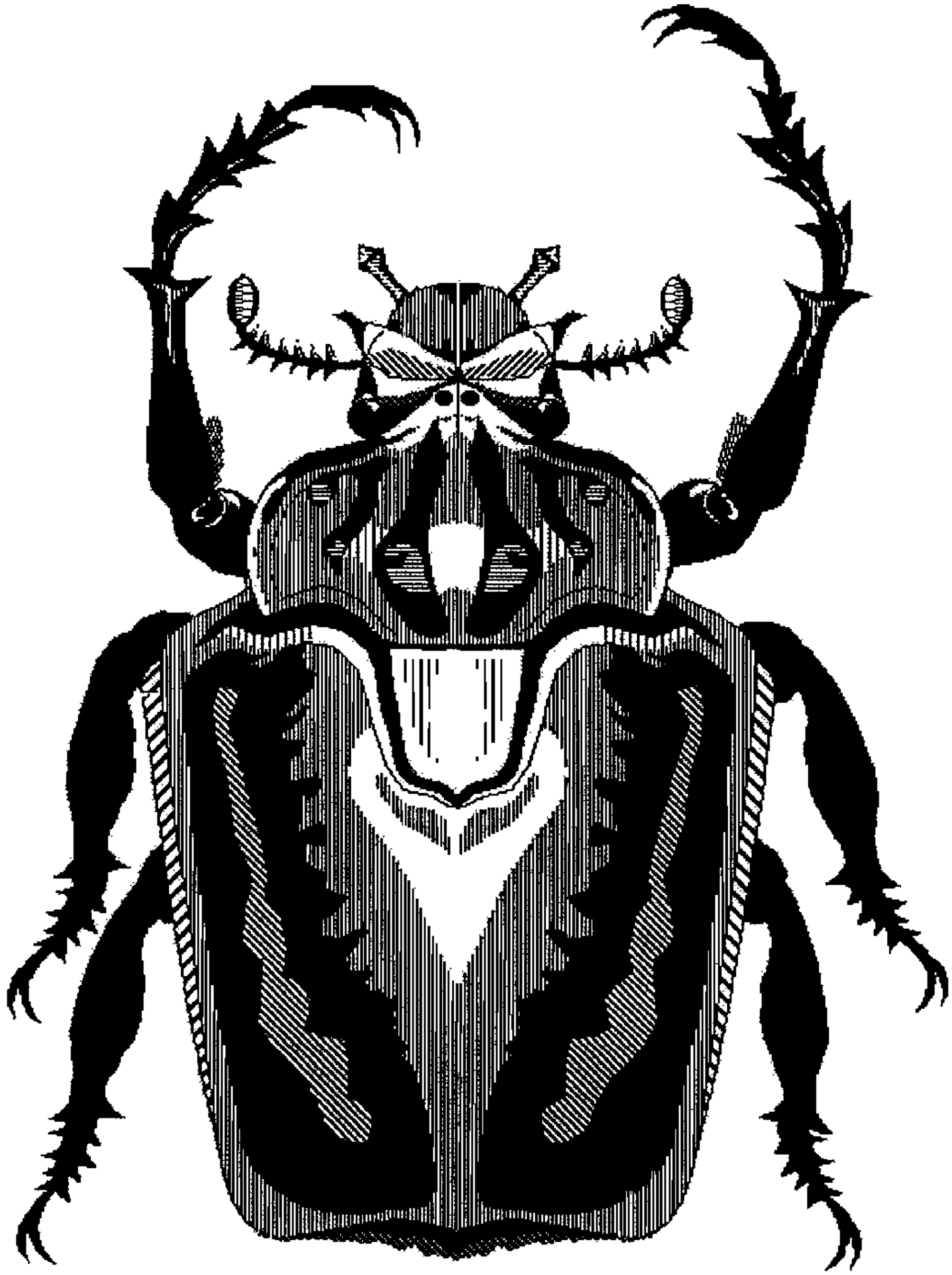

Display Packages For Exploring Insect Biodiversity

UW Madison Department of Entomology

By
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Front Cover Drawing by Anna Boyette

INSECT DISPLAY CASES FOR OUTREACH EDUCATION

University of Wisconsin, Department of Entomology
Insect Research Collection
Russell Labs

CARE OF DISPLAY CASES *Please Read:*

We encourage the use of our display cases, and we ask that you please adhere to the following guidelines for safekeeping while the displays are in your custody.

- In transport, carry display cases with the glass facing up, not on their sides.
- Set displays to be viewed on a flat surface with the glass side up, also, not on their sides, and do not allow persons viewing the cases to lean on the glass.
- **Do not** allow students to pass the cases around or pick them up to view the contents.
- Utilize these displays in supervised situations only, and please put them away carefully between uses.

Dry insects are brittle, and their appendages are easily broken. While we want you to use and enjoy these displays, please keep in mind that many of the specimens contained in the cases are irreplaceable. In order that these displays may continue to be available to teachers for years to come, *please,* minimize handling.

Thanks for your attention to care of the displays. Hundreds of person hours have gone into the preparation of the specimens and cases, and we greatly appreciate your careful stewardship.

USE OF DISPLAY CASES

Insects are great tools for teaching biological concepts. Their size, availability, significance, and the curiosity they arouse make them a wonderful addition to any science curriculum. You'll find, whether it's an ooh or an aah, your students will have an immediate reaction when you introduce our insect display cases!

In addition to biology, there are many other science themes that are well suited to a curriculum that includes insects. Biodiversity and ecology, for example, are well illustrated by Class Insecta. Beyond use in science classes, insects can make their way into other subjects' curricula. For instance, the diversity of insects around the world may be tied into a geography lesson, and the influences insects have had on the development of human civilization make fascinating history lessons.

The possibilities for using insects in your classroom are endless! In this written work, we have included suggestions for activities and some references we hope you will find useful. In order to facilitate communication between those of you using insects in your classrooms, we invite you to add ideas, suggestions, favorite activities, and comments in the space provided at the end of this booklet. We also welcome your suggestions for making new displays that best suit your needs.

We hope you and your students find our insects interesting and informative. Thank you for using the Insect Research Collection's educational displays.

For more information about insects and their role in history:

- Bugs in the System : Insects and Their Impact on Human Affairs.

  AUTHOR: May R. Berenbaum. -- Reading, Mass. : Addison-Wesley, c1995.

- Insects, the Creeping Conquerors and Human History.

  AUTHOR: Carson I. A. Ritchie -- Nashville:Elsevier/Nelson Books, c1979.

History of the Development of Outreach Display Packages

University of Wisconsin's *Science Education Scholars Program*

Display Packages for Exploring Insect Biodiversity and Specimen Preparation Techniques began as a project funded through a grant from The UW Madison Center for Biology Education. Work continued through the Science Education Scholars Program. The initial proposal grew out of the Insect Research Collection's desire for more multipurpose display cases. This medium has proven exceedingly popular for use in undergraduate programs as well as outreach to schools and the general public.

Designed to be concept oriented, these "workhorse" displays are made available to our faculty, staff, students, and other user groups (K/12 teachers, nature center and other learning center staff, etc.) for display and instructional program support purposes.

About this reference booklet

The following information includes a compilation of excerpts from Dr. Daniel Young's lab manual for his introductory entomology course. This booklet was designed to provide background information (for teachers looking for additional entomology basics), a sampling of ideas geared toward use in K-12 classrooms, and a list of references for further reading. It is intended to supplement the display cases and is directed toward teachers rather than students, although parts could be used directly in class.

WHAT IS AN INSECT?

Related Display Cases:

- Arthropods
- Common Groups of Wisconsin Arthropods
- Common Orders of North American Insects
- Insect Natural History Displays (good examples of insects in their natural settings)

Background information:

To facilitate their study and improve our understanding, animals and plants are divided into classification schemes according to their similarities. Taxonomy includes the hierarchical classification of organisms in an ordered system that, ideally, indicates evolutionary relationships. In sequence of increasing specificity, the taxonomic categories are as follows (those in bold type are the primary subdivisions) :

Kingdom-->**Phylum**-->Subphylum-->**Class**-->Subclass-->Infraclass-->Division->

Superorder-->**Order**-->Suborder--->Superfamily-->**Family**-->**Genus**-->**Species**

What is an Arthropod?

Arthropods are a group of animals characterized by paired, jointed appendages, exoskeleton (*the rigid or leathery outer body covering*), and distinct body regions. Arthropoda is a Phylum of the Kingdom Animalia. Common classes in Arthropoda include Arachnida (*spiders*), Crustacea (*crayfish, crabs, lobsters, shrimp, water fleas, barnacles, etc.*), Myriapoda (*millipedes, centipedes*), and Insecta (*insects*).

What is an Insect?

Insects comprise, by far, the largest group of arthropods, or any group of animals, for that matter. Adult insects are distinguished from other arthropods by the following characteristics:

- Body divided into three distinct regions -- head, thorax, abdomen
- Three pairs of legs
- Usually, two pairs of wings

Although there are many exceptions, particularly in immature stages of insects' lives, these simple characteristics are often sufficient for recognizing the diverse Class Insecta.

ACTIVITY IDEAS

Having students collect insects outdoors (in nearly any habitat) is a great hands–on activity. You or your students can also bring specimens into the classroom to be studied more closely. Whether in the field or in the classroom, having students work directly with insects is a valuable learning experience.

Outdoor study of Insects

Insects collected by your class can be studied while they are alive or made into an insect collection by students. Information about collecting methods can be found under "Collecting Techniques," beginning on page 13.

Students of all ages enjoy collecting by *sweeping*. Insects from sweep nets emptied on to an open, white sheet are easy to observe (see *Collecting Insects in the Air,* page 14). The sheet makes a nice, portable study area for outdoors. This method isn't preferable when the purpose of your collecting is to save what you catch. However, if you don't mind losing all or some of the specimens as they fly and crawl away, this makes a great group activity.

Collecting from rivers, streams, ponds, and lakes is great fun, too. Aquatic nets can be emptied into an inch of water in white enamel pans or plastic dish pans for closer inspection and sorting. When aquatic insects are viewed in water, they are released from the mud and vegetation that usually accompanies them, making them easier to see. Specimens can also be viewed in Plexiglas mini–aquariums brought out to the field. Use these to make a simulated view of the body of water in cross–section to give students an opportunity to see their insects as they look more naturally. Such "aquariums" can be constructed from Plexiglas rectangles sealed together with aquarium cement. Make the aquarium approximately 6" x 6" x 2"; leaving the sides spaced closely together makes it easier to view the contents.

For terrestrial insects, plastic magnifying boxes make good temporary containers. These boxes come in several sizes. We have found the 1.5" square boxes have the best magnification while still being very portable. Insects placed inside plastic boxes are easily passed around for all to see, and the magnification makes it easy to get a good view of the specimens.

When collecting, encourage students to explore a variety habitats and to look for adaptations and diversity in the organisms they find. By taking your class on collecting trips, your students can discover a small scale world they may never have been aware of before!

Indoor Study of Insects

Taking a close look at insects in your classroom has the advantage of being an activity independent of the weather. A combination of the insects in our display cases and some insects students can handle makes for interesting lessons.

One activity you might try follows: Collect a variety of arthropods (millipedes, centipedes, pill and sow "bugs" from under rotting wood and rocks; spiders). Place one arthropod each in a small, plastic magnifying box or baby food jar (if you refrigerate specimens for an hour they will slow down and be easier to place in containers). Distribute sets of these containers to students working in groups. Before telling your class what the characteristics are for determining which are insects and which are not, ask each group to devise their own classification scheme. High school students may be ready to try sort out all the classes of arthropods.

If you can develop a stock of arthropods for students to examine under microscopes, everyone can contrast and compare the specimens more thoroughly. Also, encourage students to use microscopes or hand lenses to look at specimens they are placing in their collections; even at the ordinal level, some insects require close scrutiny to identify.

Another good way to familiarize students with arthropods is to raise them in your classroom. One advantage of rearing specimens is the ease of observing their life cycles and survival strategies. Good candidates for classroom foster care can be collected or purchased from supply catalogs. The trick is to find species that will be active during the months when school is in session. Here are just a few suggestions for large insects that can be kept in a classroom for study:

- Ants collected in fall can be kept throughout the school year in an ant farm.
- Caterpillars collected in fall can be kept through metamorphosis; also, laboratory strains can be purchased and raised in all seasons (i.e. Tomato Hornworms).

- Walkingsticks found in fall can be brought indoors and fed leafy branches and lettuce.
- Aquatic insects caught in spring can be reared in class; large dragonfly naiads can be fed small minnows from a bait shop (note: most dragonflies have a two year life cycle, and it is difficult for an amateur to tell when metamorphosis will occur).
- Tobacco Hornworms can be fed raised on a special diet that you can make throughout their lifetimes.
- Tenebrionidae Beetles (e.g. mealworms, available from bait shops and pet stores) can be reared successfully graham flour and meat scraps.

Many other interesting insects can be reared successfully in class, including mosquitoes. For additional information on rearing insects here are a few good resources:

⇒ Caring for Insect Livestock: An insect Rearing Manual, Published by the Young Entomologists' Society Inc., 1915 Peggy Place, Lansing, MI 48910-2553, (517)-887-0499

⇒ Tree Hole Biology, Contact Dr. Daniel Young, Director, Insect Research Collection, UW Madison Department of Entomology.

⇒ Peterson Field Guide to Insects, Borror, Donald J. And Richard E. White, Published by Houghton and Mifflin Company, Boston (good identification guide and introductory chapters include information on rearing insects).

⇒ Bugnet -- an Internet Listserver Group about Insects where rearing topics are frequent, bugnet@listproc.wsu.edu

⇒ Sonoran Arthropod Studies Institute, P.O. Box 5624,Tucson, AZ 85703; e-mail: ArthroStud@aol.com

Taxonomy of Arthropods:

Without knowing it, most of us are natural taxonomists-- we see an arthropod and ask, "*What is it?*". Teachers can use that natural curiosity to lead students to an understanding of taxonomy. The process of systematically subdividing organisms into smaller groups, or taxa, (based primarily upon similarities and interrelationships of anatomical and morphological structure) is basic to that branch of biology referred to as systematics. (Note: a Taxonomist is someone who identifies, describes and names organisms; a Systematist determines the phylogeny, or evolutionary relatedness, of organisms.)

Insects and other arthropods are significant in all our lives, and they provide a relevant illustration of the system of scientific classification. In addition, the names of the orders, families, genera and species are clearly labeled in the display cases, making a good visual introduction to taxonomic nomenclature.

Numerous hypotheses have been proposed for the evolution of arthropods. Some scientists suggest the type of mouthpart is the primary characteristic for determining Phyla, others think the evolution of appendages should determine Phyla. Some entomological systematists use physiology and DNA to try piece together the evolutionary history of insects. These display cases are organized according to the most currently recognized classification of insects.

Insects belong to the Kingdom ANIMALIA, Phylum ARTHROPODA, Superclass HEXAPODA, and Class INSECTA. The next major level of classification beyond that of Class is the category referred to as Order. This is an especially useful level of classification in entomology, for many generalizations can be made and much can be learned about insects at the ordinal level. Aside from the ordinal level, much discussion of insects is directed toward the family level.

Many of the display case specimens are labeled with their scientific name. These names are derived from scientific nomenclature, the scientific naming system that follows specific rules. Each species has two names in this system; they are primarily Latin names. The first name is the genus, a noun representing a group of very similar organisms that are related by common descent. The genus is capitalized. The second name is the specific epithet, an adjective which is the species name. A species is a unique group within a genus with the same structural traits that can interbreed.

EXTERNAL INSECT ANATOMY

Related display cases:

- Leg Specializations
- Antennal Types
- Wing Types
- Coleoptera Diversity Worldwide (good examples of specializations and adaptations within one Order)

Adult insects are unique among existing arthropods in having the body divided into three distinct regions or tagmata (singular, tagma) : the head, thorax, and abdomen.

Primary structures in the head region include: head capsule or cranium, receptor organs, and a large area occupying the entire front of the head called the frons. Its functions are sensory and feeding.

The most conspicuous parts of the head include the receptor organs: large compound eyes and antennae. The compound eyes' surfaces are subdivided into numerous smaller units, the facets or ommatidia which represent individual lenses--each functioning individually as an operational eye. In addition to the two compound eyes, many insects also have 1- 3 ocelli (singular, ocellus). Although commonly referred to as "simple eyes," ocelli probably are not capable of forming images, but are thought to be important indicators of light intensity. They are often very highly developed in insects which are active at night.

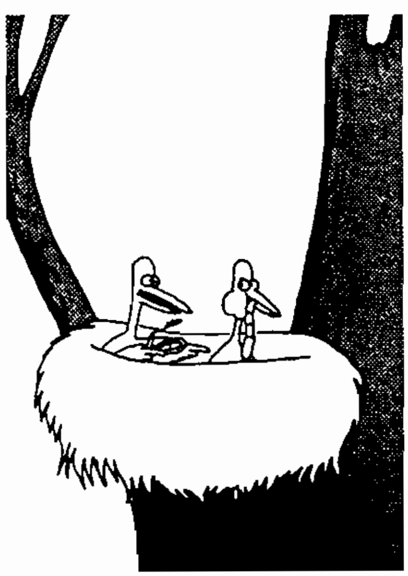
The **antennae** are the two elongate "feelers" that are inserted on the upper region of the front of the head. They are extremely important as organs of sensory reception; the specific nature of the receptors varies from one species to the next, but commonly includes the senses of smell, taste, touch and heat perception. Insect antennae are variously shaped and undergo considerable modification from group to group, depending largely upon the adaptations of the animal, its method of living, and the environmental conditions in which it normally lives. The antennae are inserted into the head at the first segment, or scape. The second segment is referred to as the pedicel. The final division of the antenna is the flagellum. The various modifications are grouped into antennal types and each has been given a descriptive term: filiform, serrate, pectinate, flagellate, moniliform, clubbed, lamellate, geniculate and plumose [see the *Antennae Types* display case for examples].

Insects have been extremely successful in adapting to all types of environments and modes of life. This has been accomplished through a multitude of modifications of all body parts from a generalized plan. Of particular significance have been the structural modifications associated with the mouthparts, since they determine the type of food utilized by the insect. The following chart shows the principal types of mouthparts, their functions and examples of insects that have that type:

TYPES OF MOUTHPARTS (con't.)

Mouthpart	Adaptation	Example
Chewing or mandibulate	Adapted for cutting or grinding solid food materials	cockroaches, crickets, beetles
Combination	May be used for the intake of both solid and liquid foods	honey bees
Sucking or haustellate	Adapted for the intake of liquid, dissolved or suspended food materials.	milkweed bugs, stink bugs, flies, butterflies

The **thorax** bears the wings and legs which are diagnostic features that will serve to define the thorax no matter how difficult the segments may become to tell apart. It is comprised of three segments, the prothorax, mesothorax, and metathorax. The prothorax is the segment directly behind the head. The mesothorax is the mid section, and the metathorax joins the abdomen. Each segment sustains one pair of legs Also, the mesothorax and metathorax each bear a pair of wings each in most insects. In modern insect groups, the prothorax never bears wings or wing-like structures.



"Donald . . .Trade you a thorax and six legs for two of your segments."

The insect **abdomen** provides the internal area in which several critical organ systems are housed -- the digestive system, the excretory system, and the reproductive system. It lacks legs but can have other "appendages" such as cerci, styli, caudal filaments, and gills.

Legs of Insects:

While having undergone a great number of modifications and specializations through the course of time, the legs of insects are nonetheless thought to represent the primitive thoracic appendages or podites. Each of the three sets of legs are composed of six serially arranged segments.

Though diversity of form seems almost endless with respect to the legs of insects, the dominating theme here, as elsewhere within the fascinating world of insects, is one of form closely and efficiently correlated to function. With this observation in mind, most specializations of insect legs can be referred to one or more of seven major categories:

Leg Type	Characteristics	Examples
Ambulatorial (walking)	a generalized type of insect leg	walkingstick, many beetles
Cursorial (running)	typified by elongate, relatively slender segments	cockroach, tiger beetle
Saltatorial (jumping)	a specialization usually limited to the metathoracic legs, frequently characterized by greatly enlarged femora (to support massive muscles)	cricket, grasshopper, flea
Raptorial (grasping)	specializations usually limited to the prothoracic legs, characterized by swollen femora (to support massive muscles) and/or development of rows of prominent spines between the femora and tibiae	preying mantis, giant water bug, ambush bug
Fossorial (digging)	characterized by flattened, spatulate form	mole cricket, cicada nymph
Natatorial (swimming)	usually involves the development of clusters of elongate "swimming hairs" which add surface area.	Backswimmer water boatman, diving beetle
Pollen carrying	characterized by enlarged size, development of numerous simple and/or branched (plumose) setae, pollen "combs," pollen "baskets."	Honey bee, bumble bee, some flower beetles

Insects walk by shifting from alternate tripods (formed by sets of three legs) of leg contact with the ground. One way this interesting method of locomotion can be investigated by students follows: Lightly sift bleached flour over a large sheet of black construction paper and turn 1 - 3 insects loose on the flour. The best tracks are left by insects with relatively long legs. Have students "track" their insects; they may be able to discern the tripod locomotion on their own.

Members of the class Insecta generally have two pairs of wings as adults. However, there is still debate about wing origin. The question of how insect wings have evolved has been addressed by many individuals, with no general consensus or unified theory. This is a good example of real science; we do not have all the answers for the way things are in our world -- science is an ongoing process. The basic accepted rule regarding wings is that the ancestral stock that gave rise to insects was wingless, as were most primitive groups of insects. A few of these ancient lines have been perpetuated through time and exist today. Included in this group would be all insects of the division Apterygota (silverfish and bristletails) -- they have never developed the thoracic structures necessary for functional wings, and probably never will. Insects of this type are spoken of as being primitively wingless.

The exception to the rule is that of secondarily wingless insects. These insects are members of the subclass Pterygota which have, through secondary specialization, lost their wings. Secondary winglessness is the predominant condition with respect to insects adapted to parasitic or otherwise sedentary life styles.

Despite their somewhat nondescript appearance, the wings of insects are living evaginations of the mesothoracic and metathoracic body walls. Nerves and other internal structures pass through the wings; for the most part, internal components lie within the wing veins. The spaces between veins are called cells. The number and arrangement of the wing veins is of great value in identification, particularly in those groups of insects that have membranous wings.

Some insects' wings work in synchrony, like Lepidoptera (butterflies and moths). However, Odonata (dragonflies and damselflies) use their wings separately for helicopter-like hovering and steering. [*The Nature video on Odonata that is available through the Insect Research Collection has great slow-motion footage of a dragonfly in flight*].

METAMORPHOSIS

Related display cases:

- 3 cases on metamorphosis:

  Paurometabolous, Hemimetabolous, and Holometabolous

Insects are an incredibly ecologically successful group of animals. Much of this success is inherent in the immense array of structural and behavioral diversity that Insecta have developed through time. However, one should pause to contemplate the underlying causes relating to *how* this group of animals has been able to withstand the environmental barriers of dominant life form in all but some of the marine ecosystems.

In addition to insects' unique metamorphosis, insects have adaptive embryonic development. Development may be recognized on the basis of whether the development takes place apart from or within the parent and how nourishment for the developing embryo is attained. Also, in a few groups of insects a single egg will develop into from two to many embryos (Polyembryony).

Another fascinating subject is insect reproduction. These amazing animals have evolved both sexual reproduction (to maintain a diverse and "healthy" gene pool) and non-fertilized ovum development, called parthenogenesis (to defray the difficulty of having two parents getting together). Also unusual, a few rather bizarre species of insects have immature stages that are known to posses mature reproductive organs. This is called Paedogenesis. Insect reproduction may be a subject to expand on with your class because it is so unique.

Metamorphosis is the amazing form of development insects undergo. This is a subject of interest to everyone. It has captured our imaginations in movies and books; it is in the realm of alien behavior! Yet, it is something we can observe in our classrooms and use for scientific study. Even the hardest to reach students can be captivated by metamorphosis taking place in your classroom.

Following eclosion (emergence from the egg) an immature insect normally goes through a series of post-embryonic stages before reaching the mature adult or imago stage. The whole series of changes is referred to as metamorphosis. Recalling that insects, like other arthropods, possess a more or less rigid exoskeleton, an immediate problem would seem to present itself as regards growth, since the exoskeleton is capable of very little expansion as a general rule. To circumvent this problem, the arthropods have evolved a mechanism intimately tied to growth whereby the exoskeleton is periodically shed and replaced by a slightly larger exuvium. The number of times that a given insect must molt in order to reach the adult stage varies greatly from one species to the next. However, each stage along the way is numbered and referred to as an instar. Thus, an immature insect is a first instar immediately following eclosion. This first instar would normally feed and grow to the point where a molt would become necessary, thus giving rise the second instar and the exuvium of the first instar. Now, the first instar may have a typical duration of three days -- or some other average length of time, and this may differ significantly from the duration of subsequent instars.

Several distinct events surround the overall process of molting. The actual event whereby the insect pulls itself out of the old cuticle and "sheds its skin" is termed ecdysis. The old exoskeleton generally splits along specific weakened areas. These commonly occur on the back of the insect in the region of the head and/or thorax.

Immediately following ecdysis, the new cuticle is rather soft, flexible and light colored. The insect resembles an "albino" and is referred to as teneral. At this time, most insects gulp air and/or water to expand the cuticle before it hardens and returns to its typical color.

[Note: The Nature video available through the Insect Research Collection shows a Dragonfly going through ecdysis and in its teneral stage.]

Some authors recognize only two types of metamorphosis -- incomplete and complete. Many other authorities subdivide these two basic types of metamorphosis into three or four categories. We recognize four categories, and three (Paurometabolous, Hemimetabolous, Holometabolous) are depicted in our display cases. The following are definitions of the four categories of development:

- **Ametabolous Development** (=ametamorhposis)
    - this type of development is restricted to those groups which continue to molt throughout adult life and are primitively wingless. The immature stages are referred to simply as "immatures". Members of the subclass Apterygota (silverfish and bristletails) this type of development.
- **Paurometabolous Development**
    - The immature stages possessing this "gradual" metamorphosis are referred to as nymphs. Adults are typically winged but some, particularly sedentary plant feeders and animal parasites, have lost them secondarily. The nymphs live in the same environment as the adults and have the same type of mouthparts and through successive instars; they are only functional in the adult stage. There are usually about five distinct nymphal instars preceding the adult stage. This type of development is typical of orders that include such insects as grasshoppers, crickets, walkingsticks, cockroaches, "true bugs."
- **Hemimetabolous Development**

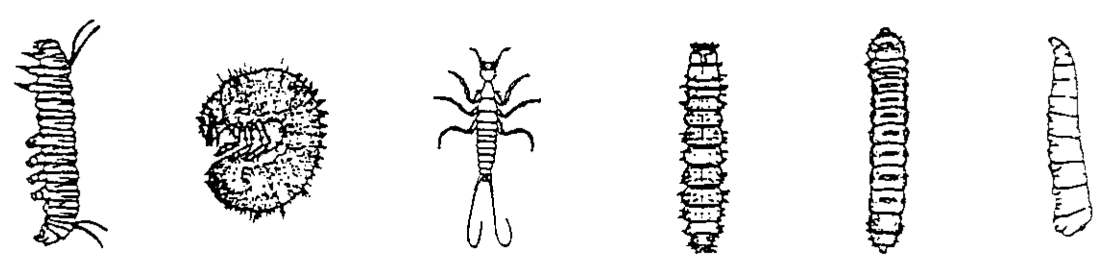
    This is a special type of gradual metamorphosis in which the immature stages, or naiads , are aquatic while the adults are terrestrial (aerial). Wing development is similar to that of paurometabolous species, but naiads possess special ventilatory organs adapted to an aquatic existence. Development is often prolonged over an entire year or even several years, and it is not unusual to fine 15 or more instars. This type of development is found in the subdivision Paleoptera, dragonflies, damselflies, mayflies, and order Plecoptera (stoneflies).

[Note: The Nature Video available for loan from the Insect Research Collection covers Hemimetabolous Development with great photography.]

- **Holometabolous Development**
    - Immature stages (larva, pupa) are usually very different from the adult in general appearance. The larva (plural, larvae) is the active feeding stage while the pupa (plural, pupae) is a transitional form characterized by nearly complete internal and external re-arrangement of organs and structural features. The pupa may be housed in a protective cocoon of silk or various other substances, or it may be formed within the hardened exuvium of the preceding larval instar (this entity is referred to as a puparium). Wing development is internal in this development. The immatures of this category frequently occupy a much different habitat than the adult; their feeding strategy may be very different. This type of post-embryonic development occurs in orders that include insects such as lacewings, beetles, bees and wasps, flies, butterflies, and moths.

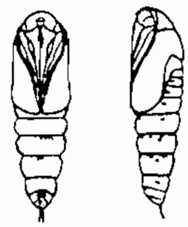
It is relatively easy to associate nymphs and, to a certain extent, even naiads with the respective adult stages. However, the taxonomic recognition of larvae is much more difficult, and should probably be restricted to recognition of larval form in primary education.

TYPES OF LARVAE:



ERUCIFORM SCARABAEFORM CAMPODEIFORM ELATERIFORM CERAMBYCOID VERMIFORM

PRINCIPLE TYPES OF PUPAE:



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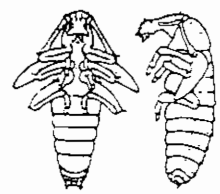

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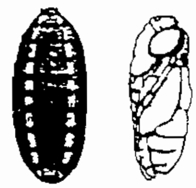


COARCTATE

Many of your students may not be aware of hemimetabolous metamorphosis, and probably most don't fully understand the other types of development or the species associated with them. To supplement discussion, displays, slides, and video on this topic, prepare rearing cages for insects representative of the developmental types. If a picture is worth a thousand words, a living organism is worth a billion! Have students participate in the preparation, rearing, and data collecting for rearing projects. Try providing eggs or larval specimens without disclosing any information about the adult stage and let students formulate and test their own hypotheses!

INSECT COLLECTIONS

Related display cases:

- Common Families of Wisconsin Beetles
- Common Families of Wisconsin Aquatic Insects
- Common Families of Wisconsin Lepidoptera

Looking for insects in their natural habitats and making observations in the field is and important part of learning about insects. Captive insects can be studied with great interest, too. In addition, it can be extremely valuable to study insect collections. For a great hands-on activity have your students put together

their own collections. Some of the educational outcomes include:

- learning that living things can be grouped on the basis of observable characteristics to facilitate study.
- seeing that biodiversity is all around us, and adaptations vary greatly with different habitats.
- discovering that living things have their own roles within ecosystems.

- becoming familiar with entomological sampling methods and equipment.
- learning and using proper methods of preservation, labeling, and study for the various insect groups.
- constructing a scientifically useful entomological collection.

Rather than have students build a collection based on sheer numbers, be sure to have your students create a scientifically useful collection. This means specimens must be preserved correctly and labeled with the correct data. Encourage students to collect a diverse assortment of specimens and identify them to order and family when possible.

COLLECTING TECHNIQUES

Insects, like all other organisms, need food to survive and their food is almost as diversified as they are. The critical factors to bear in mind in order to maximize students' field exposure to insects and their relatives, are where insects occur and how they live. Thus, seek out insects in their natural habitats in as many varied places as possible -- a meadow, a pasture, and streams, during the day, at night, etc.

Listed below are but a few common examples of areas where certain types of insects can normally be observed and collected:

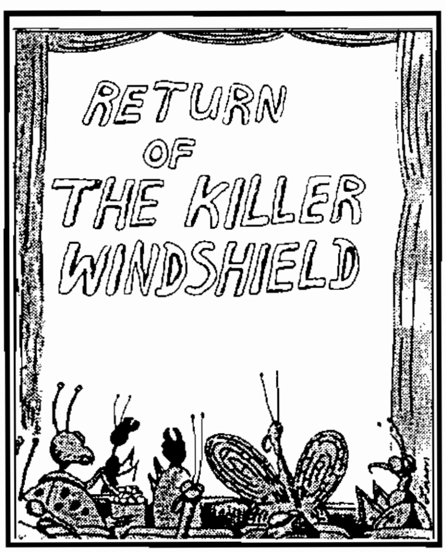
- under boards and rocks --> ants, crickets, beetles, termites
- in or around streams, ponds, lakes --> mayflies, dragonflies, damselflies, stoneflies, caddisflies, aquatic beetles, true "bugs," flies
- under loose bard, in logs and stumps --> termites, ants, bark beetles, tiger beetles, wood boring beetles
- on crops --> grasshoppers, butterflies, beetles, flies, aphids, leafhoppers, spittlebugs, plant bugs
- in the air --> butterflies, moths, flies, bees, wasps, beetles, leafhoppers, grasshoppers
- cellars and basements --> crickets, beetles, ants, silverfish
- on livestock, pets, and poultry --> fleas, sucking lice, chewing lice, flies
- in clothes, furniture, stored food --> clothes moths, carpet beetles, flour beetles, bean weevils
- around lights --> moths, beetles, true "bugs," praying mantids, mosquitoes
- around dumps or piles of refuse --> cockroaches, earwigs, beetles, flies
- on manure piles --> flies, beetles

- in, around, or on flowers and ornamental plants --> thrips, plant bugs, beetles, bees, wasps, ants, aphids, scale insects, walking sticks, insect "galls," butterflies, moths
- in houses --> crickets, cockroaches, beetles, ants, flies, mosquitoes, moths, termites, silverfish

Collecting insects in the air

An insect net is quite useful for general collecting. It may be used for collecting single specimens in flight by swooping it through the air, or by quickly clamping it over an insect resting on the ground. Another method of using the net(if made from heavy-duty muslin rather than from a fine mesh) is known as sweeping. This very productive technique is done by waving or "sweeping" the net back and forth through vegetation -- the insects fall into the net bag and accumulate in the bottom. They may be picked out singly by hand, by running a bottle inside the net and forcing them into it, or by dumping the entire contents (including leaves and so on) into a killing jar. If the latter procedure is used, the material can be sorted out after the insects have become immobilized or when dead.

Material collected by sweeping frequently includes bees and other stinging insects, so handle the bag with caution! One good technique is to insert the end of the bag along with the captured specimens into the killing jar, place the lid over the mouth of the jar as tightly as possible for a minute or so until the insects become motionless. Then remove the end of the net from the jar and put the stunned specimens back into the killing jar.



Killing jars are often used by entomologists collecting hard bodied insects. Wide mouth glass jars containing cyanide or ethyl acetate are used. The jar must be reinforced with strong tape to reduce the risk of breakage. Ethyl acetate is an ingredient of nail polish, and if used in a jar must be accompanied by an absorbent material. Plaster of Paris formed in the bottom of the jar or a piece of cotton should be moistened with ethyl acetate. The fumes will kill insects closed in the killing jar. With this method, jars must be recharged every few days. Most insect field guides describe killing jars and explain the use of cyanide.

A practical alternative to killing jars is freezing. This is a much better technique for students who are too young to be given killing jars, and it is effective enough to be utilized by any collector. Simply place collected specimens in Tupperware or other plastic container and freeze over night. Then let the insects thaw briefly before pinning and spreading.

Collecting insects in the water

If beginning students use only an aerial insect net, they will miss collecting important and even common groups of insects. For example, many insects are aquatic and spend at least a portion of their lives in water -- certain groups in stagnant ponds, and still others in cold, highly oxygenated water.

An aquatic net works well when used by two people walking upstream against the current, jarring rocks and snags in front of it. Many insects can also be collected by probing the water's edge, especially where there is vegetation. Commercial aquatic nets have a square leading edge so they can be held against a stream bed while rocks upstream are disturbed to free creatures living beneath. An old deep-fat fryer basket makes an inexpensive collecting tool that works well for collecting larger insects. The wide spacing of holes makes it easy to rinse mud back into the water, too (however, small insects will be lost).

Soft-bodied insects, like most aquatic insects, must be preserved in alcohol, not killed in a killing jar or pinned. These insects can either be killed in alcohol or in boiling water, depending on the recommended method (see the *Recommended Methods for Killing and Preserving Insects*, page 19).

Collecting insects on land

Many insects, both large and small, are common on the soil surface. Some are quite active; others live under bit of debris, leaves, etc., and wander very little. A good method for collecting the more active forms is the <u>pitfall</u>, or <u>tumble-in</u>, <u>trap</u>. The trap should be buried into the soil such that the top edge is just below the soil surface. It sometimes helps to weatherproof the trap by providing a cover, such as a board or large piece of bark supported by stones. The trap can be left empty, or <u>baited</u> with various "attractants" such as slices of fruit, vegetables, meat or bones. It should be checked frequently as some trapped insects may eat others and some may also recover and fly away. Traps set near school in a location that can be checked bi-weekly over a period of months would make a good class project.

Collecting insects in trees and shrubs

Many insects sit perched rather securely on the twigs of trees and shrubs. A good technique for collecting them is to use a <u>beating</u> <u>sheet</u>. The apparatus somewhat resembles a kite, constructed of canvas (or bed sheeting) and wooden sticks. It is used by grasping the wooden sticks where they cross, holding the sheet under a bush or shrub, and hitting the plant sharply with a strong stick such as a wooden ax handle. The beating will dislodge large numbers of insects and spiders which will drop into the canvas where they can easily be spotted an collected. The technique is also referred to as the umbrella method, since an inverted umbrella makes an adequate collecting device as well. This technique is a good cooperative activity for groups of students working together to hold the sheet, hit the tree, and gather the insects.

Collecting insects at night

While many nocturnal insects hide and shun the light during the daylight hours, large numbers are frequently attracted to lights at night. Although a yard or street light will suffice to attract some types, other lighting setups are more efficient. A light trap is easy to construct. Use an extension cord with a light socket. Coat hanger wire may be used as a support for the light. Cut the end from an old funnel and set it in a wide-mouthed jar of metal can. Place a small jar containing cotton saturated with a killing agent (such as ethyl acetate) in the bottom of the trap. The light will attract the insects, while the fumes from the ethyl acetate will cause them to drop into the funnel and fall into the can.

Due to the optical sensory physiology of insects, the most attractive "kind" of light is that near the ultraviolet end of the spectrum, thus a black light (near ultraviolet) fluorescent tubes far more efficient than an incandescent bulb with respect to attracting night-flying insects. An apparatus constructed like that shown here is very successful; the blacklight tube requires a fixture on a pole with the white sheet used as a reflective surface. Collect the insects as soon as they land on the sheet and place them in a killing jar. This technique is very good for moths, night-flying beetled, and many night-flying aquatic insects.

For night collecting, students can construct traps in class and then take turns using them at night. Have them bring in what they collect the next day, and students can compare results. Using this method, samples can be taken from around the community and students can note similarities and differences in what is collected.

RECOMMENDED METHODS FOR KILLING AND PRESERVING INSECTS FOR SCIENTIFIC STUDY

When preparing an insect collection, utilization of proper killing and preservation methods is imperative in order to assure that salient anatomical structures and general features will be kept intact as accurately as possible.

The information which follows, lists the 28 orders of insects along with recommended methods for killing and preserving both immature and adult stages. While there are a few exceptions within some of the more diverse orders, this table should serve as a good general overview of the subject.

From the following table, a few generalizations can be made:

- most adults, unless very small or soft-bodied are killed in a killing jar and dry mounted.
- Nymphs (Paurometabola), naiads (Hemimetabola), and soft-bodied adults are killed and preserved in fluid (typically 70-80% ethyl alcohol, or if not available, isopropyl)
- larvae (Holometabola) are killed in fluid (boiling water preferred) and preserved in fluid (typically ethyl alcohol or isopropyl)

RECOMMENDED METHODS FOR KILLING AND PRESERVING INSECTS

TAXON (order)	*common name*	IMMATURE	ADULT
Non-insect hexapods		A	A
Archeognatha	*bristletails*	A	A
Thysanura	*silverfish, firebrats*	A	A
Odonata	*dragonflies, damselflies*	A	K
Ephemeroptera	*mayflies*	A	A
Blattodea	*cockroaches*	A	K
Isoptera	*termites*	A	A
Mantodea	*mantids*	A	K
Orthoptera	*grasshoppers, crickets*	A	K
Phasmatodea	*walking sticks*	A	K
Dermaptera	*earwigs*	A	K
Plecoptera	*stoneflies*	A	A
Phthiraptera	*lice*	A	A
Hemiptera	*bugs, aphids, leafhoppers, etc.*	A	A;K
Thysanoptera	*thrips*	A	A
Megaloptera	*fishflies, dobsonflies, alderflies,*	A	A;K
Raphidioptera	*snakeflies*	B	K
Neuroptera	*lacewings, antlions, etc.*	B	K
Coleoptera	*beetles*	B	K
Strepsiptera	*twisted winged parasites*	B	A

Hymenoptera	*sawflies, ants, wasps, bees*	B	K
Mecoptera	*scorpionflies*	B	K
Diptera	*mosquitoes, true flies, flies*	B	K
Siphonaptera	*fleas*	B	A
Trichoptera	*caddisflies*	B	K

Key: **A** = kill and preserve in alcohol (70-80% ethyl, or if not available, isopropyl).

B = kill in boiling water and preserve in alcohol as above

K = kill in some sort of killing jar and preserve by dry mounting (i.e. Direct pinning or standard point mount).

LABELING TECHNIQUES

Related display cases:

- Techniques for Labeling Insect Specimens

Pinned and Point-Mounted Specimens

Three labels, locality label, an ecological data label, and an identification label, should accompany each insect specimen. The labels should contain the following information:

location → WI: Dane County
UW Madison Campus

date collected → 12 May 1995

name of collector → coll. Hedi Baxter

Locality Label

host or specific habitat from which the specimen was collected, or method of collection → Taken from decaying leaves

→ Taken while sweeping

Ecological Label

Taxon *(order, family, etc.)* →
Name of the person who identified the specimen *(may be different than the collector; "det." means identified or "determined" by)* →

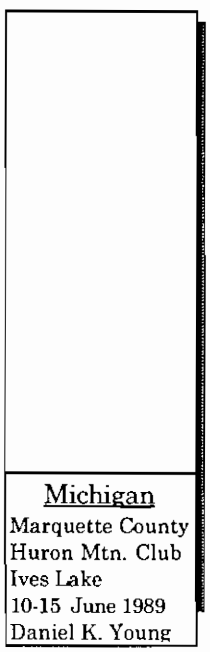
Chrysomelidae
Det. D. K. Young

Identification Label

With respect to arrangement, the locality label goes on the pin immediately beneath the specimen, followed by the ecological data label, and lastly, the identification or determination label. The required data should be filled in with black ink using a fine-point pen. Notice, too, that the pinned specimens face to the left as you read the labels.

For pointed specimens, the three labels are placed on the pin in the same sequence; again, notice the orientation of the pointed specimen, with point directed to the left. Also, the pin should pass through the right half of the labels in pointed specimens, whereas they go through the center of the label in pinned specimens.

Alcohol Preserved Specimens



Material preserved in vials requires special labeling procedures. First, never label the outside of the vial -- should the label fall off, or the writing rub off, the collection is worthless. A single label is used for all information with the exception of the determination . The label is expanded in size to conform somewhat with the size of the vial. It should curve part way around the vial so as to not move around too freely with the specimen(s). This is done to avoid unnecessary specimen damage by bumping into the label. Also, the writing on the label should face the outside of the vial in order to facilitate reading.

The locality-date-collector data are written on the bottom of the label while the ecological data go along the upper left side. Since specific methods of preservation may alter the condition and/or general appearance of specimens (especially in the case of soft-bodied or pale-colored insects), a brief description of the method of killing and preserving is also normally added to the label along the upper right margin.

The determination label is similar to that used for mounted specimens; it is also placed inside the vial.

INSECT SPECIMEN LABELS

Introduction

As you should now realize, specimens assembled into a "collection" are of very limited use to science if they are improperly labeled. Unfortunately, labeling numerous specimens by hand is a very tedious and time consuming task. To minimize labor in this process, use a computer and Xerox machine to make multiple labels that will need only a word or two added by hand.

Making labels can constitute an assignment to be turned in prior to the due date for collections. In that sequence, students get started on their labels earlier in the process than they might otherwise. In addition, it is good to recognize the importance of labeling by treating it as another project.

Preparation of Specimen Labels

Before looking at how labels are made, it is important to consider why they are made the way they are. In addition to uniformity, perhaps the two most important factors relate to economy of space utilization and permanency.

Unless one collects only the larger insects (most butterflies, moths, dragonflies, etc.) it will soon become quite apparent that the limiting factor in building a large insect collection is the size of the labels -- NOT the size of the specimens! In order to maximize the space available for specimens, entomologists have long been concerned with minimizing the size of their data labels. Thus, we are constantly battling with attaining maximal information in a minimal amount of space.

When one contemplates building a "permanent" scientific resource, a mere 50 or 100 years means very little. Yet, while perfect specimens of this age are not at all uncommon, the associated labels are often brittle, faded and nearly unreadable. For this reason, it is essential that only quality paper be used. Generally, only paper with a high cotton fiber content or "rag" is used. Such papers do not age as rapidly and have the added advantage of taking ink very well.

With the recent advent and rapid upgrading of both reduction-xerographic printing processes and word processors with laser printers, label preparation has become both inexpensive and quick. One starts with a clean, sharp original -- typically a standard sheet of paper with labels composed and printed just as they are to appear in the final size. By using copy and paste methods in columns in a word-processing computer program, a sheet full of labels can be quickly prepared. Producing labels of the correct size can be accomplished by either of two methods: Using the Xerox method, reduce the original and then reduce that new original again (usually it takes reduction both times by the maximum). On a computer one can make labels of the correct size by reducing a clear font to a 4 or 5 point size. Also, reduce the space between lines. In either method, print labels on "card stock" or 25% cotton rag paper.

Xerox method procedure

1. Using a good typewriter or computer, compose the labels illustrated in sample 1, below.
    - Spacing is very important, especially for last column (2 "alcohol labels).
    - Substitute correct month and year and your name on the labels.
2. Take this original to a copy service which has good reduction copy machines.
    - You might check to see when the machine was last serviced in order to maximize the sharpness of your copy.
3. Reduce your typed original.
    - use the maximal reduction factor.
4. Use this reduction as a second original and reduce again.
    - Again, maximal reduction factor.
    - Make several copies on either "card stock" or 25% cotton rag paper (these are the labels)
    - save the original for extra labels as needed

Computer method procedure

1. Format page in 4 or 5 columns
2. Compose one label as illustrated in sample 1, below.
    - Spacing is very important, especially for last column (2 "alcohol label"). Under format, set line spacing to .7-.8 inch.
    - Substitute correct month and year and your name on the label
    - After you have checked the label information, select the text and reduce font size to 4 - 8 points, depending on the font you choose (be sure it is a clear font when reduced -- not cursive).
3. Copy the label and paste the information that repeats until the page is full.
    - Leave space for the family (or order) name to be added on determination labels.
    - After filling the page, you may increase the point size temporarily to make the print more readable for adding the additional information.
4. Make laser print copies on "card stock" or 25% cotton rag paper or print one master and have it Xeroxed on card stock.