel that this group is different enough to warrant its own infraorder, the Aradomorpha.

2. Piesmatidae - ash-gray leaf bugs. (1 genus, *Piesma*, & 10 North American species).
* Figure 22-33 in text.
* Scutellum visible from above.
* Tarsi 2-segmented.
* Ocelli present.
* Corium and clavus reticulately sculptured.
* Pronotum with 3 longitudinal ridges.
* Juga longer than tylus.
* Small (2.5-3.5mm) phytophagous insects; often confused with tingids or lygaeids.
* Often found feeding on pigweed (*Amaranthus*). One species is an economic pest on sugar beets by vectoring a virus. One species does occur in North Dakota.

3. Berytidae - stilt bugs. (7 genera & 12 North American species).

* Figure 22-34 in text.
* Size - 5-9mm in length.
* Slender, long-legged bugs.
* Antennae 4-segmented; first antennal segment long and enlarged distally; last segment spindle shaped.
* Rostrum 4-segmented.
* Femora clavate.
* Ocelli present.
* Tarsi 3-segmented; arolia present.
* Generally feed on the sap of tender plant growth (usually on plants species in the family Solanaceae), but sometimes feeds on insect eggs and soft-bodied insects. Usually harmless to crops, rarely may damage crops such as tomatos. Has been released in tobacco as predator of Lepidoptera eggs. Will sometimes come to lights.
* May be confused with Hydrometridae or Reduviidae (Emesinae), but head is never elongate & the front legs are never raptorial.
* At least two species of Berytidae occur in North Dakota. The more common eastern U.S. genus is *Jalysus* (*wickhami* definitely occurs in ND; *spinosus* may occur in the eastern part of ND). *Neoneides muticus* has also been collected in ND.

Note: Lygaeidae *sensu lato* - The following six families used to belong in the family Lygaeidae. This group has recently been split into about 15 different families. Your text book includes 10 families in North America; we will concern ourselves with only five of these. The following characters apply to all the included families:

* Antennae 4-segmented.
* Rostrum 4-segmented.
* Ocelli present.
* Tarsi 3-segmented; arolia present.
* Antennae inserted well down on sides of head.
* Membrane with only 4 or 5 veins; both macropterous and brachypterous forms occur.

4. Rhyparochromidae - (about 165 North American species)

* Figures 22-35B, E, F in text.
* Usually have the front femora somewhat enlarged and spinose.
* These can be recognized by the intersegmental membrane between abdominal sternites 4 and 5 does not reach the lateral margin, but rather it curves anteriorly.
* Usually occur near the ground; feed primarily on seeds.
* Several species are relatively common in our region.

5. Lygaeidae - (about 75 North American species)

* Figure 22-35A in text.
* All abdominal spiracles are dorsal.
* This group now contains most of the more colorful species, several of which feed on milkweed. It also contains the false chinch bugs (*Nysius*). Most species feed on seeds.

6. Cymidae - (about 10 North American species)

* Dull yellow to straw-colored. Coarsely punctate.
* These are small, and very seed-like in appearance. Resemble the seeds of sedges and rushes on which they live.
* I collected quite a few of these at the new Mirror pool on sedges.

7. Blissidae - chinch bugs (about 29 North American species)

* Figure 22-36 in text.
* Abdominal spiracles dorsal except those on segment 7 are ventral.

* Lacks conspicuous punctures on hemelytra.
* This includes the chinch bugs (*Blissus*) and another genus even longer and more slender than the chinch bugs (*Ishnodemus*). There is at least one species of each of the above genera known to occur in North Dakota.
* Most species feed on sap (not seeds), and usually feed only on monocots. Especially *Blissus* species can be pests on corn, sorghum, etc.

8. Geocoridae - big-eyed bugs (about 27 North American species)
* Figure 22-35C in text.
* The eyes are bulging on the sides of the head, reniform (kidney shaped), almost pedunculate.
* Spiracles on abdominal segments 3 and 4 are dorsal.
* These tend to be predatory bugs.
* There are a couple species that occur in our region.

9. Pachygronthidae (Not Required) - (about 7 North American species)
* Figure 22-35D in text.
* All abdominal spiracles are ventral.
* Coarsely punctate.
* These tend to be somewhat elongate slender insects with the fore femora enlarged and often spinose.
* Feed on grasses (*Phlegyas*) or sedges and rushes (*Oedancala*).
* Again, these have been collected in the Sand Hills of southeastern North Dakota.

10. Largidae - largid bugs (7 genera & 21 North American species).
* Figures 22-37A, B in text.
* Ocelli absent.
* More branched veins and cells in wing membrane than in lygaeids; 7-8 veins arising from 2 basal closed cells.
* Pronotum rounded laterally.
* Two rather different body plans:
  - Larginae (*Largus*): large, oval, usually black and red or orange; found on foliage of plants; immatures are steel blue with large orange to red spot on dorsum.
  - Arhaphinae (*Arhaphe*): somewhat ant-like in appearance and usually found running along sandy or gravelly soil littered with dried plant material and other debris.
* Much confusion in the taxonomy of the included species.
* Some will come to lights.
* No species of this family are known from North Dakota, although one species is recorded from MN.
* Demonstration in lab - a tropical species with eyes on stalks.

11. Pyrrhocoridae - cotton stainers or red bugs. (1 genus & 8 North American species - mostly southern).
* Figure 22-37C in text.
* Medium sized (11-17mm).
* No ocelli.
* 4-segmented rostrum.
* 4-segmented antennae.
* Pronotum margined laterally.
* 3-segmented tarsi.
* Wings with at most five longitudinal veins; brachyptery occurs, but rare.
* Often strikingly colored and patterned.
* Most species are phytophagous; one European species is predaceous on termite nymphs.
* Some species are economically important in that they feed on cotton - the holes that they make in the cottom boles are avenues of entry for a fungus.
* Very abundant in the tropics. Does not occur in ND. Will come to lights in large numbers.

Superfamily Coreoidea - contains Coreidae, Alydidae, and Rhopalidae.

* Antennae 4-segmented.
* Rostrum 4-segmented.
* Wing membrane with more than 5 longitudinal veins.
* Ocelli present.
* Arolia present.

12. Coreidae - leaf-footed bugs or coreid bugs. (33 genera & about 87 North American species).

* Figures 22-38A, B, C in text.
* Medium to large in size, usually dark-colored.
* Bucculae usually extending posteriorly beyond antennal base.
* Membrane of hemelytra with numerous longitudinal veins.
* Head narrower and shorter than pronotum.
* Lateral scent gland openings are conspicuous; give off a distinct odor.
* The common name refers to the enlarged, leaf-like expansions of the hind tibiae of some species.
* Mostly phytophagous and concentrate their feeding on tender shoots. Many will come to lights.
* Some species can be serious pests:
    - The squash bug (*Anasa tristis*) is a pest on curcurbits; the damage can be due to either the feeding or also the transmission of a *Bacillus* that causes wilt.
    - The banded leaf-footed bug (*Leptoglossus phyllopus*) a pest on many vegetables; another species of *Leptoglossus* (*occidentalis* which does occur in ND) is a pest on pine.
* Species of the genera *Narnia* and *Chelinidea* occur on cactus; species of *Chelinidea* have been exported to Australia to help control *Opuntia* there.
* Several other species, although fairly rare, do occur in our region.

13. Alydidae - broad-headed bugs (12 genera and 32 North American species).

* Figure 22-38D in text.
* Head about as long and wide as pronotum.
* Bucculae short, lying wholly in front of antennal base (like pursed lips).
* Lateral scent glands conspicuous; produce a pungent scent - many say worse than pentatomids.
* All are phytophagous, usually found on foliage in wooded areas; one subfamily feeds on legumes; the other two subfamilies feed on grasses.
* In the Orient there are a couple of species that are a pest of rice (*Leptocorisa*).
* Some immatures resemble (mimic) ants; while some adults resemble spider wasps.
* Some species have stridulatory mechanisms that may be involved in forming aggregations.
* Many will come to lights.
* Most species are black or dark brown - we have 2-3 species (*Alydus*, *Megalotomus*) with this general appearance (one often has a reddish tinge to it). There is also another very long, think species (*Protenor*) which occurs on tall grasses.

14. Rhopalidae - scentless plant bugs (10 genera and 39 North American species).

* Figures 22-38E, F in text.
* Head about as long and wide as pronotum.
* Thoracic scent glands reduced or absent.
* Brachyptery occurs but is not common.
* Phytophagous, usually feeding on fruits and seeds of herbaceous plants growing in old fields, along roadsides, and other disturbed habitats.
* The common boxelder bug (*Boisea trivittata*) is black and red and occurs in large numbers on tree trunks. They can be a pest in the fall and winter when they try to enter homes to get out of the cold weather; they are harmless.
* Sometimes these are confused with lygaeids, but they can be identified by the more than 4-5 longitudinal veins in the wing membranes.
* There are several species which occur in our region.

Superfamily Pentatomoidea

* Antennae usually 5-segmented, sometimes 4-segmented.
* Tarsi usually 3-segmented (2-segmented in Acanthosomatidae).
* Pronotum hexagonal.
* Beak 4-segmented.

15. Cydnidae - burrower bugs (13 genera and 43 North American species).

* Figure 22-39B in text.
* Tibiae with strong spines (fossorial) - Figure 22-8A in text.
* Scutellum triangular.
* Small, usually less than 8mm.
* Usually shiny black or brown bugs.
* Usually found around the bases of grass or other plants; most feed on the roots of plants, but species in genus *Sehirus* will feed on above ground parts of plants (usually mints). These sometimes show paternal care of the young. Usually of no economic importance.
* Often comes to lights.
* One interesting note: because of their burrowing habits, several species have been accidently imported into the U.S. via ballasts in old sailing ships.

16. Thyreocoridae - negro bugs (4 genera and 41 North American species).

* Figure 22-39A in text.
* We will follow the book in using Thyreocoridae as the name for this group, but there are some workers who consider these to be a subfamily of the Cydnidae. Also, some workers believe that the Old World species belong in a different family from the New World species. If this is so, then the Old World species would be placed in the Thyreocoridae while the New World species would be placed in the Corimelaenidae.
* Color usually shiny black; size small (3-6mm).
* Tibiae with strong spines.
* Scutellum large, oval, covering most of abdomen.
* Phytophagous, most easily found by sweeping vegetation; they feed on flowers and developing seeds, sometimes imparting a disagreeable taste to berries.
* Sometimes confused with some Coleoptera - look at rostrum & 5-segmented antennae.

17. Scutelleridae - shield-backed bugs (16 genera & 37 North American species)

* Figure 22-40A in text.
* Tibiae having at most a few weak apical spines.
* Scutellum large, oval, usually covering most of abdomen.
* Anterolateral margin of pronotum lacking tooth or lobe in front of humeral angles.
* Medium sized (usually more than 8mm).
* Our species are all mainly browns and blacks, but in the tropics there are some spectacularly colored species.
* Phytophagous on woodland vegetation; in the south one species (*Tetyra bipunctata*) feeds on developing seeds of pine; in Old World one genus *Eurygaster* is a pest of small grains. Our most common species belong in the genus *Homaemus*.

18. Pentatomidae - stink bugs (63 genera and more than 200 North American species).

* Figures 22-40B, 22-41, 22-42 in text.
* Tibiae with at most a few weak apical spines.
* Scutellum usually triangular; a few exceptions in subfamily Asopinae (*Stiretrus*) and subfamily Podopinae (Fig. 22-40B). Also the genus *Coenus* (Fig. 22-42A) sometimes confuses students on the scutellum character.
* Produce a pungent odor.
* Common at lights.
* Some species in the tropics exhibit parental care of the eggs and first instar nymphs.

* Several subfamilies are recognized. We will examine 3: Pentatominae, Asopinae, and Podopinae.
  - Pentatominae: Basal segment of beak long and slender; mostly phytophagous; some species are of economic importance: green stink bug, *Chinavia hilare*, on beans and other vegetables; southern green stink bug, *Nezara viridula*, on many plants worldwide; brown stink bug, *Euschitus servus*, on many crops, harlequin stink bug, *Murgantia histrionica* (Fig. 22-41B), on crucifers; rice stink bug, *Oebalus pugnax* (Fig. 22-42C) on rice.
  - Asopinae: Basal segment of beak short and thick; predaceous usually on Lepidoptera or Coleoptera larvae; some studies to see if they can be of economic importance as biological control agent. For example, *Perillus bioculatus* on Colorado potato beetle; *Podisus maculiventris* (Fig. 22-41D).
  - Podopinae (Fig. 22-40B): commonly called the turtle bugs. These are dark black or brown bugs with the scutellum somewhat enlarged & U-shaped; anterolateral margin of pronotum with prominent tooth in front of humeral angle. They feed on grasses and often collected on rice in the south. I collected several specimens of a podopine from the Ekre's Grassland Preserve.

19. Acanthosomatidae - acanthosomatid bugs (2 genera and 4 North American species).
* Tarsi 2-segmented.
* Scutellum is triangular.
* Tibiae with at most a few weak apical spines.
* Some species exhibit maternal care with the female covering eggs and nymphs and vibrating wings to ward off Hymenopteran parasites.
* Usually phytophagous with decided preference to shrubs and trees; *Elasmucha lateralis* relatively common on birch trees in the north.

Other families to mention:
* Thaumastocoridae (Cimicomorpha; no Handout) - one species in U.S. occuring in Florida. These are small insects, but they are interesting in that they occur in the tops of large Royal Palm trees.

HOMOPTERA (of old)

* Essentially, the old order Homoptera no longer exists. All of its members are now contained in the order Hemiptera, and more specifically into the suborders Coleorhyncha, Sternorrhyncha, and Auchenorrhyncha. This part of the Hemiptera contains the cicadas, hoppers, psyllids, whiteflies, aphids, and scales.

* Characters that were used to separate the old Hemiptera and the old Homoptera include the homopteran characters: the uniform texture of the front wings, the beak arising from the posterior part of the head (sometimes even appearing to arise between the front coxae), and in general, the wings are held roof-like over the body (usually held flat over the back in the Hemiptera).

* All members of the old Homoptera are plant feeders, and many may be serious pests of cultivated plants. Some also transmit plant diseases. Some are beneficial and serve as a source of shellac, dyes, or other materials.

* The homopteran members undergo simple metamorphosis although the development of whiteflies and male scale insects resembles complete metamorphosis in that the last nymphal instar is quiescent and rather pupa like.

* Characters:
  * Head:
    * antennae: the **Auchenorrhyncha** (cicadas, leafhoppers, planthoppers) have **setaceous** antennae which are short, bristle-like with the segments becoming more slender distally. The **Sternorrhyncha** (aphids, white flies, scales) have **filiform** antennae which are hairlike or thread-like with the segments nearly uniform in size. Also the position of the antennae is

important. In the superfamily **Fulgoroidea** (planthoppers) the antennae are separated from the front of the head by a vertical ridge, so they arise below the eyes; while in the superfamily **Cicadoidea** (cicadas, leafhoppers), the antennae are not separated from the front of the face by a ridge so they arise more or less between the eyes (Fig. 22-9B). Also the number of antennal segments may be important.

* eyes: the compound eyes are usually well developed. Ocelli may be present or absent; if present they may be either 2 or 3 in number.

* Thorax
  * wings: The following structures of the wings may be important:
    tegula - small scale-like structure overlying base of front wing.
    costal area - portion of wing immediately behind anterior margin (will be down in Homoptera).
    anal area - posterior portion of wing, usually including anal veins (up in Homoptera).
    Y-vein - 2 anal veins in front wing meet apically to form a Y-shaped figure in the claval area of the wing (in text figure 22-10A, B they are labeled claval veins). This area is down in picture but will be up on insect).
    stigma: thickening of wing membrane along costal border near apex.
    Rs: radial sector; posterior of 2 main branches of radius (Fig. 22-12B, D, F).
    M: media; the longitudinal vein between the radius and the cubitus (Fig. 22-12).
    Hind wing: refer to fig. 22-11 for normal hind wing venation.
  * Pronotum: the shape may be important.
  * Legs:
    * Number of tarsal segments will be important - will be 1-3 segments; usually easiest to count on hind legs.
    * The number and configuration of the spines on the tibiae will also be important.
* Abdomen:
  - **cornicles**: one of a pair of dorsal tubular structures on posterior part of abdomen of aphids.

* Classification:

I. Suborder Coleorhyncha (Coleo = sheath, rhyncha = beak)
* Beak appears to arise from the prothorax.
* Prothorax has paranotal lobes.
* This order contains the single family **Perloridiidae** (10 genera and 20 species) which is restricted to Australia, New Zealand, Tasmania, and South America. This family is important (as we mentioned briefly in the Hemiptera lecture) in that it is considered very primitive and it is believed that these species are direct descendents of the fossiliferous order **Protohemiptera**. They have paranotal lobes on the prothorax (as do other fossil insects) which are thought to possibly be precursors of insect wings. Wings may have evolved from similar structures on the meso- and metathorax.

II. Suborder Auchenorrhyncha (cicadas and hoppers) (aucheno = neck or throat, rhyncha = beak).
* antennae very short and bristlelike (setaceous).
* tarsi 3-segmented.
* beak arising from back of head.
* males of many species in this suborder stridulate.
* usually active insects; good fliers or jumpers; all but cicadas are jumping insects.

A. Cicadoidea
* Tegulae usually absent.
* No Y-vein in anal area of front wing.
* Antennae not separated from front of head by vertical carina, thus arising on front of head between eyes (Figs. 22-9B).

1. Cicadidae (cicadas) (22 genera & 166 North American species).

* Figure 22-43 in text.
* Large insects (20-50 mm) with front wings membranous.
* 3 ocelli.
* Metathoracic legs are not modified for jumping; tarsi lack empodia.
* Adults are sometimes called "locusts," their numbers and noise sometimes being confused with true locusts of the Orthoptera; they are also sometimes called harvestflies because of their usual appearance in the latter half of the summer in temperate regions (near harvest time).
* Males produce loud sound. The sound is characteristic for each species. Also makes different sound for courting and for alarm. The sounds are produced by a pair of **tymbals** located dorsally at the sides of the basal abdominal segment. The sound is amplified by a **resonating chamber** made up of a large tracheal air sac extending from the metathorax to, in some species, the 6th abdominal segment. Both sexes possess **tympana** or hearing organs located ventrad and posteriad of the tymbals.
* Deposit their eggs in the twigs of trees and shrubs by means of an eversible ovipositor. This usually kills the twig, and can cause considerable damage especially to nursery stock.
* The nymphs fall to the ground and burrow under the soil where they spend the next 1 to 17 years feeding on roots, usually of perennial plants. The length of time spent underground varies with the species.
* You can often see the cast skins of the last nymphal instar as it passed to adult on the trunk of trees, etc. The adult lives for about a month.
* Two common types of cicadas are the annual or dog-day cicadas and the periodical cicadas.
    - The dog-day cicadas are blackish with green markings and appear each year (their life cycle is at least 4 years).
    - The periodical cicadas have the wing veins and the eyes marked with red or orange and they do not appear each year (their life cycle is 13 to 17 years). There are 6 species of periodical cicadas, 3 with 13 year life cycles and 3 with 17 year life cycles. Since their are 5 broods of the former, and 13 broods or the latter, one need not wait the prerequisite time to find each species. (See article by Simon).
* Other areas of the world also have interesting cicadas. One species in the Philippines sounds like an air-raid siren, another in Japan is said to sound like hot frying fat, and members of one genus in Australia lack tymbals and tympanna and as such are silent.

2. Membracidae (treehoppers) (45 genera & about 200 North American species).

* Figure 22-46 in text.
* Medium in size (rarely more than 10-12mm).
* Two ocelli.
* Metathoracic legs modified for jumping.
* Pronotum broadly extended backward over wings and abdomen, concealing scutellum and often forming bizarre shapes, often with horns, spines, or keels on pronotum.
* Some species are shaped like thorns.
* Beak not extending to hind coxae.
* Phytophagous, feeding usually on trees and shrubs, some on grasses and herbaceous plants. Many come to lights.
* As with the cicadas the females lay their eggs by inserting them into the stems of plants which can cause damage. In northern areas the eggs overwinter. Nymphs are sap-suckers on plant stems. Many secrete honeydew, and a few are attended by ants. Some species have a symbionic relationship with ants are even placed underground

on plant roots, or defended by the ants in return for the honeydew. Adult females will sometimes guard the eggs and young.

* A few species are considered to be economically important usually by the damage caused by their egg laying. The three-cornered alfalfa hopper is a pest on alfalfa - their feeding will girdle the stem near base; and the buffalo treehopper is a pest on apple and other trees.

3. Cercopidae (froghoppers or spittlebugs) (7 genera & 54 North American species).

* Figure 22-47 in text.
* Small insects, usually less than 13mm. They are usually brown or grey in color, but some have very distinctive coloration (for example the two-lined spittle bug with its distinctive red and black coloration).
* Two ocelli.
* Pronotum not covering head or scutellum.
* Hind tibiae with l or 2 stout spines laterally and a circlet of spines at apex; Metathoracic legs are modified for jumping.
* They usually feed on shrubs, trees, or herbaceous plants.
* The common name froghoppers comes from the squat appearance of the adults.
* The nymphs surround themselves with a frothy mass or spittle, hence the common name spittlebug. The spittle comes from fluid coming from the anus and from a mucilaginous substance secreted by epidermal glands on the 7th and 8th abdominal segments. A ventral channel extending from the mesothoracic spiracles to the anus provides air which the abdominal appendages mix with these exudates to produce the froth. In Europe, these bugs are known as cuckoo-spit bugs.
* All species exude honeydew; one species in Madagascar exudes honeydew in such quantity that infested trees are called "weeping trees."
* Females oviposit eggs in leaf sheaths of grasses or other plants. Eggs overwinter.
* One meadow species (*Philaenus spumarius*) causes economic damage by stunting clover. A couple other species are pests of pine trees.

4. Cicadellidae (leafhoppers) (225 genera & over 2500 North American species).

* Figure 22-49 in text.
* Relatively small (usually 2-13mm). Many beautifully marked with different colors.
* Large family in terms of numbers of species.
* Two or less ocelli.
* Hind legs modified for jumping. Hind tibiae with l or more rows of small spines.
* They occur on almost all types of plants, including trees, shrubs, grasses, flowers, and many field and garden crops. They feed principally on the leaves of their food plant. Most are host specific. Many come to lights.
* Leafhoppers can overwinter as eggs, nymphs, or adults - most often as eggs inserted into stems or leaf sheaths. Many species produce honeydew.
* Adults of some species stridulate, via tymbals similar to cicadas, but the sounds are usually inaudible to humans.
* There are many economically important pest species in this group, and this is the most important family in the Cicadoidea. They may cause damage to plants in 5 major ways:
    1. Removal of excessive amounts of sap and destruction of chlorophyll.
    2. Interference with plant physiology by the mechanical blockage of xylem or phloem vessels.
    3. Oviposition in stems or twigs can kill the terminal portions of the plant.
    4. Large number of species are vectors of plant diseases. (curly top in sugar beets).
    5. Leaf curling or stem bending and stunting caused by growth inhibition in the area of leafhopper feeding.

* Large number of subfamilies (some authors raise to family level) - key and brief descriptions in text.

B. Fulgoroidea (planthoppers)

* Tegulae usually present (Fig. 22-51F).
* 2 anal veins in front wing usually meeting distally to form Y-vein (Fig. 22-10A, B – claval veins).
* Antennae separated from front of head by vertical carina, thus arising on sides of head beneath eyes (Fig. 22-9C) except some Cixiidae.
* The families of Fulgoroidea can be placed into one of two groups based upon the structure of the hind tarsi. In the Delphacidae, Derbidae, Cixiidae, Dictyopharidae, Fulgoridae, and Achilidae the second segment of hind tarsus has a row of apical spines and the apex is truncate or emarginate (Fig. 22-10C). In the Tropiduchidae, Flatidae, Acanaloniidae, and Issidae the second segment of hind tarsus has 2 apical spines (one on each side), and the apex is usually rounded or conical (Fig. 22-10D).

1. Delphacidae (26 genera & about 150 North American species).

* Figures 22-51B, J in text.
* This is the largest of the planthopper families.
* Hind tibia with large flattened apical spur (moveable); 2nd segment of hind tarsi with row of apical spines (Fig. 22-10C).
* Many dimorphic with long or short wings.
* Most species feed mainly on Poaceae and Cyperaceae. A few species serve as vectors of plant diseases. At one time the Hawaiian sugarcane industry was threatened by the sugarcane delphacid (*Perkinsiella saccharicida*)

2. Derbidae (14 genera & about 47 North American species).

* Figure 22-51K in text.
* They are small, delicate, moth-like insects; they are usually elongate with long wings; cosmopolitan in distribution, but most common in the tropics.
* Terminal segment of beak short, not more than 1½ times as long as wide.
* 2nd segment of hind tarsi with a row of apical spines.
* Feed on woody fungi.

3. Cixiidae (26 genera & 145 North American species).

* Figures 22-51A, D in text.
* Head not or only slightly prolonged in front.
* 2nd segment of hind tarsi with a row of terminal spines.
* Frons either without carinae or with median carina only.
* Median ocellus usually present (at apex of frontal carina adjoining clypeus).
* The wings are often hyaline and ornamented with spots along the veins.
* They overwinter as nymphs, and at that stage are subterranean feeders on roots of grasses and other plants such as alfalfa, yucca, sage, and saltbush.
* Adults are active jumpers and flyers.
* More common in the tropics.
* Do come to lights; sometimes can catch by beating pine.

4. Dictyopharidae (16 genera and 64 North American species).

* Figures 22-51G-I in text.
* Head sometimes prolonged in front; frons bears 2 or 3 carinae.
* 2nd segment of hind tarsi with a row of terminal spines.
* Median ocellus absent.
* Wings usually not overlapping at apex.
* They usually feed on Poaceae in wet meadows; overwinter as eggs.

* The genus *Scolops* shows the remarkable prolongation of the head. Species of one subfamily are wingless inhabitants of arid areas. One species is a pest of coffee. Some come to lights.

5. Fulgoridae (7 genera and 15 North American species).
* Figure 22-51M in text.
* Can be quite large in the tropics - one species can have a wingspan of 150mm.
* Anal area of hind wing reticulate with many cross veins.
* 2nd segment of hind tarsi with a row of terminal spines.
* This is a large, diverse, and often bizarre family in tropical areas. The lantern-fly has a prolonged head resembling that of an alligator (or a peanut). The name comes from the erroneous belief that it is luminous.
* Some species exude waxy filaments which appear as streamers as the insect flies.
* Uncommon. Some come to lights.

6. Achilidae (Not Required) (3 genera and 46 North American species).
* Figure 22-51C in text.
* Terminal segment of beak very long, reaching hind coxae.
* 2nd segment of hind tarsi with a row of terminal spines.
* Front wings overlapping at apex.
* Y-vein extends to apex of clavus (Fig. 25-3 A).
* Uncommon. Nymphs occur in rotten wood and under loose bark where they feed on fungi.
* Adults are sap suckers on woody plants - apparently conifers in U.S. Some come to lights.

7. Flatidae (14 genera and 33 North American species).
* Figure 22-51F in text.
* 2nd segment of hind leg with two apical spines (one on each side).
* Front wings with numerous crossveins on costal and/or apical margins, held almost vertically at rest.
* Clavus with numerous small pustule-like tubercles.
* Most species are green or brown and wedge-shaped, resembling bits of leaves. One Southeast Asian species is pink with darker markings - when they form aggregations, the combined effect is the appearance of a raceme of flowers.
* Generally are sap suckers on woody plants.

8. Acanaloniidae (1 genus and 18 U.S. species)
* Figure 22-51E in text
* Front wings with reticulate venation, held almost vertically at rest; wings rounded apically rather than rectangular or triangular as in the previous family.
* 2nd segment of hind tarsi with two apical spines (one on each side). Hind tibia with spines at apex only.
* Adults occur on grasses, herbaceous, and woody vegetation.
* Some workers believe that this group should be a subfamily of Issidae.

9. Issidae (23 genera and 127 North American species).
* Figure 22-51L in text.
* Front wings variable in size and shape, often shorter than abdomen, but if longer than abdomen, then usually oval. This family contains both macropterous and brachypterous individuals. In general, the macropterous individuals have a wing shape resembling that of the Acanaloniidae, with the venation like that of the Tropiduchidae.
* 2nd segment of hind tarsi with two apical spines (one on each side). Hind tibiae usually with spines on sides in addition to apical ones.

* The forelegs of some species are enlarged with a leaf-like femur and tibia.
* Head produced or not; many North American species have a weevil-like snout.
* Uncommon.

II. Suborder Sternorrhyncha (psylids, whiteflies, aphids, & scale insects) (sterno = sternum, rhyncha = beak)

* Beak appearing to arise from between the procoxae, occasionally absent.
* Antennae usually long and filiform, occasionally absent.
* Tarsi l or 2-segmented, or atrophied.
* These are often small, sedentary insects. Many species are sessile. As a whole, the Sternorrhyncha are of the greatest economic importance of the hemipteroid orders. Many species are colonial, and many serve as vectors of plant diseases. Many are multivoltine and as such have great reproductive potential. Some species have complex life histories alternating apterous and brachypterous forms and/or alternate hosts. Others are sedentary with a complex development approaching complete metamorphosis.
* This suborder contains 4 superfamilies: Psylloidea, Aleyrodoidea, Aphidoidea, and Coccoidea.

A. Psylloidea - this superfamily contains a single family: the Psyllidae.

1. Psyllidae (jumping plantlice) (28 genera and 257 North American species)

* Small, 2-5 mm long; usually resemble miniature cicadas in form.
* Have 3 ocelli.
* Front wings membranous or thicker than hind wings; wings held rooflike over body at rest.
* Antennae 5-l0 (usually l0) segmented.
* Tarsi 2-segmented; hind legs modified for jumping.
* Many species exude a waxy secretion and so may be confused with woolly aphids (Eriosomatidae).
* They insert their eggs into plant tissue or lay stalked eggs. The nymphs are flattened with conspicuous wing pads.
* Many species are associated with a particular host plant; some species are gall forming (example: the small gall on hackberry is caused by psyllids of the genus *Pachypsylla*).
* The tomato psyllid can transmit the virus disease psyllid yellows to solanaceous plants. The pear psylla and the apple sucker are pests imported from Europe.

B. Aleyrodoidea - contains the single family Aleyrodidae.

1. Aleyrodidae (whiteflies) (19 genera and about 100 North American species).

* Minute insects, usually 2-3 mm long.
* Wings opaque, covered with whitish powder; front and hind wings about same size. Wings are held flat over abdomen.
* Has 2 ocelli.
* No cornicles.
* Tarsi 2-segmented.
* Antennae 7-segmented.
* Females may lay up to 250 stalked eggs on the undersurfaces of leaves of their host plant. Eggs may be generally distributed or arranged in circles. First instar nymphs are active crawling insects; instars 2-4 are sessile and resemble scale insects. The 5th instar, which has been called a pupa, is quiescent. Adults emerge through a T-shaped dorsal suture in the "pupal" exoskeleton. Imaginal disks (wing pads) develop internally during the life of the nymph, but are external in the eclosing adult.
* A few species of whiteflies are parthenogenetic.

* The adults of many species are unknown and the classification of the group is based on nymphal characters.
* The greenhouse whitefly is now a cosmopolitan pest of horticultural plants.

C. Aphidoidea

* When winged they have two pairs of membranous wings with the hindwings smaller.
* Winged forms have 3 ocelli.
* Antennae have 3-6 segments.
* This superfamily has been split into as many as 10 families, or all members have been grouped in a single family, the Aphididae. We will recognize four families: Aphididae, Eriosomatidae, Adelgidae, and Phylloxeridae.

1. Aphididae (aphids or plant lice) (224 genera & 1351 North American species; 3000 species worldwide).

* Wings membranous without whitish powder, held rooflike over body; Front wing with Rs vein present and M vein branched; Hind wing much smaller than Front wing.
* Cornicles nearly always present and conspicuous. (Cornicles are paired tubular processes occurring on the 5th or 6th abdominal segments of most species).
* Soft-bodied with pearlike shape.
* Antennae 6-segmented.
* Tarsi 2-segmented.
* Are often found in groups on plant stems or leaves.
* They secrete large amounts of honeydew so they are often attended by ants which imbibe the liquid and actively defend the aphid colony.
* They may have their own chemical defense via secretions from the cornicles.
* These can be of major economic importance. Reasons are their tremendous reproductive potential (up to 12 generations per year), and they are known to vector certain plant diseases (e.g. *Myzus persicae*, the peach aphid, is known to vector over 100 viruses).
* Some species have soldier morphs which defend the colonies by gripping predators with their enlarged raptorial forelegs and piercing them with the sharply pointed frontal horns or the feeding stylets. This might be considered to be altuistic social behavior as these soldier morphs do not molt or reproduce.
* They can have a very complicated life history including alternation of hosts (called **alternation of generations**). Some terms that you should know (**this section I have been skipping**):
  - **Primary plant host** - in species with alternate host plants, the plant upon which they can successfully hibernate as eggs.
  - **Viviparae** - female aphids other than the fundatrix which reproduce parthenogenetically.
  - **Fundatrix (-ices)** - viviparous parthenogenetic females developing from fertilized eggs (stem mother).
  - **Oviparae** - females that lay hibernating eggs.
  - **Sexuals** - oviparae and males.
  - **Sexupara** - viviparae which produce sexuals.
  - **Exules** - aphids born on the secondary host plant.
  - **Hiemalis (-ae)** - specialized viviparae which overwinter on the secondary host plant.
* The text illustrates (p. 337) a typical life history (that of the rosy apple aphid, *Dysaphis plantaginea*): The rosy apple aphid overwinters as eggs laid on apple twigs (primary plant host) in the fall. As trees leaf out in the spring, the eggs hatch into apterous females (fundatrix) which reproduce parthenogenetically giving rise to another generation of wingless females (viviparae). In late spring a generation of macropterous females is produced. By early summer, these have migrated to

narrow-leafed plantain (secondary plant host) where several generations of wingless females (exules; last generation are sexupara) are produced. In late summer, winged males and females (sexuals, oviparae) are produced which migrate back to apple where mating occurs. The females then produce the overwintering eggs.

2. Eriosomatidae (woolly and gall-making aphids)

* Cornicles indistinct or absent.
* Media vein not branched (U.S. species only)
* Usually with large numbers of wax glands on abdomen.
* Antennae 6-segmented.
* Sexuals (mating males & females) have atrophied mouthparts and do not feed.
* Most of these aphids have alternate hosts.
* Oviparae produce only a single egg.
* Generally the primary host is a tree or shrub, while the secondary host is a herbaceous plant.
* Of those species that produce galls, usually only the primary host is so effected.

3. Adelgidae (pine and spruce aphids) (2 genera and 22 North American species).

* Forewings with only 3 veins (has the R, Cu_1 and Cu_2 veins; lacks the Rs and M veins) reaching outer margin; the Cu_1 and Cu_2 are separate all the way to their origin.
* Antennae 3 to 5 segmented. Wingless parthenogenic females have 3-segmented antennae; sexuals possess 4-segmented antennae; while alate parthenogenic females have 5-segmented antennae.
* No cornicles.
* Parthenogenetic forms are oviparous.
* All but one species are confined to the northern hemisphere.
* Most species have alternate hosts, but in all cases both the primary and secondary host is a conifer, and the primary host is always spruce.
* Unlike the Aphididae, these insects overwinter as nymphs (at the base of spruce twigs) and all females are oviparous. Many produce galls.

4. Phylloxeridae (phylloxeras) (1 genus and 29 North American species).

* Fore wing venation similar to Adelgidae except Cu_1 and Cu_2 are stalked (joined together at their bases). Wings are held flat over back.
* Antennae 3-segmented.
* No cornicles.
* They are minute insects which do not secrete honeydew.
* They may have complex life histories as do the aphids, but parthenogenic forms are always oviparous (as in Adelgidae).
* An important species, the grape phylloxera (*Phylloxera vitifoliae*), is rarely damaging to American grape species where it may form stem, leaf, or root galls. The species was devastating to the European wine industry in the 19th century after its introduction. The problem was solved, through the suggestion of C. V. Riley, by grafting resistant American rootstalks onto European plants.

D. Coccoidea

* Females are wingless and usually legless and sessile.
* Males have only a single pair of wings (rarely wingless); lack mouthparts (do not feed); the abdomen terminates in one (rarely two) long stylelike process; and the hind wings are reduced to a small halterelike process that usually terminates in a hooked bristle.
* The life histories can be fairly complex. In general the first instar nymph has legs and are quite active (they are called **crawlers**). After the first molt, the insects usually lose

the legs and antennae and they become sessile. Often a waxy scale is secreted over the insect. The female usually remains under the scale until where it eventually produces its eggs or young. The males develop much like the females except the last nymphal instar is quiescent, similar to a pupal stage. The wings develop externally in the pupa.

1. Margarodidae (giant coccids and ground pearls) (41 North American species).
* Some of the largest species in the superfamily (up to 25mm).
* Species of the genus *Margarodes* live on the roots of plants and form wax-like cysts which may resemble pearls.
* The cysts of some tropical species are used in making varnish.
* The cottony cushion scale, *Icerya purchasi*, is an important pest of citrus in the west. Remember the famous biocontrol program: the cottony cushion scale was accidently introduced into California in about 1868 from Australia. By 1890 it had just about wiped out the citrus industry in California. An Australian lady beetle, *Rodolia cardinalis* was introduced into California. Within a few years the cottony cushion scale was eliminated as a serious pest.

2. Ortheziidae (ensign coccids) (27 North American species).
* Females are distinctly segmented, elongate oval, and are covered with hard, white, waxy plates.
* Most often found on roots.
* One species is a common pest in greenhouses.

3. Kerridae (lac scales) (6 North American species).
* Females are globular in form, legless, and live in cells of resin.
* U.S. species live on cactus and other desert plants.
* Most species produce lac or resin, and one Indian species produces so much that it is harvested and used in making shellac and varnish.

4. Coccidae (soft scales, wax scales, & tortoise scales) (about 85 North American species).
* Females are elongate oval (sometimes flattened).
* They usually have a hard smooth exoskeleton or a covering of wax.
* Legs are usually present.
* Antennae are usually reduced or absent.
* There are a number of important pests. There are a number of them listed in your text on p. 342.
* The Chinese wax scale is an important oriental scale in that the males secrete large amounts of white wax that is harvested and used to make candles.

5. Kermesidae (gall-like coccids) (about 30 North American species).
* Females are rounded and resemble small galls.
* Generally found on twigs or leaves of oaks.
* One species, the tamarisk manna scale, is believed to have produced the manna mentioned in the bible (see handout). They produce large amounts of honeydew which in the arid regions drys quickly into thick layers of a sugarlike material called manna.

6. Dactylopiidae (cochineal insects) (5 North American species).
* Resemble mealybugs.
* Females are red, elongate oval, are distinctly segmented, and are covered with white waxy plates.
* A Mexican species has been important in the past for producing red pigments used in red dyes. Now synthetic dyes have replaced this source.

7. Diaspididae (armored scales) (largest family of scales - 300 North American species).

* Females are small, soft-bodied, and are concealed under a scale covering which is usually free from the body of the scale.
* The shape of the scale varies and is often distinctive for the species.
* Body segmentation is usually indistinct.
* They lack eyes and legs, and the antennae are either vestigial or absent.
* Reproduction may be bisexual or parthenogenic; some species are oviparous, giving birth to living young.
* The first instar young are called crawlers, and are active insects which can disperse a relatively far distance.
* Many species are important pests. The San Jose scale was accidently introduced into the U.S. in about 1880; it has spread and is now an important pest of many orchard trees and shrubs. The oystershell scale is an important pest on most fruit trees and many ornamental trees. Other pests listed in text (p. 345).

8. Pseudococcidae (mealybugs) (more than 300 North American species)

* Body is covered with a mealy or waxy secretion.
* Female is elongate oval, segmented, and has well-developed legs.
* May lay eggs or give birth to living young.
* There are several important pest species: the citrus mealybug and the citrophilus mealybug on citrus, and the longtailed mealybug is often found in greenhouses.

9. Eriococcidae (ericoccid scales) (about 55 North American species).

* Similar to pseudococcids, but body only lightly covered with wax
* Important pest: the European elm scale on elms.