BENHA UNIVERSITY,

FACULTY OF SCIENCE,

ENTOMOLOGY DEPARTMENT.

GENERAL ENTOMOLOGY 1 (111E)

Prepared by

Staff members of Entomology Department

Reviewed by

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LEARNING OBJECTIVES

After completing this course students should be able to:

- Define the term "Entomology".
- Explain why we need to study insects.
- Determine the relation between insects and relatives.
- Outline different types of insect habitats.
- Explain how insects see, walk, fly, hear and feed.
- Determine the general characters of insects.
- Discuss the methods of protection in insects.
- Differentiate between the types of insect metamorphosis.
- Conclude the benefits and the damage caused by insects.

Evaluation: There will be a midterm exam and a final exam. These may be a combination of multiple choice, true/false, fill-in, and discussion questions. They will be worth 50 points. The midterm will be announced.

Coordinator: Prof. Abdelwahab A. Ibrahim

CONTENTS

Why we need to study insects?

- Insects are the dominant animal life form on earth. Insects have a huge impact on our lives. They are a critical part of the ecosystems that support human life. We depend on pollinators and other beneficial insects for food production, natural pest control, and waste decomposition. But, insects also cause great losses to crops, stored products, forests, and buildings. Insect pests affect millions of people worldwide with diseases, causing illness or even death. Insects are an exciting and challenging field of study.

- If you have an interest in environmental issues, evolution, genetics, preventing disease, water quality, feeding the hungry, healthcare, or even law enforcement, a degree in entomology may be just what you are looking for!
- Professional entomologists have careers in teaching, research, cooperative extension, structural pest control (preventing damage to homes and other structures), industrial and institutional pest control (keeping insects out of your area and other public places), public health agencies, pest-management consulting, agricultural business, consulting for law enforcement agencies, environmental monitoring services, quarantine and other regulatory agencies.
- Even if you don’t want to be a professional entomologist, but you are interested in anything you’ve read so far, the study of insects can also be a valuable addition to degrees in other areas, such as horticulture, animal science, forestry, education, medicine and veterinary science.

Insects and their relatives

- Insects are a class of arthropods. Like other arthropods, they have exoskeletons made from the carbohydrate chitin, segmented bodies, and jointed appendages. Insects are distinguished by having three major body segments (head, thorax, and abdomen), with three pairs of legs attached to the thorax. Ancestral head appendages have been modified to form antennae and mouth parts, while abdominal appendages are either absent or modified to aid in reproduction. Most insects possess wings as adults, also attached to the thorax.

- Many people call some animals as spiders, centipedes, ticks, scorpions by insects. Yet, this is not correct. Though they are close relatives of the insects and classified in one phylum with them (Arthropoda).

- Another name of the insect class Hexapoda (six-legged) explains why the listed above animals cannot be included in this class: insects have six legs, ticks and spiders 8 legs, scorpions and centipedes even more.

- There are two main subclasses of insects:

  1. Apterygota — primitive and wingless.

  2. Pterygota — more advanced and winged.

- The first subclass comprises insects of the most primitive constitution. Usually they are unseen by people; most of them feed on decaying remains of other organisms. They are widely found in soil, forest litter, moss, decaying wood, and take part in soil formation. Mostly, they are of tiny size (though there are some of 50mm). Non-specialists know few about them.

- More often we encounter in our life the representatives of the second subclass — more advanced winged insects. It is from this group of insects that we form our ideas about them.

- Most representatives of this group, in the adult stage, have wings (independent of whether this wings are used for flying or not). Some species of this subclass lost their wings because they adapted themselves to a specific way of life; nevertheless, by some other features (peculiarities of the structure of respiratory system, mouthparts, etc) they are close to winged insects. For example, bedbug (has no wings, but in their order (Hemiptera) there are many species with developed wings.

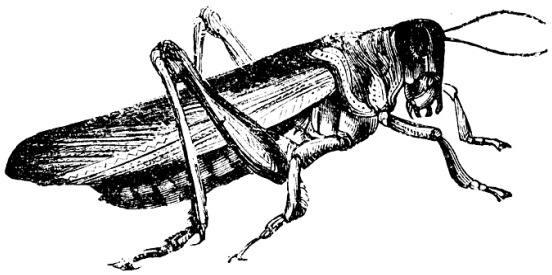
- Insects are divided up into 32 orders, or groups of insects.

- Insects have an amazing number of differences in size, shape, and behavior, but they all have 4 characteristics in common.

All insects must have:

* Three body parts: head, thorax and abdomen
* Six jointed legs
* Two antennae to sense the world around them
* An exoskeleton (outside skeleton)

- If all four of these things are not true, then the animal can't be called an insect!



Diversity of insects

Insects are the most diverse of all groups of organisms, with over 800,000 species named and many thousands, probably millions, yet to be discovered. Insect diversity may be linked to their close association with the angiosperms (flowering plants). The Coleoptera (beetles) are the most diverse of all insect orders, with at least 350,000 species, representing one fourth of all known animal species. (Asked what could be inferred about the work of the Creator from a study of His works, British scientist J. B. S. Haldane is reported to have quipped, "an inordinate fondness for beetles.") The evolutionary reasons for the mind-boggling diversity of this single order are not clear. Other major orders of insects include the Diptera (flies), Hymenoptera (bees and wasps),

Hemiptera (true bugs), and Lepidoptera (moths and butterflies). Note that each name describes the wing (ptera means "wing"). For instance, Diptera means "two wings," referring to the presence of only one wing pair in this order. In the Coleoptera ("sheath wings"), the first pair of wings is modified into a hard covering for the rear pair, which is easily observed in a lady beetle, for instance.

Insect habitats

- The majority of insects live on land. Insects occur also inside the Arctic and Ant-arctic Circles, though in these regions they are active only during short summer period.
- Insects can be found also high in the mountains and in absolutely waterless deserts. For example, in the Namib desert in South Africa, where there are never rains and there are no plants, live darkling beetles, feeding only on the scraps of plants brought by wind from distant places (hundreds of kilometers). They obtain the moisture necessary for life in biochemical way: water in their organisms is produced in the process of oxidation of dry food!
- All areas in crown of trees, all litter of grass, moss, and lichens, and also soil to the depth where roots of plants are present and even deeper are mastered by insects. In

Turkmenistan, for example, a termite was found at a depth of up to 12 meters.

- Many insects live in caves.
- Insects which developed the ability of flying mastered the air; the best fliers among them rise to the altitudes of several hundred meters. However, insects can be found even higher: at the altitudes of several kilometers. They are brought here by ascending currents of air, and then these insects are carried by the wind to very large distances.
- Some insects became absolutely aquatic, i.e. breathing by oxygen dissolved in water. Other insects live in water and breathe by the oxygen dissolved in it only at the stage of larva. And at the stage of winged adult, they leave water.

- There are insects which, though live in adult stage in water, nevertheless breathe by oxygen in air, rising to the surface.
- There are some insects, which live on water surface, running on it on their long legs.

Insects' Life Span

- Mayflies in the adult stage live from several hours to several days; some species — only 1 day. Because of this, they are also called day-flies.
- Life of bagworm moths in the adult state lasts for… minutes.
- Pine weevils and darkling beetles live in the adult stage for 2-3 years.
- Queens of domestic bees live for 3 years (5 years maximum); worker bees — only 26-40 days.
- Female ants can live up to 15 years. On the contrary, the life of the male ants lasts for days: after copulation they die.

Mayfly

Size of Insects

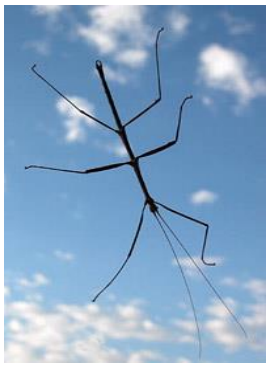
- Insects measure in average from 3 to 20 mm. The smallest insects can be less than 0.25 mm for example, feather-winged beetles and fairy flies. The largest specimens of modern insects are found in the tropics.
- One of the largest beetles on the Earth — a rare insect living in the South America, the giant long-horned beetle. The length of its body, according to different sources, is from 16 to 21 cm!
- The maximal length of the male Hercules beetle, occurring in Central and South America, together with its “tusk” is quoted from 15 to 18 cm! However, its body weight is less than that of the long-horned beetle.
- The elephant beetle can be up to 12 cm long. Male acteon beetles from South America have a body of 9 cm long, 5 cm wide, and 4 cm thick.
- The longest of all insects are stick insects or walking sticks. Their length of the body can be up to 35 cm!
- Among moths and butterflies the largest one is the white witch. Its wing span is up to 30 cm. Atlas moth has a wing span of 24 cm.

- The largest insect that ever lived on the Earth is the fossil dragonfly Meganeura of the carboniferous period: its wing span was 1 meter and its length of the body was 60 cm!

The giant long-horned beetle Hercules beetle

The elephant beetle Acteon beetles

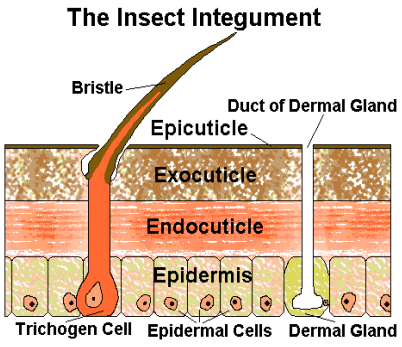
The white witch Atlas moth

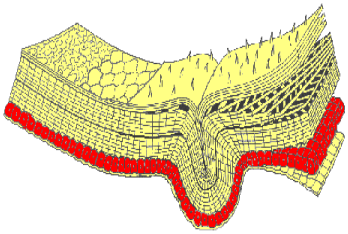


Walking stick

Insect skeleton

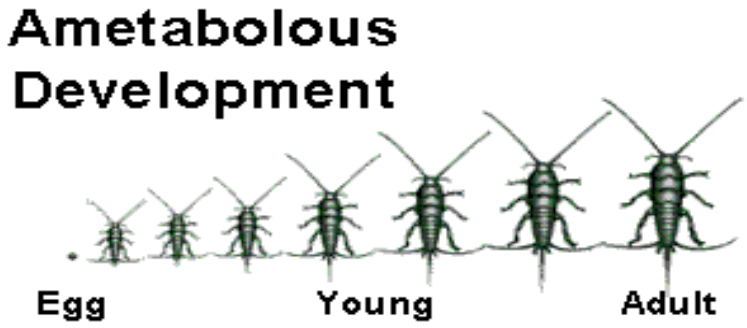
- Insect's skeleton is located on the outside of its body.
- This exoskeleton gives shape and support to the body's soft tissues, provides protection from attack or injury, minimizes the loss of body fluids in both arid and freshwater environments, and assures mechanical advantage to muscles for strength and agility in movement.
- The exoskeleton can resist physical and chemical attack.
- It is covered by a layer of wax that prevents desiccation.
- It may be as elastic as rubber or as hard as some metals.
- Freedom of movement is ensured by membranes and joints in the exoskeleton.
- Muscles that attach directly to the body wall have maximum strength and optimum mechanical advantage (leverage). An ant, for example, can lift up to 50 times its own body weight.





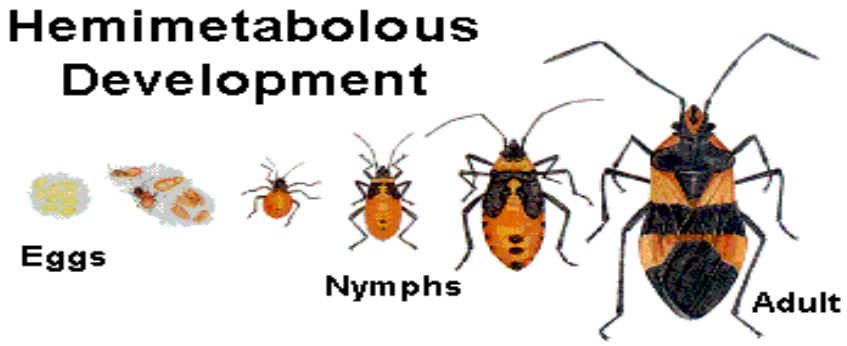
Insect metamorphosis

- Because insects have a tough, non-living outer covering or **exoskeleton**, they cannot grow steadily, but have to grow in stages by periodically shedding the exoskeleton. This process is called moulting or **ecdysis**. The stages between moults are called **instars**.
- Each time an insect molts, it gets a little larger. It may also change physically in other ways depending on its type of metamorphosis: ametabola, hemimetabola, or holometabola.
- **Ametabolous insects** undergo little or no structural change as they grow older. Immatures are called **young**; they are physically similar to adults in every way except size and sexual maturity.

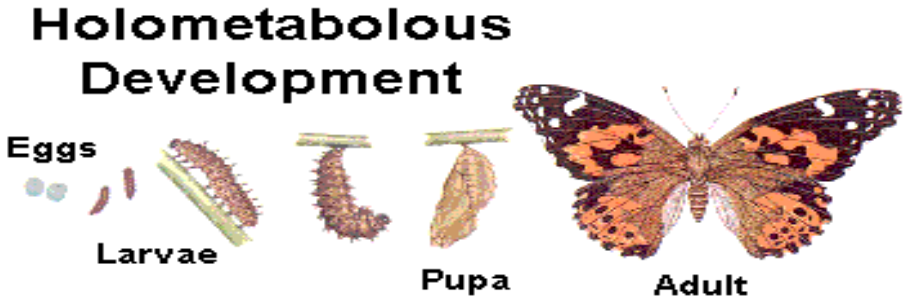


- **Hemimetabolous insects** exhibit gradual changes in body form during morphogenesis. Immatures are called **nymphs** or, if aquatic, **naiads**. Maturation of wings, external genitalia, and other adult structures occurs in small steps from molt to molt. Wings may be completely absent during the first instar, appear in the second or third instar as short

wing buds, and grow with each molt until they are fully developed and functional in the adult stage.



- Holometabolous insects have immature forms (larvae) that are very different from adults. Larvae are "feeding machines",. They become larger at each molt but do not acquire any adult-like characteristics. When fully grown, larvae molt to an immobile pupal stage and undergo a complete transformation. Larval organs and appendages are and replaced with new adult structures.



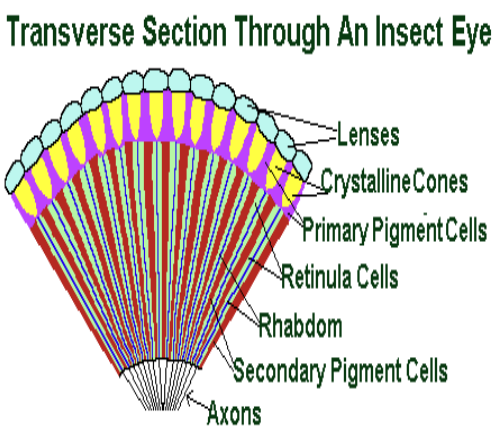
Vision in insects

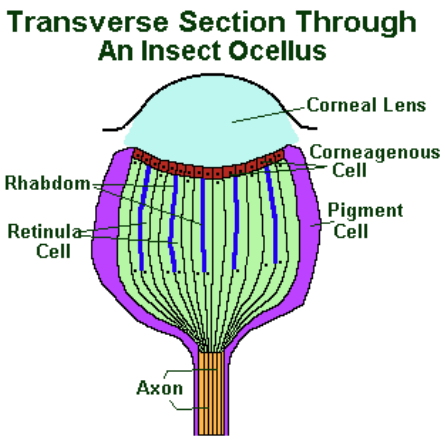
- The eyes of insects are truly wonderful!
- A fly sitting of a flower easily looks around: it may look up, down, back. It does this without turning the head: its eyes are large and round — about half the head size!
- The eyes of a dragonfly are even larger. They are two huge iridescent hemispheres looking in all directions simultaneously. A dragonfly flies and, like a fighter pilot, watches everything in the air. If a horse fly or mosquito flies by, the dragonfly turns and catches it in the air.
- Eyes of flies, dragonflies, and most of other insects are called compound and have a complex structure: they consist of many convex hexagonal facets.
- Each facet represents the surface of a separate small eye called ommatidium. And the number of ommatidia may be staggering! In the compound eyes of dragonflies there may be as many as 28 000 ommatidia, in the eyes of butterflies 17 000, housefly 4000! Such eyes ensure a very wide field of vision.
- Moreover: many well-flying insects in addition to compound eyes have also 2 or 3 simple eyes situated on the head between the compound eyes.

- The eyes of aquatic whirligig beetles are quite unusual. Each eye is divided horizontally by a partition in two parts: the lower part ensures vision in water, the upper part — in air. Thanks to this, whirligig beetles can watch the situation in two environments simultaneously.

- There are insects with very small eyes or with no eyes at all, for example worker termites living under-ground. Completely blind insects are found also in caves.

- Scientists found out that bees remember their hive not just by outer appearance, but also by view of the surroundings. If one moves the hive on the ground 2 meters away, the bees coming back to it be-come confused, flying to the place where the hive was formerly. But if the hive is placed of a raft on a lake and the raft is moved to some distance (even to a kilometer), the bees easily find their hive, because the hive on the raft is the only mark of the lake surface.



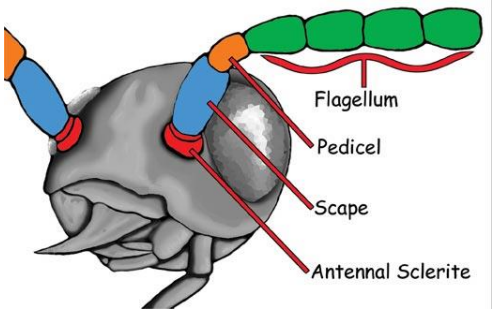


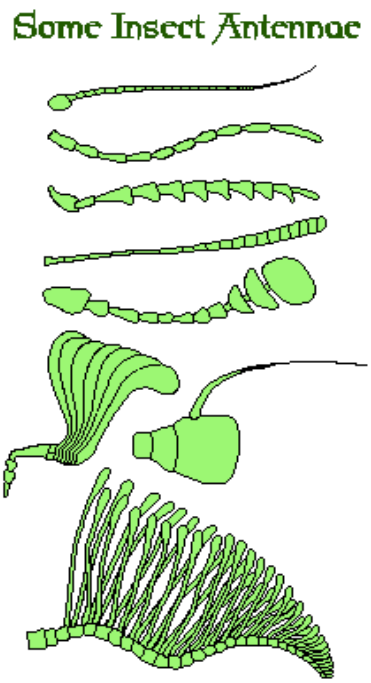
Insect Antennae

- Usually antennae consist of a large number of segments, though in some insects they are short and contain few segments. Such are, for example, the antennae of flies and dragonflies: they are made of just 3 segments.
- The antennae of beetles comprise normally 11 segments, those of hymenopterans (wasps, bees, ants, etc) — 12-13 segments.
- The antennae of such insects as grasshoppers and some wood-boring beetles can be longer than the body.
- Several forms of antennae are distinguished.
- Why do insects need antennae?

  It turns out they need it for detecting odors! That is with the help of antennae insects… smell! It is in this way that insects discover and find food. In the same way, they find partners for mating. For example, males of the Actiasselene come to a female, attracted by its scent, to 11 km; male gypsy moths — to 3.8 km.
- Antennae are used also as tactile organs.
- With their help, insects perceive also the temperature and humidity of the environment.

- Tactile receptors are present not on the antennae only, but also on all parts of the body. Usually they have a form of hairs and bristles.
- Movably attached hairs are also organs for perceiving movements of air including very faint ones — from another flying or walking insect.
- In some cases such organs of sense replace completely the vision for the insect. An example of this is a blind cave beetle. Eyeless, it orients very well in its cave-home.





How Do Insects Hear?

- Insects are the only of all invertebrates which have been proved of being capable of distinguishing sounds. A classic proof is an experiment with crickets, when in one room a chirping male was placed in front of a microphone, and in another room with a speaker — a female. When the microphone was switched on, the female moved to the speaker.

- Insect’s eardrum is a thin part of cuticle sensitive to air vibrations. Adjacent to it inside is an extended trachea with nerves coming to it. The sensitive receptors are located either on the trachea or on the eardrum.

- In grasshoppers and crickets these organs are located on the tibiae of the forelegs, in water bugs and some butterflies on the chest, in other butterflies, locusts, cicadas on the abdomen, in some lacewings on the wings.

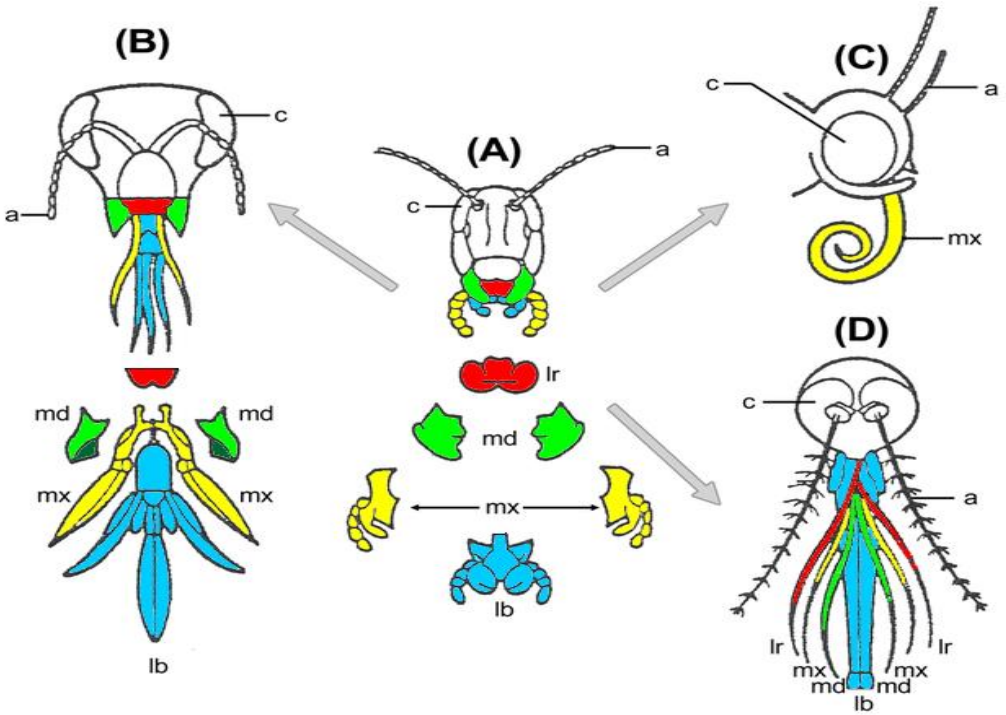
- Sometimes the organs of hearing in insects are represented not by an eardrum, but by other structures sensitive to vibrations. These are so called chordotonal organs, Johnston's organs, etc. They are present, for example, in mosquitoes on the second segment of antenna.

Mouthparts of Insects

- There are various kinds of mouthparts found in insects: chewing, siphoning, piercing-sucking, sponging.
- Take a grasshopper, for instance. When it gnaws a grass blade, it does it not with teeth but with jaws: hard notched lamellas. It has two pairs of them!
- Not only grasshoppers can gnaw and bite off, but also beetles, cockroaches, and many other insects.
- On the contrary, butterflies cannot do it. They have a different kind of mouth. To eat sweet nectar, butterfly does not need to open the mouth; its mouth is a long proboscis. When a butterfly does not eat, the proboscis is coiled. But once a butterfly sits down on a flower, it extends the proboscis and dips it into the nectar. This proboscis is nothing else but highly elongated jaws, grown together by sides.
- The mouth of mosquitoes also looks like a long proboscis. It is formed by elongated needle-shaped jaws covered with lips.
- How do bumblebees extract nectar from flowers?

  They have a long flexible proboscis, which is formed by the lower jaw and lower lip and ends with a “tongue”. By this tongue bumblebees reach for nectar and lick it off.

- In the same way bees collect nectar, though the bee's tongue is shorter than that of bumblebee.
- The mouths of flies are various. The housefly has a soft proboscis with a pad on its end. With it the fly licks food off.
- A horse fly has a whole set of piercing and cutting instruments in its mouth. The reason for it is that horse flies feed on blood of animals, and to reach for the blood they need first to cut the skin.
- Yet, there are insects which in adult stage… do not eat at all. Therefore, they do not need mouth. They have no mouth at all!… Such are mayflies and male armored scales.



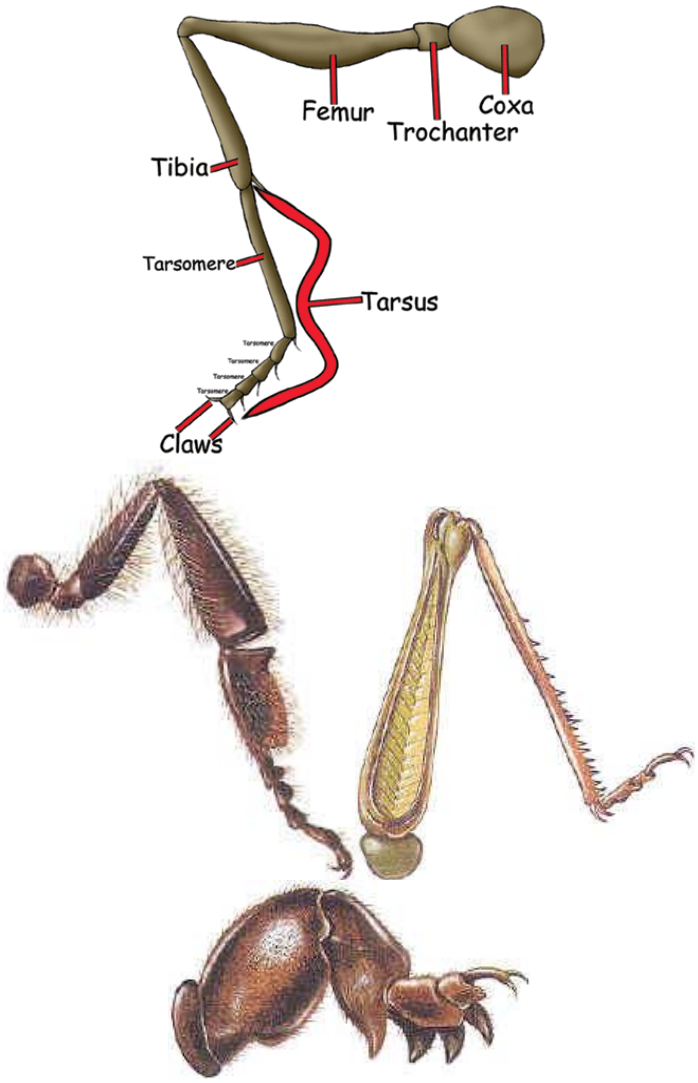
Insect Legs

- The thorax of an adult insect always comprises three segments, each with a pair of legs.
- Legs are also made up of segments; the number of such segments is from 1 to 5, but not more.
- If all pairs of legs are equally developed, such legs are called walking (Cockroaches, ground beetles). Such legs are adapted for walking over firm surface.
- How do water striders manage to walk over water? On their legs there is a fat layer preventing wetting of the legs and allowing the insect to remain on the water surface.
- Moving in big leaps is advantageous in life in grass or foliage of trees. In many insects moving in that way we see elongated strong femurs and long tibiae of the hind legs. Such legs in locusts, grasshoppers, fleas are called Jumping legs.
- The life of adult insects in the soil leads to enhancing the role of the forelegs. Such insects have limbs for digging with typical enlargements of the tibiae, for example, in mole crickets (Gryllotalpidae).
- In insects that use forelegs for catching pray, femurs and tibiae of the forelegs are elongated and have spines. Such legs are called seizing legs, for examples praying mantis.

- Many insects living only in water have legs with elongated flat tibiae covered with long hairs. Such legs, serving as paddles, are present in water bugs and water beetles.

- Bees and bumblebees have a whole set of instruments on the legs. Among them are brushes for collecting pollen, baskets for carrying this pollen, and brushes for cleaning the body of pollen.

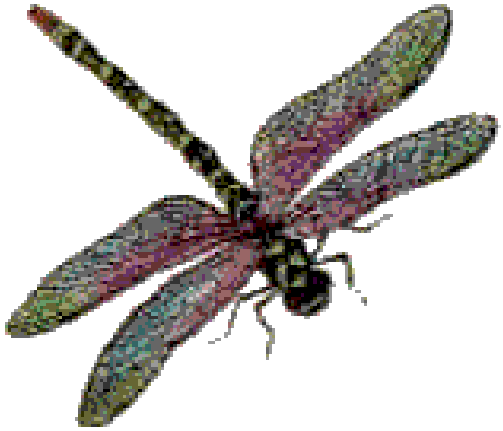
- Besides it, on insects' legs there are also organs of sense (Butterfly and houseflies can taste by their legs).



Insect Wings

- Most of adult higher insects have wings. The wings are attached to the spinal part of the thorax, to the second and third segments.

- The wings look like elastic membranes stiffened with a network of veins. Through these veins, at the time when the wings were formed, nutrients were coming with hemolymph (insect's blood). Then the veins hardened and became a kind of framework for supporting the wings in flight.



- How many wings do insects have?

  Let us look at a dragonfly. It is straightforward to see that it has four wings. The front and the hind wings look almost the same; in flight they move independently.

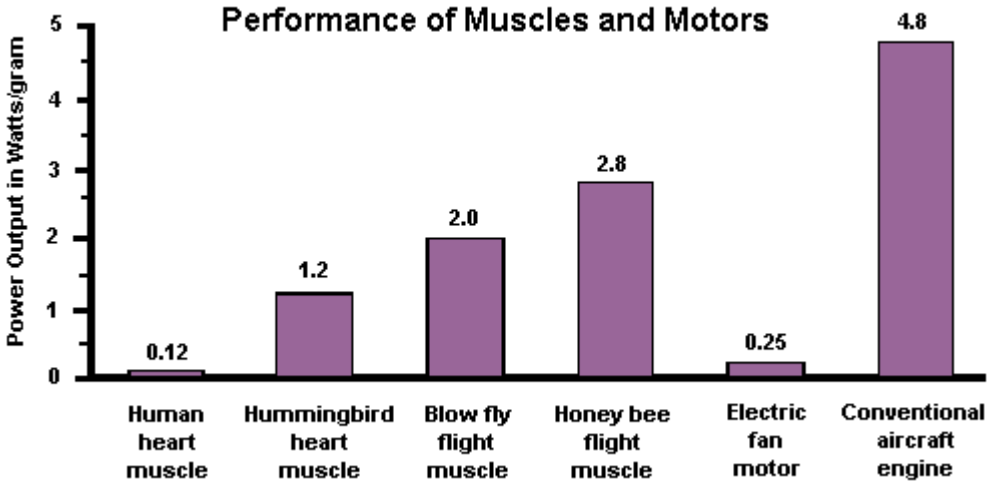
- Bees and wasps also have two pairs of wings. However, their front and hind wings are fixed together by special tentacles, and they move in flight as a one big wing.

- There are two-winged insects, for example, flies and mosquitoes. Their hind pair of wings turned into club-shaped appendages — halteres, which are rich with sensitive hairs.

- **Flight in insects**

  Insects are the only invertebrates that can fly. Judging from the fossil record, they acquired this ability about 300 million years ago -- nearly 100 million years before the advent of the first flying reptiles. Flight gave these insects a highly effective mode of escape from predators that roamed the prehistoric landscape. It was also an efficient means of transportation, allowing populations to expand more quickly into new habitats and exploit new resources.

  The forces of natural selection have shaped insect flight into a remarkably efficient process employing principles of aerodynamics that human engineers do not yet fully understand. Although the metabolic cost of flight (calories per unit of lift) is similar to that of birds and bats, an insect's flight musculature produces at least 2X more power per unit of muscle mass (see chart below). This high efficiency is largely due to elasticity of the thorax -- 90-95% of the potential energy absorbed by flexion of the exoskeleton is released as kinetic energy during the wings down stroke.



Efficient use of energy allows some insects to travel great distances or remain airborne for long periods of time. More than 200 species, including moths, dragonflies, locusts, flies, and beetles are known to migrate over long distances by air. The migratory locust, can fly for up to 9 hours without stopping. Large swarms occasionally traverse the Mediterranean Sea.

Speed and manuverability are traits usually associated with the more highly advanced orders of insects, but some primitive insects (notably the dragonflies) are remarkably agile fliers: they can hover, turn while hovering, and even fly backwards or sideways. For their size, some species are remarkably swift. Large hawker dragonflies (family Ashnidae) have been clocked at a top speed of 58 km/hr (36 mph) over level ground. By comparison, the fastest human sprinters run only about 36 km/hr (22.5 mph).

How do Insects Breath?

- Insects lack lungs. Their basic respiratory system is tracheas. Tracheas of insects are auriferous tubes which end on the sides of the body as small breathing holes (spiracles). Fine-branched parts of tracheae — tracheoles — permeate the entire body, covering organs and even penetrating inside some cells. In this way, oxygen is delivered to the cells of the body, and the gas exchange is ensured without use of the circulatory system.

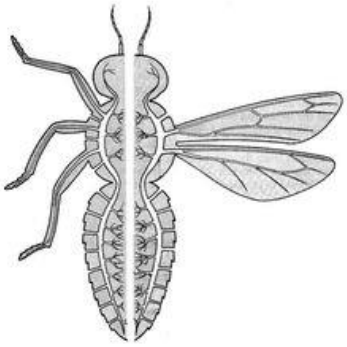
- Many insects living in water (water beetles and true bugs, larvae and pupae of mosquitoes, etc) have to rise to the surface to take in air, i.e. they also have air breathing. Larvae of mosquitoes and some other insects, for the time of renewing the air in the tracheal system, get “hanged” from beneath to the surface of the water with the help of water-resistant hairs.

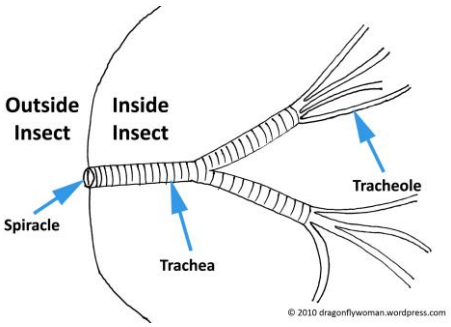
- Water beetles (water scavenger beetles, true water beetles) and true bugs (for example, backswimmers), having breathed at the surface, take on an additional supply of air under their wing covers before they submerge.

- In larvae of insects living in water, damp soil, tissues of plants, skin breathing plays a big role.

- Well-adapted to water life, larvae of mayflies, and other insects have no open spiracles. They take in oxygen through

the surface of all parts of the body where the covering is thin enough, especially through the surface of leaf-shaped outgrowths permeated by a network of tracheas. Larvae of the midge Chironomus also have respiration through the skin — through the whole surface of the body.





Reproduction in insects

A few species, notably the fireflies, produce light, used as a signal in courtship, by a chemical reaction. The sexes are separate in insects, and reproduction is usually sexual, although in many insect groups eggs sometimes develop without fertilization by sperm (see parthenogenesis). In some insects, such as bees, unfertilized eggs become males and fertilized eggs females. In others, such as aphids, all-female generations are produced by parthenogenesis. Eggs are usually laid in a sheltered place; in a few insects they are retained and hatched internally. After hatching, the insect must molt periodically as it grows, since the rigid exoskeleton does not allow much expansion. A new, soft exoskeleton forms beneath the old one, and after each molt the insect undergoes a rapid expansion before its new covering hardens. The stages between molts are called instars; the final instar is the adult.

Means of Protection in Insects

- Coloration has great biological meaning. Insects, which are not protected by other means, have special coloration, which make these insects hardly noticeable for predators, for birds, first of all. This type of coloration is called cryptic.
- It is not only coloration that can be cryptic, but the form of the body as well. For example, mantis' elongated body resembles a blade of grass. The cryptic coloration and form

of the body of walking sticks and caterpillars of the geometrid moth make them look like twigs.

- Some insects are well protected from predators by repulsive odor or taste, and sometimes — by venomous glands.
- In the world of insects, there are cases of similar appearance of two different species, when one of the species has a warning coloration and is inedible or dangerous for predators, while the other species is unprotected and mimic the former.
- On the surface of insects' body there are special glands which secrete odorous substances.
- In some species, glands secrete poisonous substances.
- It is known that poisonous hairs of many caterpillars can cause inflammatory processes on human skin.

Benefits of insects

Pollination of plants

- The most important benefit of insects is the pollination of flowering plants. Flowering plants are the main source of food and moisture for the majority of insects. At the same time, most of the flowering plants (that is, those with cross-pollination) depend of insects-pollinators.
- Insects are attracted by plants' odors and bright colors.
- Fruiting plants has to be pollinated: the pollen of one flower has to be brought to of another one. It is insects visiting flowers that ensure such pollination.
- Insects come to flowers for collecting pollen (some beetles, many hymenopterans) or for the sake of sweet nectar (flies, butterflies, many hymenopterans).
- Sometimes insects use corollas of flowers as an asylum or come inside a flower cluster for placing there their young. All kinds of insects' visits are used by plants for pollination.
- Many plants cannot reproduce without such pollination by insects. And we — gather harvests!

Insects as food

- Insects represent an important food source for a wide variety of other animal species.

- Insects were an important source of nutrition for our early human ancestors. Today, they are still collected and eaten by people of many cultures.

Biogeochemical cycling of nutrients

- As consumers, scavengers, and decomposers, insects play a vital role in the biogeochemical cycling of nutrients. Insects help aerate the soil, improve its retention of rainwater, and enhance its fertility. Flies and dung beetles prevent the build-up of manure from large animals and speed up its decomposition by fungi and bacteria.

Parasites and predators

- As parasites and predators of other organisms, insects are part of a natural system of checks and balances that strengthens community stability and prevents explosive population growth from overrunning natural resources. So far, over 6000 insect species have been tested and released as biological control agents to fight insects and weeds that we regard as pests.

Insect products

- **Honey**

Honey is the complex substance made when the nectar and sweet deposits from plants and trees are gathered, modified and stored by honey bees as a food source for the colony. Honey is also gathered by humans from the nests for many purposes.

- **Beeswax**

Worker bees of a certain age will secrete beeswax from a series of glands on their abdomens. They use the wax to form the walls and caps of the comb. As with honey, beeswax is gathered for various purposes.

- **Pollen**

Bees collect pollen in the pollen basket and carry it back to the hive. In the hive, pollen is used as a protein source necessary during brood-rearing. In certain environments, excess pollen can be collected from the hives of bees. It is often eaten as a health supplement.

- **Propolis**

Propolis (or bee glue) is created from resins, balsams and tree saps. Honey bees which nest in tree cavities use propolis to seal cracks in the hive. Some honey bees use

propolis to defend against ants by coating the branch from which their nest is suspended to create a sticky moat. Propolis is consumed as a health supplement in various ways and also used in some cosmetics.

- **Silk**

A silkworm, *Bombyx mori*, is the source of a unique natural fiber used to make silk cloth. Silk is the strongest of all natural fibers. It is comparable to steel or nylon in tensile strength, but considerably more elastic. It can be dyed, woven into fabrics that are warm in winter, cool in summer, resistant to wrinkling, and light in weight.

- **Shellac**

A product of a scale insect, was widely used as a varnish (protective coating) for floors, furniture, draperies, photographs, playing cards, and dried flower arrangements.

- **Cochineal**

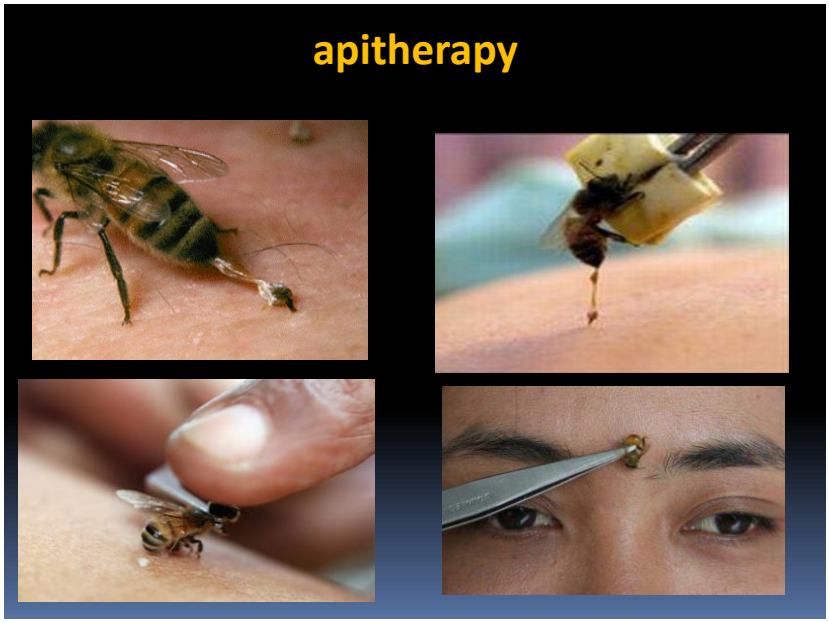
A pigment extracted from a scale insect was highly valued for the intensity and permanence of its color, it is very expensive because of its scarcity. It is still used as a coloring agent in foods, beverages, cosmetics (especially lipsticks), and art products.

- **Tannic acid**

A chemical compound widely used in the leather industry (for tanning and dying) and in the manufacture of some inks. Most of the world's supply of tannic acid was obtained from the Aleppo gall, an abnormal plant growth found on oak trees in Asia Minor. The trees produce gall tissue in response to a chemical substance secreted by tiny wasps (family Cynipidae) that infest the trees. Larvae of these wasps live and grow inside the galls which provide both food and shelter for the insect invaders. Today, there is no commercial market for oak galls because tannic acid can be extracted more economically from the quebracho tree.

Medical and Therapeutic Value

- Certain fly larvae are now used for cleaning deep wounds **(maggot therapy**). A chemical secretion known as **allantoin** was extracted from these maggots and used as antibiotic until penicillin and other antibiotics became commercially available in the 1940's.
- Honey bees (or their products) have been used for medicinal purposes. This practice, known as **apitherapy**
- Research has uncovered other substances with anti-viral, anti-fungal, and anti-inflammatory activity in a variety of other insects.



- Some entomologists believe that pharmaceutical companies will find enough new drugs in the class Insecta to keep them busy for many hundreds of years.
- Specialists in **forensic entomology** can often deduce how, when, or where a crime was committed. Insects can provide accurate information about the time of death, the number and location of wounds, and even whether the body has been moved from one place to another.

Benefits of insects to science and technology

- Scientists destroyed the theory of spontaneous generation, when they found that maggots appear on dead meat are laid by house flies.
- The study of insects has increased our overall understanding of biology.
- The fruit fly (*Drosophila melanogaster*) has contributed much to our knowledge of genetics.
- The first association between pathogens and disease was noticed by Louis Pasteur's studying of silkworm diseases (1865-1870).
- Toxicology relies heavily on insects to assess the toxicity of products.

Other benefits for insects

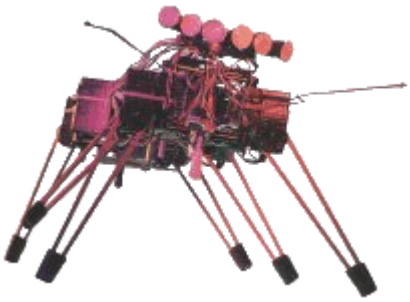
- Entomologists trained parasitic wasps in screening for explosives, drugs, chemical weapons, and mine detection using a device known as the "Wasp Hound.
- Wasps are better than dogs in this field because wasps are cheap to produce, easily trained and are beneficial to farmer.
- In wasp Hound, Bees may be more appropriate for open areas, while the Wasp Hound may be better in buildings.

Insects in robotic industry

- Scientific research has most often focused on how to destroy insects rather than on learning about the ways in which they

function. How does a fly land with such precision, a bee find its way from flower to hive, or a cockroach move so quickly?

- Scientists have recently realized that insects could guide the next wave of advances in biomimetic robotics.
- A life-size, robotic fly has taken flight at Harvard University. Weighing only 60 milligrams, with a wingspan of three centimeters, the tiny robot's movements are modeled on those of a real fly. While much work remains to be done on the mechanical insect, the researchers say that such small flying machines could one day be used for detecting harmful chemicals.



Harmful insects

Plant Pests

- Many insect species feed directly on the tissues of living plants.
- Many insects that feed on plants also serve as vectors of plant diseases. All major plant pathogens are spread by insects, including viruses, bacteria, protozoa, fungi, and nematodes.

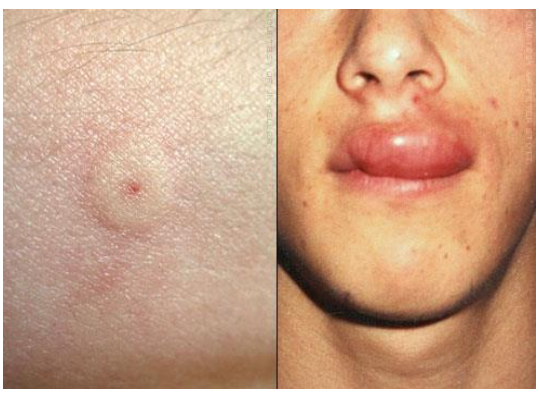
- The **economic impact** of insects is measured not only by the market value of products they destroy and the cost of damage they inflict but also by the money and resources expended on prevention and control of pest outbreaks.

- Economists generally agree that insects destroy around 10% of gross national product in large, industrialized nations and up to 25% of gross national product in some developing countries.

Health problems caused by insects

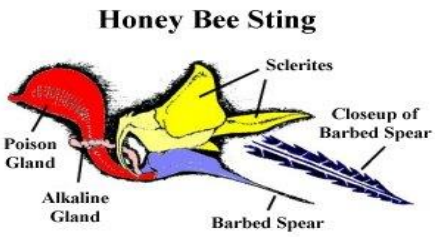
- Insects have a profound impact on the health of humans and domestic animals by causing annoyance, inflicting bites and stings, and transmitting disease.
- Insects greatly affected human civilizations. In Africa, army ants can cause the evacuation of an entire village. Ttse-tse flies prevent colonization of large parts of central Africa because they spread the sleeping sickness.

- Some insects cause no damage or injury. They may be annoying, like chirping crickets that keep you awake at night, or dance flies that swarm around your head.



- Buzzing or swarming insects are often a serious threat to animal producers. Large fly populations (even non-biting flies) can decrease the animal weight and its eggs or milk production.
- Some people are so afraid of insects that it can affect their ability to function normally. These people suffer from **Entomophobia.**

- Many insects feed on blood. Their mouthparts are designed for piercing and sucking of blood (mosquitoes, bugs, fleas, etc.). The localized reaction to an insect bite (pain, swelling, redness, etc.) is usually a physiological (inflammatory) response to these injected compounds.
- Ants, wasps, and bees have a true stinger. Some predatory and parasitic insects sting to kill or immobilize their prey, whereas most other species sting only as a defensive behavior to kill or drive away potential predators. In the U.S.A. wasps kill more people than snakes, spiders and scorpions combined.



- Skin and eye irritation, respiratory inflammation, and various types of chronic allergies may also be caused by insects hairs, scales, exuviae, and fecal products.

- Larvae of certain flies (Diptera) are adapted to invade and consume the tissues of a vertebrate host. An infestation by any of these flies is known as **myiasis**

- Insects are among the most important vectors of pathogens. The term **zoonosis** (or zoonotic disease) refers to any infectious disease that is transmitted (by a vector) from an animal reservoir to a human being.
- Over 200 human diseases can be spread by insects and related arthropods.

- The World Health Organization (WHO) estimates that as many as 4 million people die each year from the consequences of arthropod-borne disease.

- It is estimated that nearly one-fourth of the population of Europe (20-25 million people) died of plague (The Black Death which is transmitted by fleas) during the 14th century.

- In 1990, about seventy percent of the population of Tanzania was infected with malaria-transmitted by mosquitoes.

- Elephantiasis, Leishmania, Dengue fever, Rift valley fever widely distributed diseases in the world and are transmitted by insects.

Insects and war

- Over the course of human history, more soldiers have died from lice or mosquitoes than from bullets and bombs. These insects spread diseases that have affected entire armies.
- Body lice are notorious for the spread of epidemic typhus, often called trench fever because it thrives so well in the unsanitary conditions of wartime. Malaria and yellow fever, both transmitted by mosquitoes, have also taken a deadly toll -- especially when battles have been fought in tropical and subtropical climates.

- The wartime impact of insect-borne disease has decreased ever since the discovery of modern chemical insecticides. The turning point came during World War II (1942-1945) when American forces gained a tactical advantage over their enemies by using DDT, a newly discovered insecticide, to kill the lice and mosquitoes that spread disease. In fact, DDT has been credited with saving more lives than penicillin, particularly in the Pacific theater. The Japanese army was not well-equipped to fight insect-borne disease, and some historians believe that widespread epidemics of typhus and malaria would have soon forced Japan to surrender, even if the United States had not dropped the atomic bomb.

Some interesting facts about insects

- Dragonflies have as many as 30,000 lenses in each eye.
- A cockroach can survive for a month without eating anything but will die within 9 days approximately without water.
- The fastest runners are cockroaches, which can move almost a foot per second.
- Worker ants may live seven years and the queen may live as long as 15 years.
- Honeybees have to make about ten million trips to collect enough nectar for production of one pound of honey, travelling a total distance equal to twice the distance around the world.
- Approximately 2,000 silkworm cocoons are needed to produce one pound of silk.
- Crickets are good temperature reader as its chirps differ according to the weather. People know whether its hot or cold depending on the chirps crickets make.
- Houseflies find sugar with their feet, which are 10 million times more sensitive than human tongues.
- Ants can lift and carry more than fifty times their own weight.
- Wasps feeding on fermenting juice have been known to get "drunk' and pass out.
- The queen of a certain termite species can lay 40,000 eggs per day.
- Beetles account for one quarter of all known species of plants and animals. There are more kinds of beetles than all plants.

- The term "honeymoon" comes from the Middle Ages, when a newly married couple was provided with enough honey wine to last for the first month of their married life.
- To survive the cold of winter months, many insects replace their body water with glycerol, which acts as an "antifreeze" against the temperatures.
- There are nearly as many species of ants (8,800) as there are species of birds (9,000) in the world.
- Some types of crickets and grasshoppers have their ears on their front legs.
- Mounds of African termites can get up to 40 ft high. They use an intricate system of ventilation shafts which helps control the inner temperature.
- Mosquitoes have killed more human beings than the combined death toll of all the wars in history.
- The Slave-maker ants raid the nests of other ants to steal their pupae. When these pupae hatch, the new-born ants are made slaves and work as slaves throughout their lives.
- Stick insects can live up to 3 years in the wild, on the average.
- A small colony of Madagascar hissing cockroaches can eat a large carrot in one day.
- Only female mosquitoes bite humans.
- The Black ants and Wood ants can spray formic acid. For this reason some birds put them on and into their feathers because this acid helps them to get rid of parasites.