

Introduction to Medical Entomology

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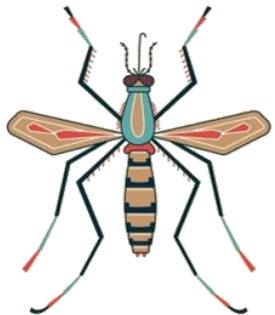
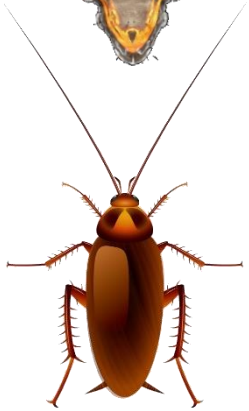
What is Entomology?

notched = segmented

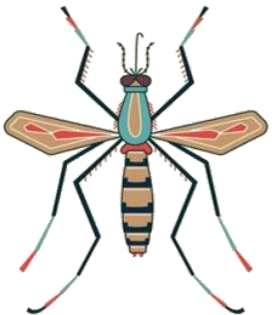
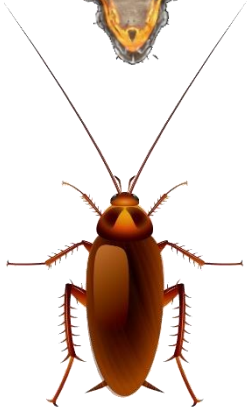
entomon = insects

logia = study

Entomologia = study of insects



Coverage of Insect Researches



Behavior, Ecology, Evolution, and Systematics

- Other areas focuses on anatomy, physiology, biochemistry, and genetics.

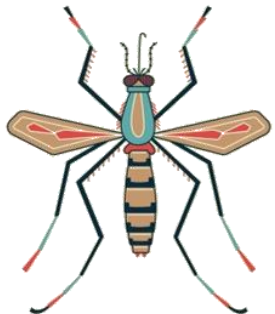
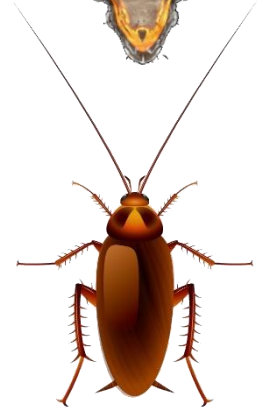


Why Insects?

- Biologists work with insects for many reasons:
 - ease of culturing in a laboratory, and rapid population turnover.



- availability of many individuals are important factors, minimal ethical concerns

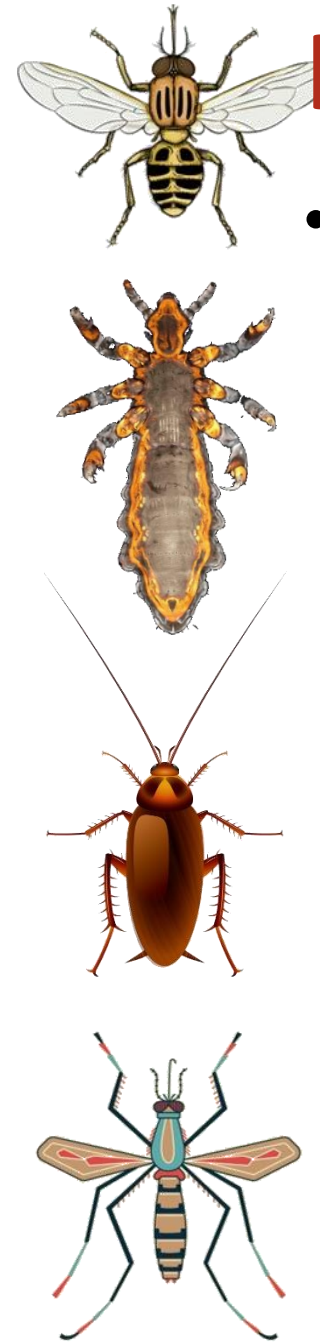
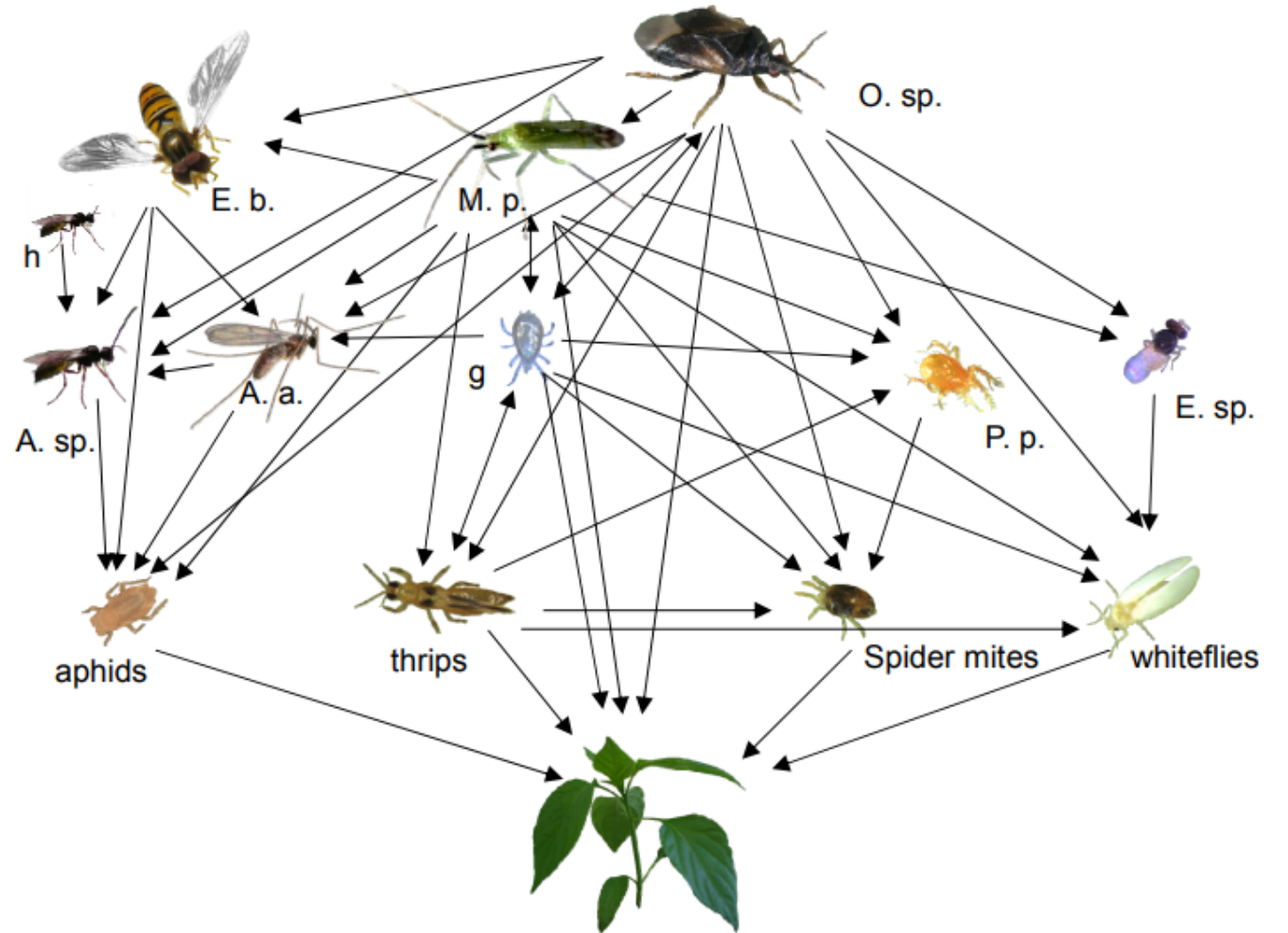
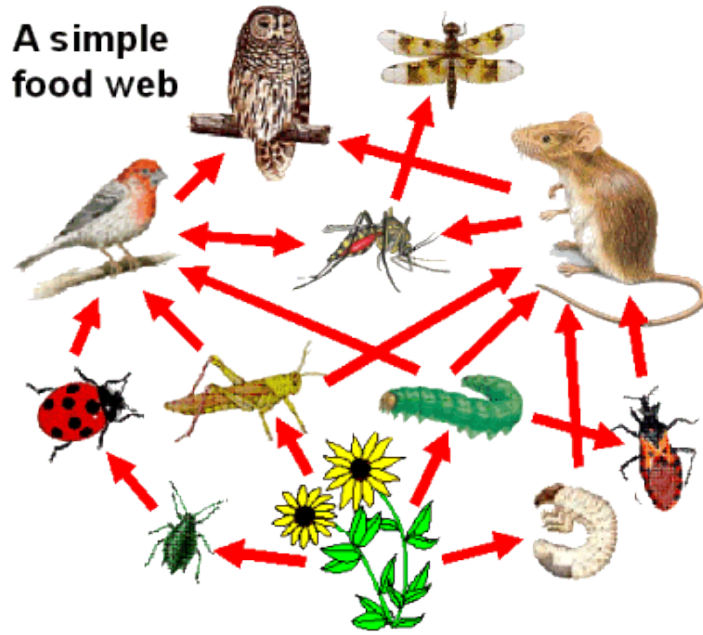


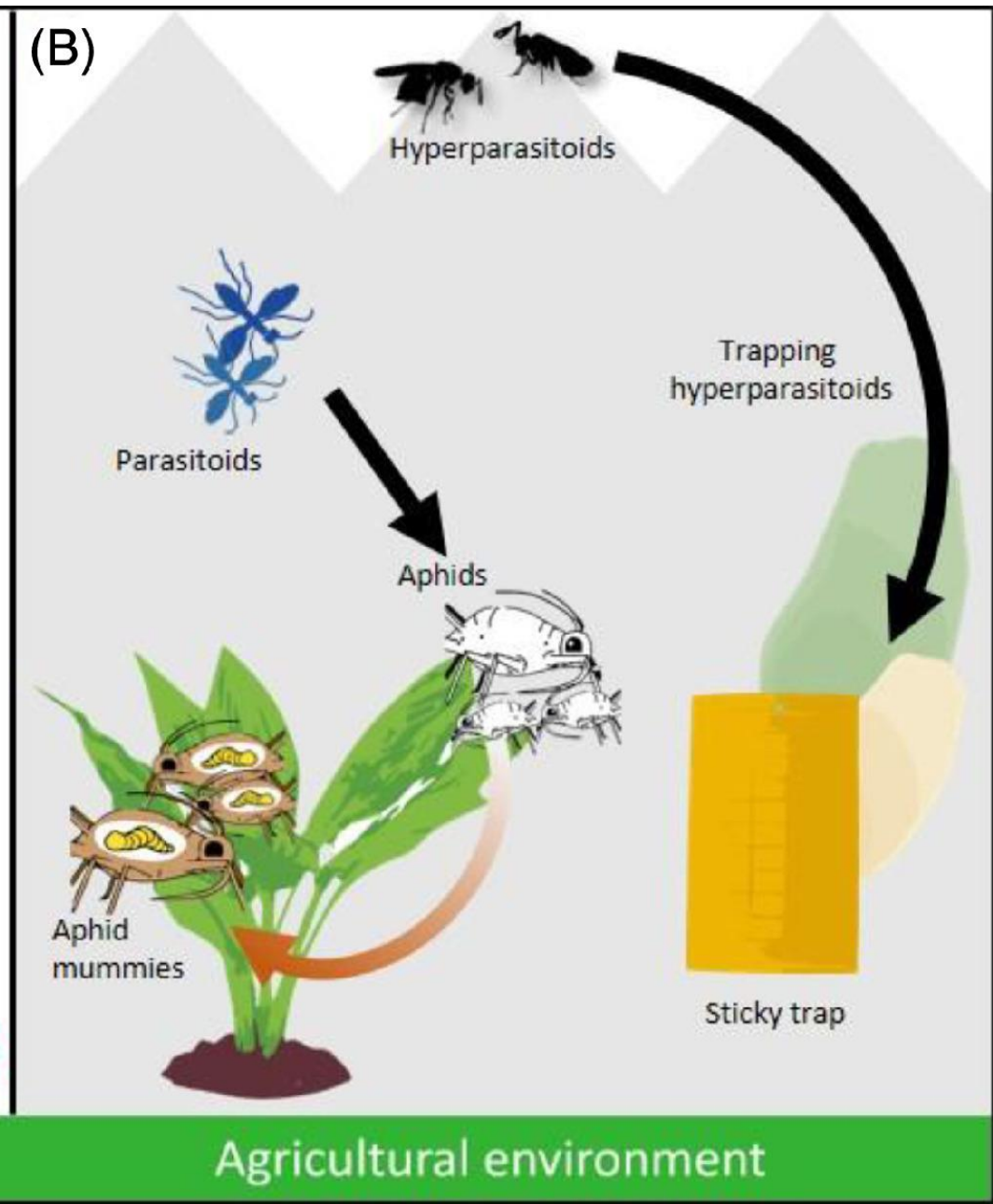
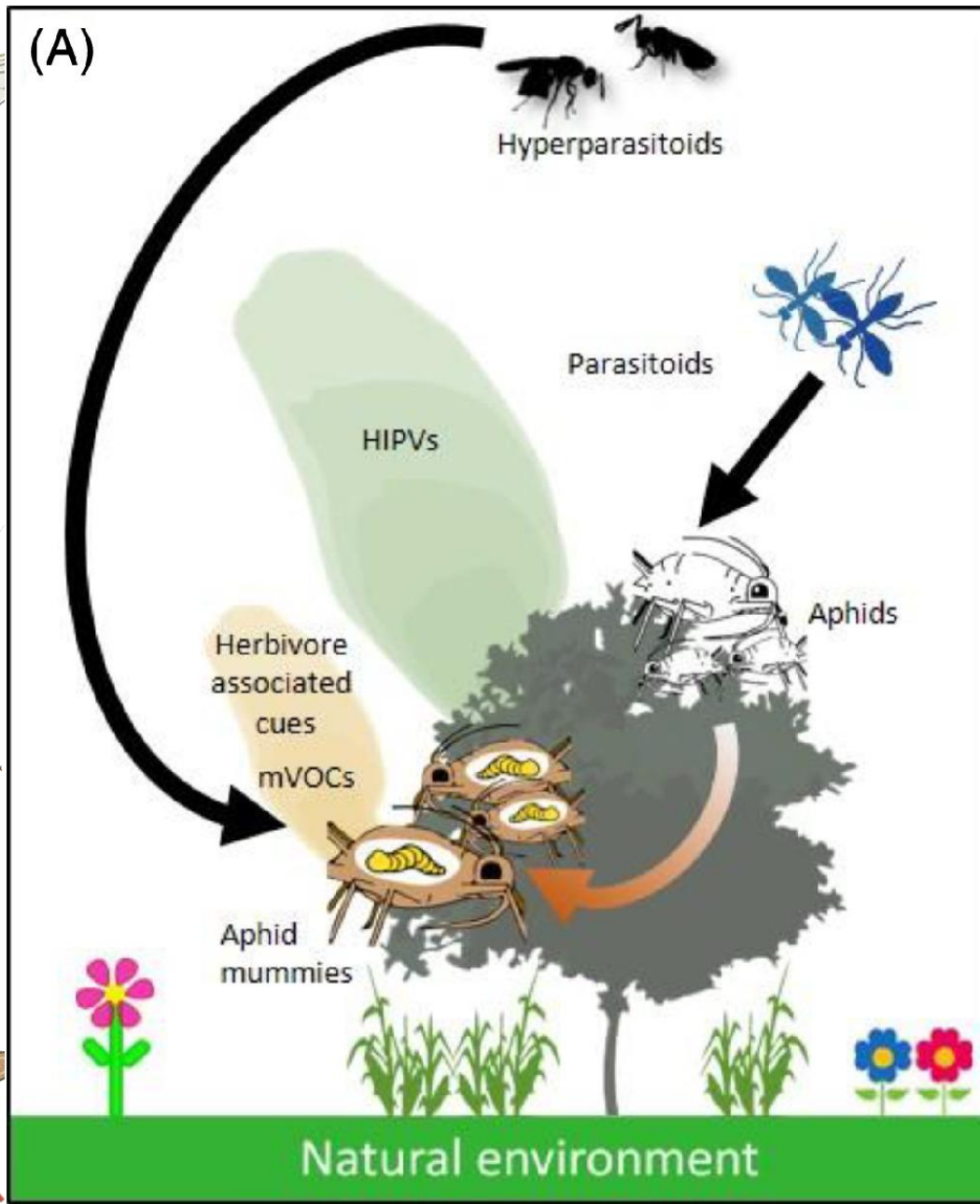
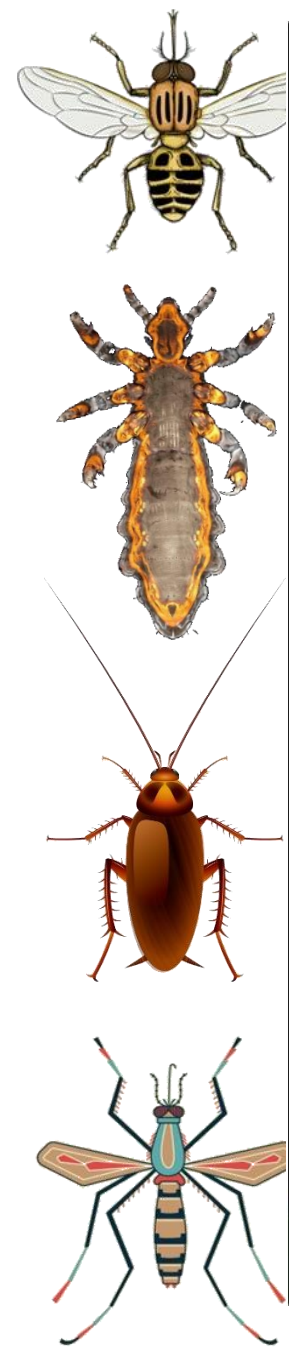
Importance of Insects

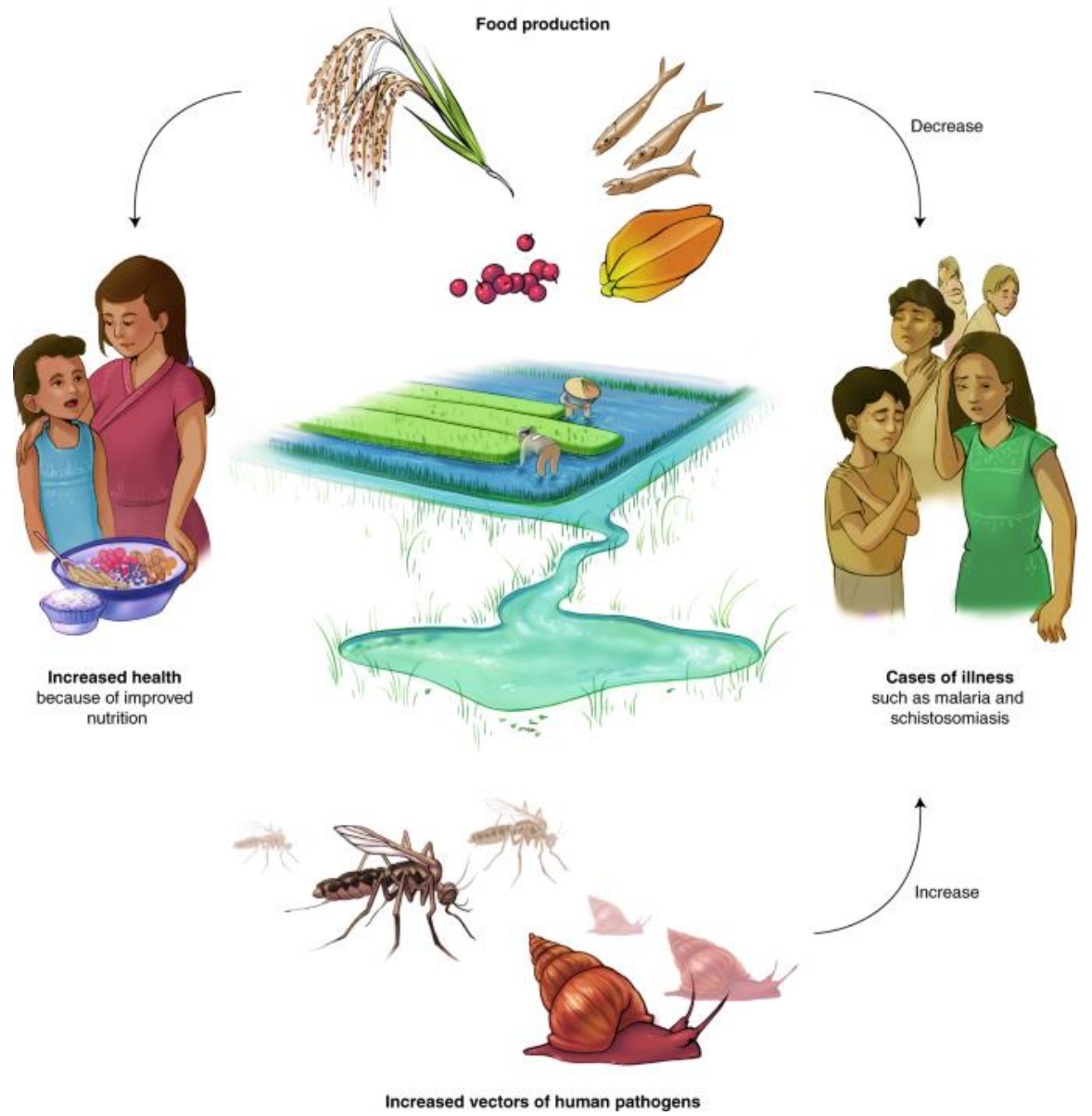
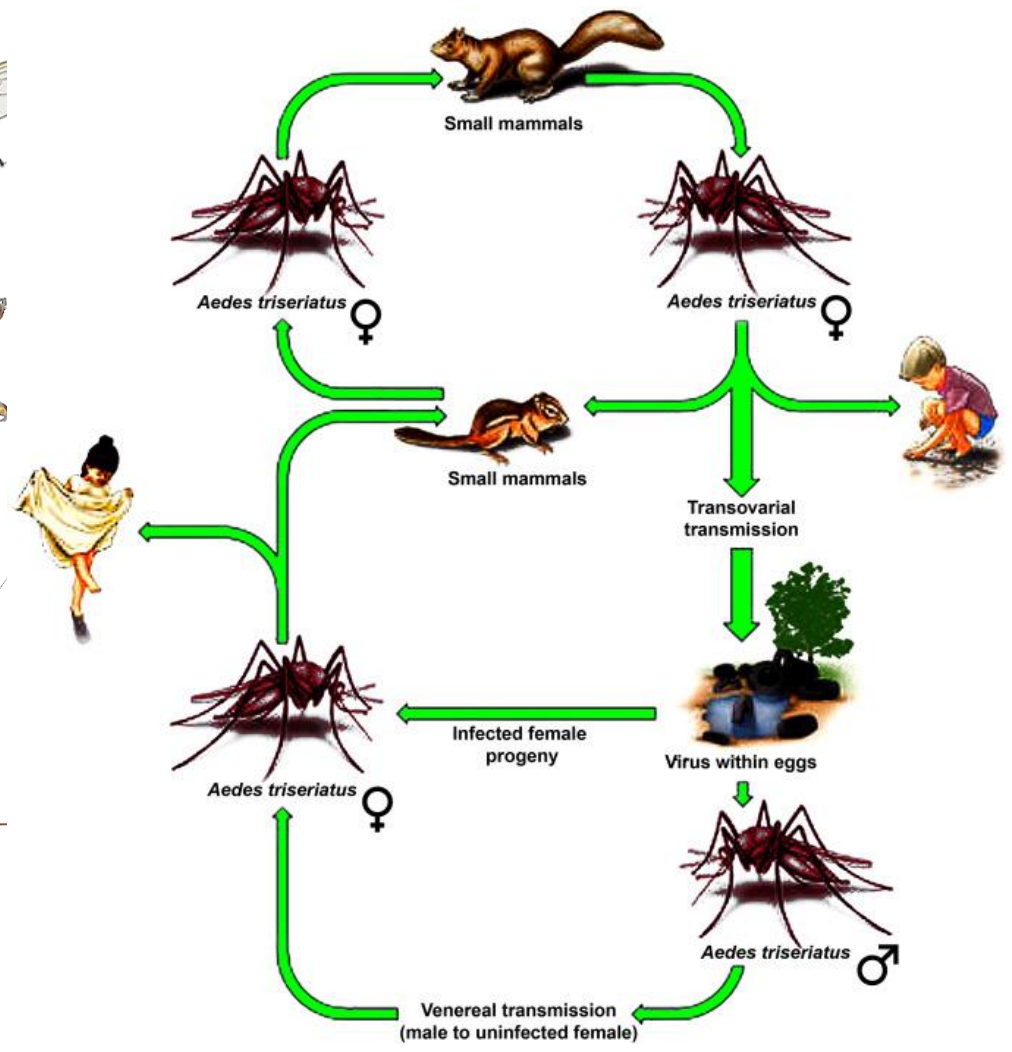
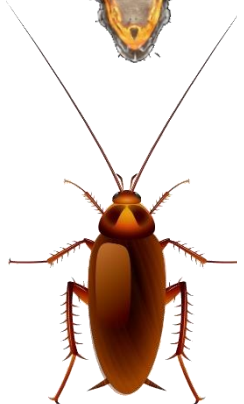
- Their ecologies are incredibly variable.

- Insects may dominate food chains and food webs in both volume and numbers.

A simple food web





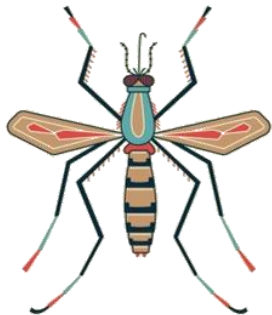
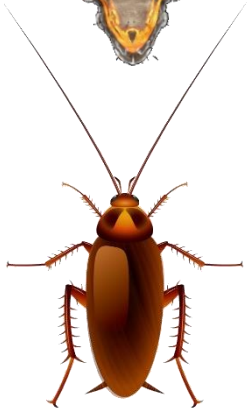


Importance of Insects

- Feeding specializations of insect groups:

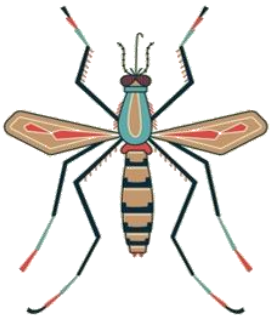
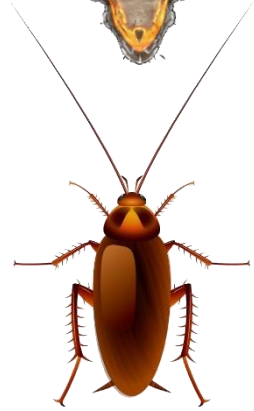
- Ingestion of detritus, rotting materials, living and dead wood,

- herbivory (phytophagy),





- aquatic filter feeding



- predators



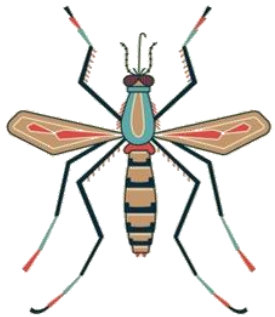
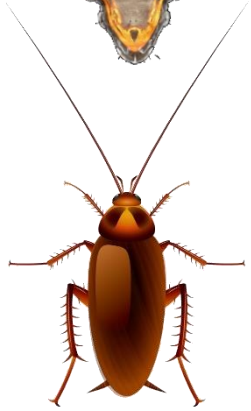
- Sap feeder



- parasitoid

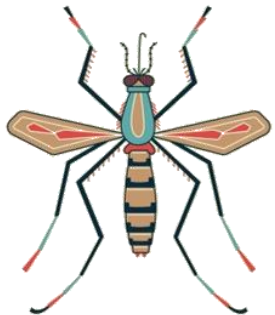
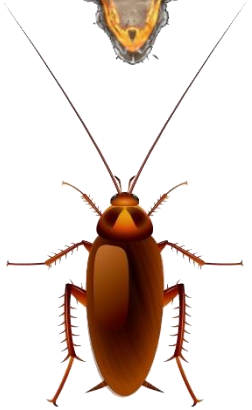


- blood feeding



Kinds of Insect Interaction between species

Type	Definition
Mutualism (++) ^a	Both species benefit from an association
Symbiosis (++, +-, +0 or -0)	The close association of two or more species living together, no matter which kind of influence one has on the other
Antagonism (+-, -)	One species has a negative effect on the other species (predation, parasitism), or both species exert a negative effect (competition)
Amensalism (-0)	One species has a negative effect on the other, but there is no measurable reciprocal effect (e.g. highly asymmetric competition)
Competition (-)	Exploitation of a common and limiting resource by two or more species
Commensalism (+0)	One species benefits from an association without any benefit to, or harm from, the other species.
Parasitism (+-)	Individuals of one species live in or on a living host, sapping the host's resources for a relatively prolonged period, and exerting a negative, but not necessarily a fatal, effect on the host
Predation (+-)	Individuals of one species kill and eat individuals of another species – the prey species





Inquilinism (+0, +−)

One species enters the domicile of another habitually, with or without causing damage to the host species

Browsing (+−)

Eating tender plant shoots, twigs or leaves of woody plants

Grazing (+−)

Feeding on growing herbage such as grass, nibbling or cutting at surface growth while passing across a patch of vegetation

Cropping (+−)

Cutting off the upper or outer parts of a plant

Exophytic (+−)

External feeding on a plant

Endophytic (+−)

Internal feeding on a plant

Obligate

A necessary relationship for the existence of a species or individual

Facultative

A relationship that may be used, but is not essential

Specialist

A species with a narrowly defined diet

Generalist

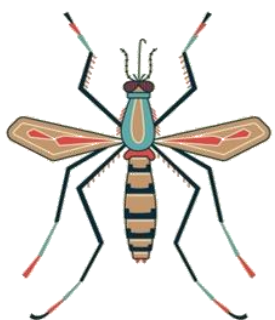
A species that feeds broadly across many host or prey species

Direct interaction

A species has an immediate effect on another by directly influencing the recipient of the interaction

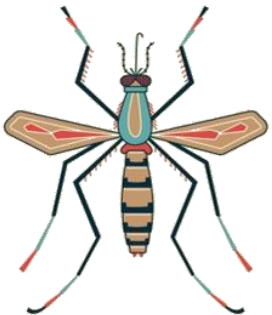
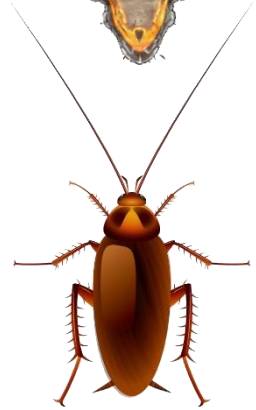
Indirect interaction

A species influences another recipient species by altering the conditions to which the recipient species is exposed

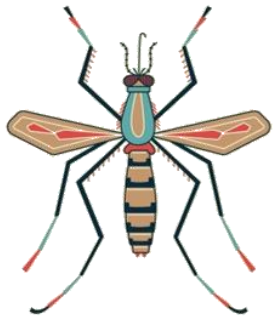
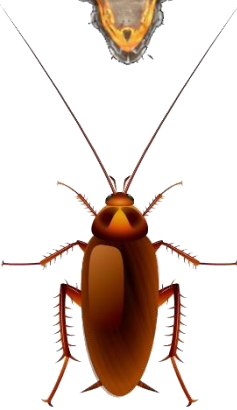


Insect Lifestyles

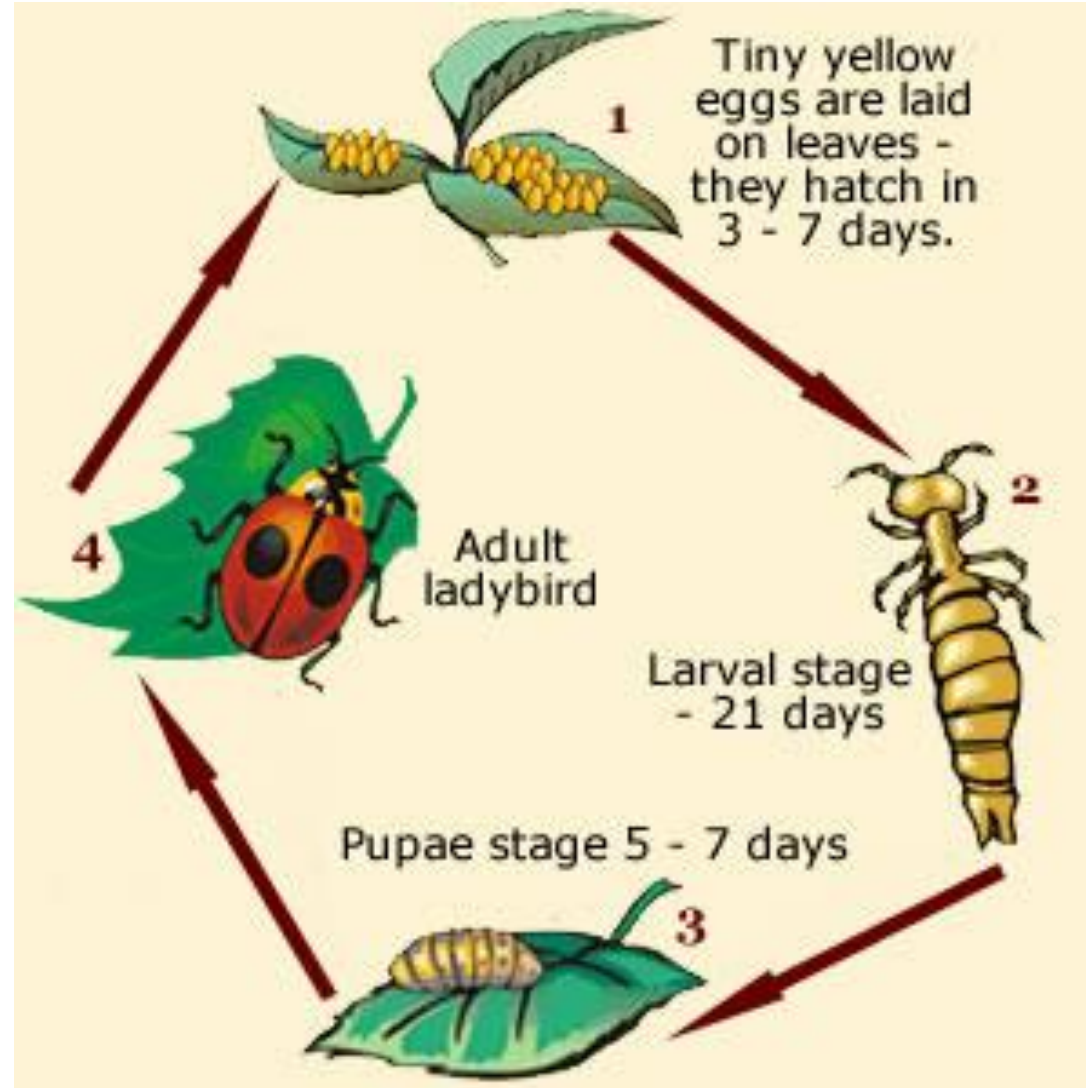
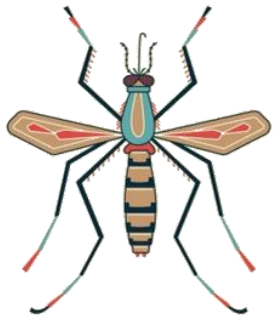
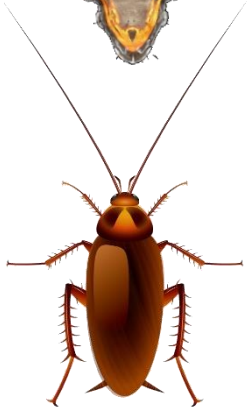
- Their lifestyles may be solitary, gregarious, sub-social, or highly social.



- They may be conspicuous, mimics of other objects, or concealed, and may be active by day or by night.



• Insects life cycles allow them to survive in wide range of conditions.

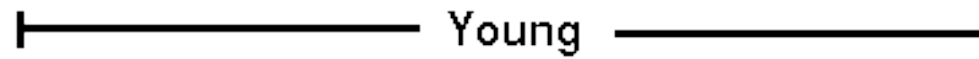
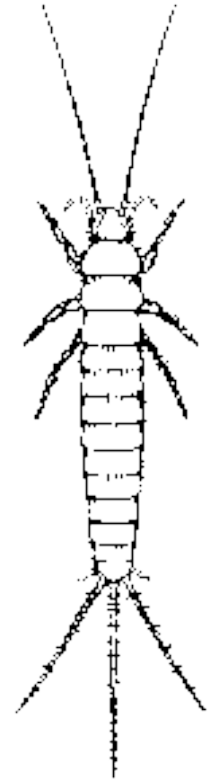
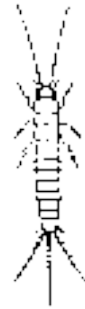


Types or Pattern of Insect Development

Ametabolous Development

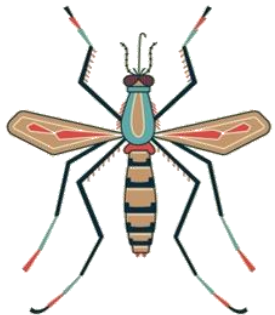
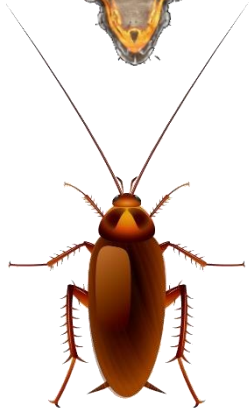


Egg



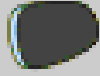
Young

Adult



Holometabolous

Egg



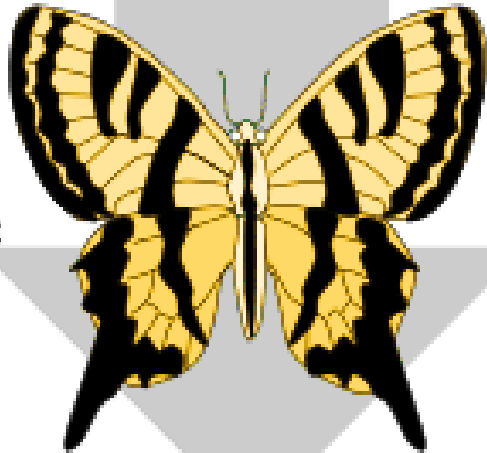
Larvae



Pupa

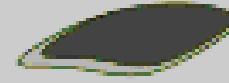


Adult



Hemimetabolous

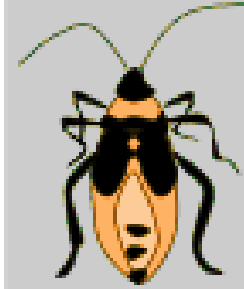
Egg



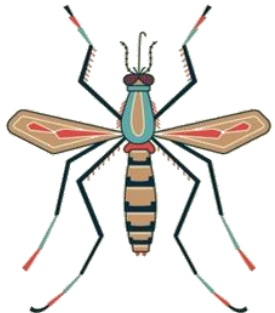
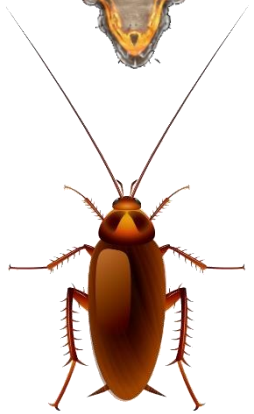
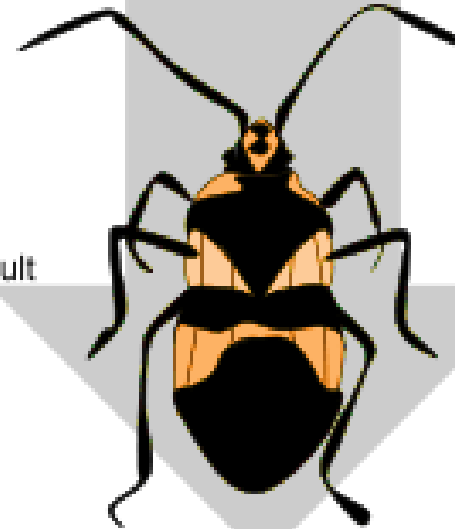
Young Nymph



Later Nymph



Adult



Ametabolous vs Hemimetabolous

More Information Online WWW.DIFFERENCEBETWEEN.COM

Ametabolous

Hemimetabolous

DEFINITION

Ametabolous insects do not show metamorphosis

Hemimetabolous insects show gradual or partial metamorphosis

METAMORPHOSIS

No metamorphosis

Simple or gradual metamorphosis

STAGES IN THE LIFE CYCLE

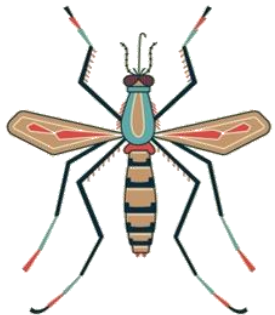
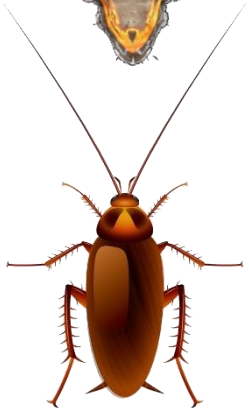
Eggs, immature stage and adults

Eggs, nymphs and adults

EXAMPLES

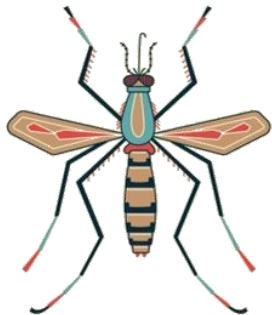
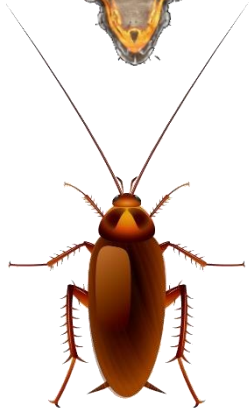
Springtails, silverfish, and firebrats

Grasshoppers, mantids, cockroaches, termites, dragonflies, and all true bugs



Incomplete vs Complete Metamorphosis

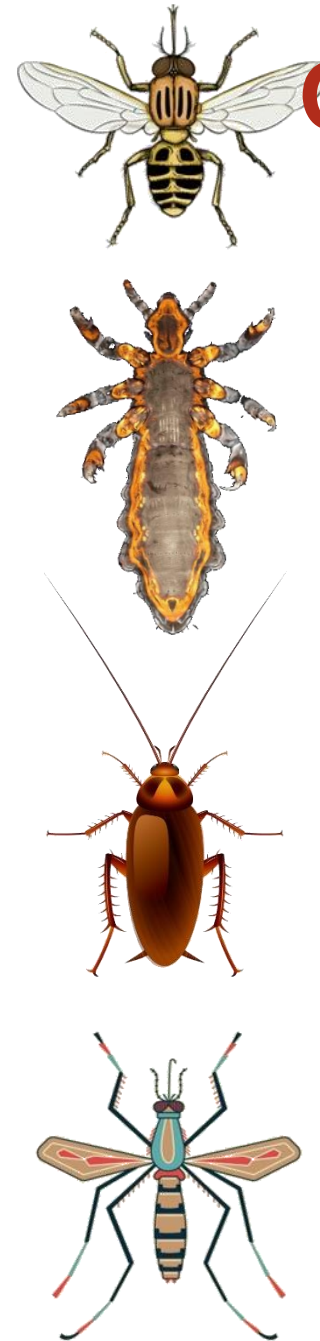
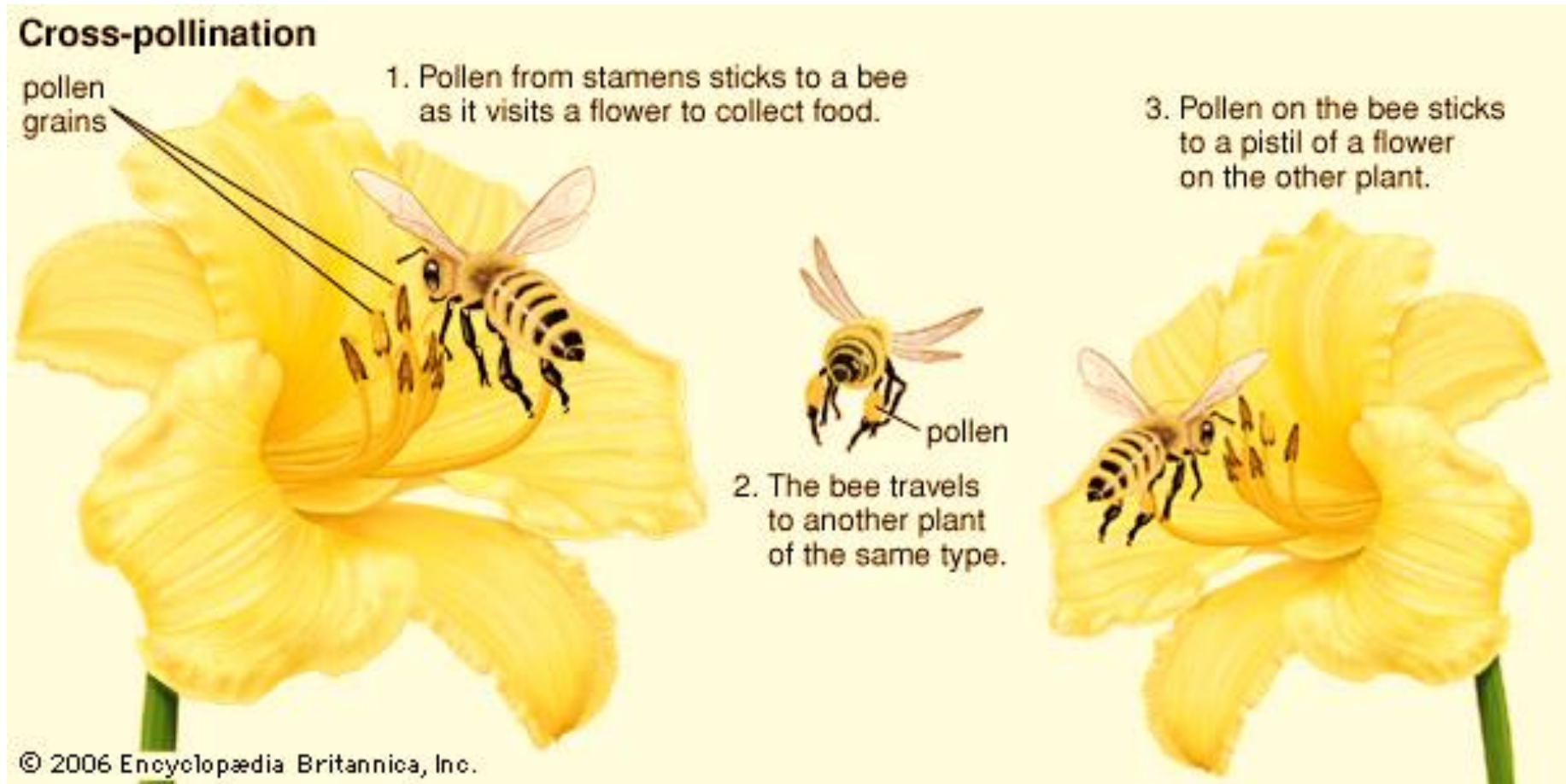
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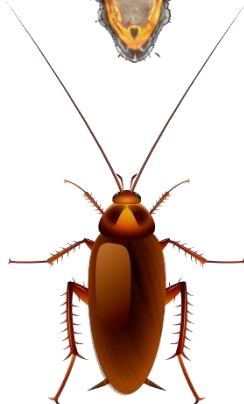
	Incomplete Metamorphosis	Complete Metamorphosis
DEFINITION	A type of metamorphosis that has only three stages in the life cycle.	A type of metamorphosis that has four stages in the life cycle.
STAGES IN THE LIFE CYCLE	Incomplete metamorphosis has three stages; eggs, nymphs and adult.	Complete metamorphosis has four stages; eggs, larvae, pupa and adult.
INTERMEDIATE STAGE HABITS	Nymphs almost look similar as the adults do, and the food habits are the same in both.	Larva is completely different from the adult in body form as well as food habits.
INVOLVEMENT OF STAGES	Nymphs are involved in incomplete metamorphosis.	Complete metamorphosis involves with larval and pupal stages.
ORGANISMS	Cockroaches, grasshoppers, dragonflies, and true bugs, etc.	Beetles, bees, ants, butterflies, moths, fleas, and mosquitoes, etc.
SYNONYMS	Imperfect metamorphosis and hemimetabolous.	Perfect metamorphosis and holometabolous.

Other Ecosystem Process

- Insects are important in plant propagation, including pollination and seed dispersal;



• Other pollinators



Bumblebees



Long antennae; 2 pairs of wings; round and furry; 8-30mm

Honey bees



Long antennae; 2 pairs of wings; striped ginger-brown; 5-15mm

Butterflies



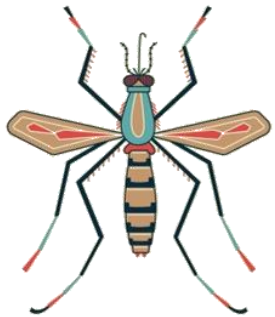
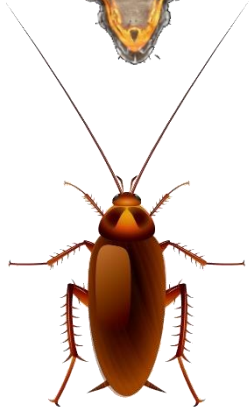
Club-like antennae; butterflies rest with their wings closed

Moths



Feathery antennae; most moths rest with their wings open

• Other pollinators



— Solitary bees —



Long antennae; 2 pairs of wings; narrower than bumblebee; 3-15m

— Hoverflies —



Short club-like antennae; large eyes; hovers or darts in flight

— Beetles —



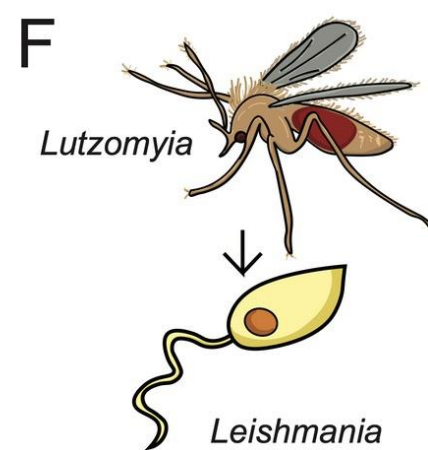
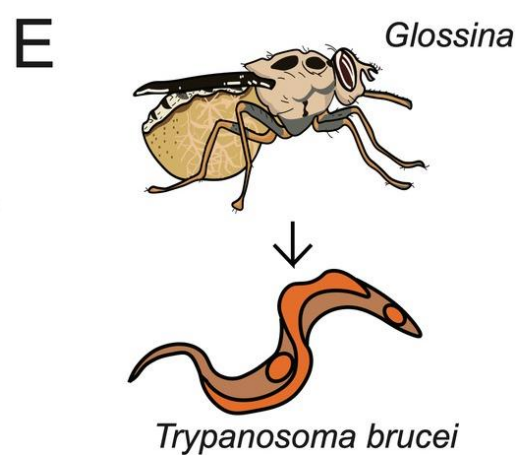
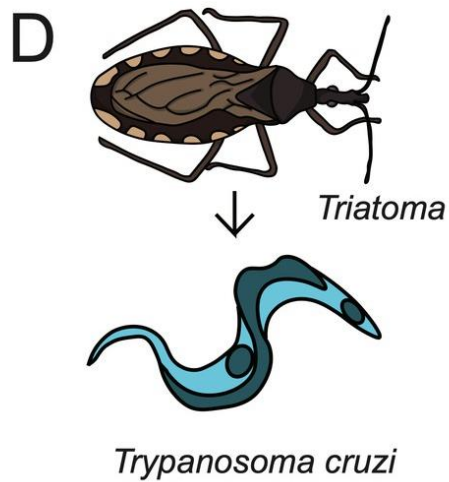
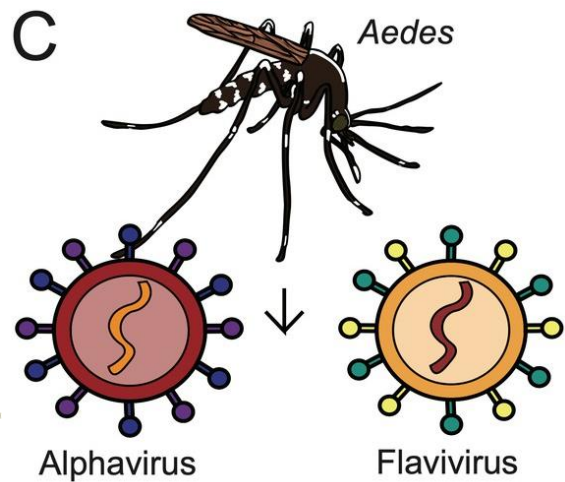
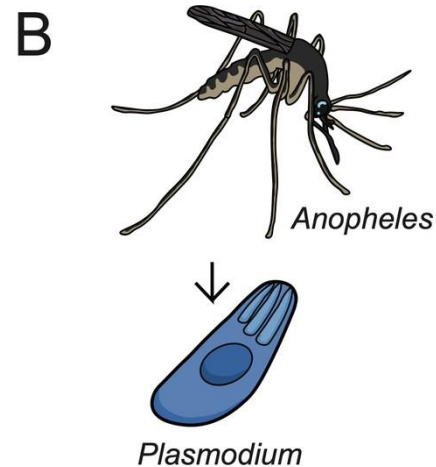
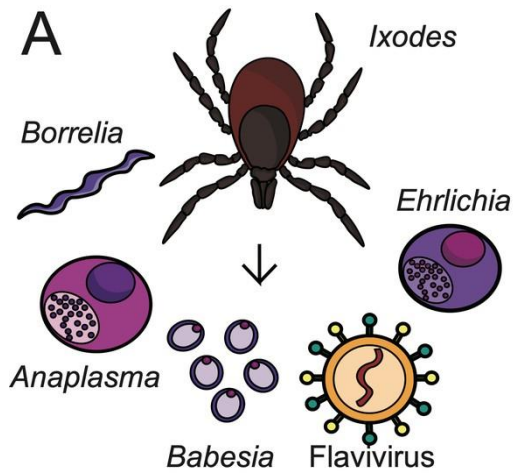
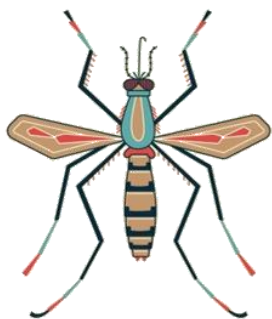
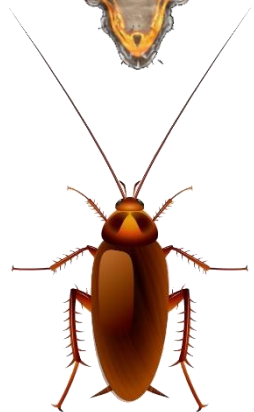
Wing cases meet in the middle in a T shape

— Other flies —



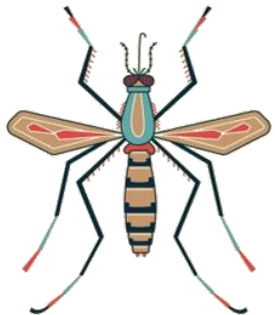
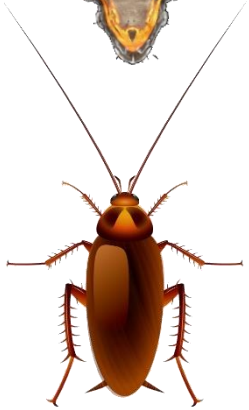
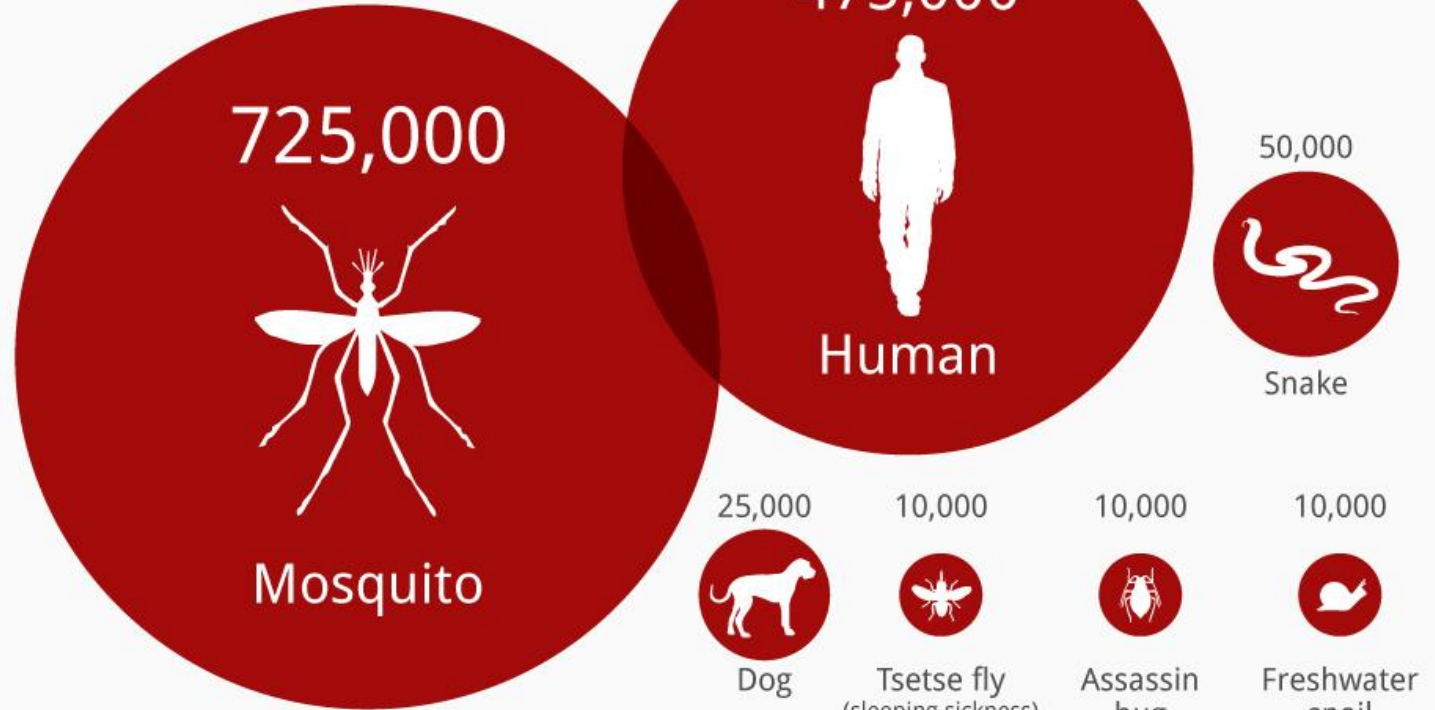
Short antennae; 1 pair of wings; large eyes

•maintenance of animal community structure, through transmission of diseases of large animals, and predation and parasitism of smaller ones

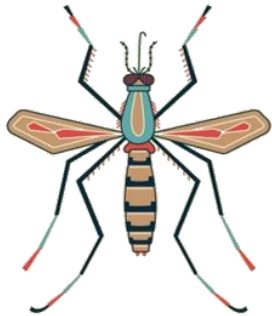
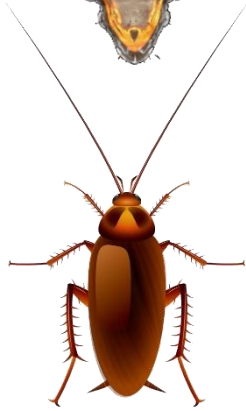


The World's Deadliest Animals

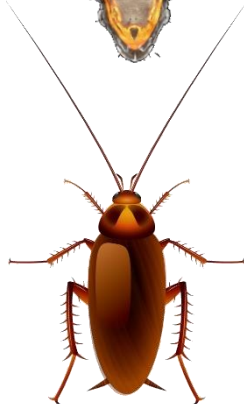
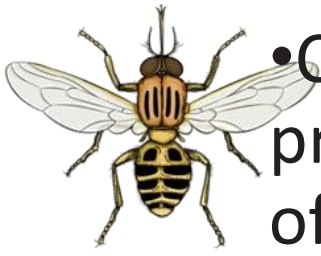
Number of people killed by animals per year



- Some insects were considered keystone species.

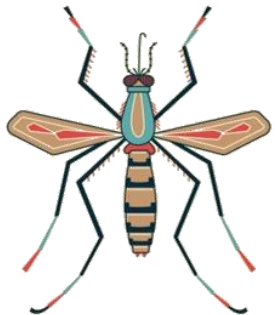
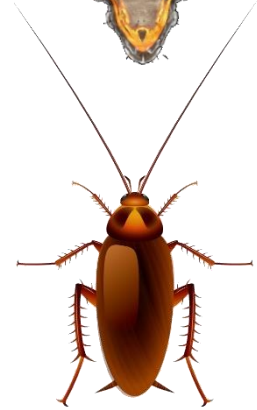


• Certain insects provide valuable services, such as those provided by predatory beetles and bugs or parasitic wasps that control pests, often go unrecognized, especially by city dwellers.





•Silk from the cocoons of silkworm moths, *Bombyx mori*, has been used for fabric for centuries.

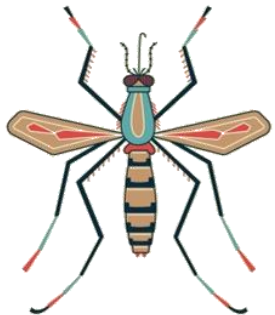
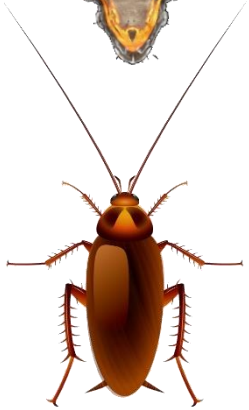
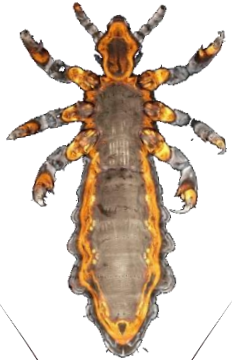


The lac insect *Kerria lacca*, is a source of a commercial varnish called shellac.

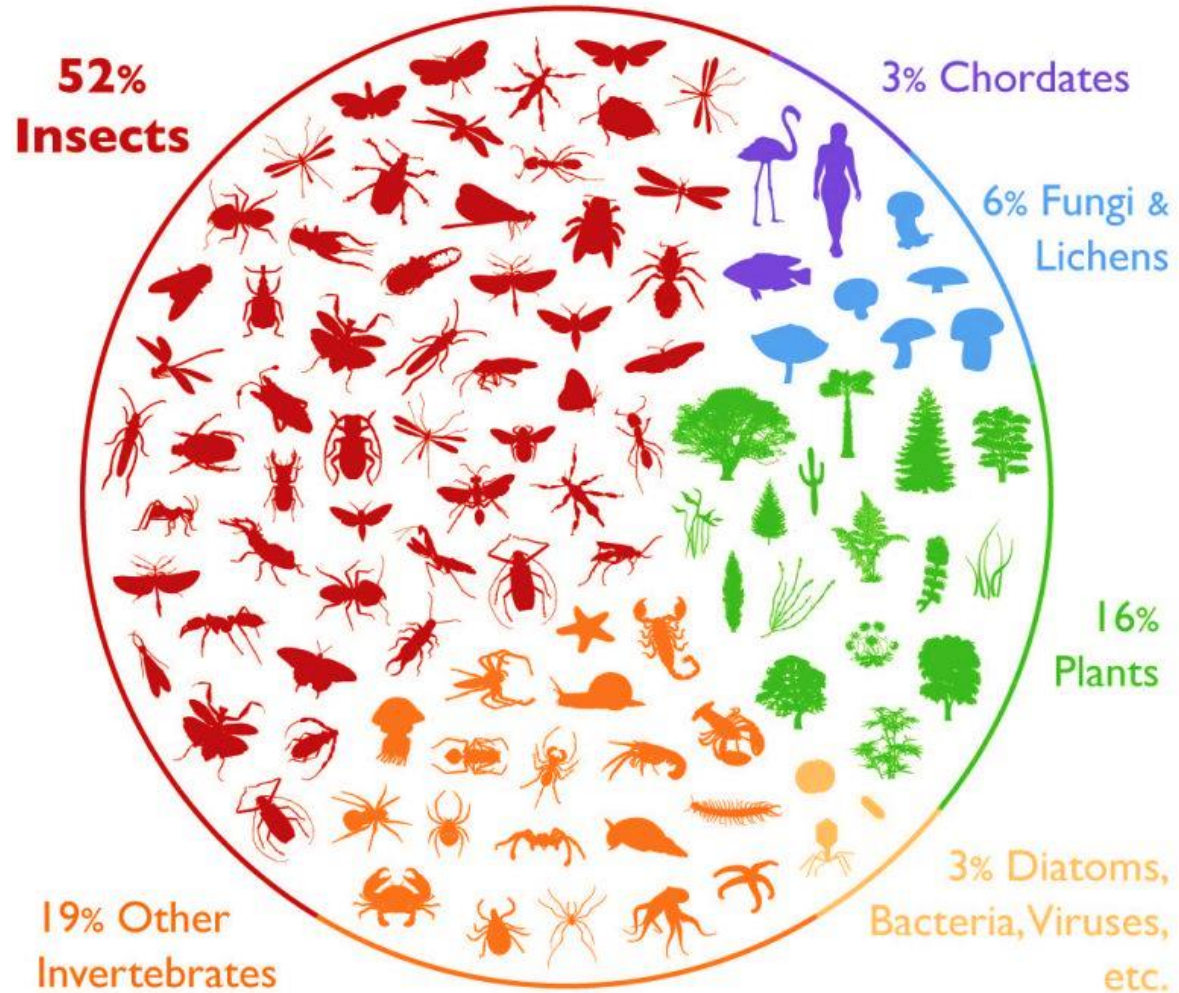
The red dye cochineal is obtained commercially from scale insects of *Dactylopius coccus* cultured on *Opuntia* cacti.



Organisms Diversity

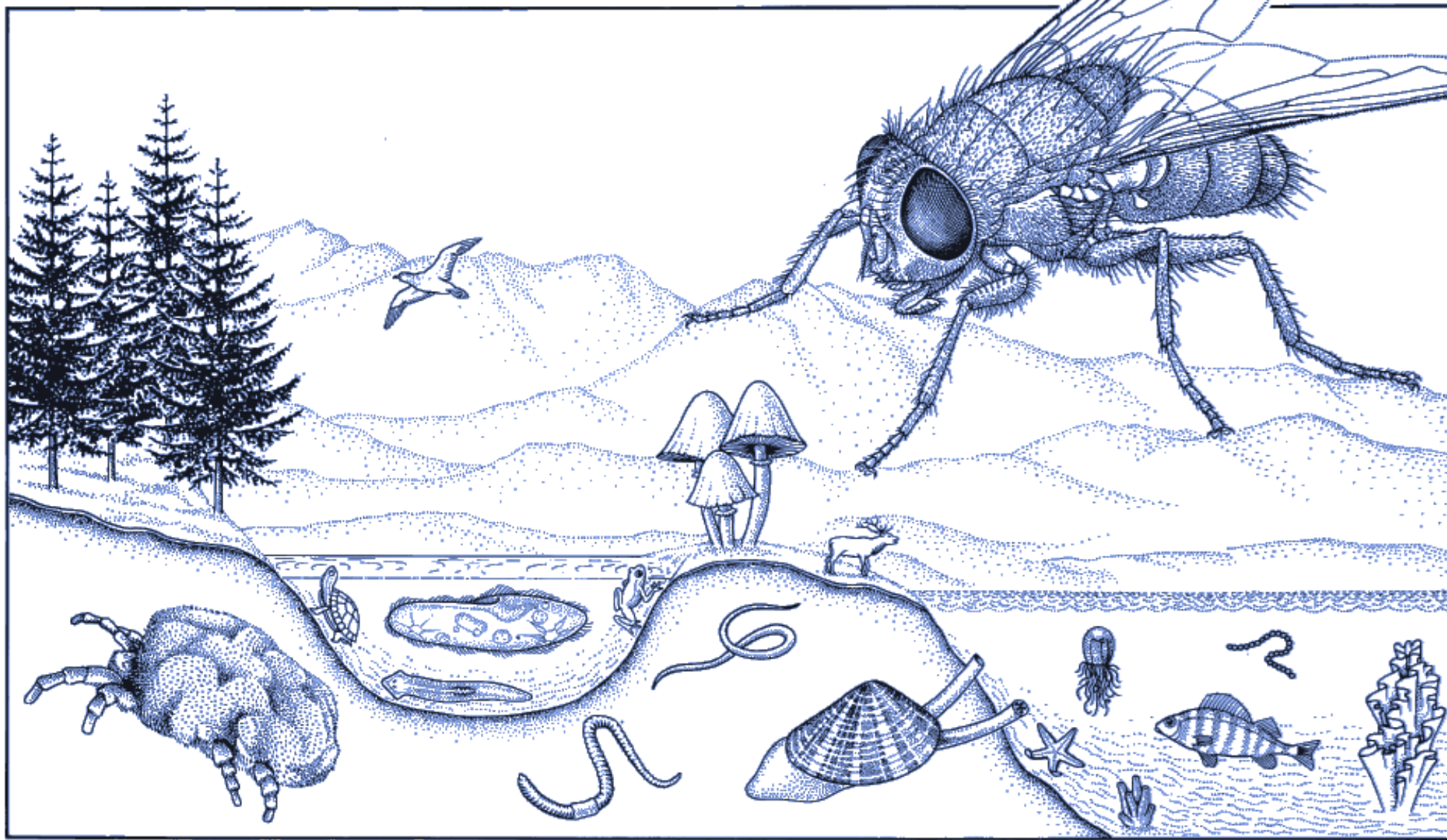
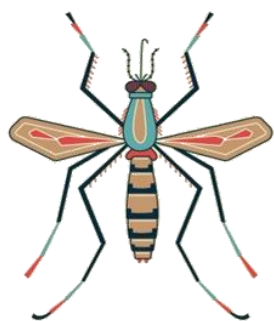
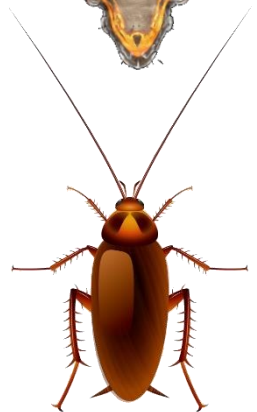


EARTH'S INHABITANTS

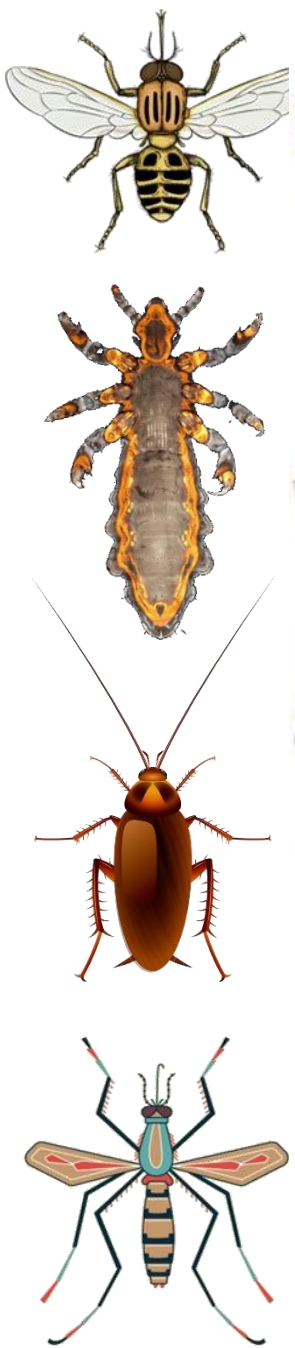
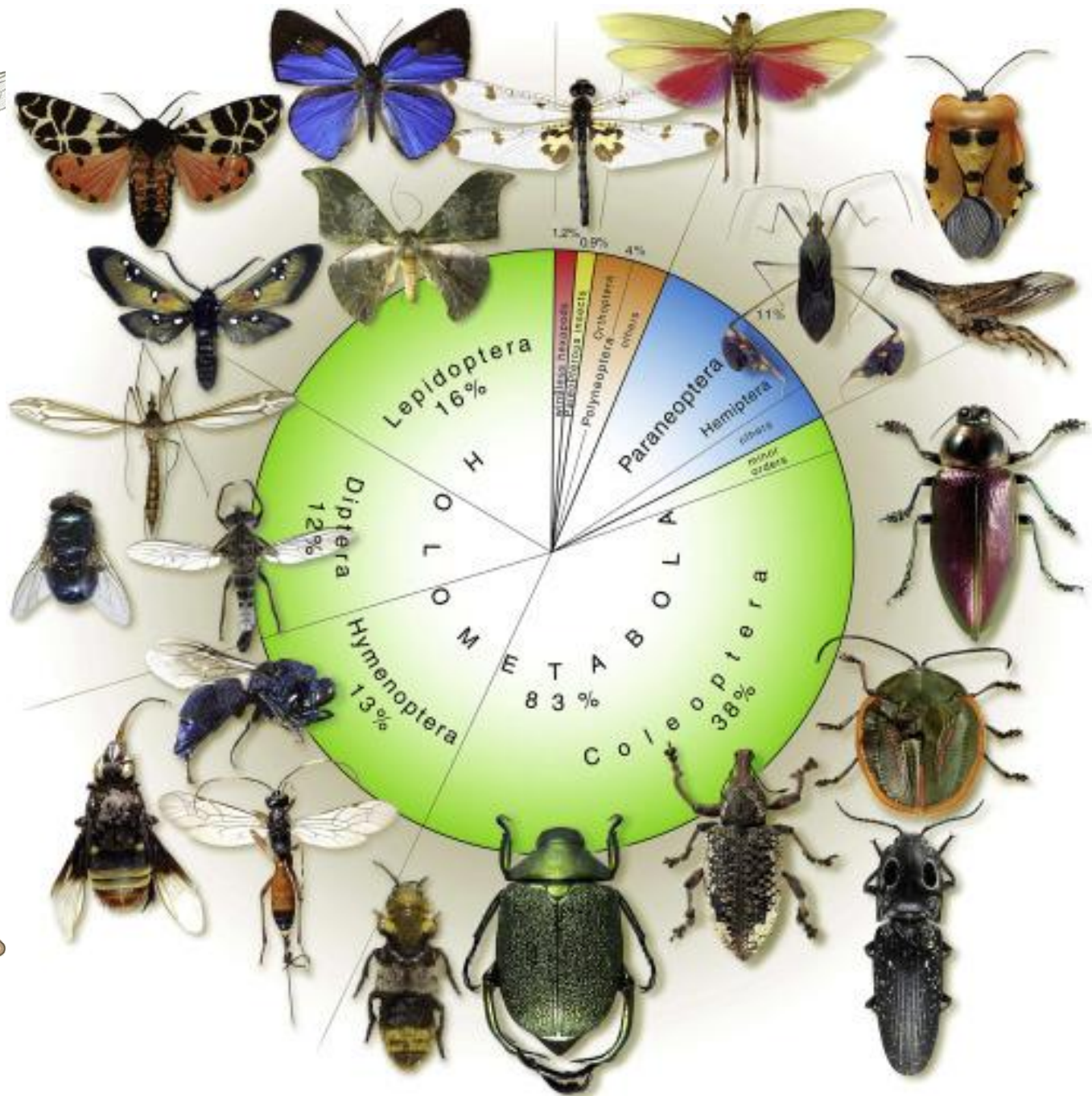


Data: Chapman 2009

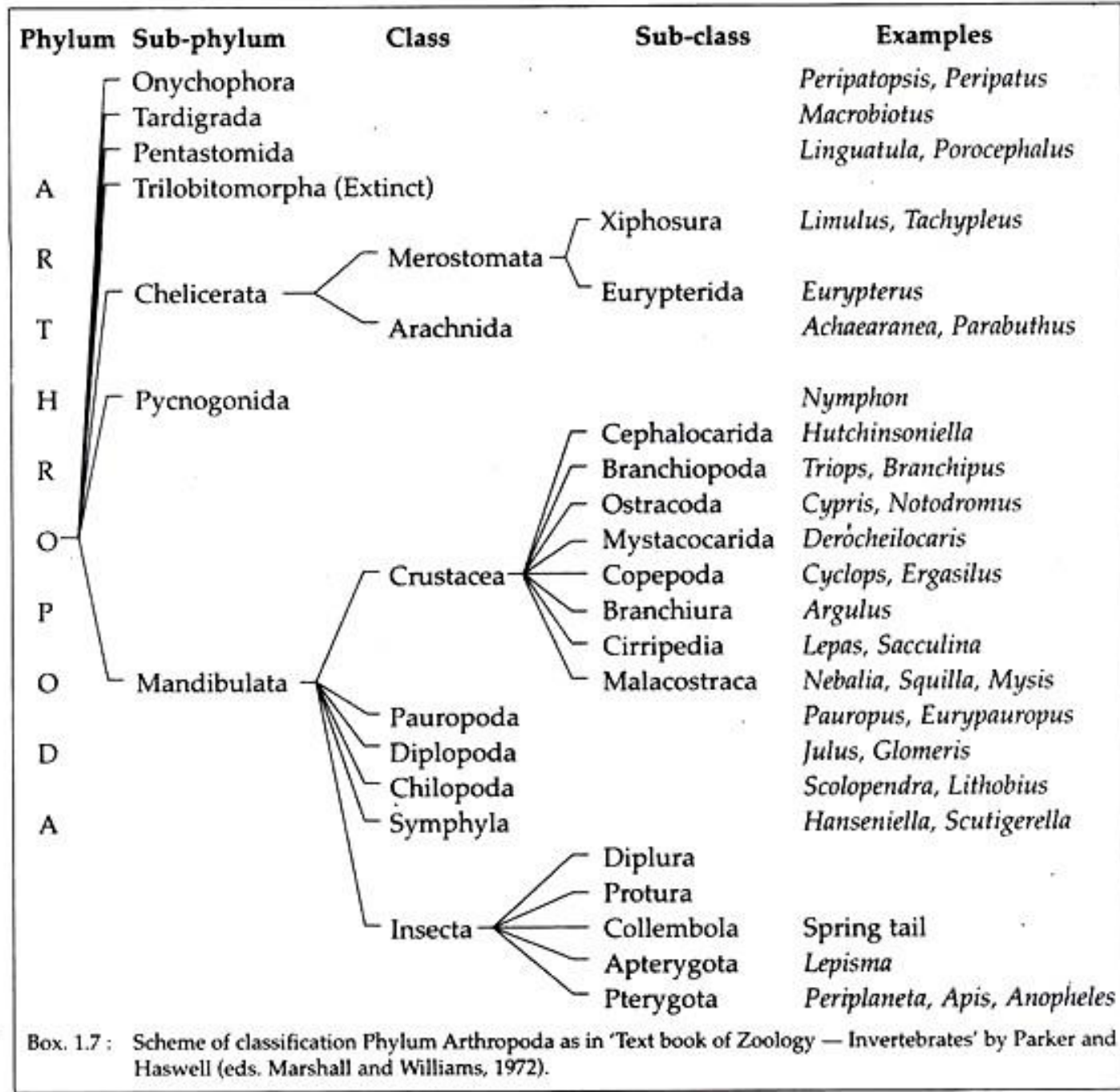
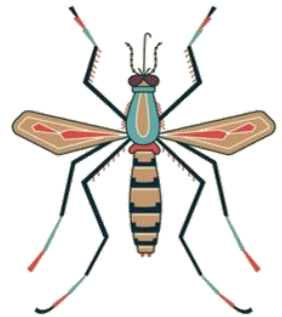
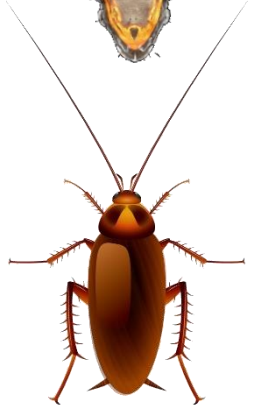
Art: Cara Gibson 2015



Insect Order Diversity



Evolution of Insects



Box. 1.7 : Scheme of classification Phylum Arthropoda as in 'Text book of Zoology — Invertebrates' by Parker and Haswell (eds. Marshall and Williams, 1972).

Naming and Classifying Insect

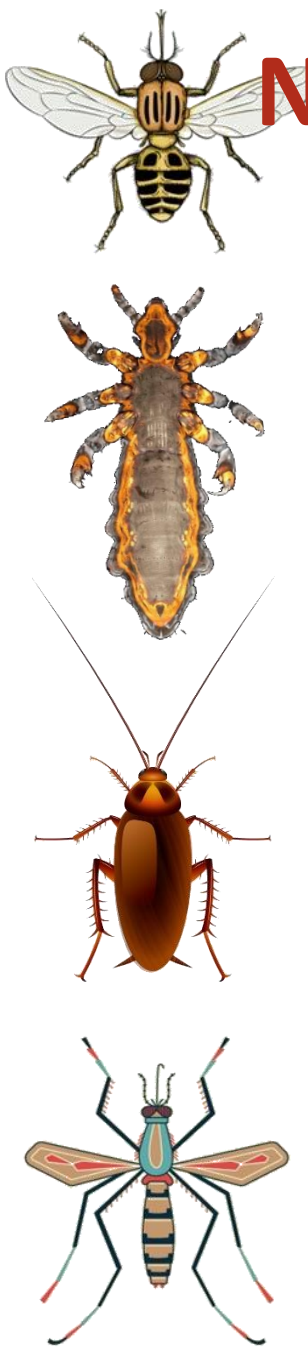




Table 1.1 Taxonomic categories (obligatory categories are shown in **bold**).

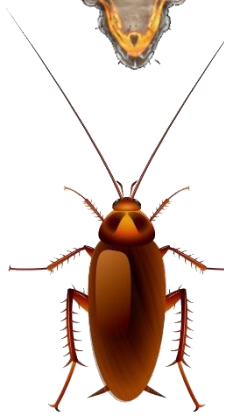
Taxon category	Standard suffix	Example
Order		Hymenoptera
Suborder		Apocrita
Superfamily	-oidea	Apoidea
Family	-idae	Apidae
Subfamily	-inae	Apinae
Tribe	-ini	Apini
Genus		<i>Apis</i>
Subgenus		
Species		<i>A. mellifera</i>
Subspecies		<i>A. m. mellifera</i>

TABLE 1.1 Outline of the Hexapoda (following Borror et al. 1989)



 Entognatha


- 
1. Protura (Myrientomata) — proturans
 2. Collembola (Oligentomata) — springtails
 3. Diplura (Entognatha, Entotrophi, Aptera) — diplurans

Insecta

- 
4. Microcoryphia (Archaeognatha; Thysanura, Ectognatha, and Ectotrophi in part) — bristletails
 5. Thysanura (Ectognatha, Ectotrophi, Zygentoma) — silverfish, firebrats

Pterygota — winged and secondarily wingless insects

- 
6. Ephemeroptera (Ephemera, Plecoptera) — mayflies
 7. Odonata — dragonflies and damselflies
 8. Grylloblattaria (Grylloblattodea, Notoptera) — rock crawlers
 9. Phasmida (Phasmatida, Phasmatoptera, Phasmatodea, Cheleutoptera; Orthoptera in part) — walkingsticks and timemas
 10. Orthoptera (Saltatoria, including Grylloptera) — grasshoppers and crickets
 11. Mantodea (Orthoptera, Dictyoptera, Dictuoptera in part) — mantids
 12. Blattaria (Blattodea; Orthoptera, Dictyoptera, Dictuoptera in part) — cockroaches

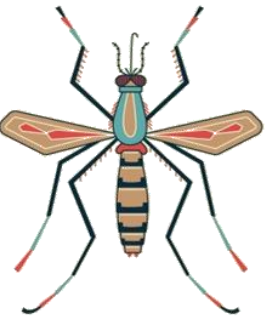
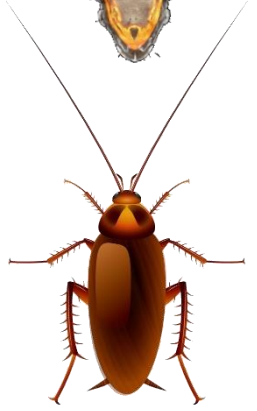
- 
13. Isoptera (Dictyoptera, Dictuoptera in part) — termites
 14. Dermaptera (Euplexoptera) — earwigs
 15. Embiidina (Embioptera) — webspinners
 16. Plecoptera — stone flies
 17. Zoraptera — zorapterans
 18. Psocoptera (Corrodentia) — psocids
 19. Phthiraptera (Mallophaga, Anoplura, Siphunculata) — lice
 20. Heteroptera (Hemiptera) — bugs
 21. Homoptera (Hemiptera in part) — cicadas, hoppers, psyllids, whiteflies, aphids, and scale insects
 22. Thysanoptera (Physapoda) — thrips
 23. Neuroptera (including Megaloptera and Raphidioptera) — alderflies, dobsonflies, fishflies, snakeflies, lacewings, antlions, and owlflies
 24. Coleoptera — beetles
 25. Strepsiptera (Coleoptera in part) — twisted-wing parasites
 26. Mecoptera (including Neomecoptera) — scorpion flies
 27. Siphonaptera — fleas
 28. Diptera — flies
 29. Trichoptera — caddisflies
 30. Lepidoptera (including Zeugloptera) — butterflies and moths
 31. Hymenoptera — sawflies, ichneumonids, chalcids, ants, wasps, and bees



Class/order	Common names	Important as
<i>HEXAPODA</i>		
Collembola	Springtails	Detritivores (note that Collembola are noninsect hexapods)

INSECTA
 Exopterogota—insects with simple metamorphosis

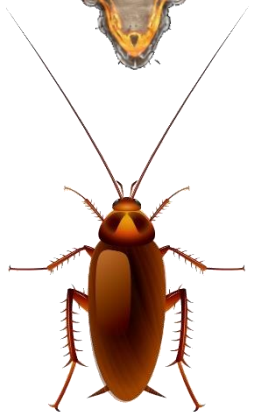
Ephemeroptera	Mayflies	Aquatic scrapers
Odonata	Dragonflies and damselflies	Aquatic and terrestrial predators
Orthoptera	Grasshoppers, locusts, katydids, and crickets	Herbivores and detritivores, including many crop pests
Phasmatodea	Walkingsticks and leaf insects	Herbivores
Dermaptera	Earwigs	Primarily detritivorous, but some herbivores
Plecoptera	Stoneflies	Aquatic herbivores, detritivores, and predators
Blattodea	Cockroaches and termites	Detritivores, including household pests
Mantodea	Mantises	Predators
Hemiptera	True bugs, cicadas, hoppers, aphids, and scale insects	Herbivores, including many crop pests and disease vectors, and predators
Thysanoptera	Thrips	Pollen feeders and predators
Psocoptera	Bark and book lice	Detritivores
Phthiraptera	Lice	Parasites and disease vectors





Endopterogota—insects with complex metamorphosis

Coleoptera	Beetles	The largest order, with 40% of the known species of hexapods; herbivores, including major crop pests, detritivores, and predators
Neuroptera	Lacewings, snakeflies, alderflies, and antlions	Predators
Hymenoptera	Sawflies, bees, wasps, and ants	Herbivores, including pollinators, predators, and omnivores
Trichoptera	Caddisflies	Aquatic filter-feeders
Lepidoptera	Butterflies and moths	Herbivores, including many crop pests, and pollinators
Siphonaptera	Fleas	Parasites and disease vectors
Mecoptera	Scorpionflies	Predators and detritivores
Diptera	True flies	Herbivores, detritivores, predators, and parasites, including many disease vectors
Chilopoda	Centipedes	Predators
Diplopoda	Millipedes	Detritivores
Crustacea	Crustaceans	Aquatic or semiaquatic herbivores, detritivores, and predators
Arachnida	Spiders, mites, and scorpions	Herbivores, detritivores, predators, and parasites, including many disease vectors



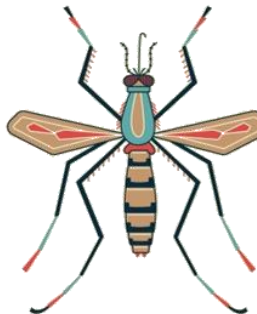
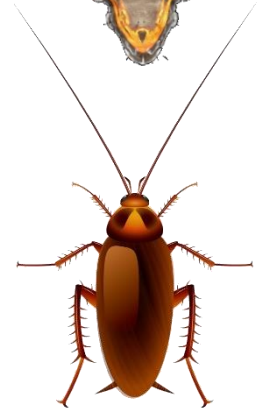


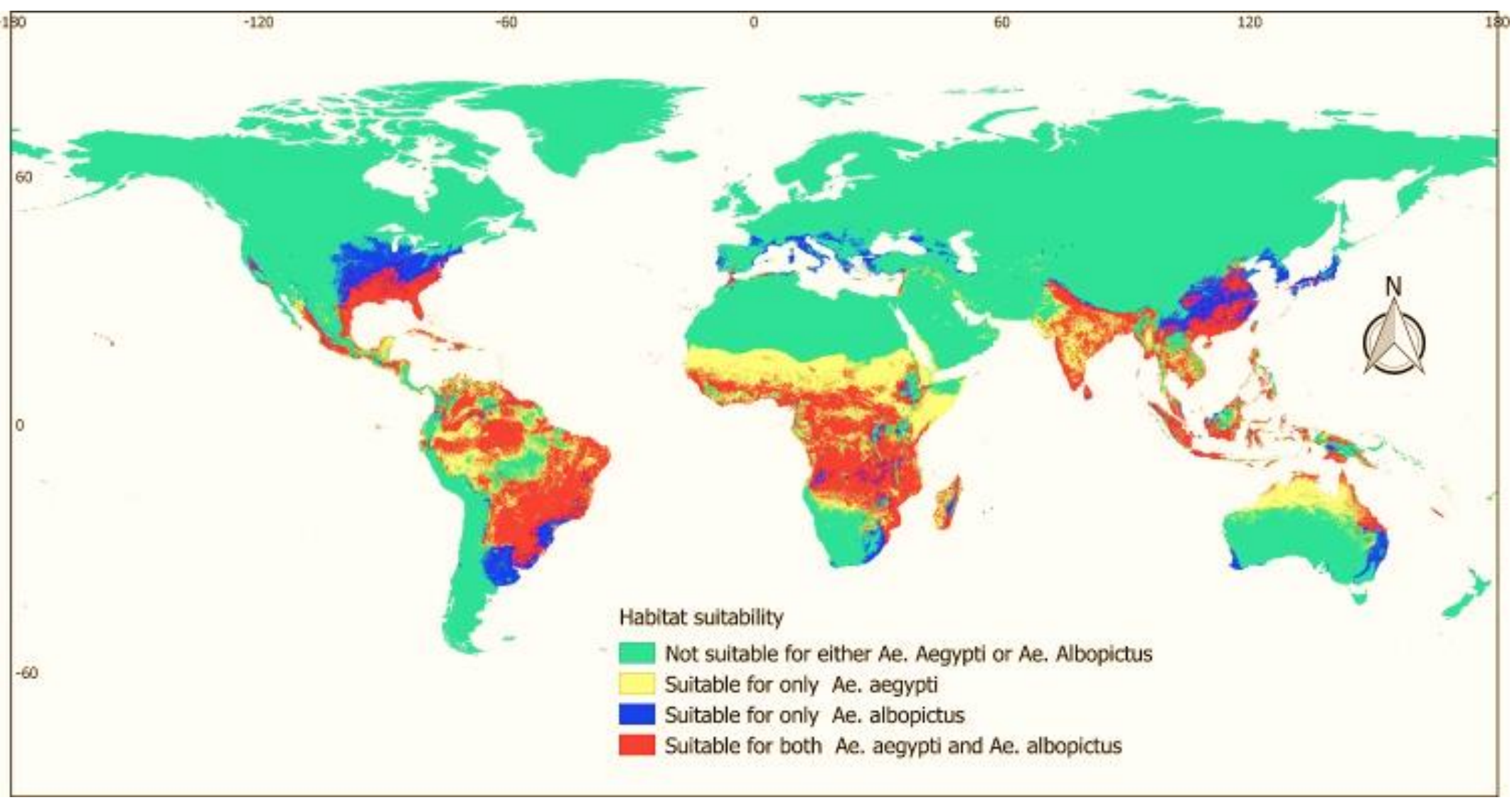
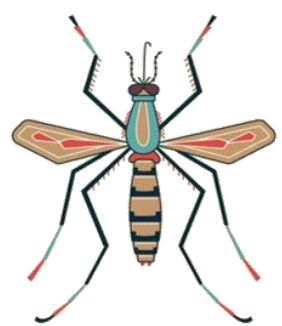
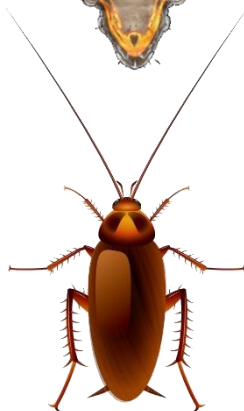
Distribution of Insect Species Richness

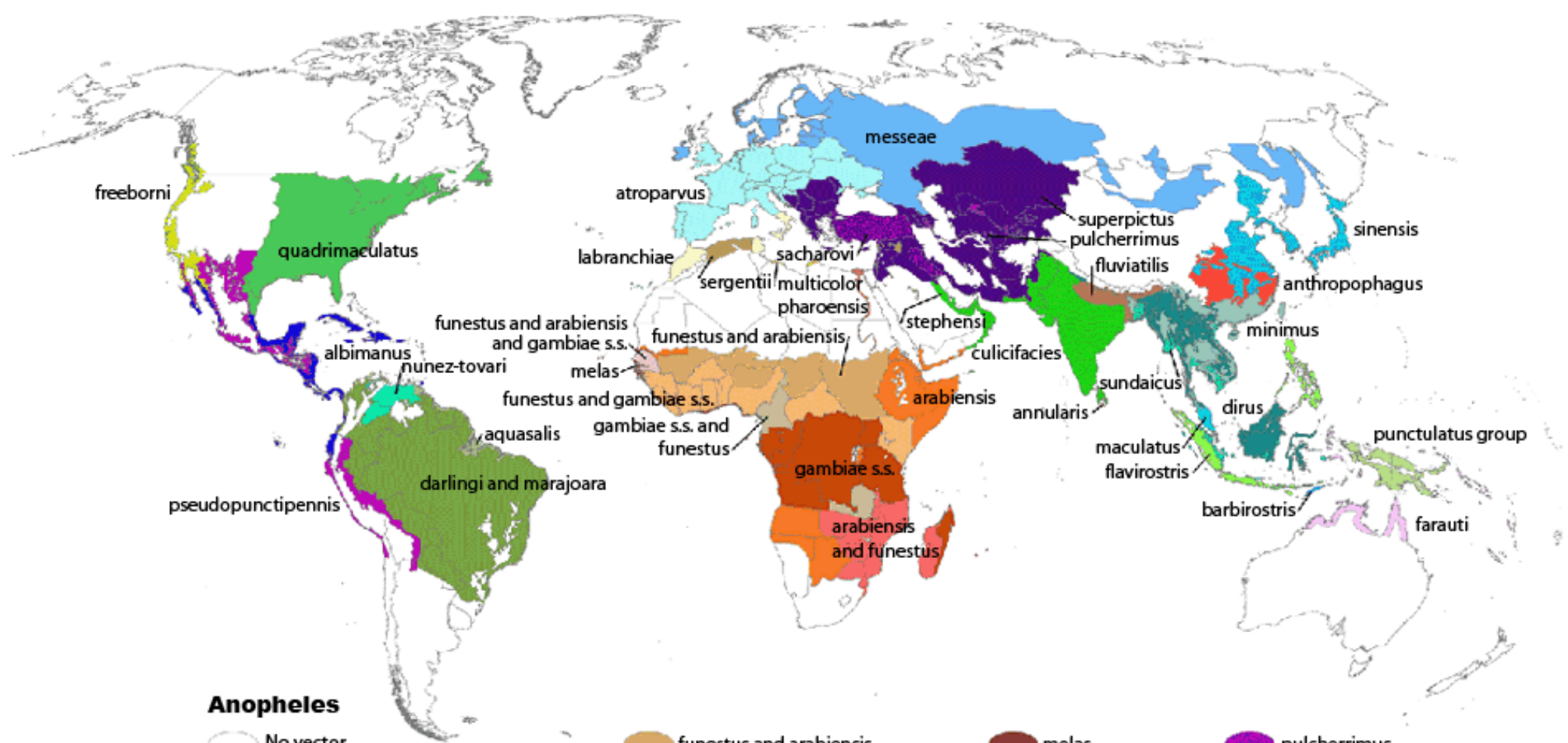
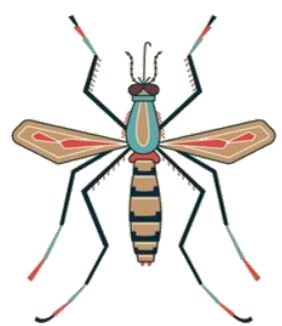
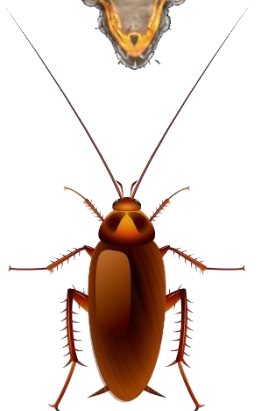
- The regions in which additional undescribed insect species might occur cannot be in the northern hemisphere, where such hidden diversity in the well-studied faunas is unlikely.

- Evidently, just as species-richness patterns are uneven across groups, so too is their geographic distribution.

- Tropical species richness appears to be much higher than that of temperate areas







Anopheles

- No vector
- albimanus
- annularis
- anthropophagus
- arabiensis
- arabiensis and funestus
- aquasalis
- atroparvus
- barbirostris
- culicifacies
- dirus
- farauti
- flavirostris
- fluviatilis
- freeborni
- funestus and arabiensis
- funestus, arabiensis and gambiae s.s.
- funestus and gambiae s.s.
- gambiae s.s.
- gambiae s.s. and funestus
- labranchiae
- maculatus
- darlingi and marajoara
- melas
- messeeae
- minimus
- multicolor
- nunez-tovari
- punctulatus group
- pharoensis
- pseudopunctipennis
- pulcherrimus
- quadrimaculatus
- sacharovi
- sergentii
- sinensis
- stephensi
- sundaicus
- superpictus

ARTHROPODS

Chelicerata
(claw mouth)

Crustacea
(hard shelled)

Insecta
(segmented)

Myriapoda
(many feet)

Trilobita
(three lobed)

Feeding
pincers

No Antennae

Several pairs of
jointed legs
Hard protective
outer shelves
Two pairs of
antennae
Eyes at the end
of the stalk

Three body
parts

Six legs

Exoskeleton

Two antennae

Head and long
repeating
trunk

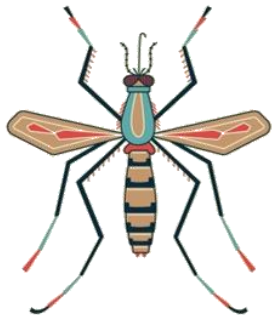
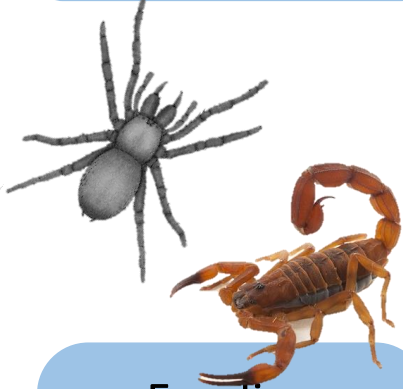
Two antennae

Many legs

Three lateral
body parts

Segmented
thorax

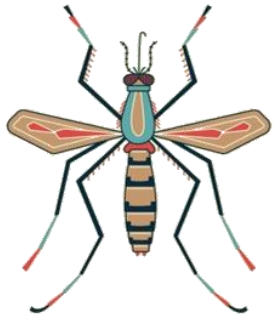
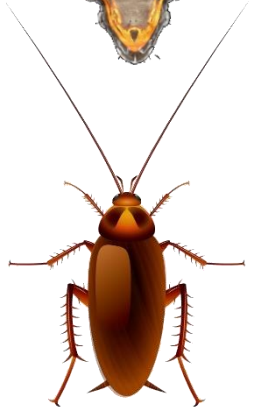
Tail section





Medical Entomology

- Study of insects, insect-borne diseases, and other associated problems that affect humans and public health.



Arthropod Orders of Medical Importance

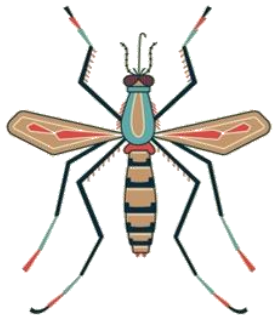
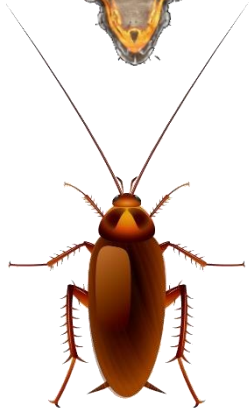


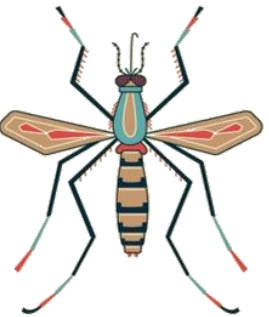
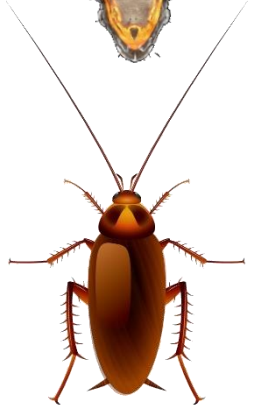
TABLE 1.1 Principal Orders of Insects and Arachnids of Medical-Veterinary Interest

Order	Common Names
Class INSECTA	
Order Blattaria	Cockroaches
Order Phthiraptera	Lice
Order Hemiptera	True bugs: bedbugs, kissing bugs, assassin bugs
Order Coleoptera	Beetles
Order Siphonaptera	Fleas
Order Diptera	Flies: mosquitoes, black flies, no-see-ums, horse flies, deer flies, sand flies, tsetse flies, house flies, stable flies, horn flies, bot flies, blow flies, flesh flies, louse flies, keds, etc.
Order Lepidoptera	Moths and butterflies
Order Hymenoptera	Wasps, hornets, velvet ants, ants, bees
Class ARACHNIDA	
Order Scorpionida	Scorpions
Order Solpugida	Solpugids, sun spiders, camel spiders, barrel spiders
Order Acari	Mites, ticks
Order Araneae	Spiders



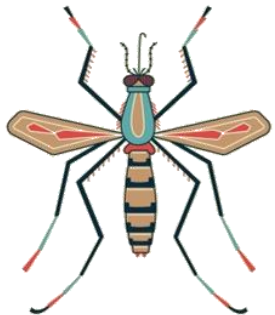
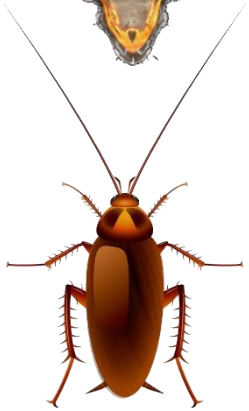
Type of Problems Caused by Arthropods

- Annoyance due to biting and non-biting activities.

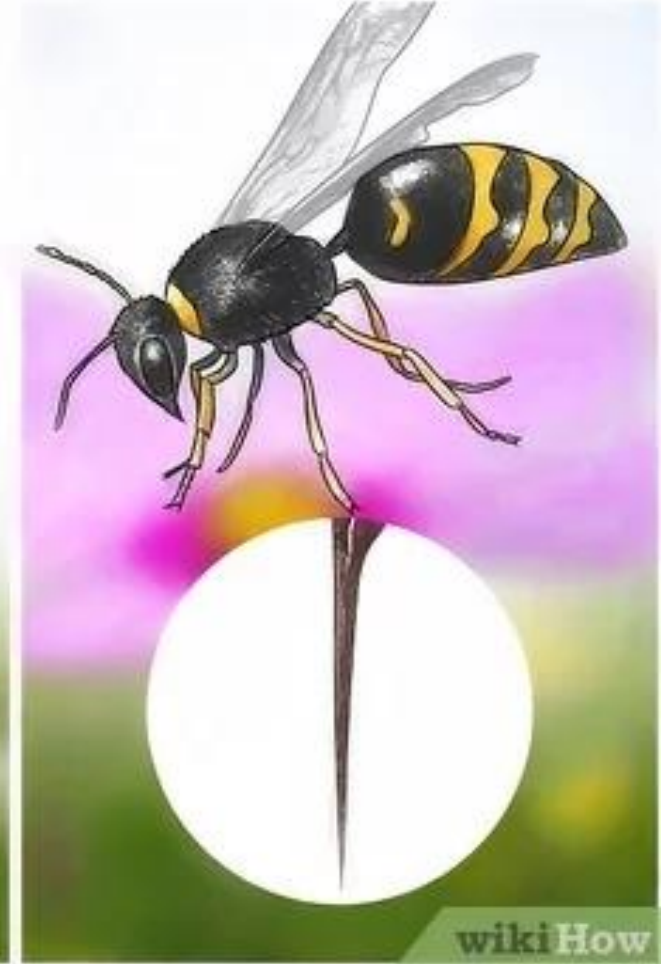
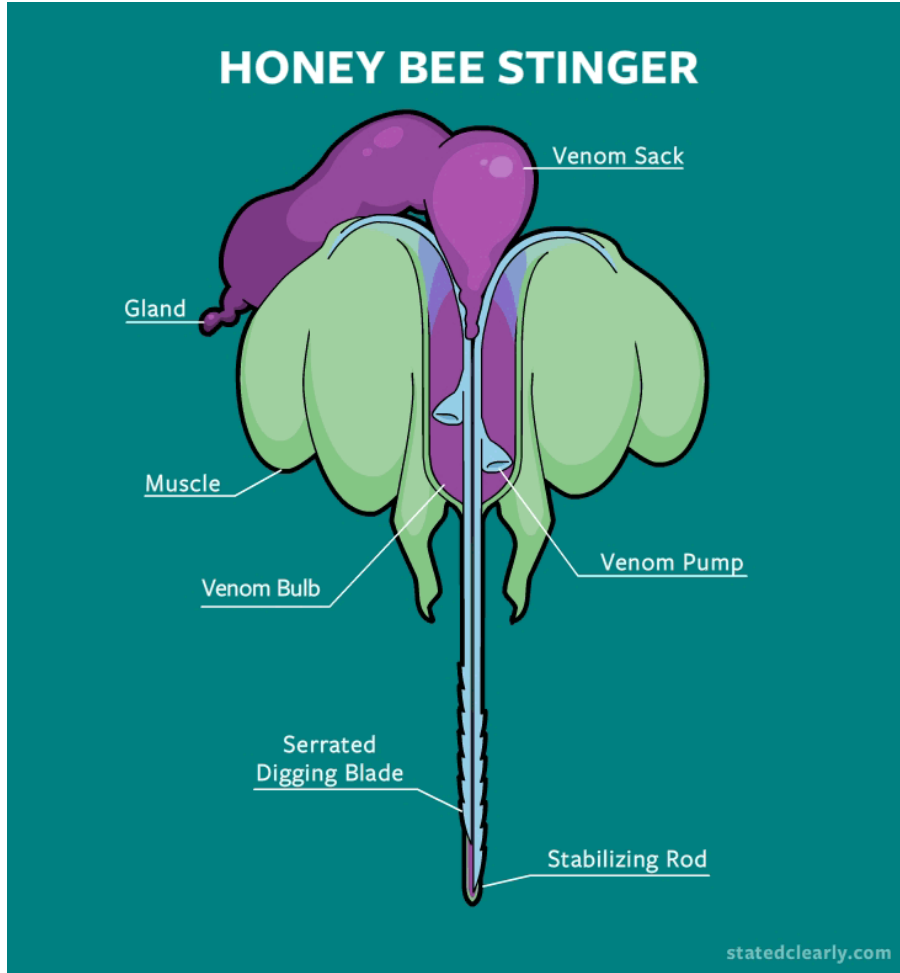
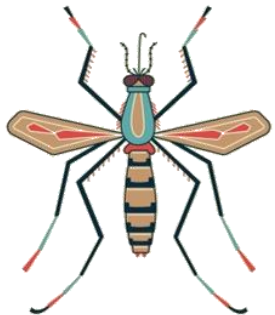
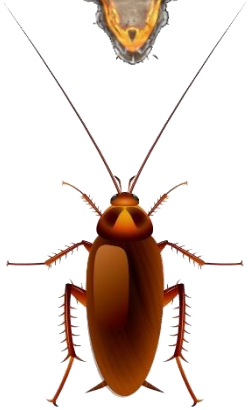


• **Toxins and Venoms**

- **Poison** – any substance that when it enters the body affects normal physiological function.
- **Toxins** – poison of plant or animal origin that results to toxicosis.
- **Venom** – is a poisonous mixture of compounds containing 1 or more toxins, w/c is produced in a venom gland and injected using a specialized morphological structure.

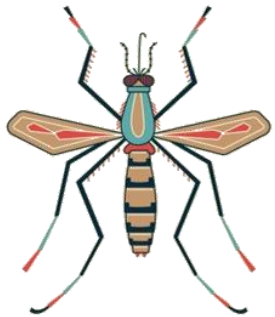
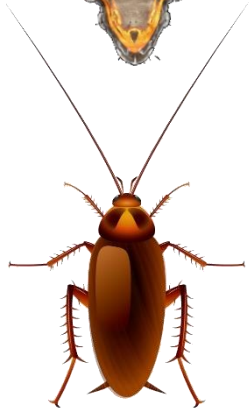


• Toxins and Venoms



- **Allergic reactions**

- A wide spectrum of allergic reactions can occur in humans through bites, direct contact allergies and inhaling allergenic airborne particles insects.



Five-stage sequence in allergic reactions

Involves no skin reaction but leads to hypersensitivity

Immediate-sensitivity then hypersensitivity reaction

No reaction (or the victim is desensitized)

Stages

1

2

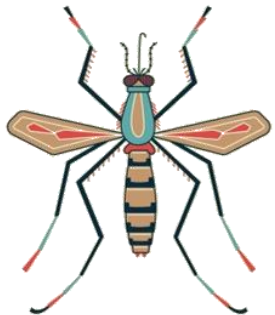
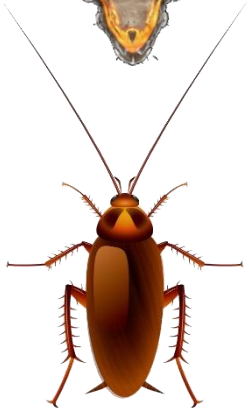
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4

5

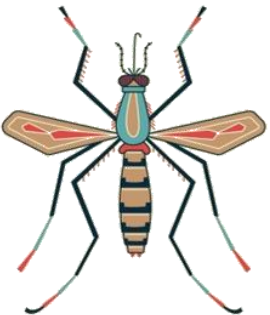
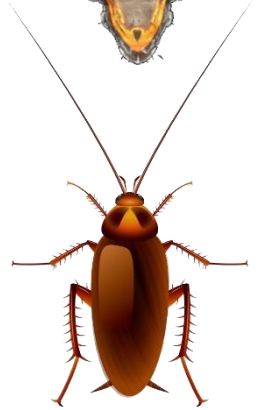
delayed-hypersensitivity reaction

Immediate-sensitivity reaction only



• Invasion of Host Tissue

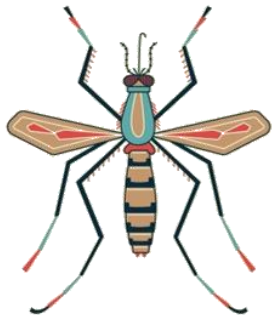
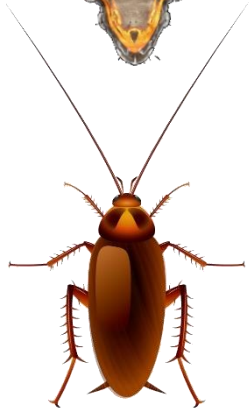
- Some arthropods invade the body tissues of their host.
- Degrees of invasion varying from subcutaneous infestations to invasion of organs such as the lungs and intestines.
- Invasion of tissues by fly larvae is called **myiasis**.



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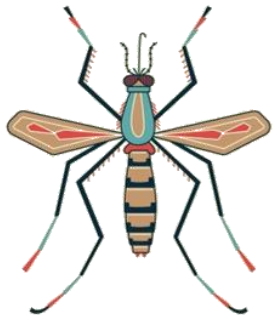
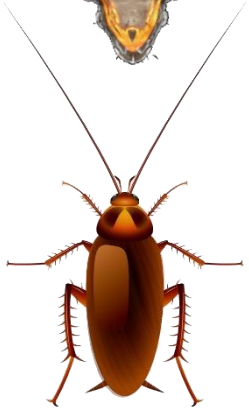
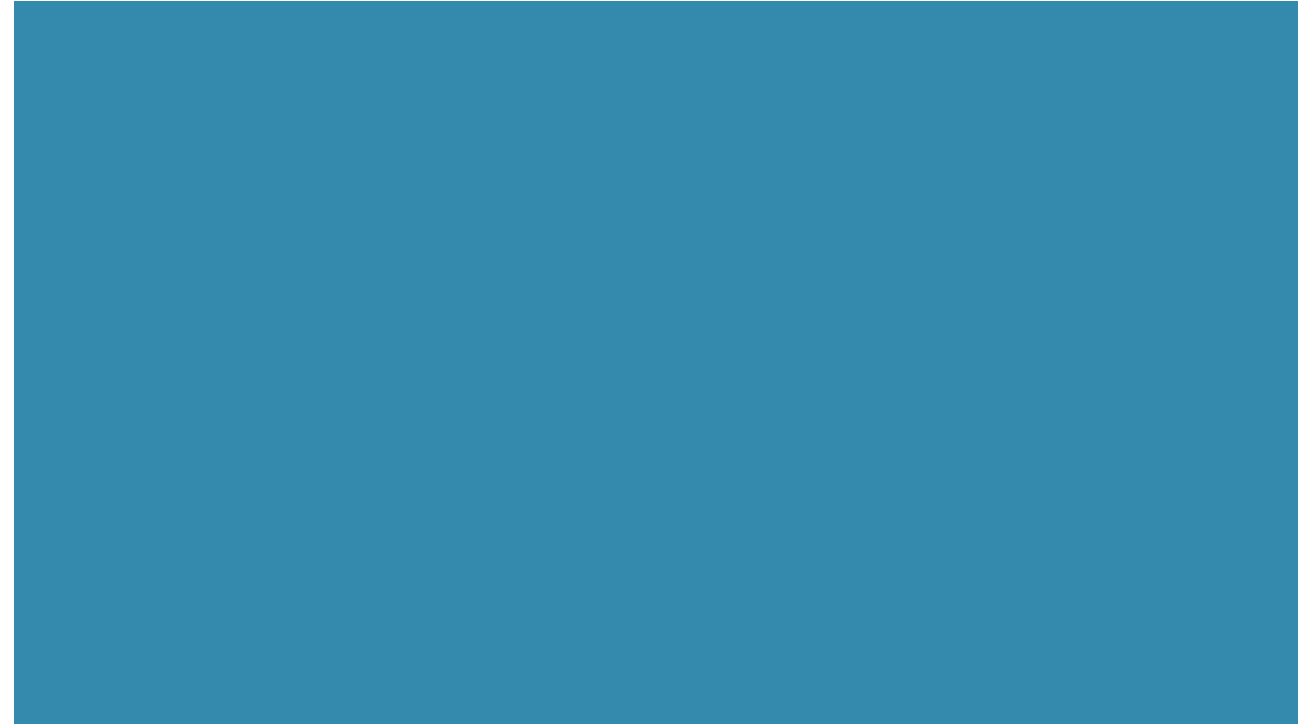
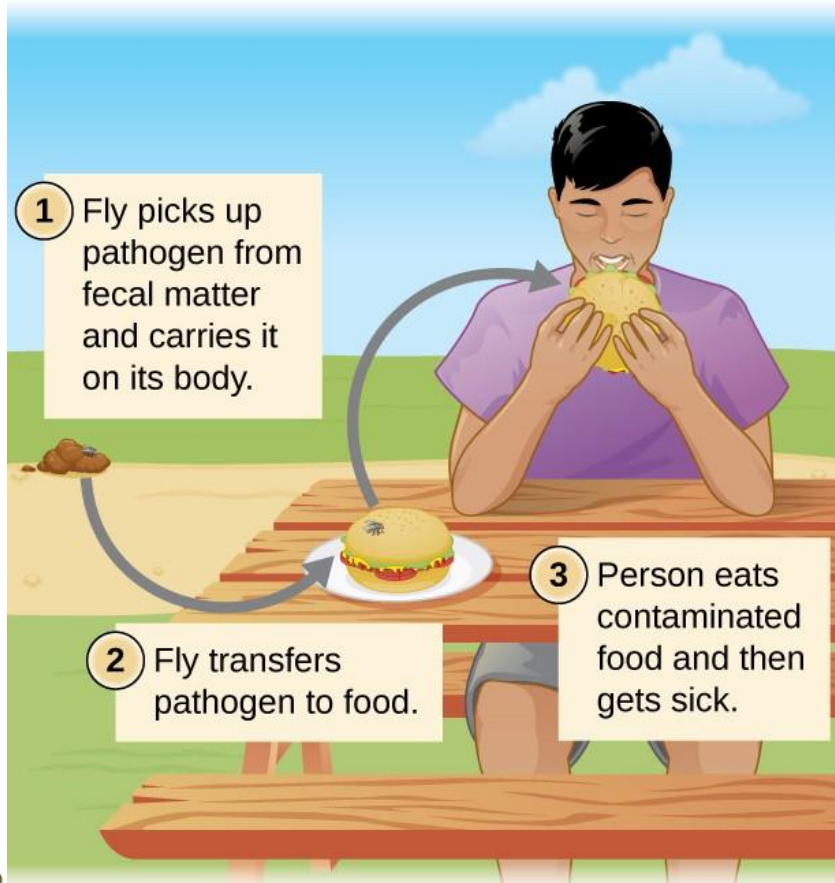
Arthropod-Borne Diseases



Arthropod Vectors	Diseases Grouped by Causative Agents
Mosquitoes	<p>VIRUSES: yellow fever, dengue, Rift Valley fever, myxomatosis; Eastern equine encephalomyelitis, Western equine encephalomyelitis, Venezuelan equine encephalomyelitis, St. Louis encephalitis, LaCrosse encephalitis, Japanese encephalitis, Murray Valley encephalitis, Chikungunya fever, Onyong nyong fever, Ross River fever, West Nile fever, Zika encephalitis</p> <p>PROTOZOANS: malaria</p> <p>FILARIAL NEMATODES: Wuchererian filariasis, Bancroftian filariasis, dog heartworm</p>
Black flies	<p>FILARIAL NEMATODES: human onchocerciasis (river blindness), bovine onchocerciasis</p>
Biting midges	<p>VIRUSES: bluetongue disease, epizootic hemorrhagic disease, African horse sickness, leucocytozoonosis, Oropouche fever</p> <p>FILARIAL NEMATODES: equine onchocerciasis, mansonellosis</p>
Sand flies	<p>VIRUSES: sand fly fever, vesicular stomatitis. BACTERIA: Oroya fever (Veruga Peruana)</p> <p>PROTOZOANS: leishmaniasis</p>
Horse flies and deer flies	<p>VIRUSES: equine infectious anemia, hog cholera</p> <p>BACTERIA: tularemia</p> <p>PROTOZOANS: surra (livestock trypanosomiasis)</p> <p>FILARIAL NEMATODES: loiasis, elaeophorosis</p>
Tsetse flies	<p>PROTOZOANS: African trypanosomiasis, nagana</p>
Triatomine bugs	<p>PROTOZOANS: American trypanosomiasis (Chagas disease)</p>
Lice	<p>VIRUSES: swine pox.</p> <p>BACTERIA: epidemic typhus, trench fever, louse-borne relapsing fever</p>
Fleas	<p>VIRUSES: myxomatosis</p> <p>BACTERIA: plague, murine (endemic) typhus, tularemia, cat flea rickettsiosis, cat scratch disease</p>

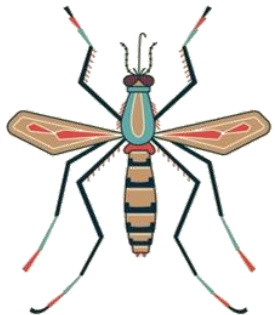
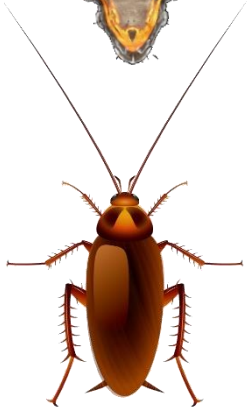
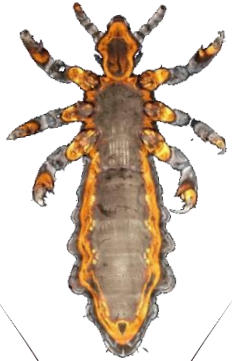
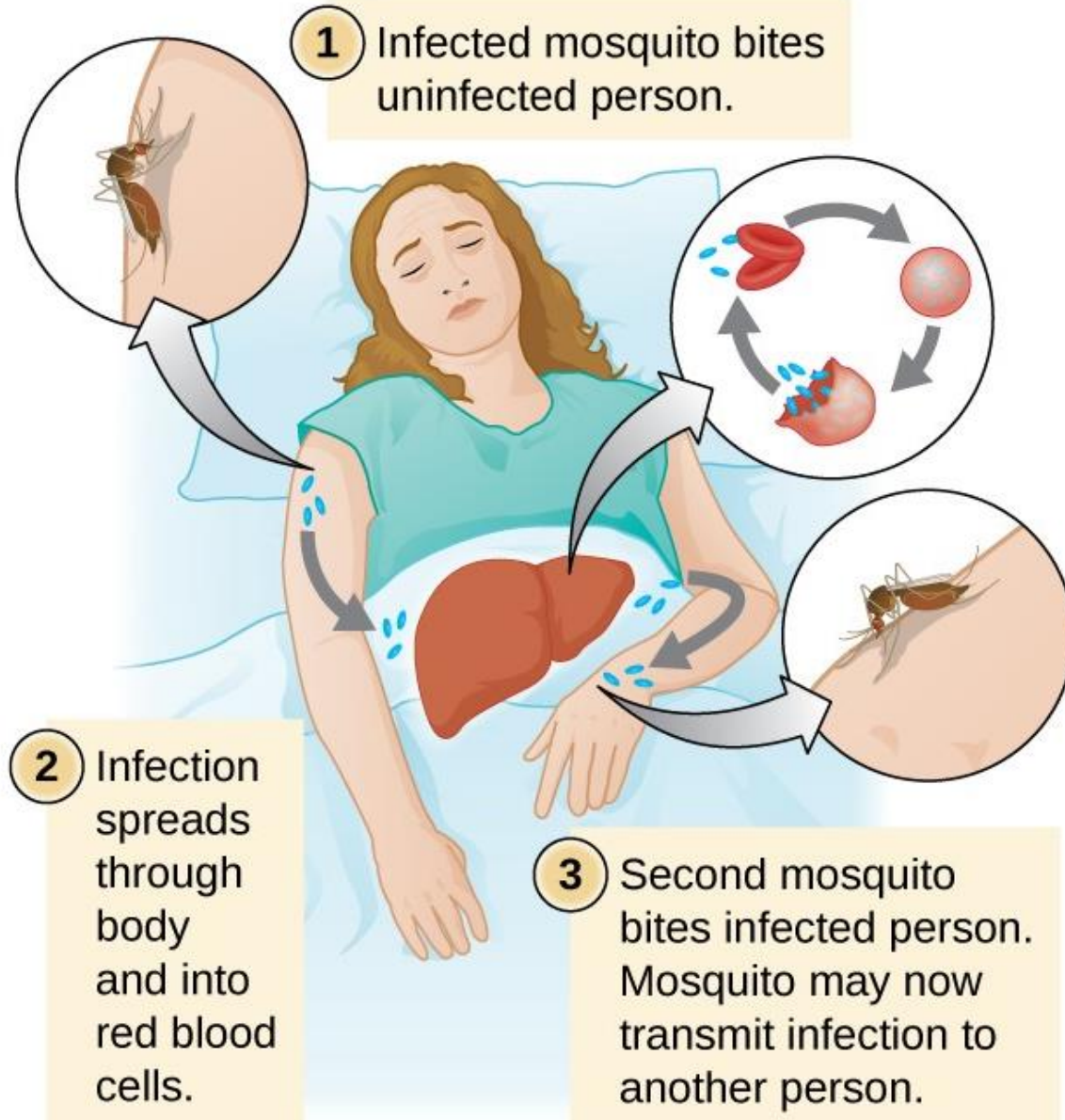
Modes of Pathogen Transmission

- Mechanical Transmission



Modes of Pathogen Transmission

• Biological Transmission



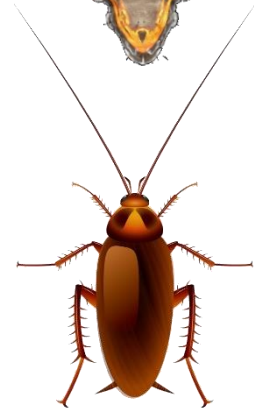
Other Health Related Conditions Associated with Insects and Arthropods



- **Entomophobia, Arachnophobia, and Acarophobia.**

- Delusional disorders variously known as **delusory parasitosis, delusional parasitosis, delusions of parasitosis, Ekbom syndrome, and Elliott disease.** (Fear/phobia w/ psychological problems)

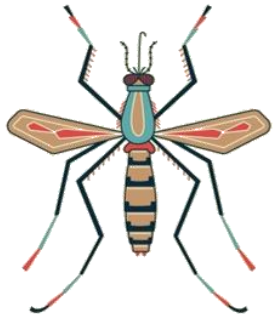
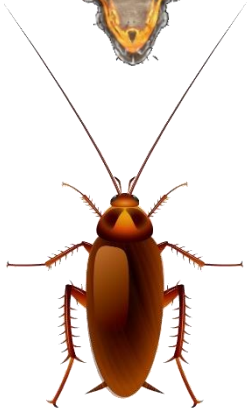
- **Formicophilia** is an unusual human psychosexual disorder, where an individual experiences self-induced sexueroptic arousal and orgasm when ants, cockroaches, or other small creatures (e.g., snails) are allowed to crawl, creep, or nibble on the body, notably, the genitalia, perianal area, or nipples.





Host Defenses

- **Behavioral defenses** include evasive, offensive, or defensive action against biting flies such as mosquitoes, black flies, ceratopogonids, stable flies, and horse flies.
- **Immunological defenses** against arthropods vary with different arthropods and with respect to previous exposure to the same or antigenically related taxa.



Insects Counter Measures to Host Defenses

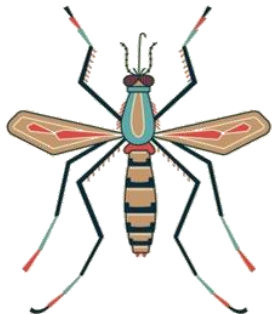
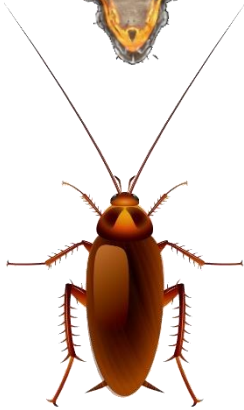


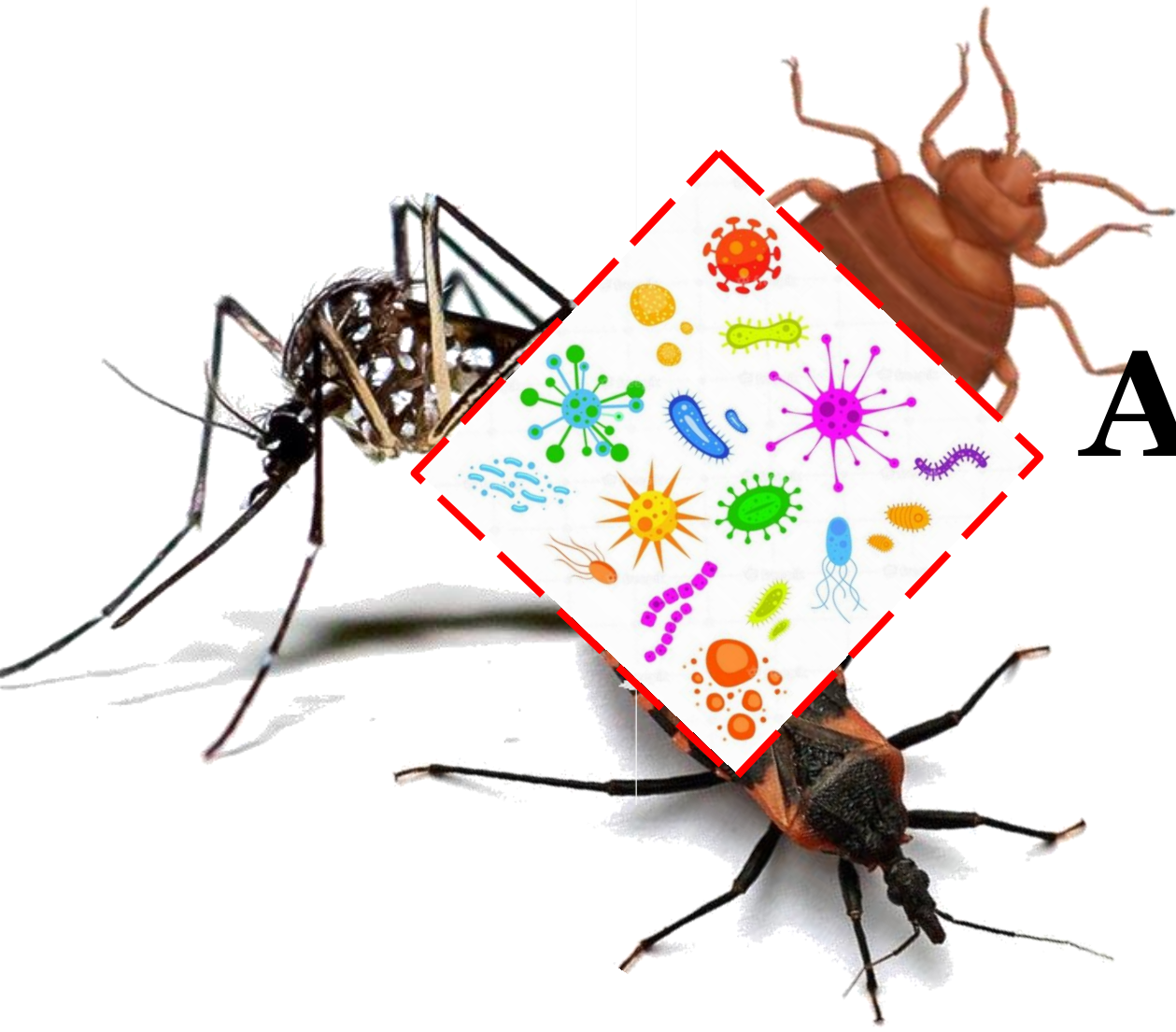
- Inoculation of immunomodulators or immunosuppressive compounds into the bite site.

- **Anticoagulants**
- **Local analgesics**
- **Apyrase**

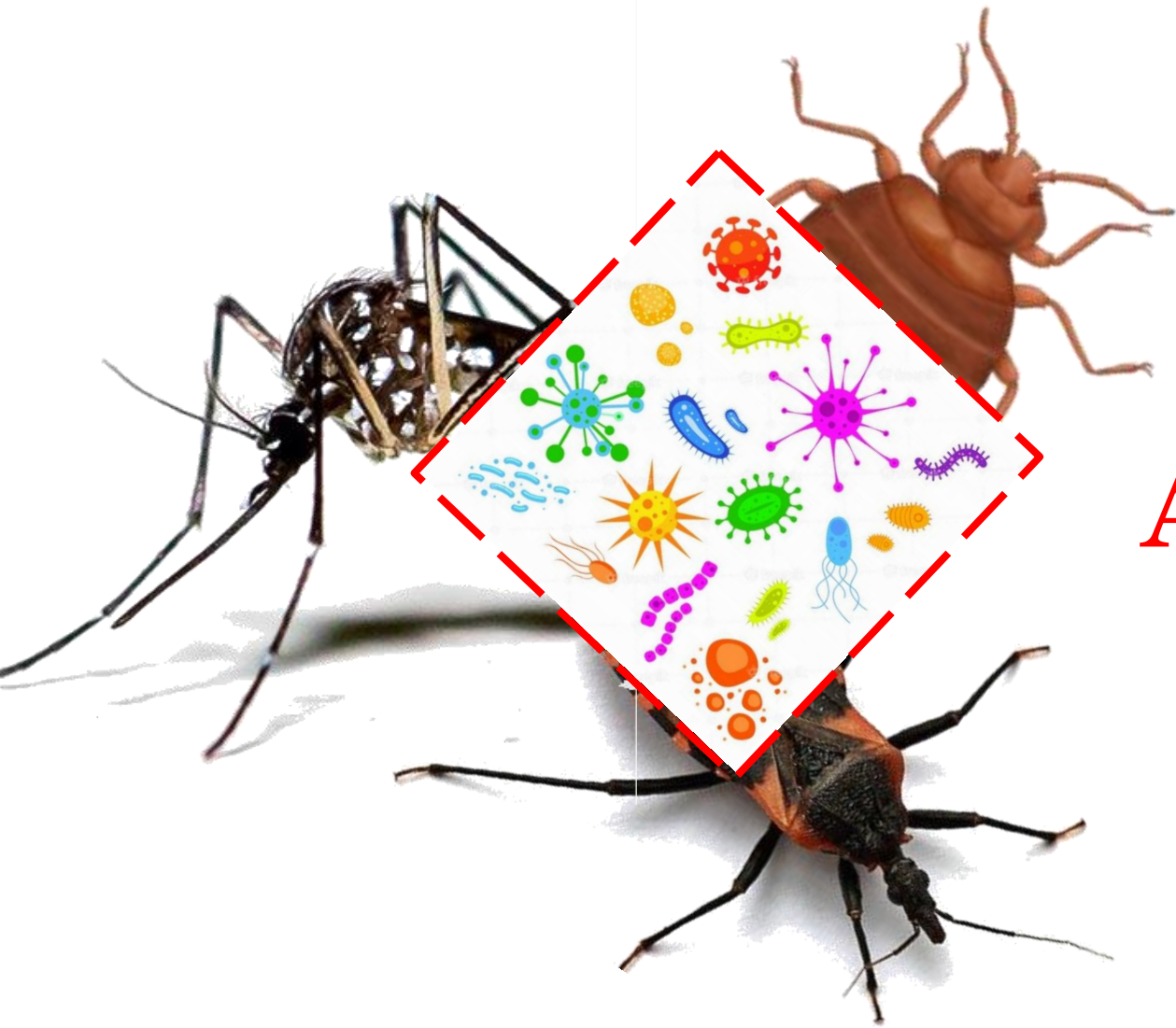
- various enzymes and other factors to promote blood or tissue digestion.

- The host immune response may tag these as antigens and may elicit an immune response, such as localized or systemic toxic responses and itching





Any Question?



Review the next topic

Evolution of Arthropods as Disease Vectors

Chapter 2, pp. 9 – 23

Biology of Disease
Vectors