Hexapoda

- External Structure and Locomotion
- Nutrition and the Digestive System
- Gas Exchange
- Circulation and Temperature Regulation
- Nervous and Sensory Functions
- Excretion
- Chemical Regulation
- Reproduction and Development

EXCRETION

ii) rectum

- ✓ In the rectum, water, certain ions, and other materials are reabsorbed, and the uric acid is eliminated.
- ✓ excretion of uric acid is advantageous for terrestrial animals because it minimizes water loss.
- ✓ The conversion of primary nitrogenous wastes (ammonia) to uric acid is energetically costly.
- ✓ Nearly half of the food energy a terrestrial insect consumes may be used to process metabolic wastes.
- ✓ In aquatic insects, ammonia simply diffuses out of the body into the surrounding water.

CHEMICAL REGULATION

- ✓ The endocrine system controls many physiological functions of insects, such as cuticular sclerotization, osmoregulation, egg maturation, cellular metabolism, gut peristalsis, and heart rate.

ECDYSIS

Neurosecretory cells of the subesophageal ganglion manufacture ecdysiotropin

↓

This hormone travels in neurosecretory cells to a structure called the corpora cardiaca

↓

The corpora cardiaca then releases thoracotropic hormone, which stimulates the prothoracic gland to secrete ecdysone.

↓

Ecdysone initiates the reabsorption of the inner portions of the procuticle and the formation of the new exoskeleton

CONTROL OF ECDYSIS

In immature stages, the corpora allata produces and releases small amounts of juvenile hormone.

The amount of juvenile hormone circulating in the hemocoel determines the nature of the next molt.

Large concentrations of juvenile hormone result in a molt to a second immature stage, intermediate concentrations result in a molt to a third immature stage, and low concentrations result in a molt to the adult stage.

Decreases in the level of circulating juvenile hormone also lead to the degeneration of the prothoracic gland

in most insects, molts cease once adulthood is reached

after the final molt, the level of juvenile hormone increases again

now it promotes the development of accessory sexual organs, yolk synthesis, and the egg maturation.

Pheromones

- ✓ Pheromones are chemicals an animal releases that cause behavioral or physiological changes in another member of the same species.
- ✓ Pheromones are often so specific that the stereoisomer of the pheromone may be ineffective in initiating a response.
- ✓ Wind or water may carry pheromones several kilometers, and a few pheromone molecules falling on a chemoreceptor of another individual may be enough to elicit a response

FUNCTIONS OF INSECT PHEROMONES

Sex pheromones—Excite or attract members of the opposite sex; accelerate or retard sexual maturation. Example: Female moths produce and release pheromones that attract males.

Caste-regulating pheromones—Used by social insects to control the development of individuals in a colony. Example: The amount of "royal jelly" fed a female bee larva determines whether the larva will become a worker or a queen.

Aggregation pheromones—Produced to attract individuals to feeding or mating sites. Example: Certain bark beetles aggregate on pine trees during an attack on a tree.

Alarm pheromones—Warn other individuals of danger; may cause orientation toward the pheromone source and elicit a subsequent attack or flight from the source. Example: A sting from one bee alarms other bees in the area, who are are likely to attack.

Trailing pheromones—Laid down by foraging insects to help other members of a colony identify the location and quantity of food found by one member of the colony. Example: Ants often trail on a pheromone path to and from a food source. The pheromone trail is reinforced each time an ant travels over it.

REPRODUCTION AND DEVELOPMENT

One of the reasons for insects' success is their high reproductive potential. Reproduction in terrestrial environments, however, has its risks. Temperature, moisture, and food supplies vary with the season. Internal fertilization requires highly evolved copulatory structures, because gametes dry quickly on exposure to air. In addition, mechanisms are required to bring males and females together at appropriate times

❖ Internal regulation:

- interactions between endocrine glands (primarily the corpora allata) and reproductive organs.

❖ External regulating factors:

- may include the quantity and quality of food, photoperiod, Population density, temperature, and humidity

❖ Mating behavior

- May involve pheromones (moths, order Lepidoptera).
- Visual signals (fireflies, order Coleoptera).
- Auditory signals (cicadas, order Homoptera; and grasshoppers, crickets, and katydids, order Orthoptera).

- ❑ Tactile stimuli from the antennae and other appendages help position the insects for mating.
- ❑ Abdominal copulatory appendages of the male usually transfer the sperm to an outpocketing of the female reproductive tract, the sperm receptacle
- ❑ Females may use an ovipositor to deposit eggs in or on some substrate.

The developmental patterns of insects reflect degrees of divergence between immatures and adults and are classified into three (or sometimes four) categories:

1) Ametabolous metamorphosis

- ✓ The primary differences between adults and larvae are body size and sexual maturity.
- ✓ Both adults and larvae are wingless.
- ✓ The number of molts in the ametabolous development of a species varies.
- ✓ molting continues after sexual maturity.
- ✓ Silverfish (order Thysanura) have ametabolous metamorphosis

2) Paurometabolous metamorphosis

- ✓ involves a species-specific number of molts between egg and adult stages, during which immatures gradually take on the adult form.
- ✓ The external wings develop, adult body size and proportions are attained, and the genitalia develop during this time.
- ✓ Immatures are called nymphs.
- ✓ Examples: Grasshoppers (order Orthoptera) and chinch bugs (order Hemiptera)

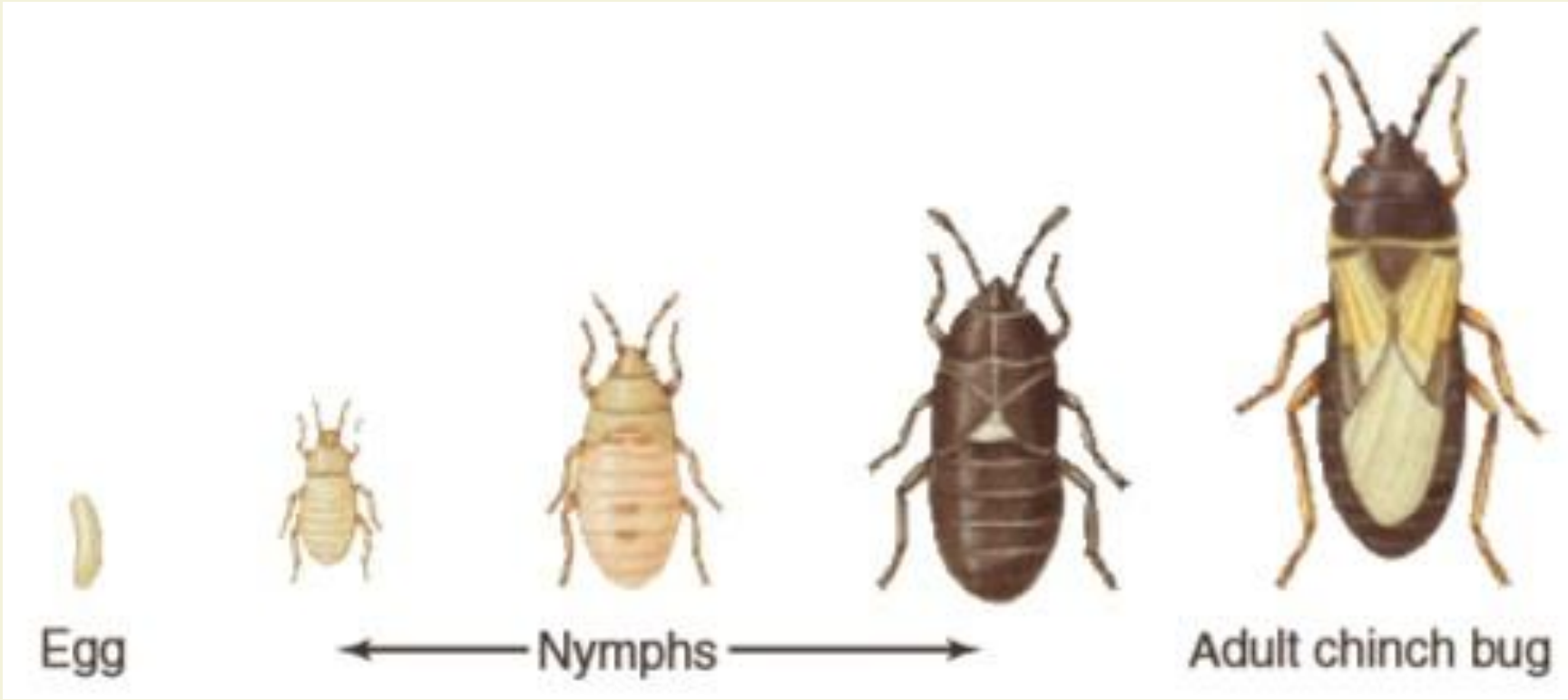

Fig: Paurometabolous Development of the Chinch Bug, *Blissus leucopterus* (Order Hemiptera). Eggs hatch into nymphs. Note the gradual increase in nymph size and the development of external wing pads. In the adult stage, the wings are fully developed, and the insect is sexually mature.

3) Hemimetabolous metamorphosis

- ✓ Immature form of insect is much different from the adult form usually due to the presence of gills (e.g., mayflies, order Ephemeroptera; dragonflies, order Odonata).
- ✓ This kind of development is called hemimetabolous metamorphosis
- ✓ The immatures are aquatic and called naiads.

4) Holometabolous metamorphosis

- ✓ Immatures are called larvae because they are very different from the adult in body form, behavior, and habitat.
- ✓ The number of larval instars is species specific, and the last larval molt forms the pupa.
- ✓ The pupa is a time of apparent inactivity but is actually a time of radical cellular change, during which all characteristics of the adult insect develop.
- ✓ A protective case may enclose the pupal stage.
- ✓ The last larval instar (e.g., moths, order Lepidoptera) constructs a cocoon partially or entirely from silk.

CONT….

- ✓ **Chrysalis**(e.g., butterflies, order Lepidoptera) and **puparium** (e.g., flies, order Diptera) are the last larval exoskeletons and are retained through the pupal stage.
- ✓ Other insects (e.g., mosquitoes, order Diptera) have pupae that are unenclosed by a larval exoskeleton, and the pupa may be active.
- ✓ The **final molt** to the adult stage usually occurs within the **cocoon**, **chrysalis**, or **puparium**, and the adult then exits, frequently using its mandibles to open the cocoon or other enclosure. This final process is called **emergence** or **eclosion**.

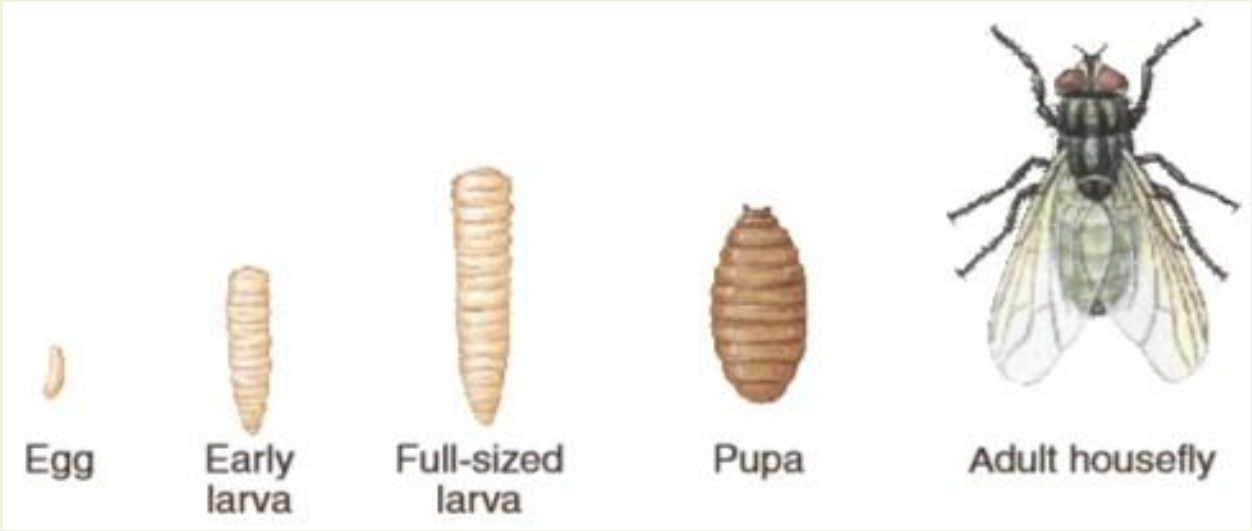

Fig: Holometabolous Development of the Housefly, *Musca domestica* (Order Diptera). The egg hatches into a larva that is different in form and habitat from the adult. After a certain number of larval instars, the insect pupates. During the pupal stage, all adult characteristics form.

INSECT BEHAVIOR

- ✓ Insects have many complex behavior patterns.
- ✓ Most of these are innate (genetically programmed).
- ✓ For example: A newly emerged queen in a honeybee hive will search out and try to destroy other queen larvae and pupae in the hive. This behavior is innate.
- ✓ Similarly, no experience taught her how queen-rearing cells differ from the cells containing worker larvae and pupae.
- ✓ Some insects are capable of learning and remembering, and these abilities play important roles in insect behavior

Social Insects

- ✓ Social behavior is particularly evident in those insects that live in colonies.
- ✓ Usually, different members of the colony are specialized, often structurally as well as behaviorally, for performing different tasks.
- ✓ Social behavior is most highly evolved in the bees, wasps, and ants (order Hymenoptera) and in termites (order Isoptera).

Example: Honeybees (order Hymenoptera)

- ✓ Have three castes in their colonies. A single queen lays all the eggs.

Workers

- ✓ Are female, and they construct the comb out of wax that they produce. They also gather nectar and pollen, feed the queen and drones, care for the larvae, and guard and clean the hive. These tasks are divided among workers according to age.

Drones

- ✓ Develop from unfertilized eggs, do not work, and are fed by workers until they leave the hive to attempt mating with a queen.

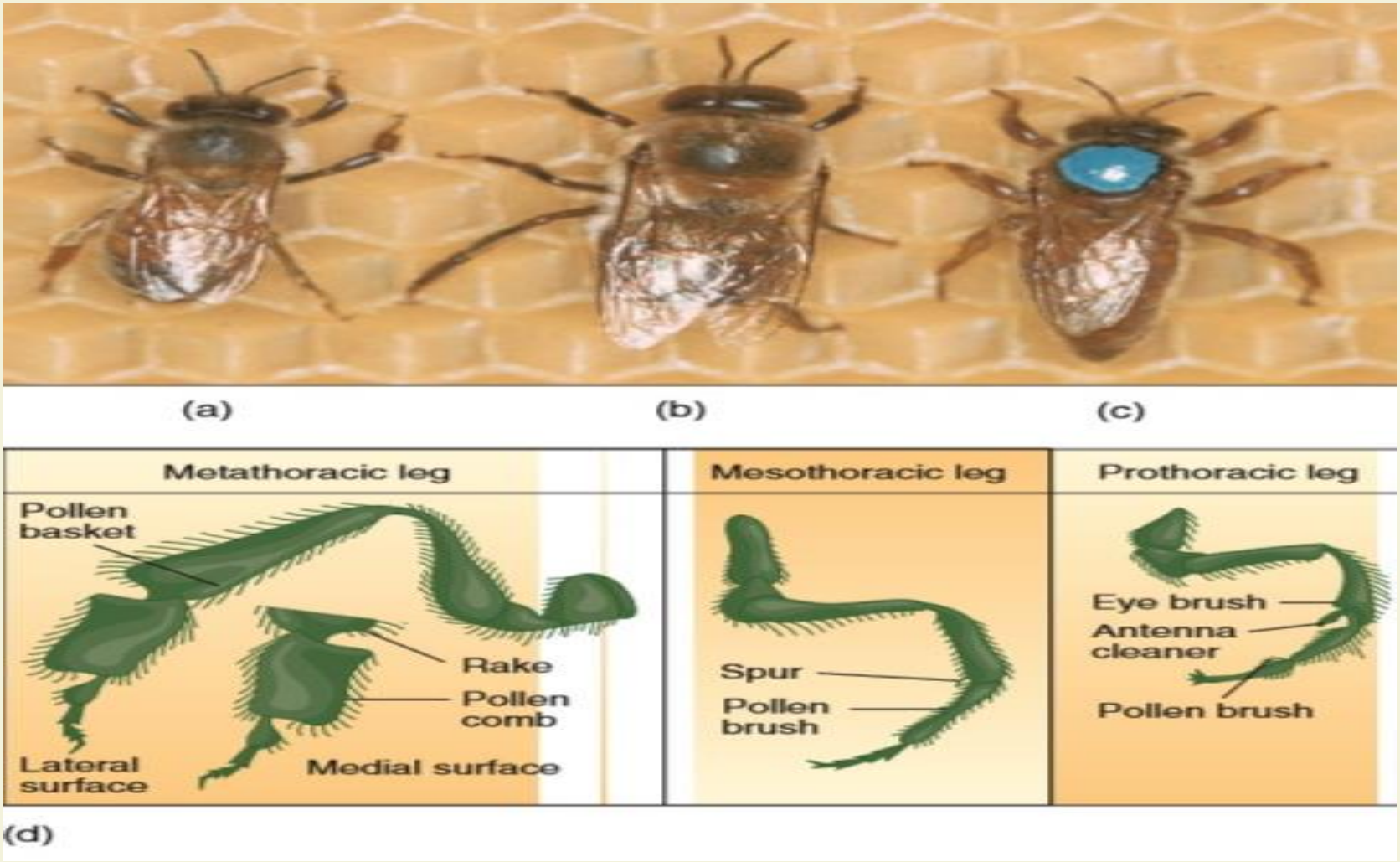

Fig: Honeybees (Order Hymenoptera). Honeybees have a social organization consisting of three castes. Eye size and overall body size distinguish the castes. (a) A worker bee. (b) A drone bee. (c) A queen bee marked with blue to identify her. (d) The inner surface of metathoracic legs have setae, called the pollen comb, that remove pollen from the mesothoracic legs and the abdomen. Pollen is then compressed into a solid mass by being squeezed in a pollen press and moved to a pollen basket on the outer surface of the leg, where the pollen is carried. The mesothoracic legs gather pollen from body parts. The prothoracic legs of a worker bee clean pollen from the antennae and body.

Casteregulating Pheromone

- ✓ A pheromone that the queen releases controls the honeybee caste system.
- ✓ Workers lick and groom the queen and other workers.
- ✓ In so doing, they pick up and pass to other workers a casteregulating pheromone.
- ✓ This pheromone inhibits the workers from rearing new queens.
- ✓ As the queen ages, or if she dies, the amount of caste-regulating pheromone in the hive decreases.
- ✓ As the pheromone decreases, workers begin to feed the food for queens ("royal jelly") to several female larvae developing in the hive.
- ✓ This food contains chemicals that promote the development of queen characteristics.
- ✓ The larvae that receive royal jelly develop into queens, and as they emerge, the new queens begin to eliminate each other until only one remains.
- ✓ The queen that remains goes on a mating flight and returns to the colony, where she lives for several years.

INSECTS AND HUMANS

- ✓ Only about 0.5% of insect species adversely affect human health and welfare.
- ✓ Provided commercially valuable products, such as wax, honey, and silk etc.
- ✓ Insects are responsible for the pollination of approximately 65% of all plant species.
- ✓ Insects are also agents of biological control.
- ✓ Soil-dwelling insects play important roles in aeration, drainage, and turnover of soil, and they promote decay processes.
- ✓ Insects are used in teaching and research, and have contributed to advances in genetics, population ecology, and physiology.
- ✓ Parasitic insects include head, body, and pubic lice (order Anoplura); bedbugs (order Hemiptera); and fleas (order Siphonaptera).
- ✓ Insect-transmitted diseases, such as malaria, yellow fever, bubonic plague, encephalitis, leishmaniasis, and typhus, have changed the course of history.
- ✓ Insects feed on crops and transmit plant diseases, such as Dutch elm disease, potato virus, and asters yellow