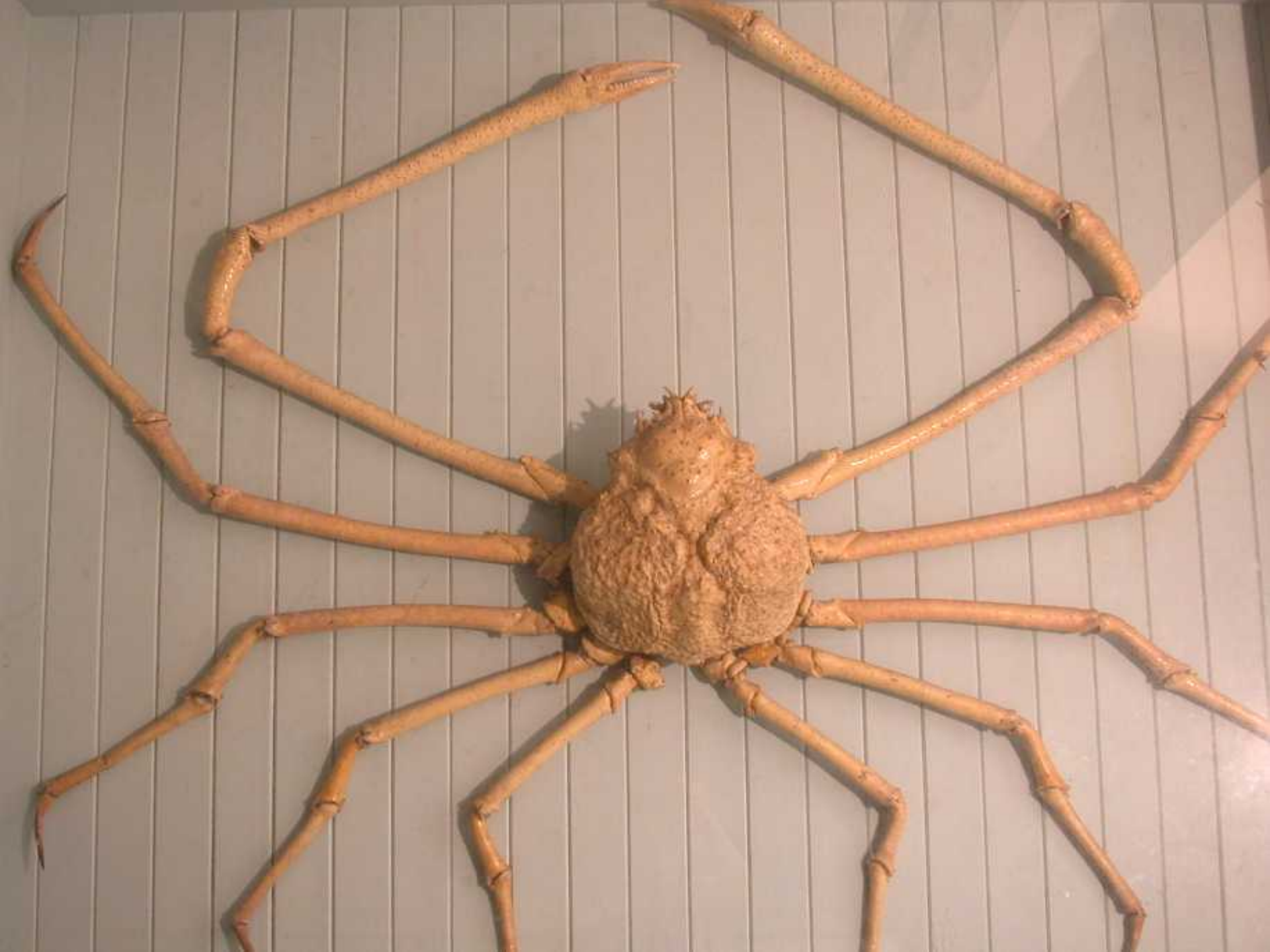
Chapter 39: Insects

39-1 The Insect World

39-2 Insect Behavior



39-1 The Insect World

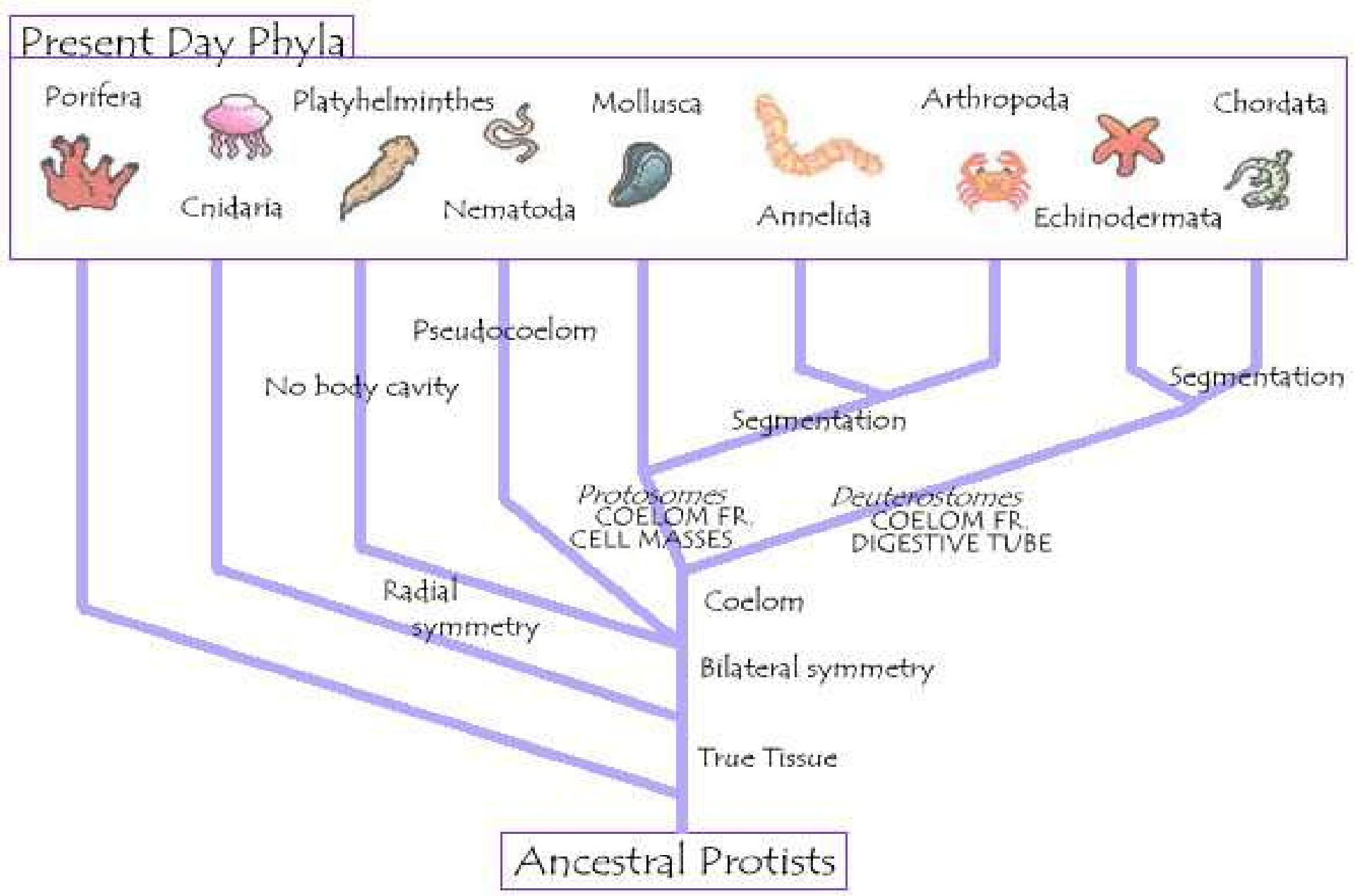
(Subphylum Uniramia, Class Insecta)

I. Characteristics and Classification of Insects

• 3 body tagmata: HEAD, THORAX, ABDOMEN, MANDIBLES, 1 pair of ANTENNAE, 3 pairs of JOINTED LEGS (on thorax), and 1-2 pairs of WINGS (most species).

Critical Thinking

(1) Insects and crustaceans both belong to the phylum Arthropoda and share many characteristics. The largest crustacean, the Japanese Spider Crab, has a leg span of 4 meters. In contrast, the largest insects, such as the Atlas Moth, has a wingspan of only 25 centimeters. Why do you suppose the largest crustaceans are so much larger than the largest insects?

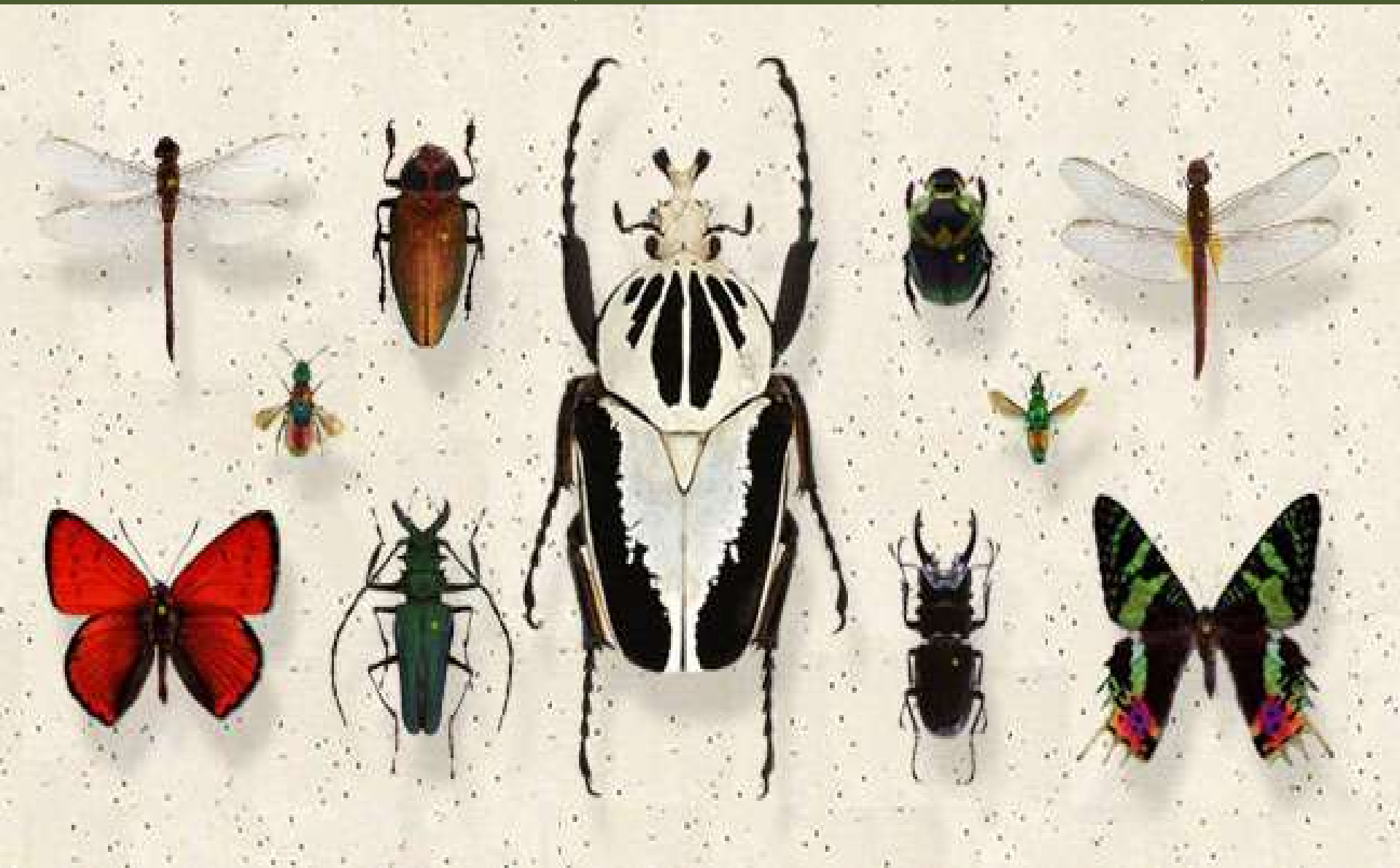


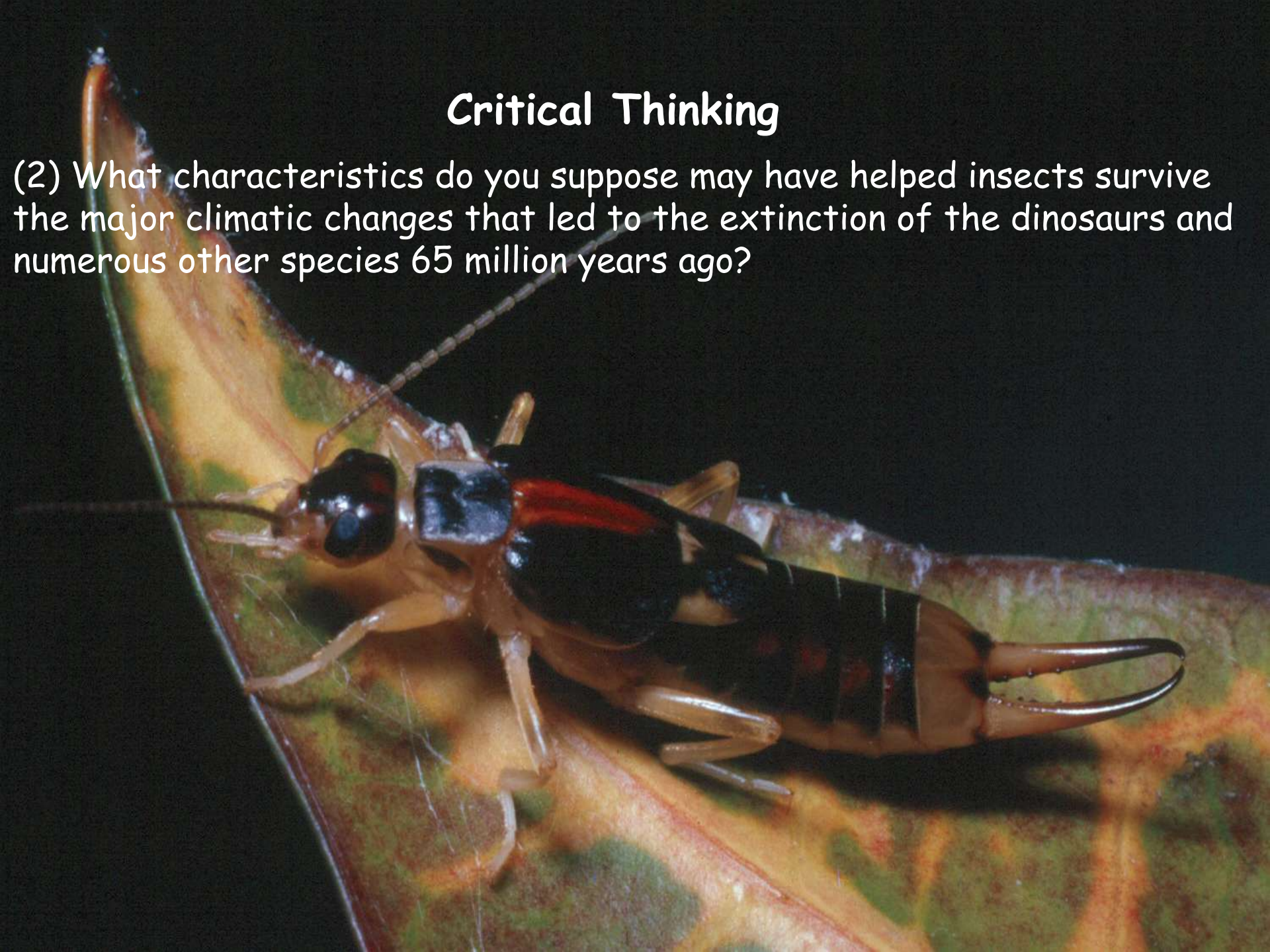
Phylogenetic Tree of *KINGDOM ANIMALIA*

Hair Trigger 24

(1) Entomology (i.e., study of INSECTS)

- 30+ ORDERS based on mouthparts, number of wings, and development.





Critical Thinking

(2) What characteristics do you suppose may have helped insects survive the major climatic changes that led to the extinction of the dinosaurs and numerous other species 65 million years ago?

(A) The Success of Insects

- Adaptations include a LIGHT and FLEXIBLE exoskeleton, SMALL size, ability to FLY, and rapid REPRODUCTION.

Critical Thinking

(3) Squids and other cephalopods possess a CLOSED-circulatory system that supports an active lifestyle by circulating blood quick through their bodies. Many insect species, such as dragonflies and bees, are also very active, BUT all insects have an OPEN-circulatory system. How might insects maintain active lifestyles while having an open-circulatory system?

(B) Insects and People

• Harmful → CROP damage, DISEASE (e.g., Malaria), PROPERTY damage (e.g. termites)

•Beneficial → pollinators, food sources, and MAKERS of honey, wax, and silk.

Critical Thinking

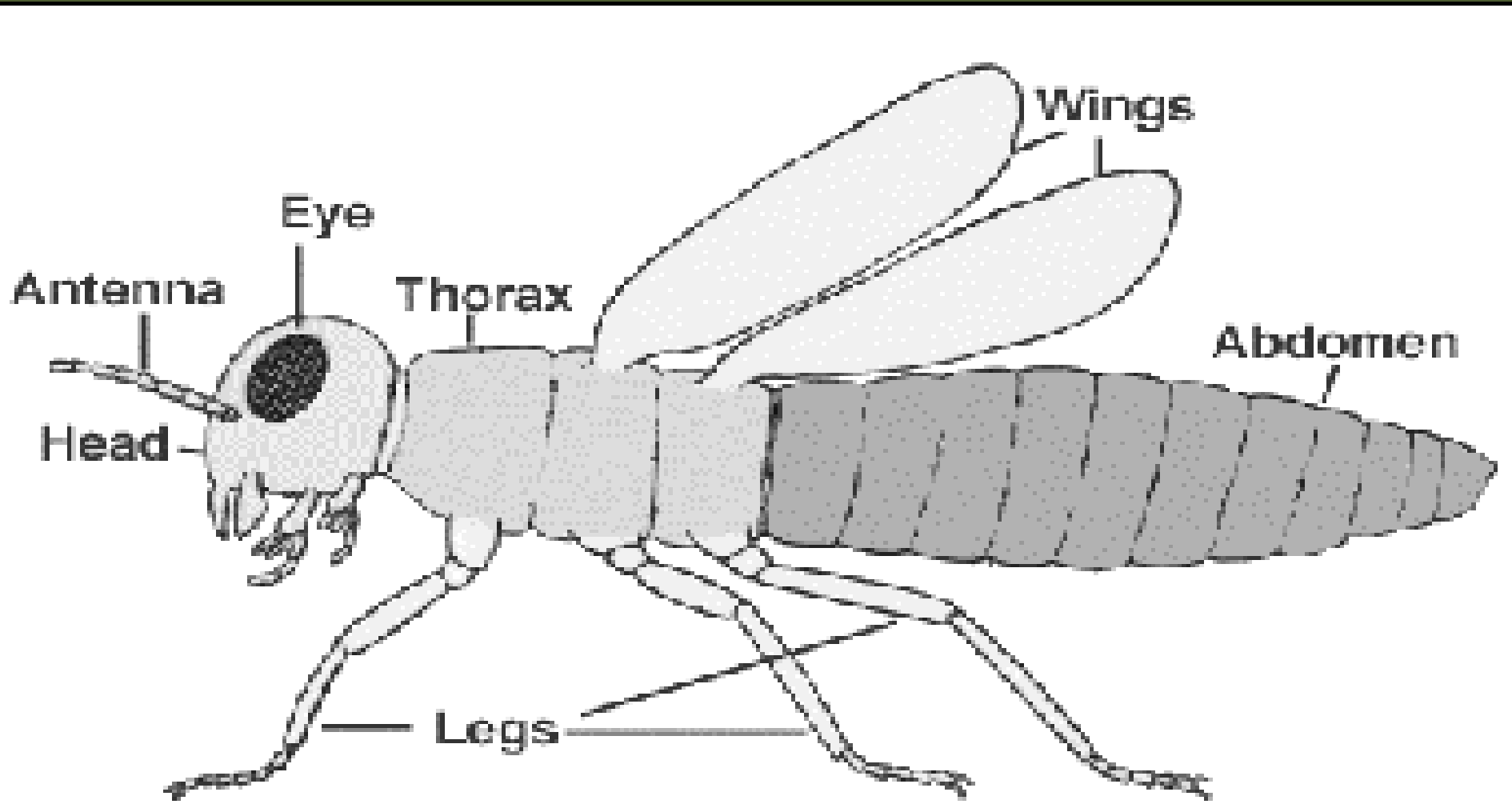
(4) Farmers who use an insecticide to control insect pests often find that strains of insects resistant to the insecticide rapidly appear. How do you suppose these insecticide-resistant strains develop? And why might this resistance happen so quickly among insect species?

II. The Grasshopper (e.g., representative insect)

• Remember that the insect world is extremely diverse, there is no "typical" insect

(A) External Structure

• Body (head-thorax-abdomen), 1 pair antennae, 3 pairs legs, 2 pairs wings, and SIMPLE and COMPOUND eyes.



Thorax divided into 3 parts:

(1) Prothorax: attaches to head and has first pair walking legs

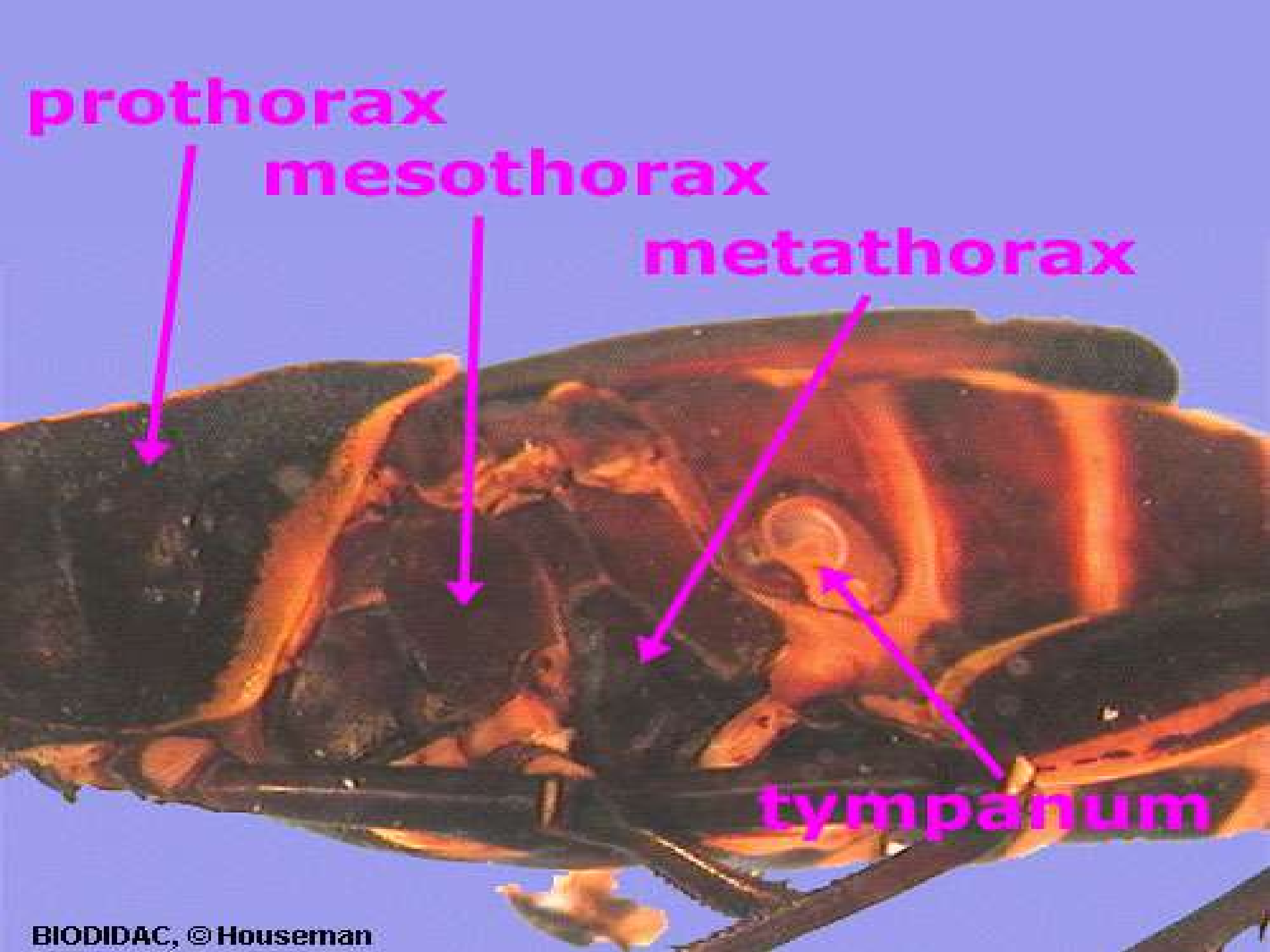
(2) Mesothorax: middle, has forewings and 2nd pair walking legs

-forewings have a leathery cover and protect hindwings when not in flight, also help with gliding

(3) Metathorax: attaches to abdomen, has hindwings and large jumping legs

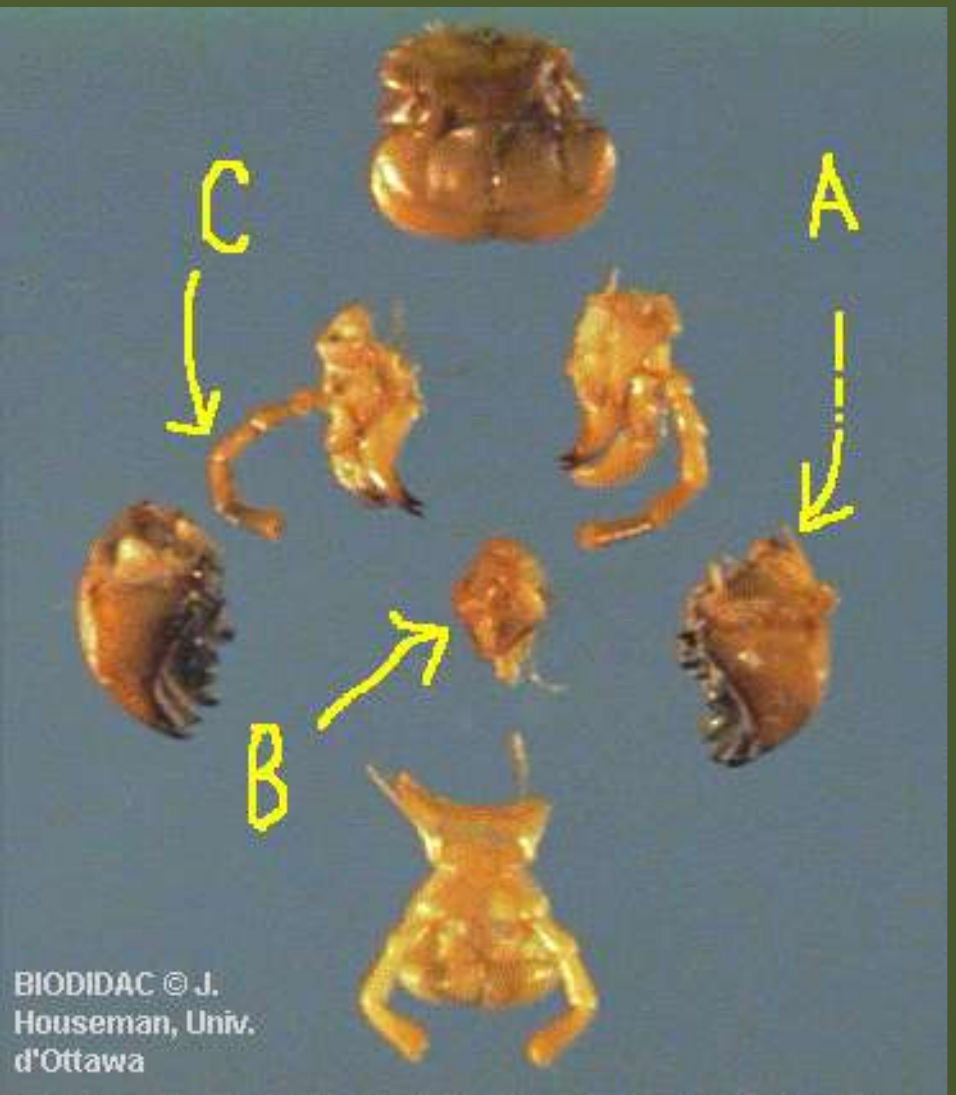
-hindwings actually propel flight

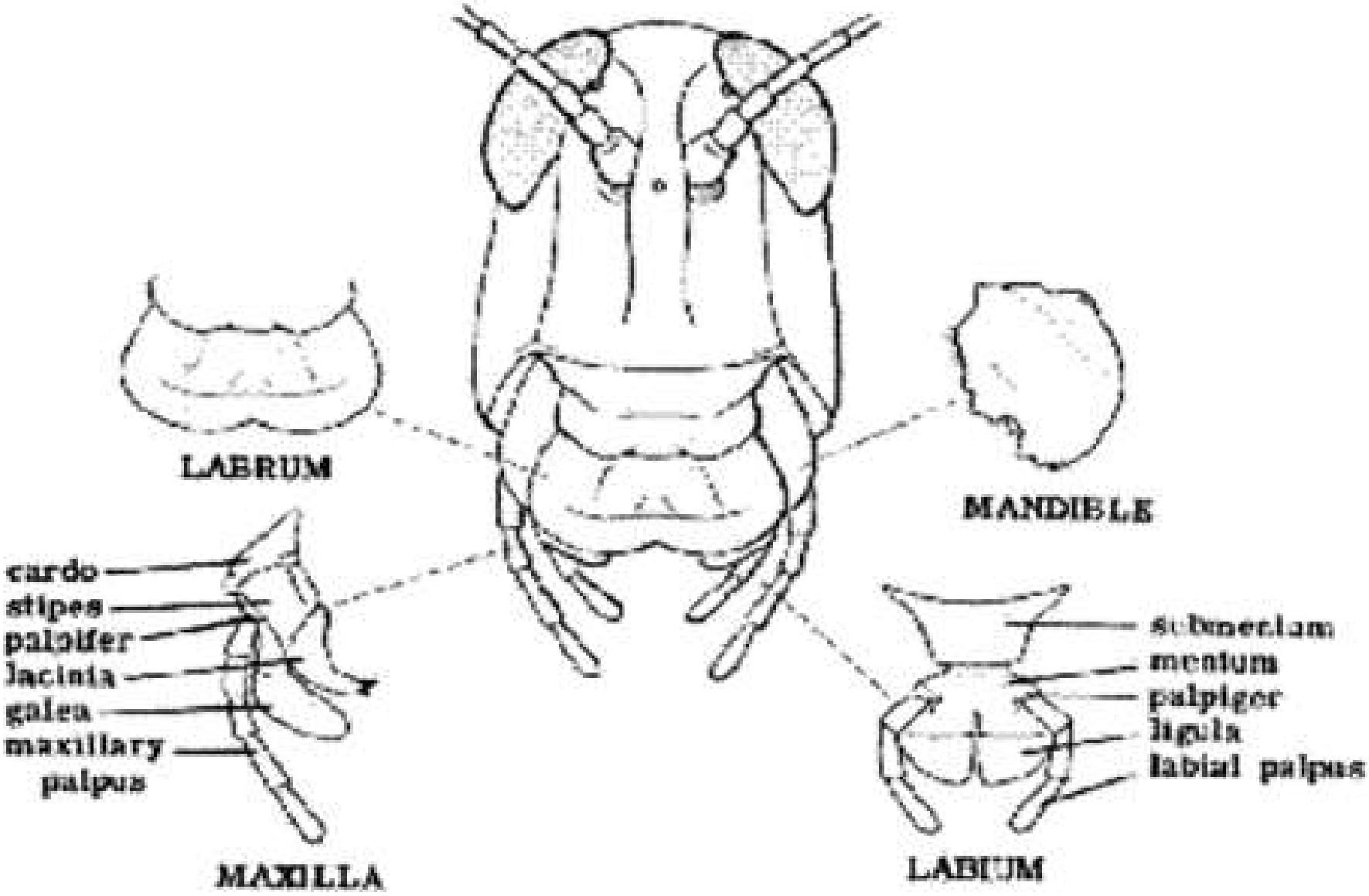
*Note: wings are an outgrowth from exoskeleton, did NOT evolve from legs (i.e. birds, bats)



(B) Feeding and Digestion

- Mouthparts specialized for CUTTING and CHEWING leaves and grass (i.e., grasshoppers are PRIMARY consumers or HERBIVORES)

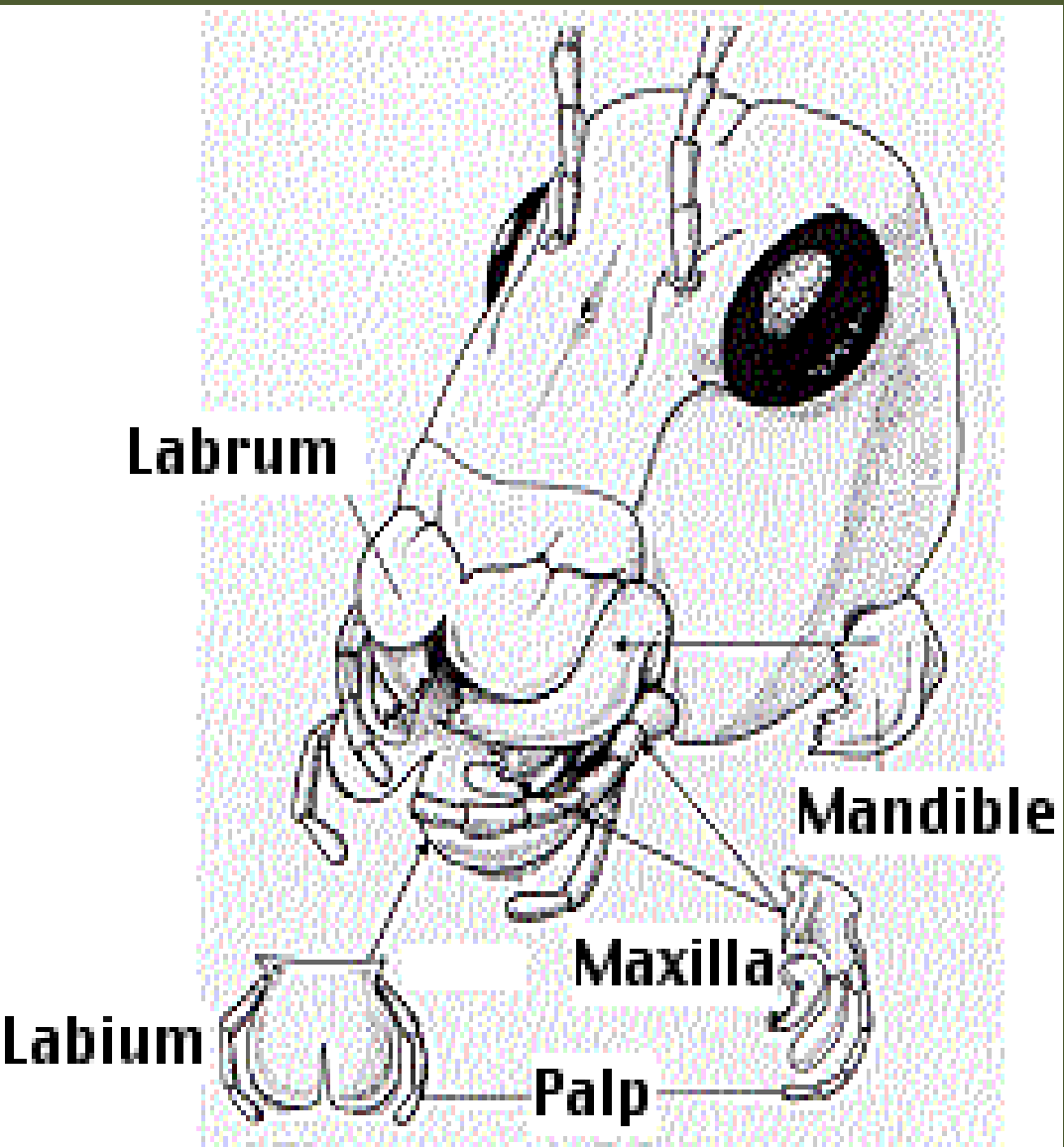


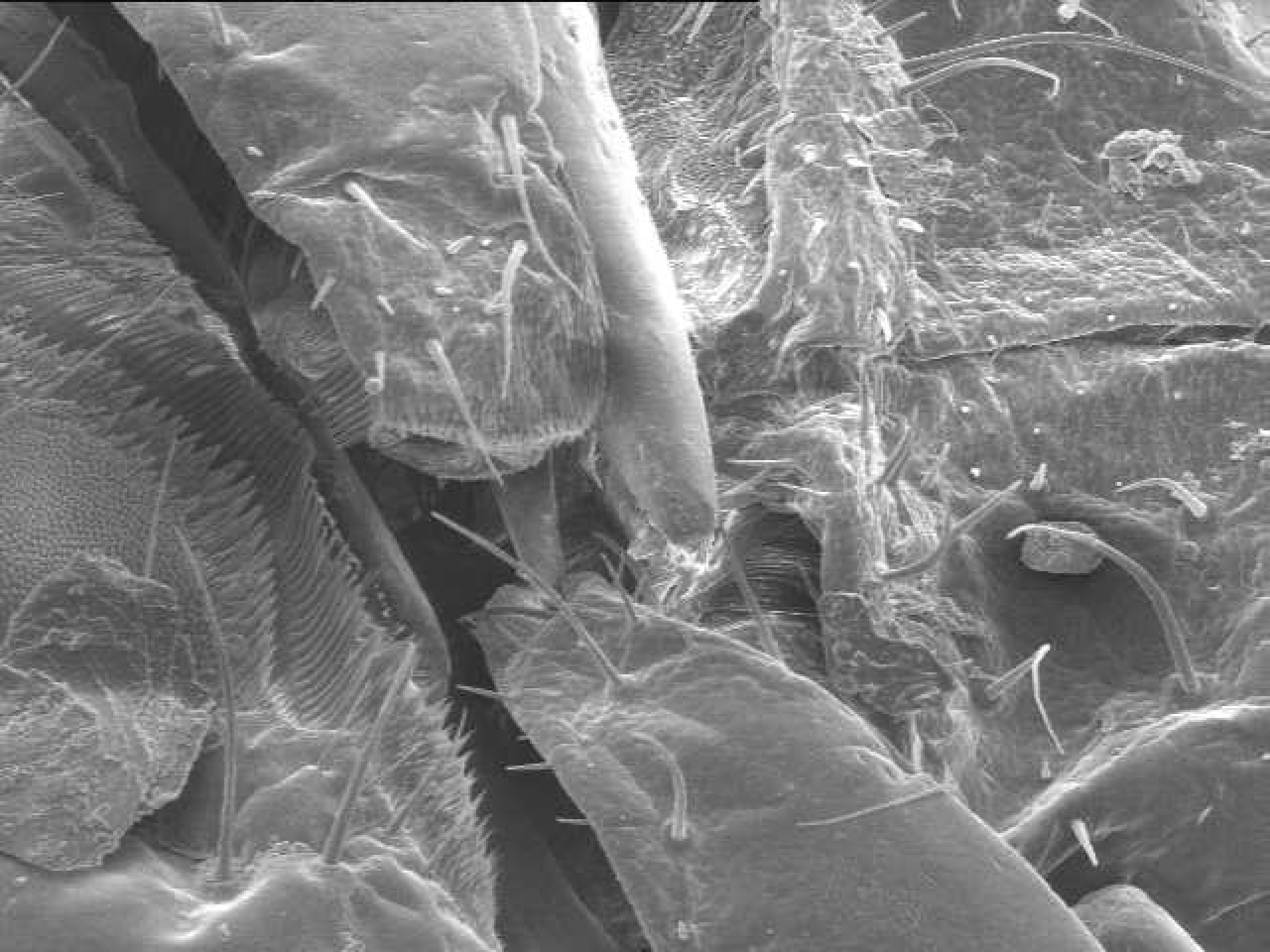


Grasshopper head and mouthparts.

Labrum & Labium (i.e., upper and lower LIPS, respectively)

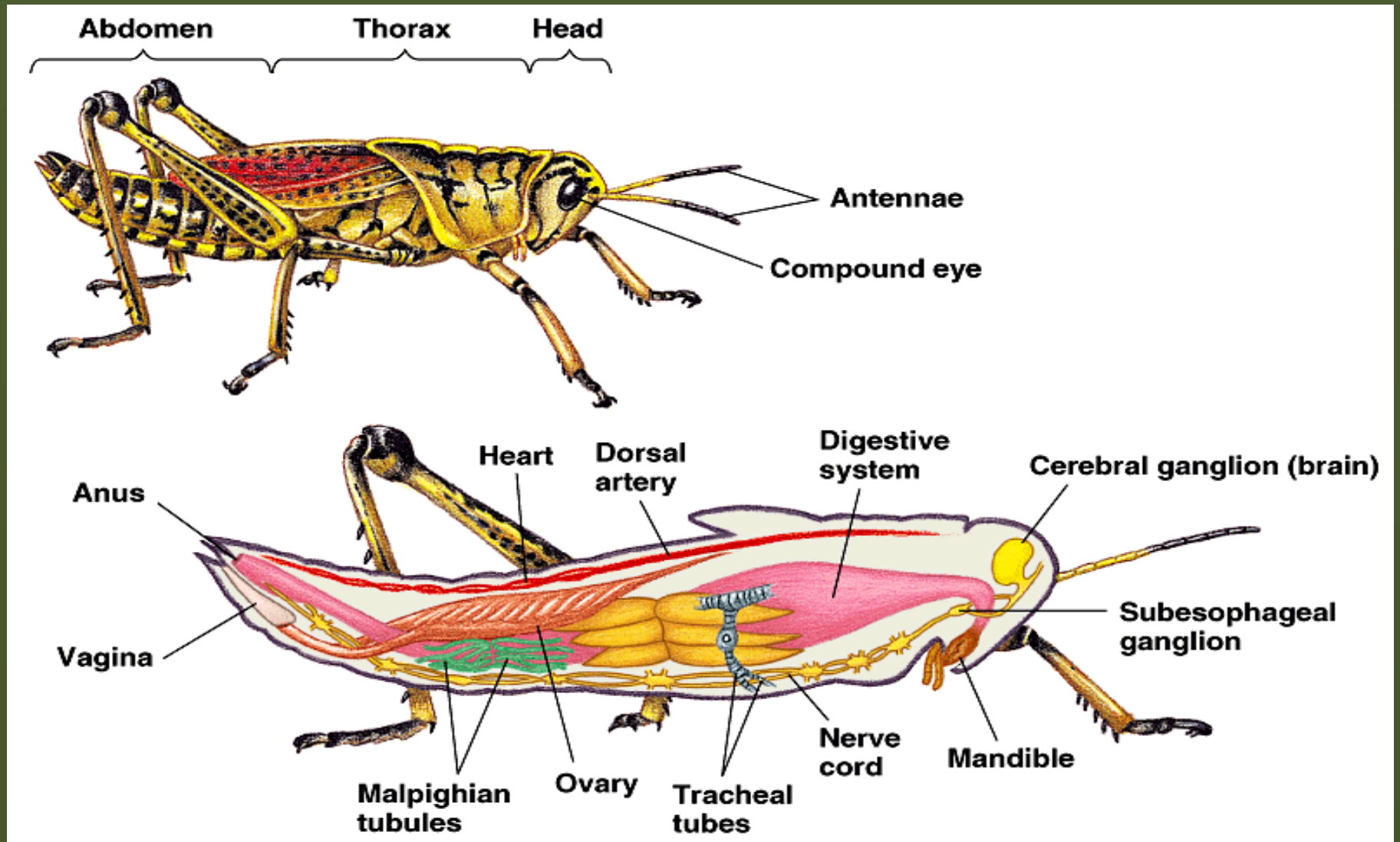
- HOLD food so sharp-edged mandibles can TEAR off edible bits.





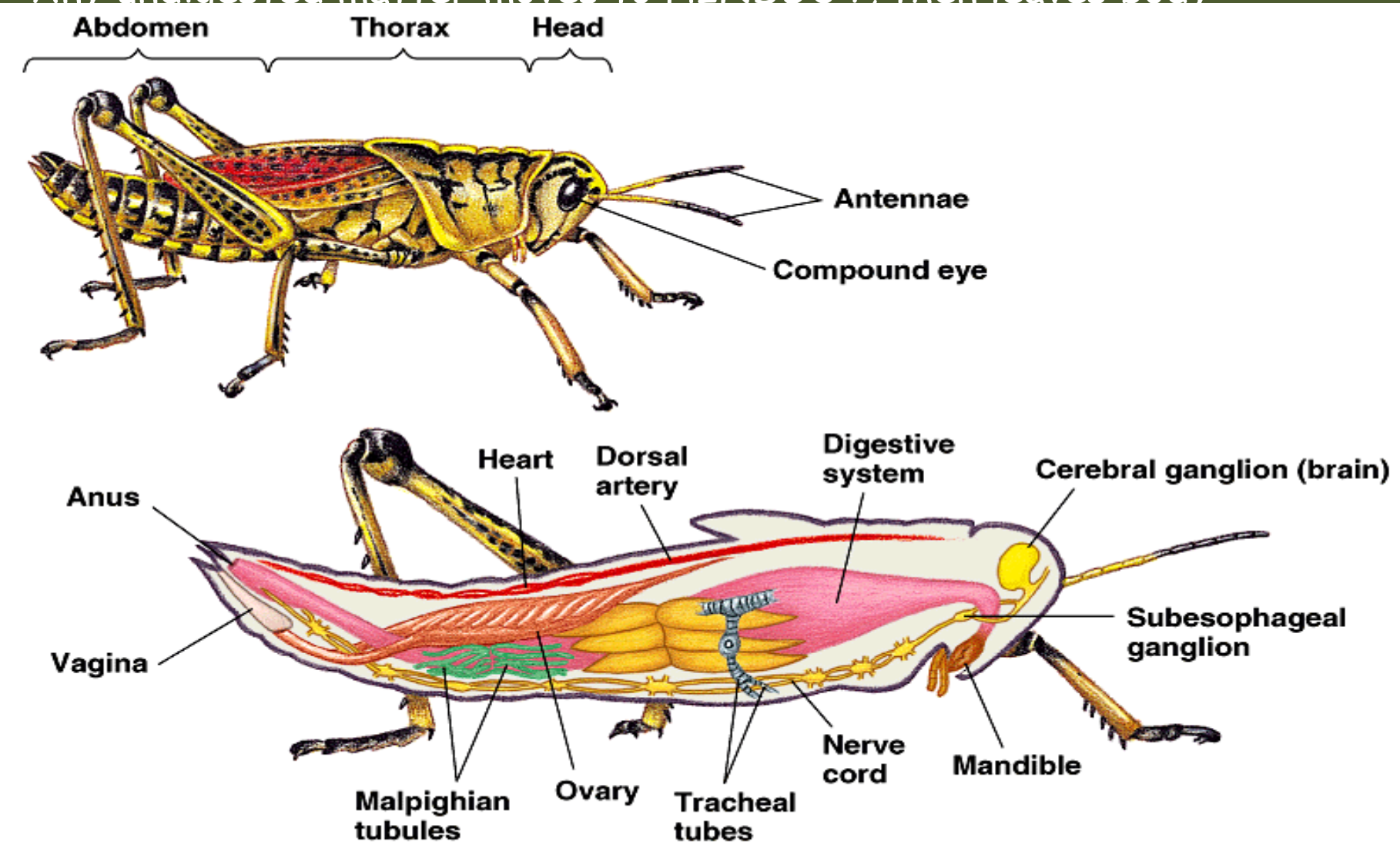
Salivary Glands (inside the mouth)

- Saliva MOISTENS food → sent through esophagus into crop and gizzard for DIGESTION.



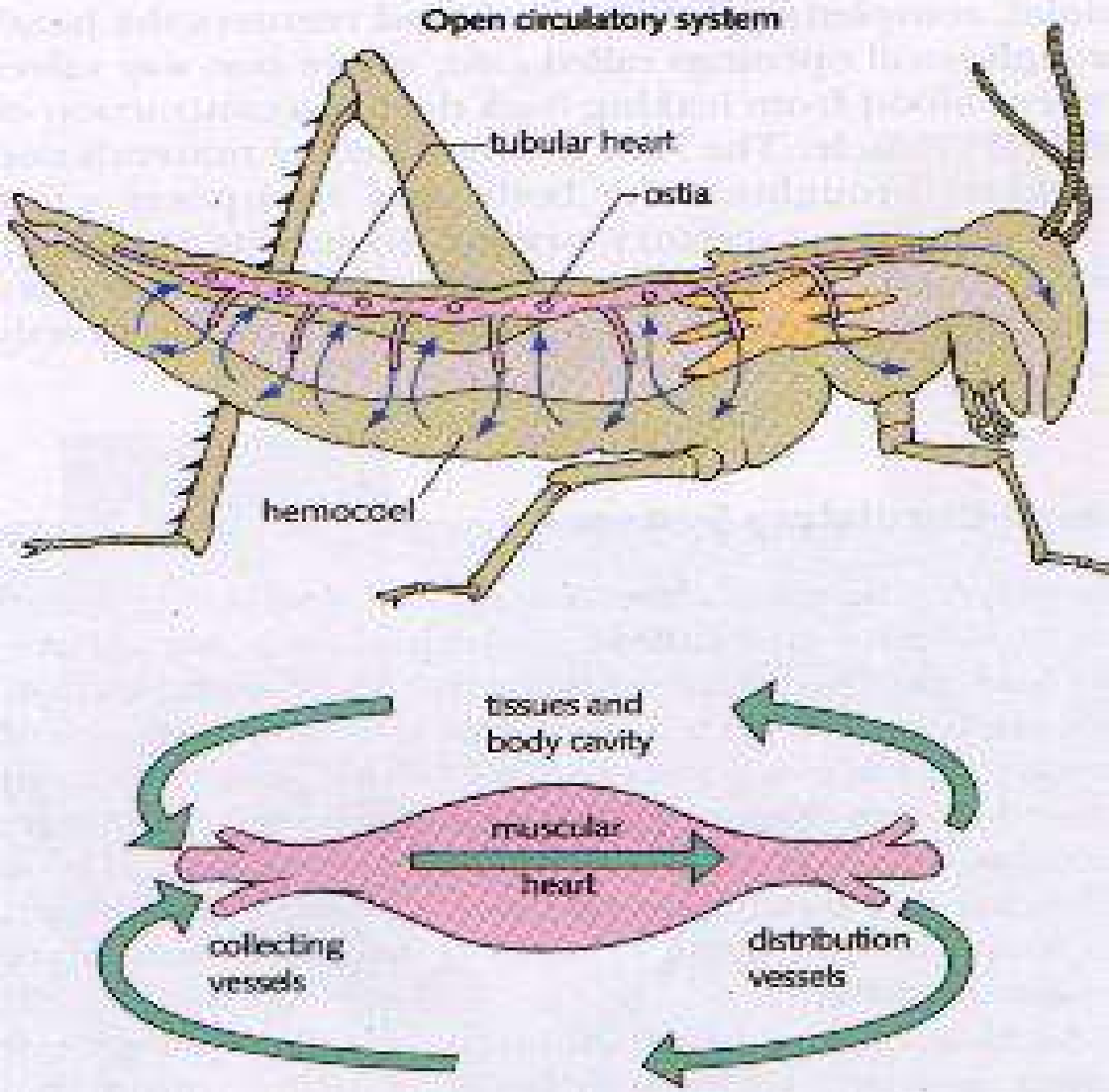
• Shredded food mass enters the MIDGUT, bathed in enzymes secreted by gastric ceca. Nutrients absorbed into coelom through wall.

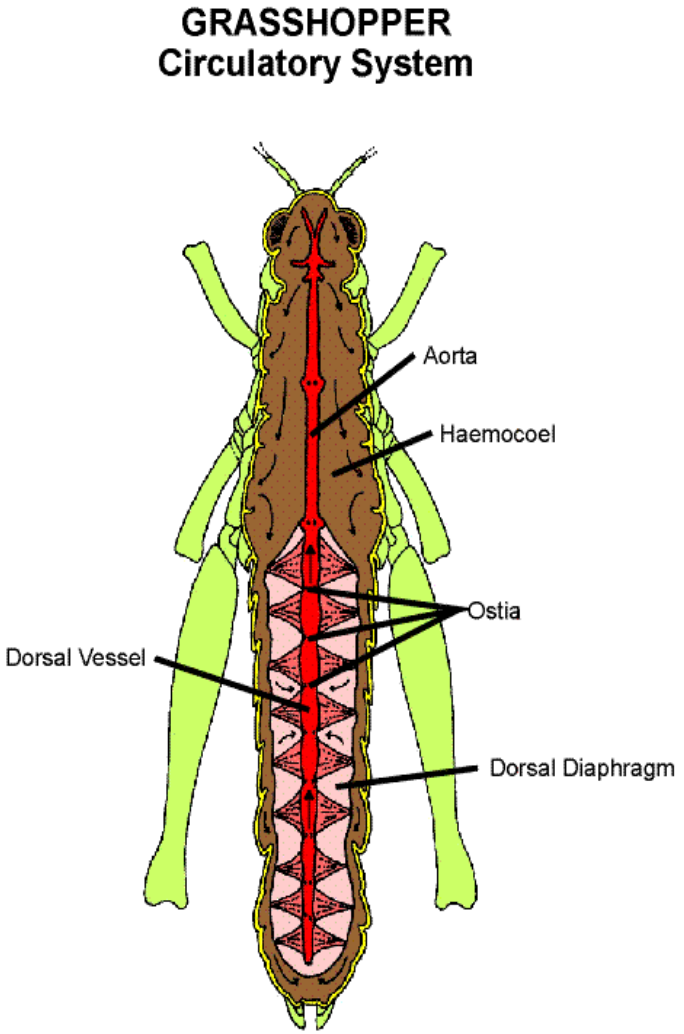
•Any undigested matter moves to HINDGUT, then leaves body

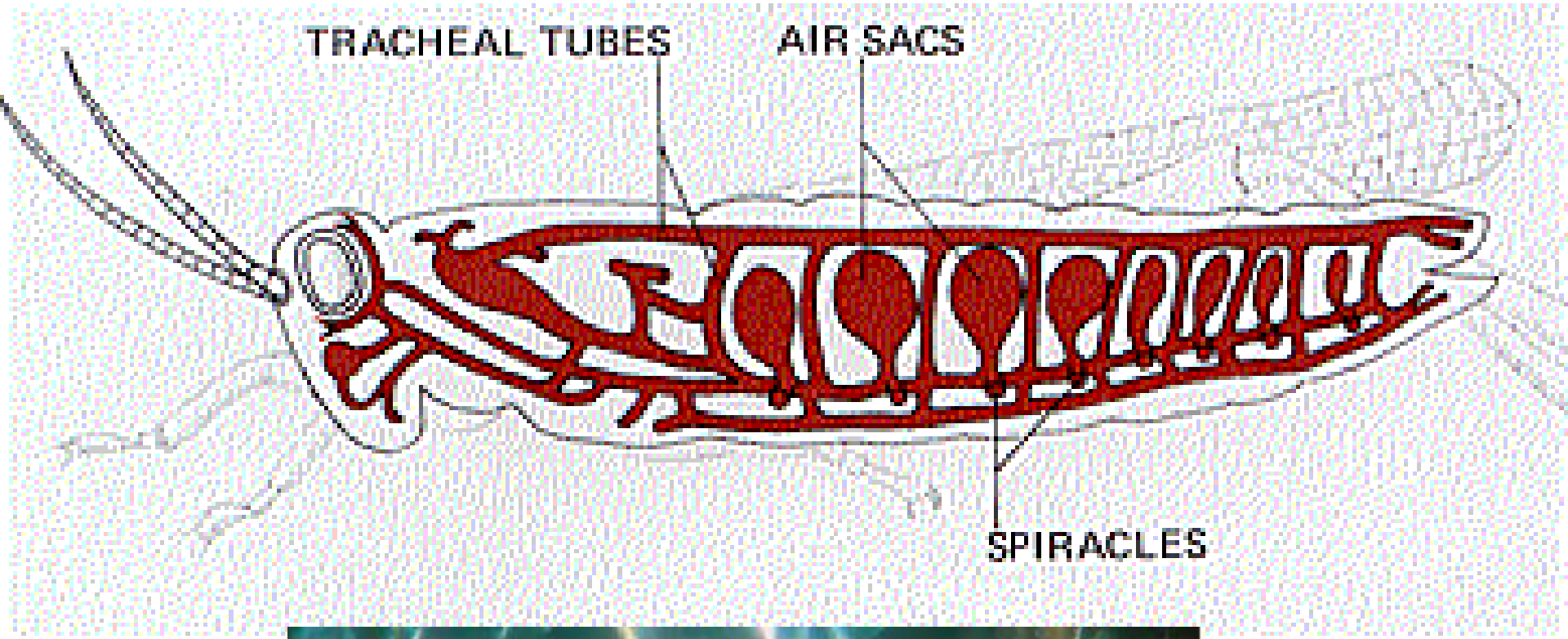


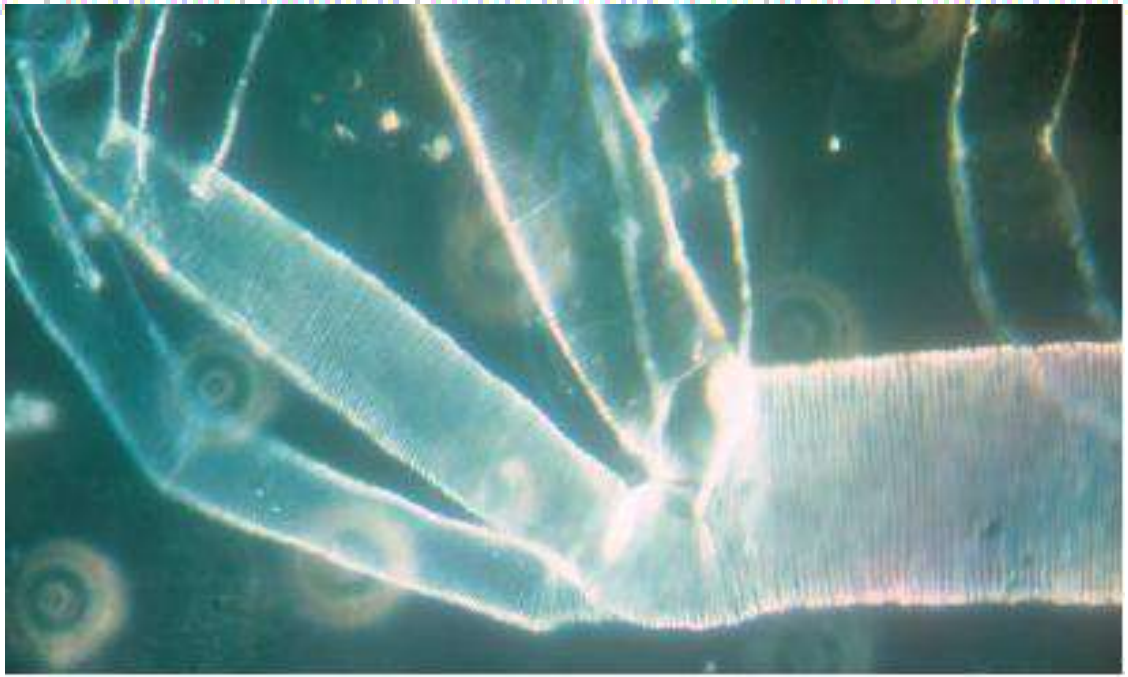
(C) Circulation, Respiration, and Excretion (OPEN-circulation)

- GASES diffuse via branched trachea; Malpighian tubules REABSORB water just like in spiders (i.e., a TERRESTRIAL adaptation).



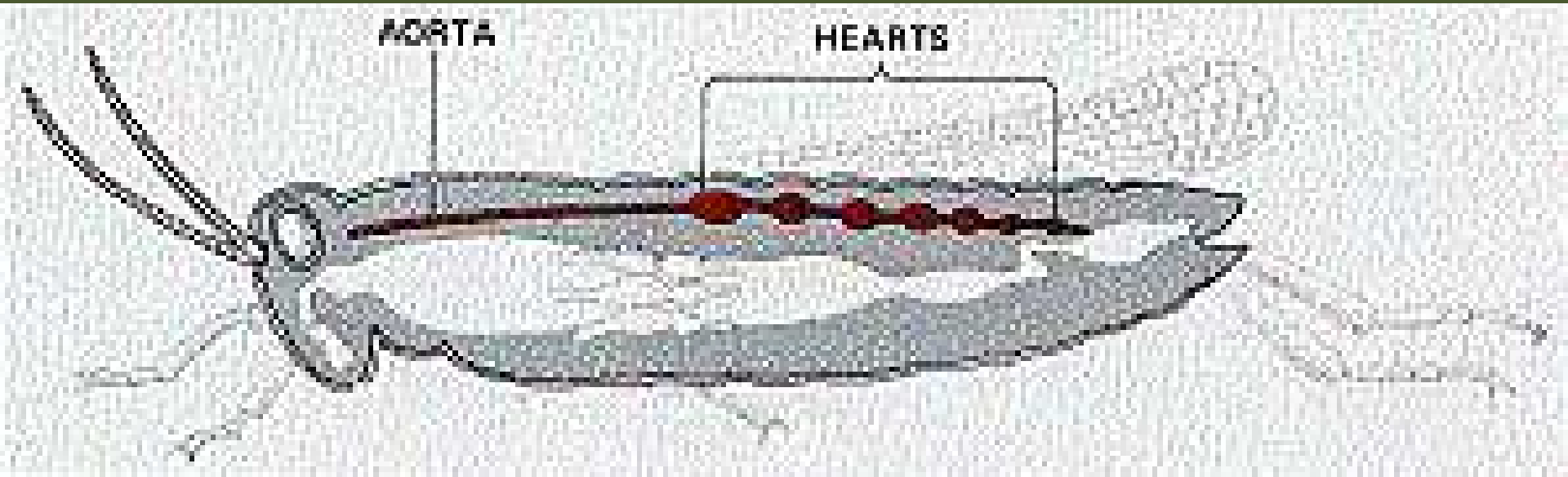



TRACHEAL TUBES
AIR SACS
SPIRACLES



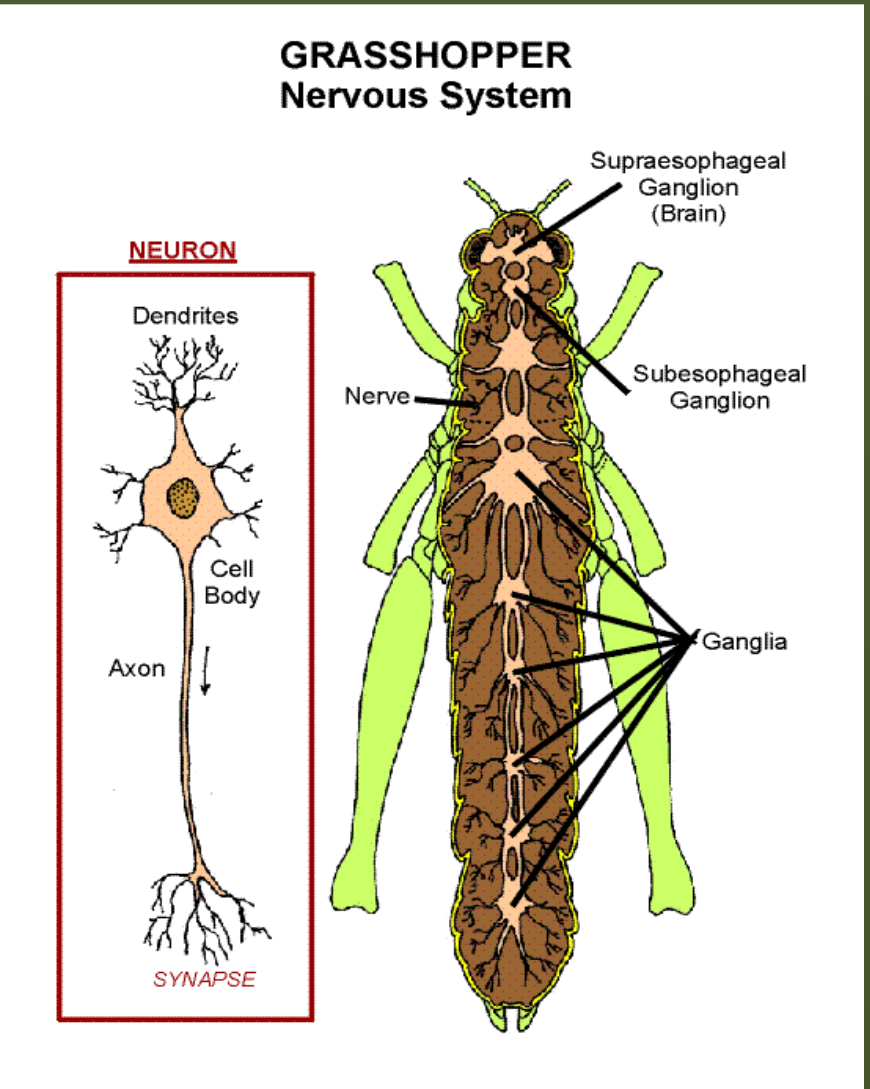
(1) Aorta (e.g., a LARGE dorsal VESSEL following the heart)

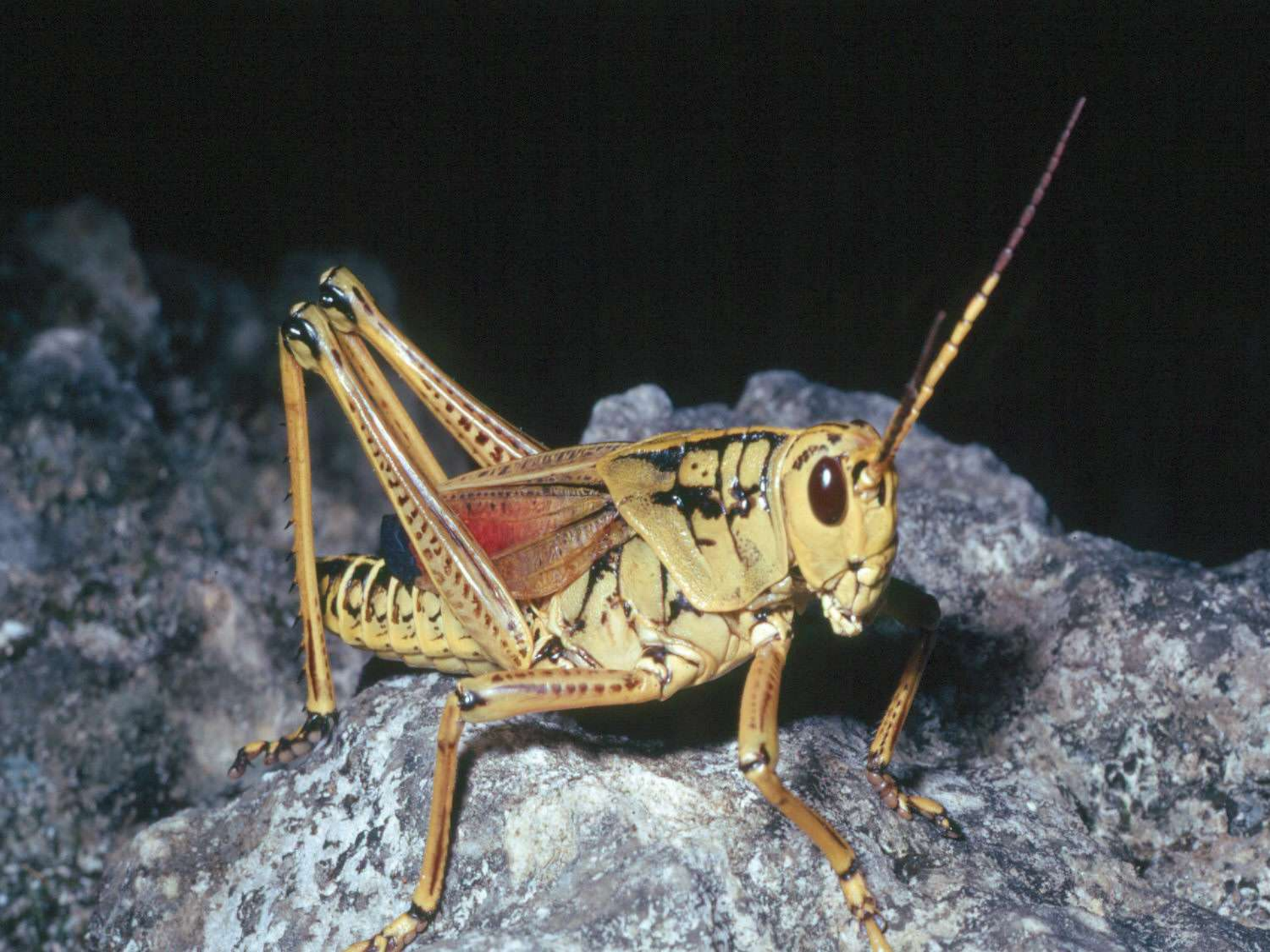
- PUMPS hemolymph through coelom toward abdomen and back to HEART.



(D) Neural Control (data taken in VIA antennae, eyes, and hairs)

• BRAIN and VENTRAL NERVE CORD with GANGLIA connect to MUSCLE and TYMPANUM.

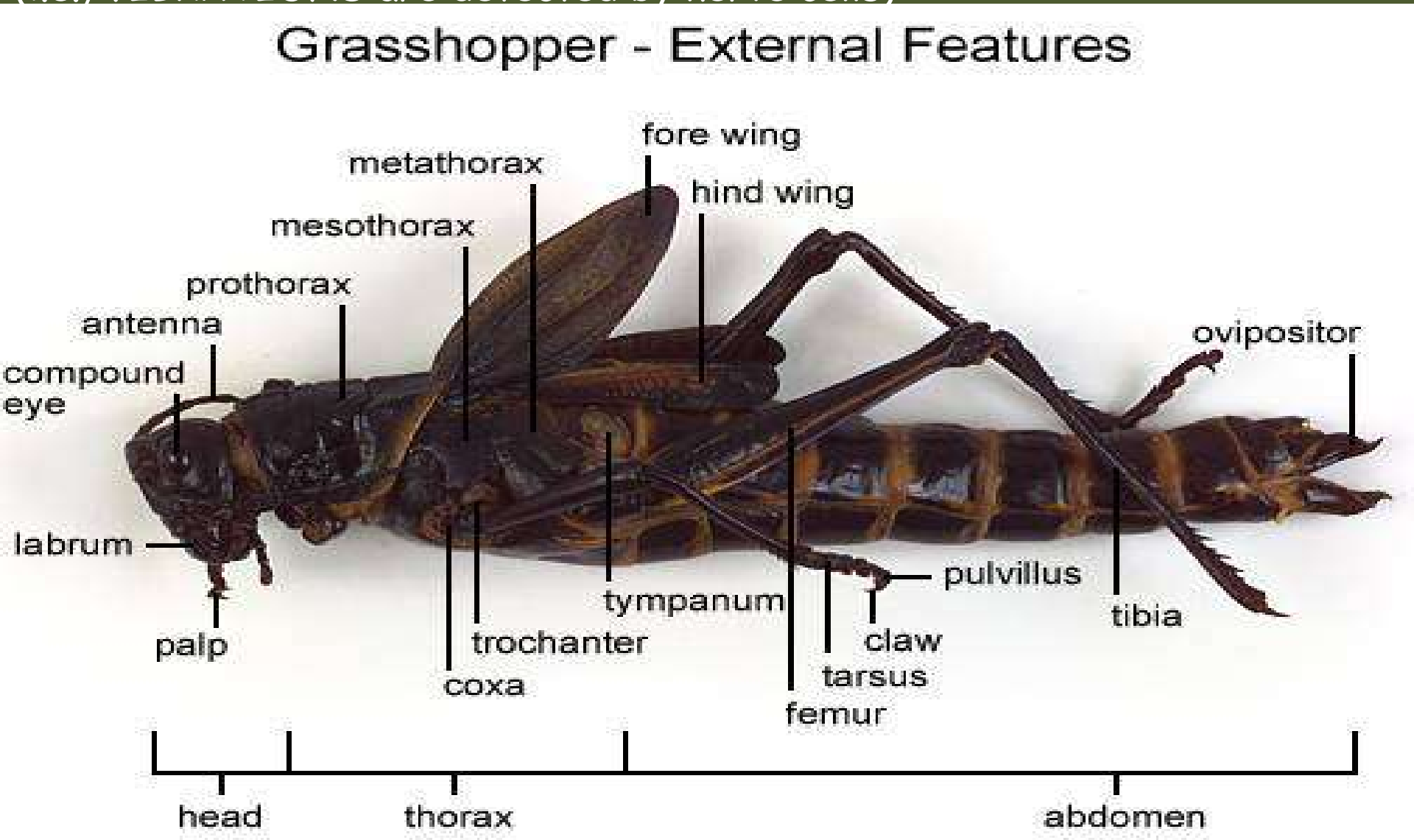




(1) Tympanum (i.e., an adapted SOUND-sensing organ ("insect-ear")

- Oval MEMBRANE covering an air-filled CAVITY.

(i.e., VIBRATIONS are detected by nerve cells)



Grasshopper - Tympanum (Close Up)

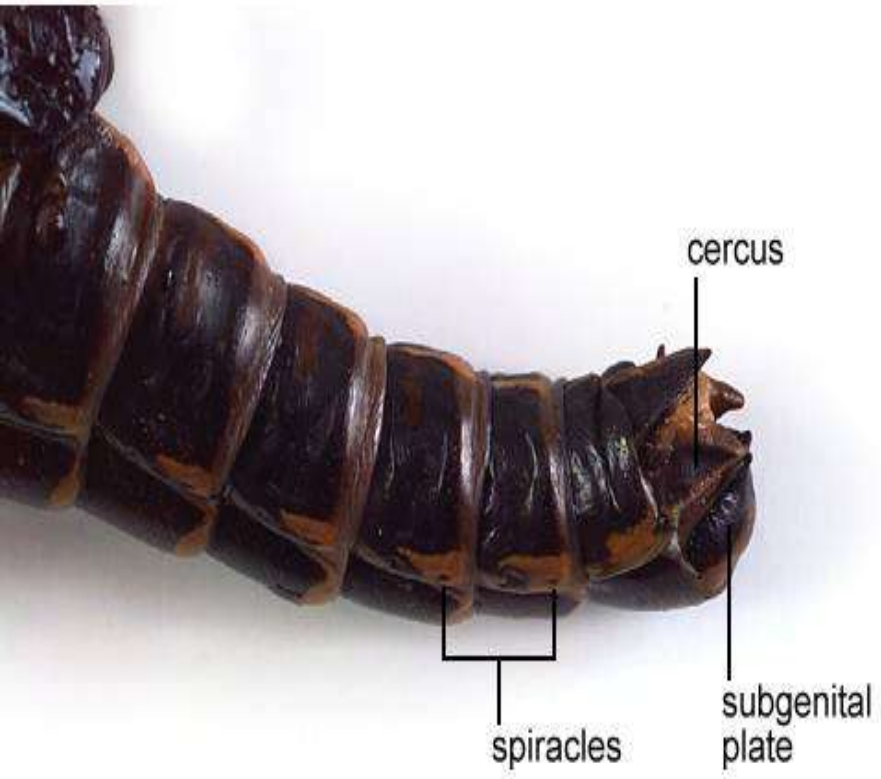
(E) Reproduction (grasshoppers have SEPARATE sexes, as do ALL insects)

• Male deposits SPERM into female receptacle, fertilizes eggs(zygotes released by ovaries…INTERNAL fertilization).

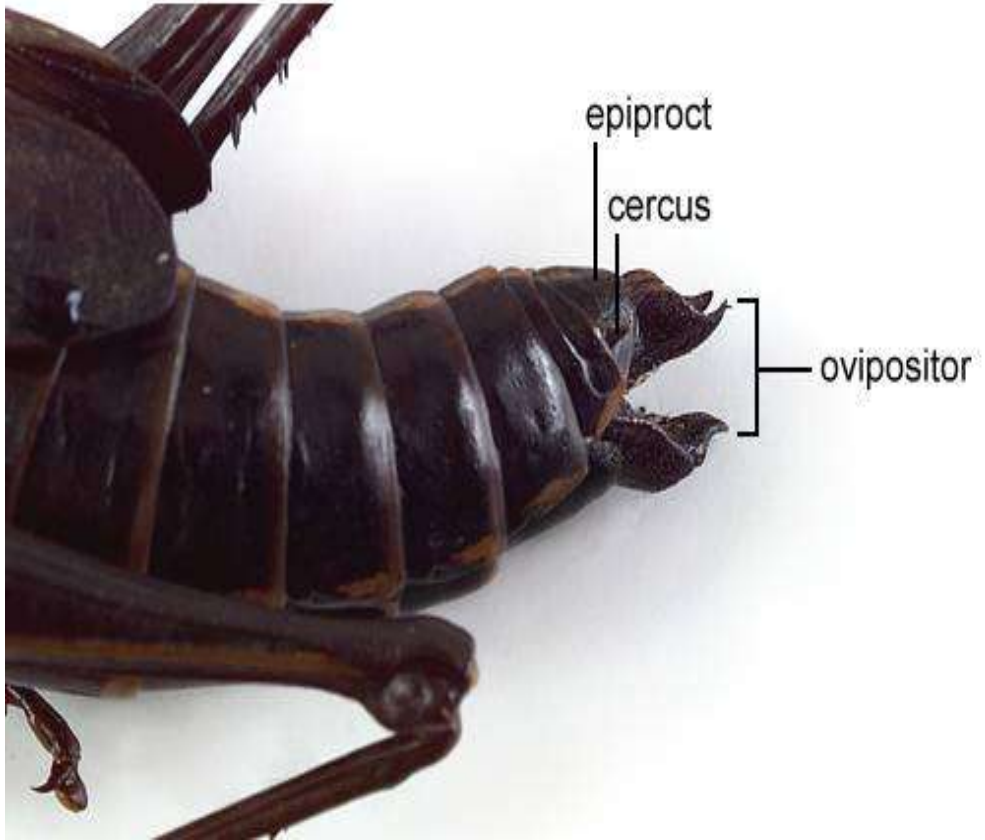
(1) Ovipositor (located on LAST segment of the female's abdomen)

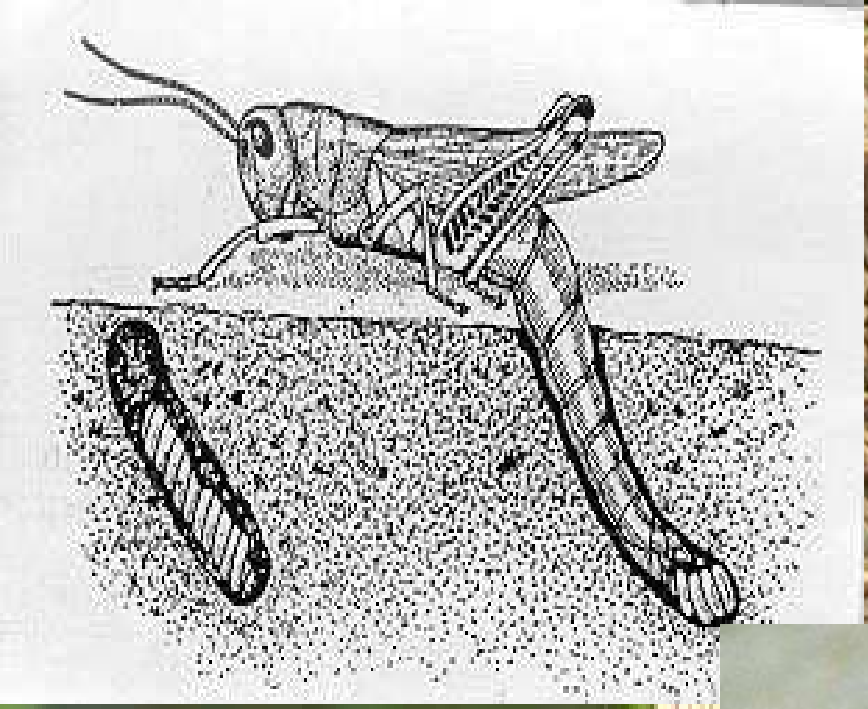
• Pointed organ DIGS a hole in the SOIL, where ZYGOTES can be laid.

Grasshopper - Abdomen (Male)



Grasshopper - Female Abdomen





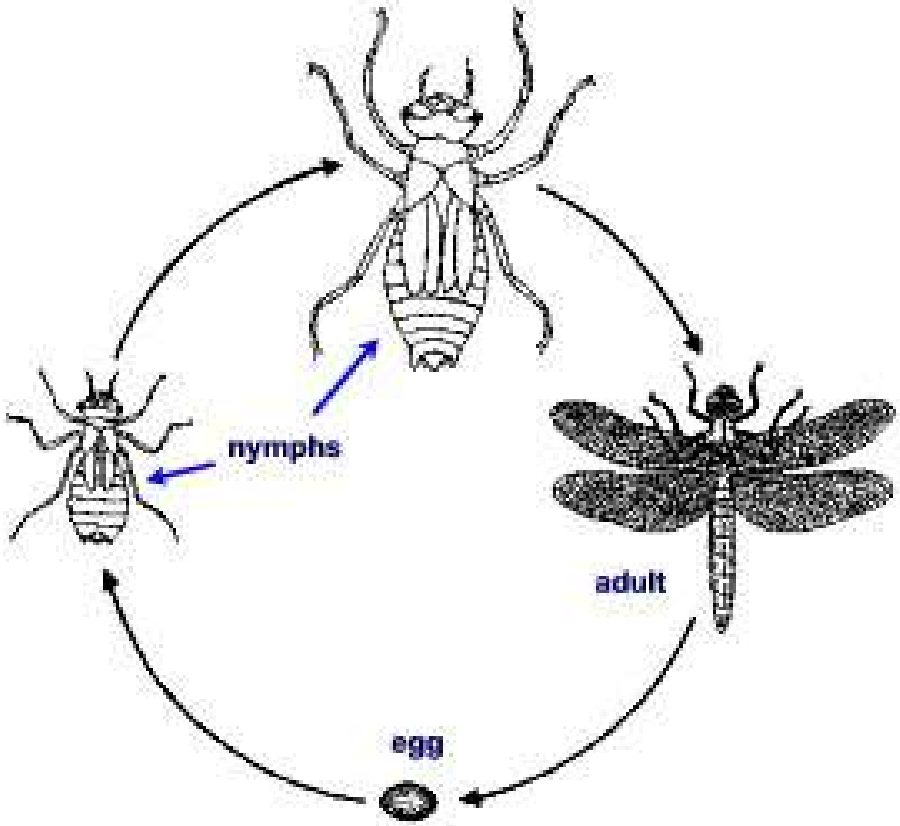

Chorthippus parallelus, mating

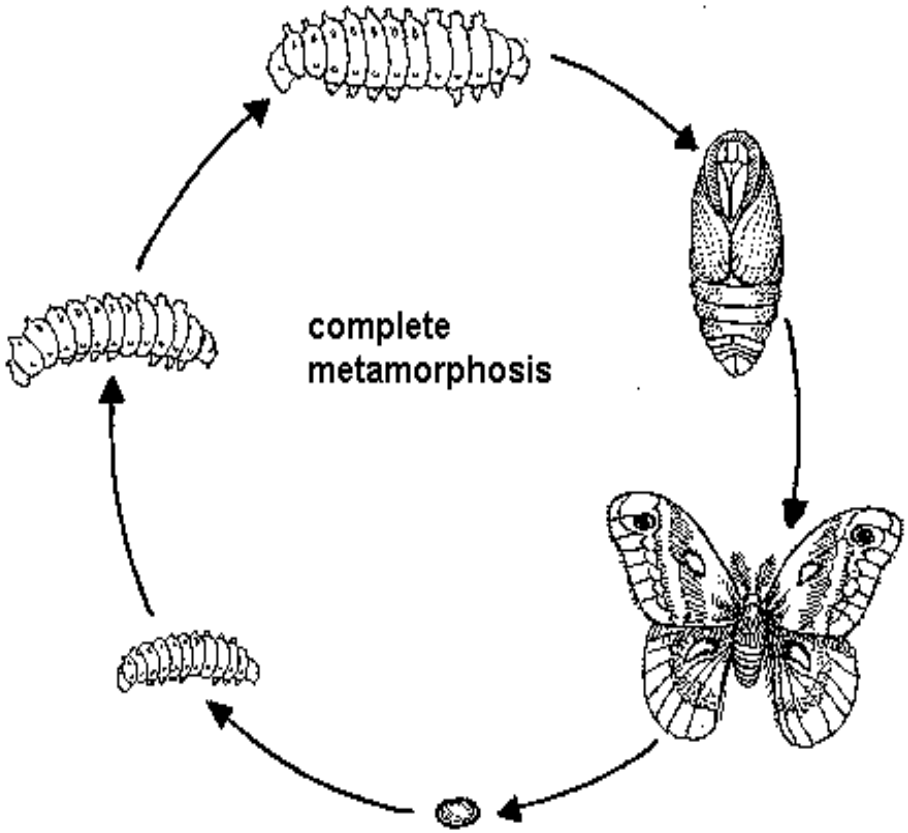
III. Development

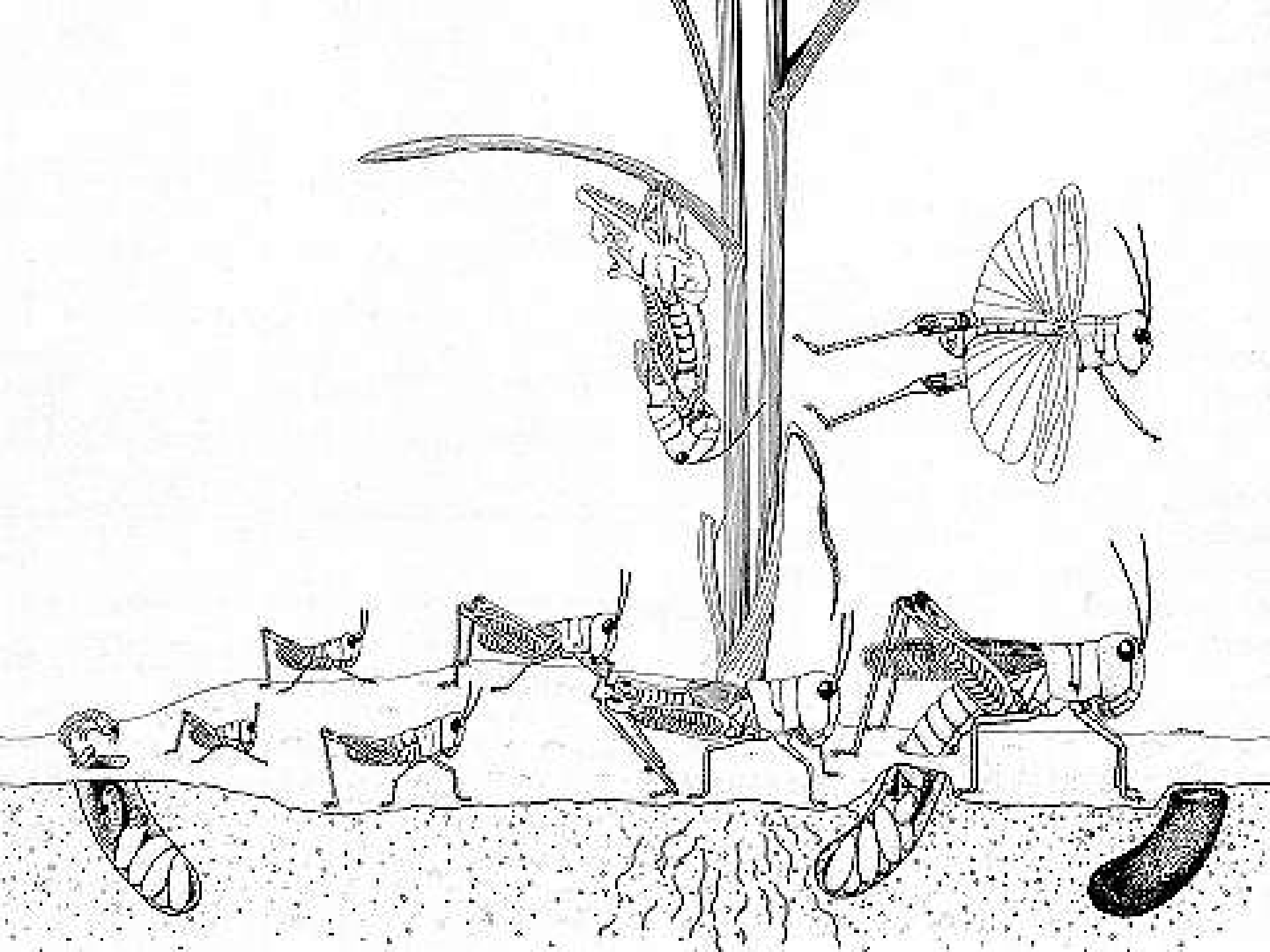
• Juvenile undergoes several RAPID MOLTS before reaching ADULT size, and becoming sexually MATURE (i.e., metamorphosis).

(1) Metamorphosis (developmental change process)

• TWO TYPES exist; INCOMPLETE and COMPLETE.





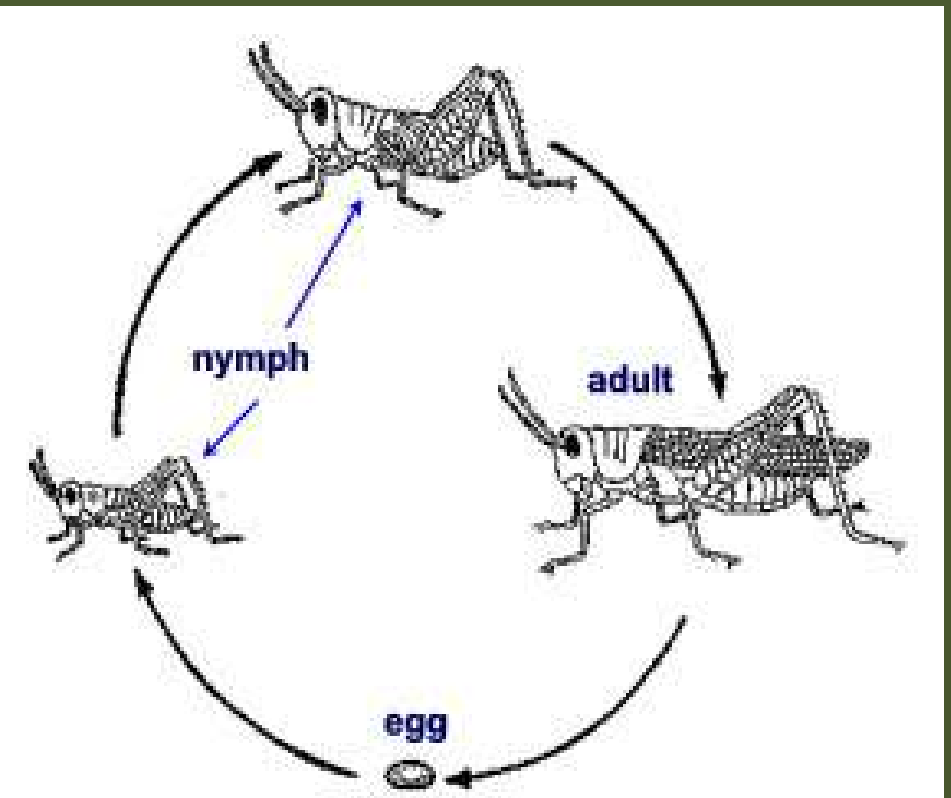


(A) Incomplete Metamorphosis (ONE stage)

• NYMPH (immature form) hatches from EGG and MOLTS before becoming an adult (NO larval stage present).

(1) Nymph (include grasshoppers, dragonflies, and termites)

• RESEMBLES adults but NOT sexually mature and LACK functional wings.




©Marlin E. Rice

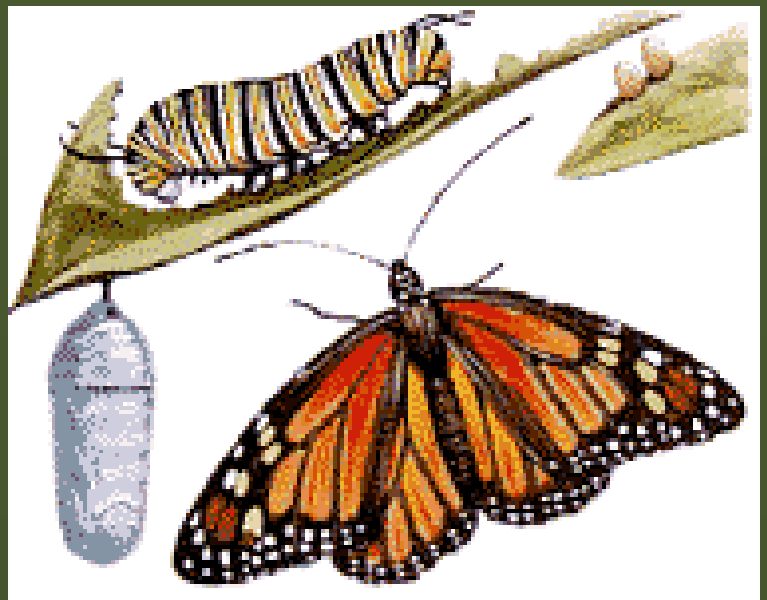
(B) Complete Metamorphosis (TWO stages)

• LARVA hatches from EGG and MOLTS before becoming a PUPA → develops into ADULT.

(Neither larva NOR pupa resembles the ADULT, unlike the NYMPH)

(1) Pupa (Stage of Metamorphosis)

• Stage where insect changes from a LARVA to an ADULT (encased in a protective COCOON).



(2) Chrysalis (for 140,000 butterfly species, *Order Lepidoptera*)

- Casing PUPA of BUTTERFLY larvae develop BEFORE an adult emerges.





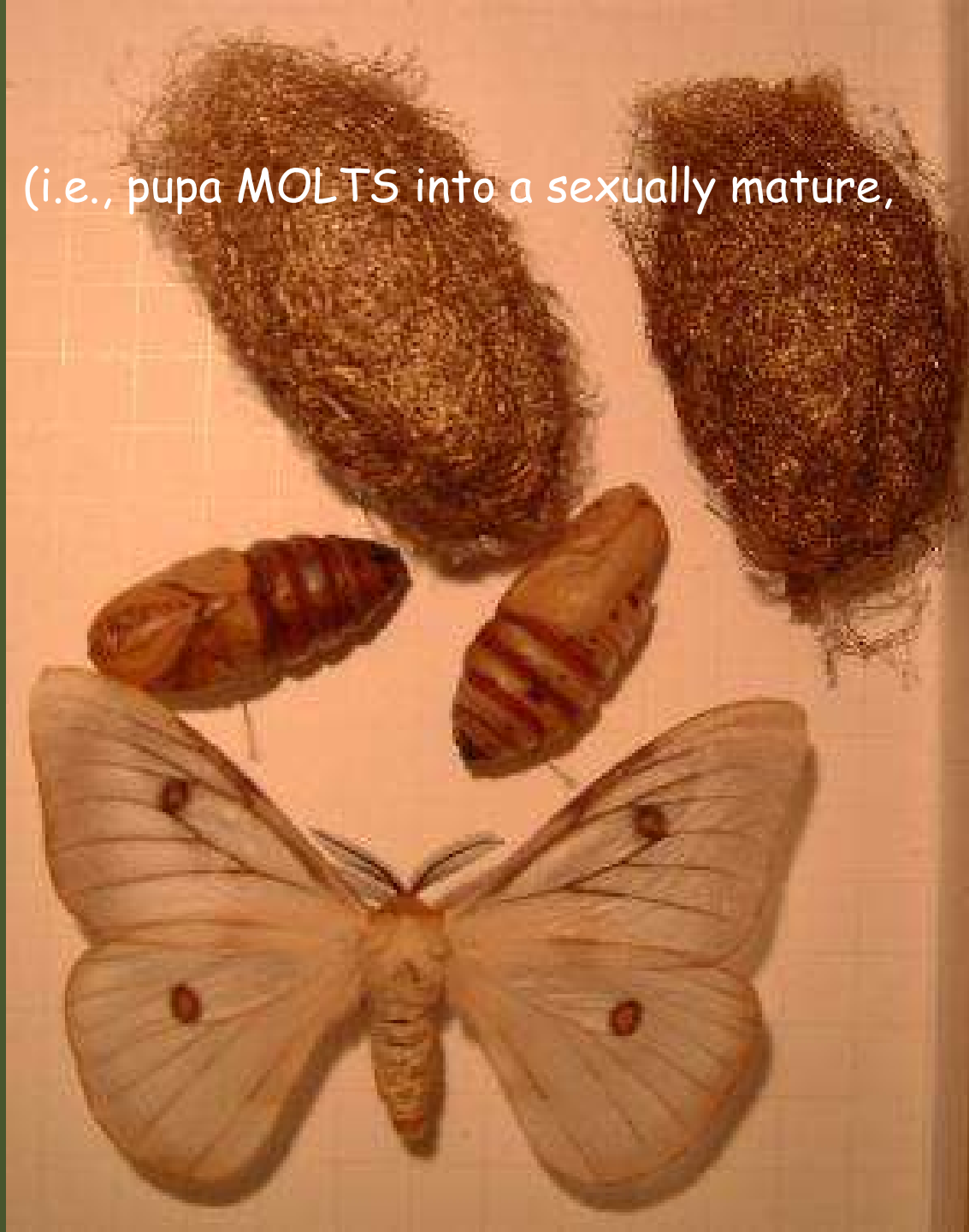







(3) Cocoon

• Casing PUPA of MOTH larvae (i.e., pupa MOLTS into a sexually mature, winged moth).



(C) Importance of Metamorphosis (mosquito larvae vs. mosquito adults)

• Enhances survival by HELPING insects survive HARSH weather; [ALSO LARVAL and ADULT stages fulfill different FUNCTIONS, live in different HABITATS, and eat different FOODS. (i.e., occupy different)]

IV. Defense (e.g., passive AND aggressive defenses have evolved)

• Success owed to defenses → camouflage, venomous stingers, and even hot stream of noxious chemicals (bombardier beetles).

(1) Warning Coloration

- BOLD, bright color PATTERNS convey DANGEROUS or VENOMOUS.


Benjamin
Cummings

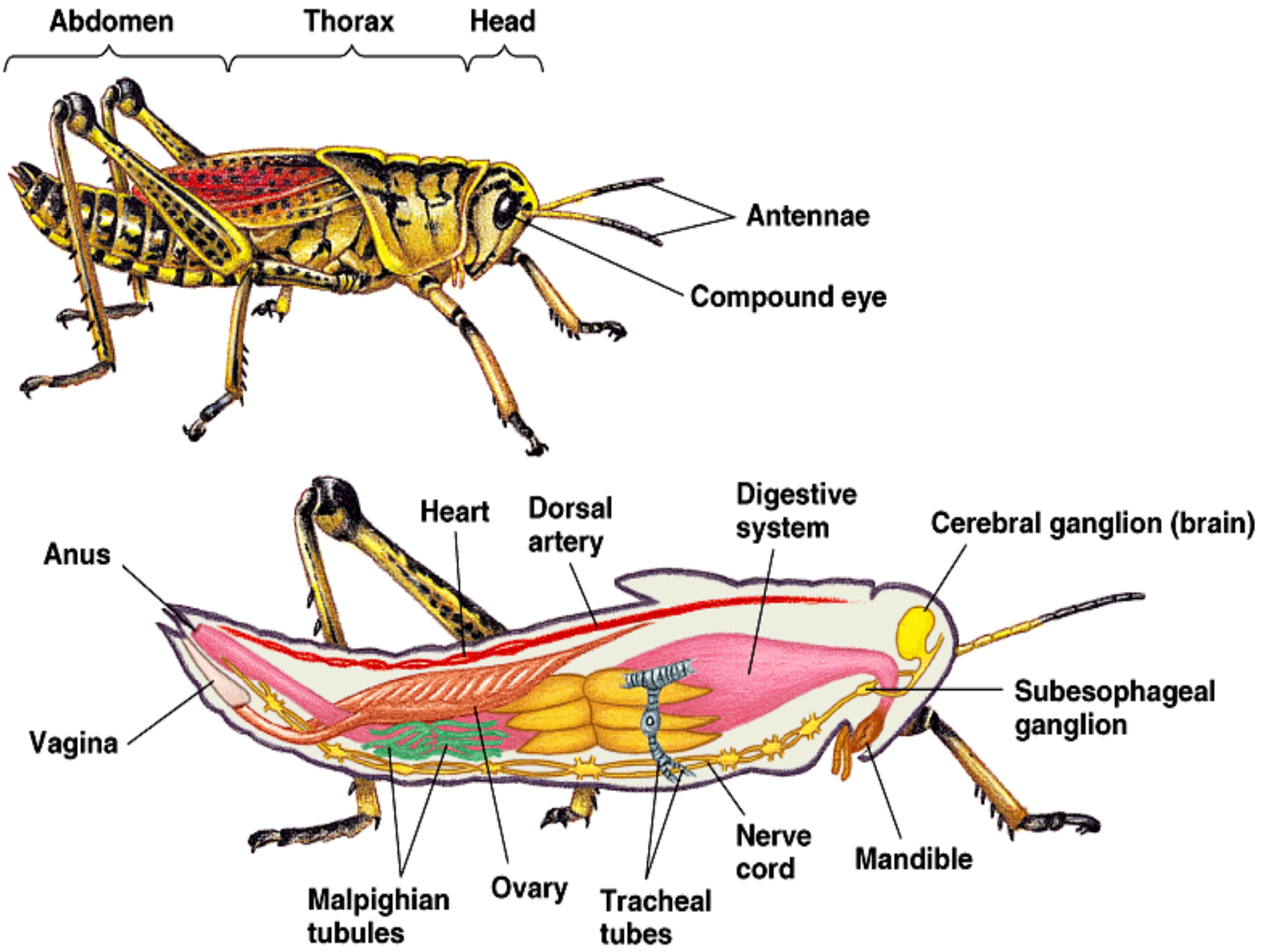
(2) Mullerian Mimicry

- Dangerous species mimics coloration of ANOTHER dangerous species

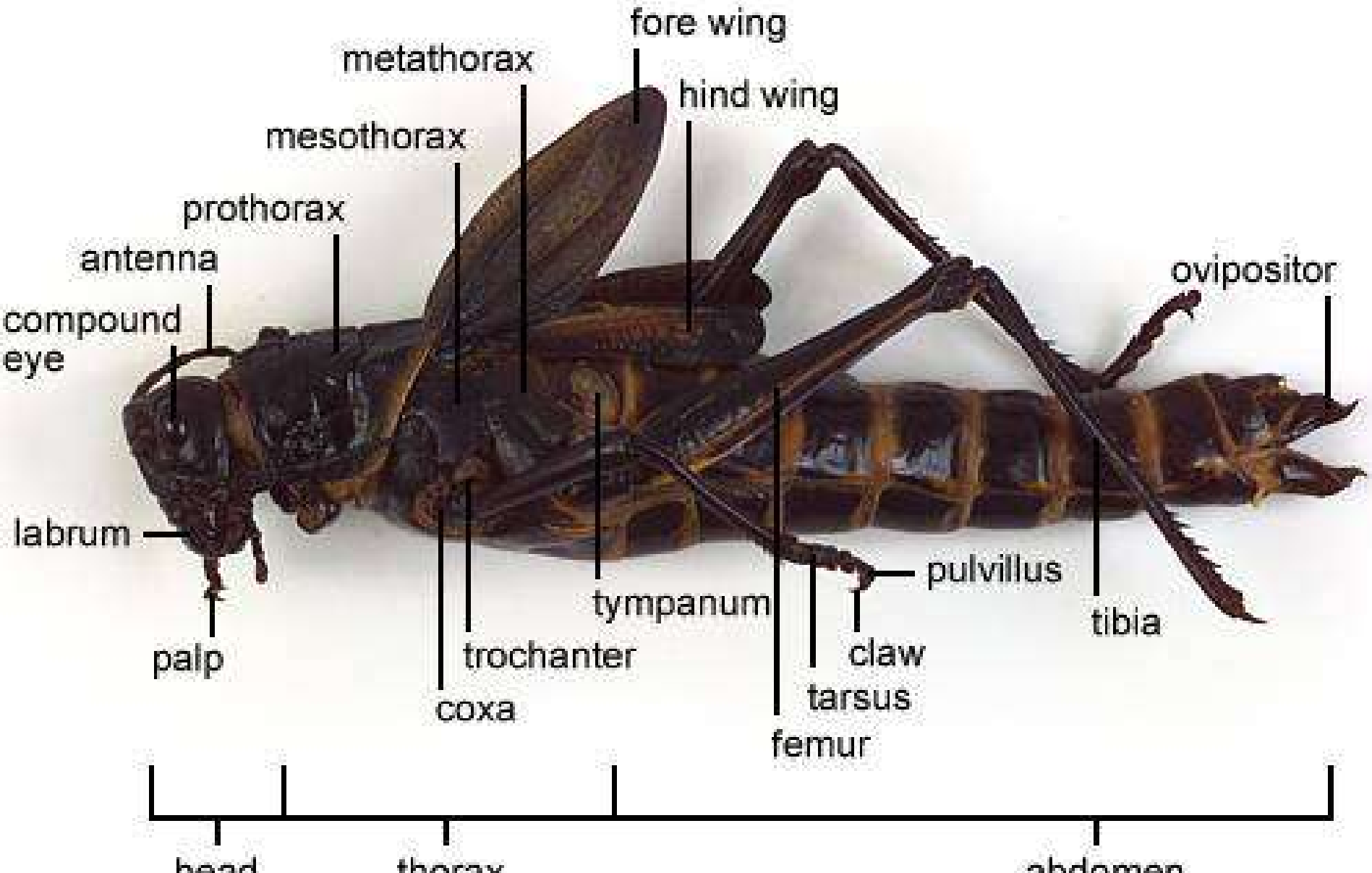
(e.g., bees and wasps display a pattern on black and yellow stripes)

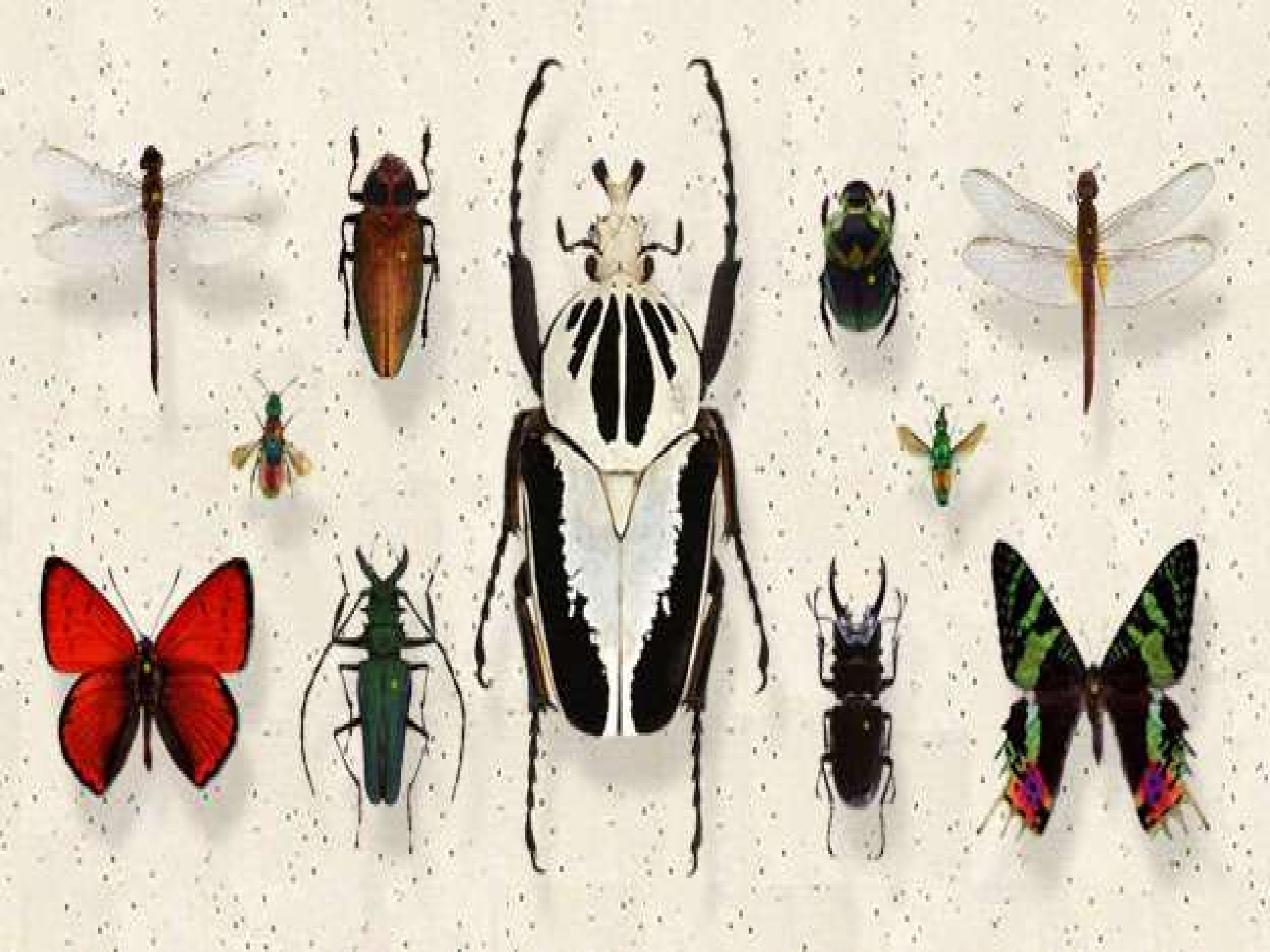
(3) Batesian Mimicry

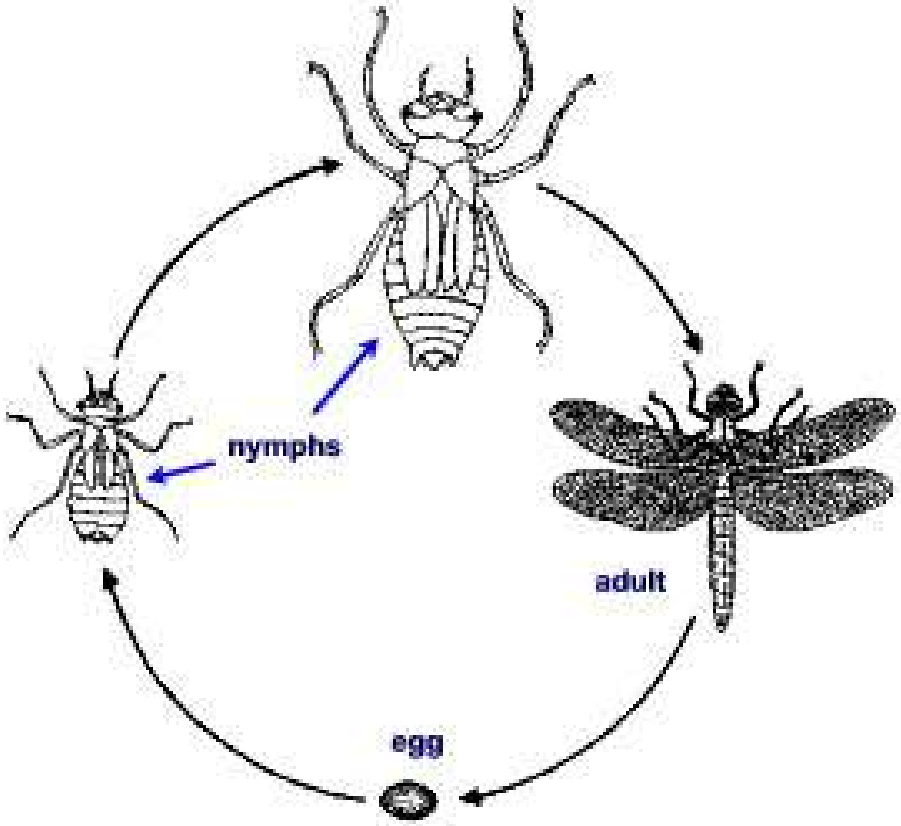
• HARMLESS species mimics warning coloration of a DANGEROUS species (e.g., Syrphid fly mimicking the bumblebee)

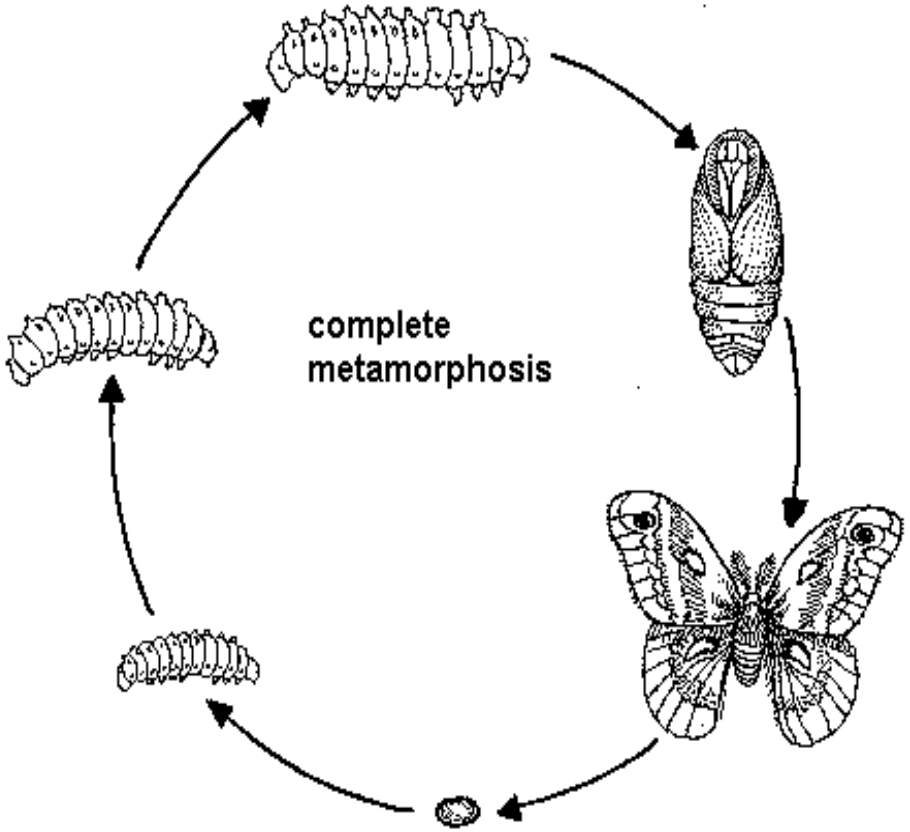

Abdomen
Thorax
Head
Antennae
Compound eye
Anus
Heart
Dorsal artery
Digestive system
Cerebral ganglion (brain)
Subesophageal ganglion
Vagina
Malpighian tubules
Ovary
Tracheal tubes
Nerve cord
Mandible

Grasshopper - External Features






nymphs
adult
egg

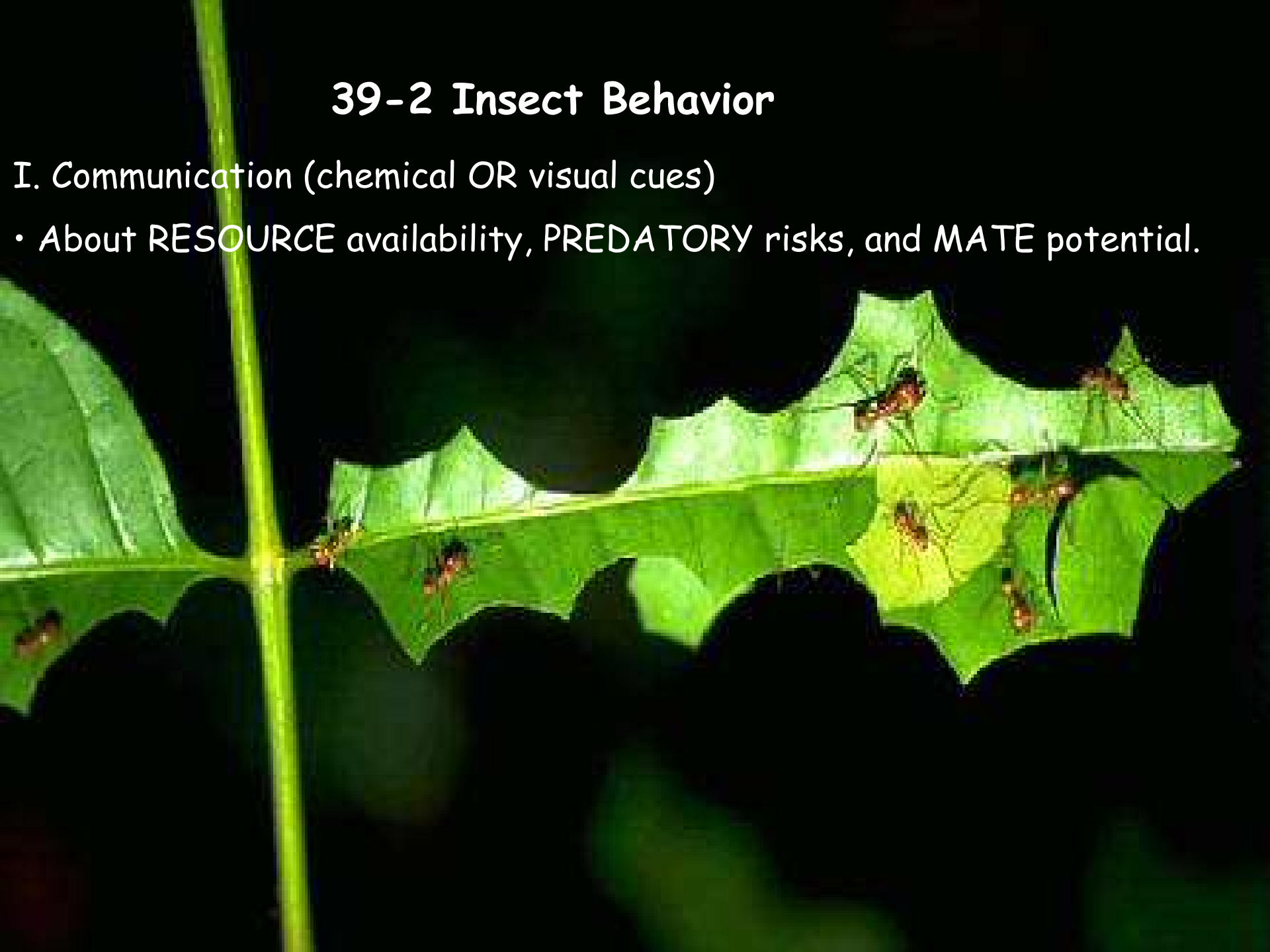

complete
metamorphosis


NIKE

39-2 Insect Behavior

I. Communication (chemical OR visual cues)

- About RESOURCE availability, PREDATORY risks, and MATE potential.



(1) Pheromone

• Chemical influences BEHAVIOR or DEVELOPMENT of members of SAME species.

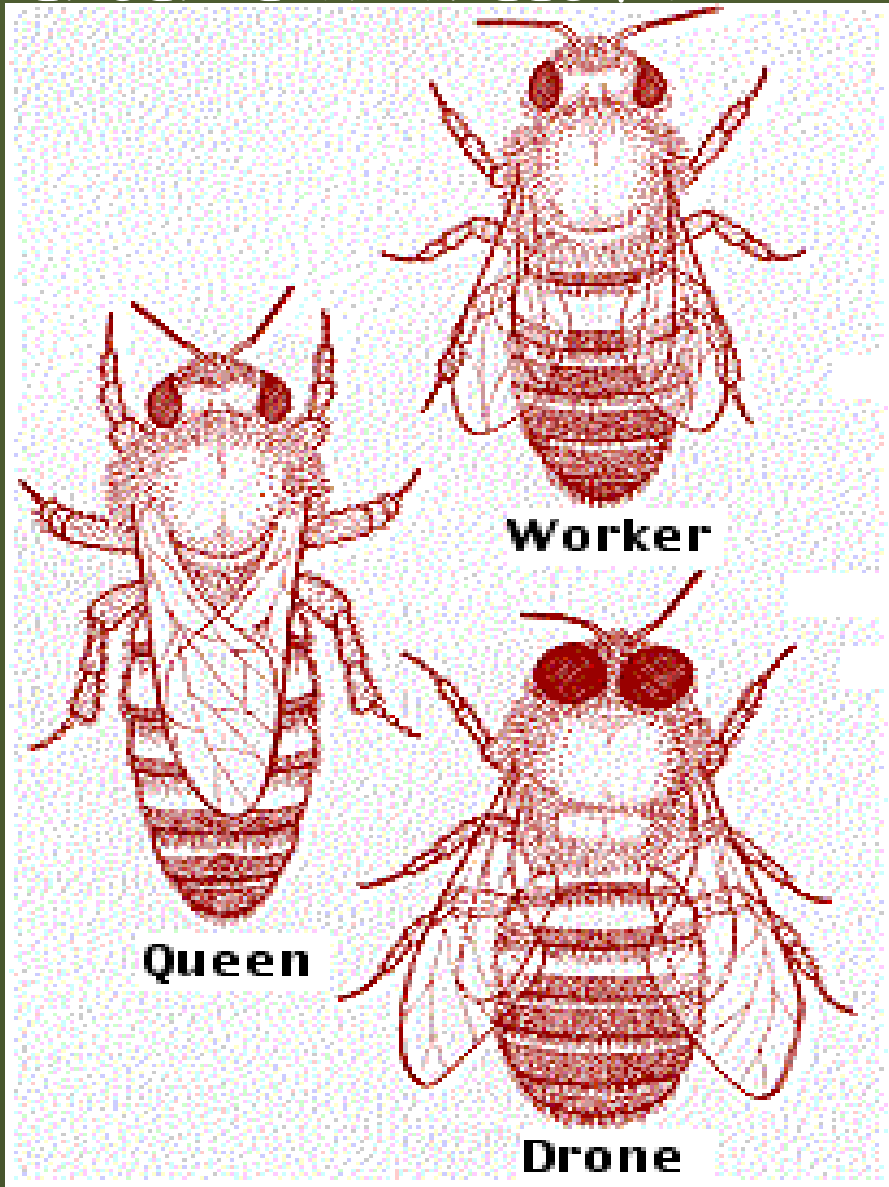
EX: ANT trails, female SILKWORM moth (pheromone), male CRICKETS (chirping at species-SPECIFIC frequency), female MOSQUITOES (buzzing), FIREFLIES (light patterns for mating)

II. Behavior in Honeybees (similar to wasps, ants, and termites)

• In SOCIAL colonies, members INNATELY programmed to GATHER food, PROTECT colony, and REPRODUCE.

(1) Social Insects (live in complex colonies or societies)

• DIVISION of labor creates INTERDEPENDENCE and a NEED for communication.



(2) Innate Behavior (behavior known at BIRTH ~ STINGING)

• Neither taught NOR learned → GENETIC programmed during development. (i.e., hard-wired)

(3) Worker Bees (up to 80,000 per hive)

• STERILE females make up MAJORITY of hive; workers perform ALL hive duties EXCEPT reproduction.

The Worker Bee - She does it all, from building the combs, standing at guard duty, feeding the babies to collecting nectar and pollen to feed the colony. She is also the one that stings! During warmer weather the workers only live for about 6 weeks.

Critical Thinking

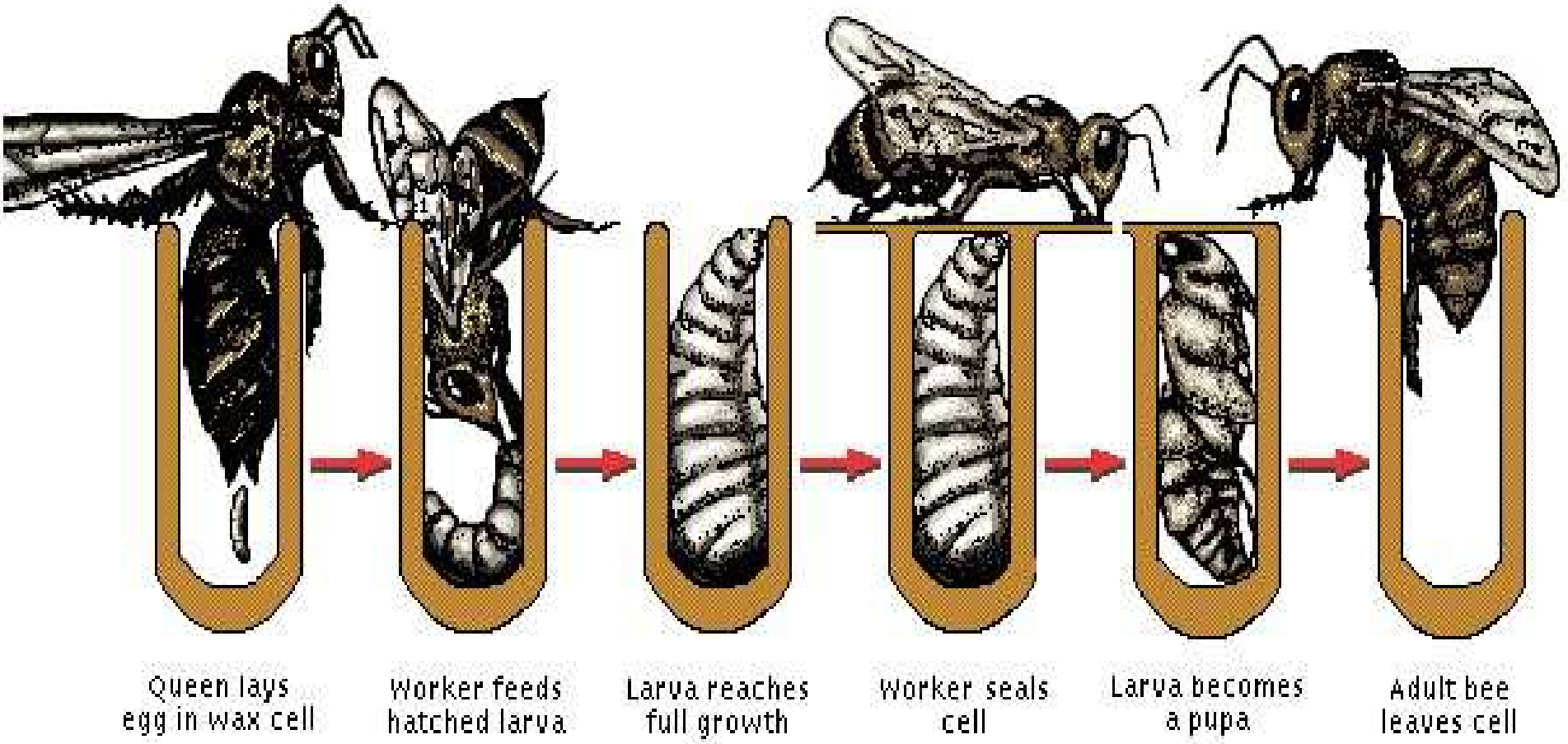
(5) During their lives, worker bees move from first feeding and caring for larvae inside the hive to later gathering nectar and defending the hive. Why do you think this sequence is more advantageous for the hive than the reverse sequence might be?

(4) Queen Bee

- ONLY fertile female in hive, and ONLY function is to REPRODUCE.

This is a picture of the queen bee in our observation hive. We painted the white spot on her, to make her easier to find. She is walking on brood (baby bees) that will be hatching soon, looking for a empty cell to lay an egg in. A queen bee can lay as many as 2000 eggs a day and can choose to lay a boy (drone) bee or a girl (worker) bee at will. A queenbee can live for 4 to 5 years.

This is a picture of the queen bee in our observation hive laying an egg. She will drop a small egg into the cell and then move on to the next empty cell. The worker bees will then take care of the developing bee until it hatches. Worker bees hatch in about 21 days, Drone bees hatch in about 24 days.

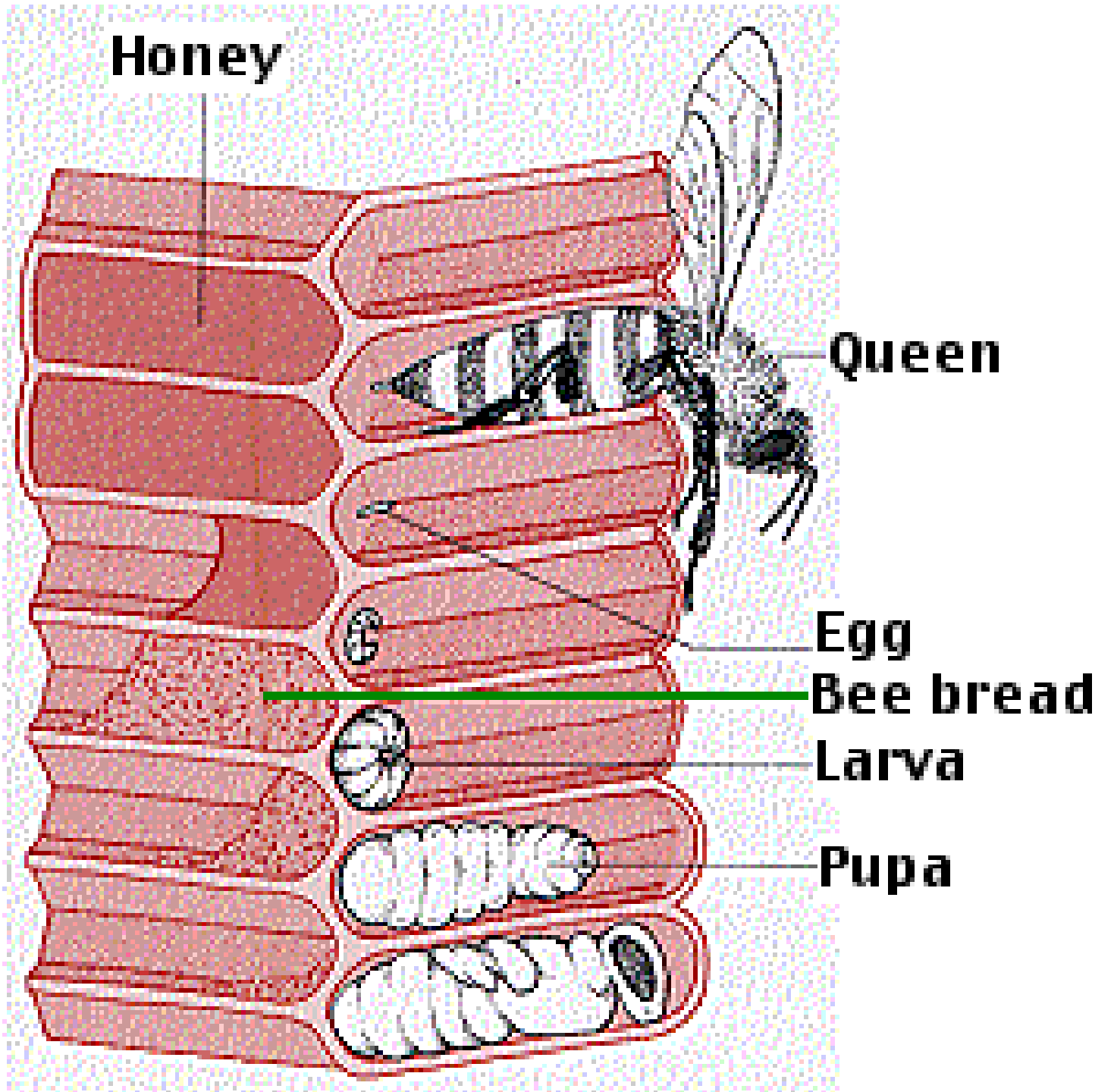

Queen lays egg in wax cell
Worker feeds hatched larva
Larva reaches full growth
Worker seals cell
Larva becomes a pupa
Adult bee leaves cell

(5) Drones (hive may reach a few HUNDRED during SUMMER months)

• Stinger-LESS males develop from UN-fertilized eggs (parthenogenesis) and are required to DELIVER SPERM to QUEEN.

NOTE: Mouthparts are too SHORT to obtain nectar so drones must DEPEND on the WORKER bees to feed them; as HONEY supply diminishes, drones are KILLED off by workers and bodies are CLEARED from the hive.

The Drone Bee - His only reason for living is to mate with a virgin queen bee and then he dies. He does not even have a stinger. If he happens to live to the Fall, the worker bees will force him out of the hive and since he can not make food for himself he will die.


Honey
Queen
Egg
Bee bread
Larva
Pupa

(A) Worker Bees (6 week lifespan, NUMEROUS tasks)

• FEED honey and pollen to QUEEN, DRONES, and LARVAE;
(NOTE: ovipositor REPLACED with a barbed STINGER and venom sac).

(1) Royal Jelly (made by WORKER BEES)

• High PROTEIN substance FED to QUEEN and LARVAE during 1ST week;
(becomes replaced with WAX, used to build and repair honeycomb).

(B) The Queen Bee

• Diet of ROYAL JELLY throughout her LARVAL development; PERMITS secretion of "QUEEN FACTOR" upon EMERGING.

(NOTE: ONLY leaves the hive to MATE with a drone and then RETURNS)

(1) Queen Factor (released UNTIL hive becomes OVERCROWDED)

• PREVENTS other FEMALE larvae that were FED royal jelly from developing into QUEENS.

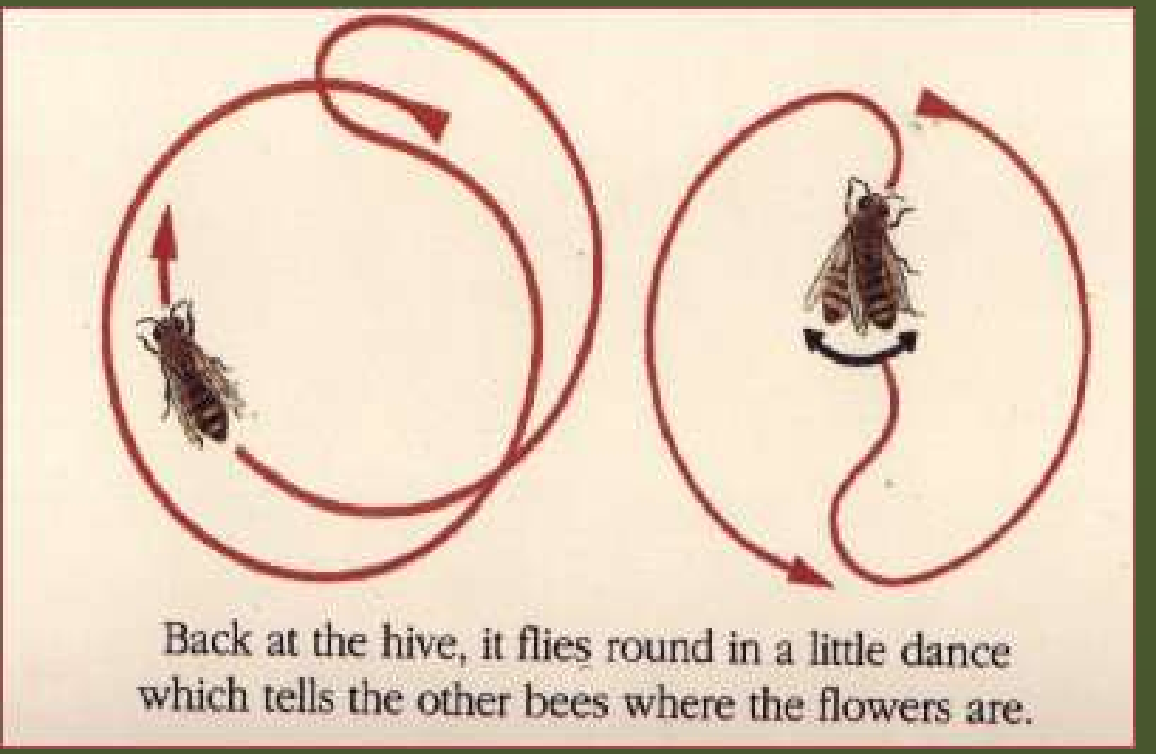
(C) Dances of the Bees (Austrian entomologist, Karl von Frisch, 1973)

- When honeybees LEAVE hive and FIND a source of pollen and nectar, HOW do they COMMUNICATE the location to other workers in hive?

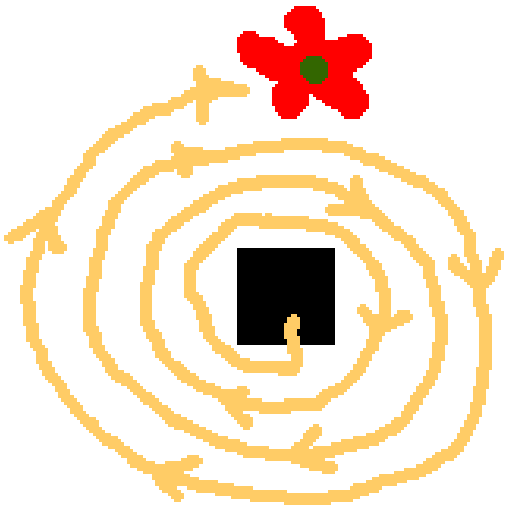
NOTE: A GLASS-walled hive with several FEEDING STATIONS were used to study the "SCOUT BEES" activity.

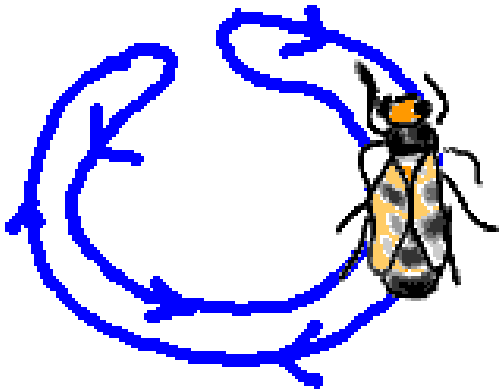
(1) Round Dance (conveys food source is CLOSE to the hive)

• SCOUT bee circles to RIGHT and then to LEFT → but NO information about DIRECTION of food source is conveyed.



Back at the hive, it flies round in a little dance which tells the other bees where the flowers are.

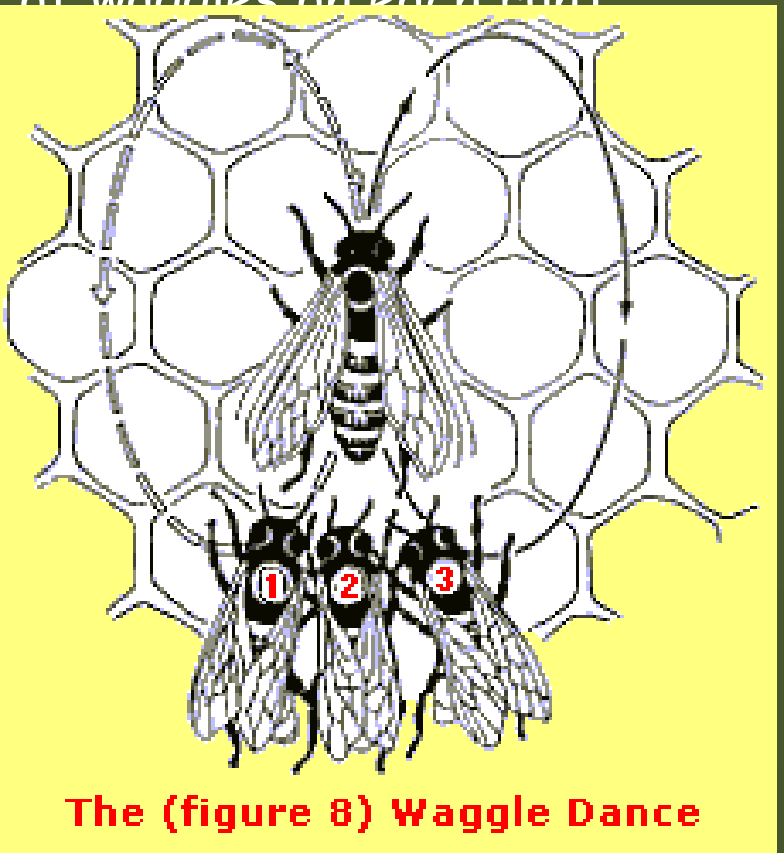




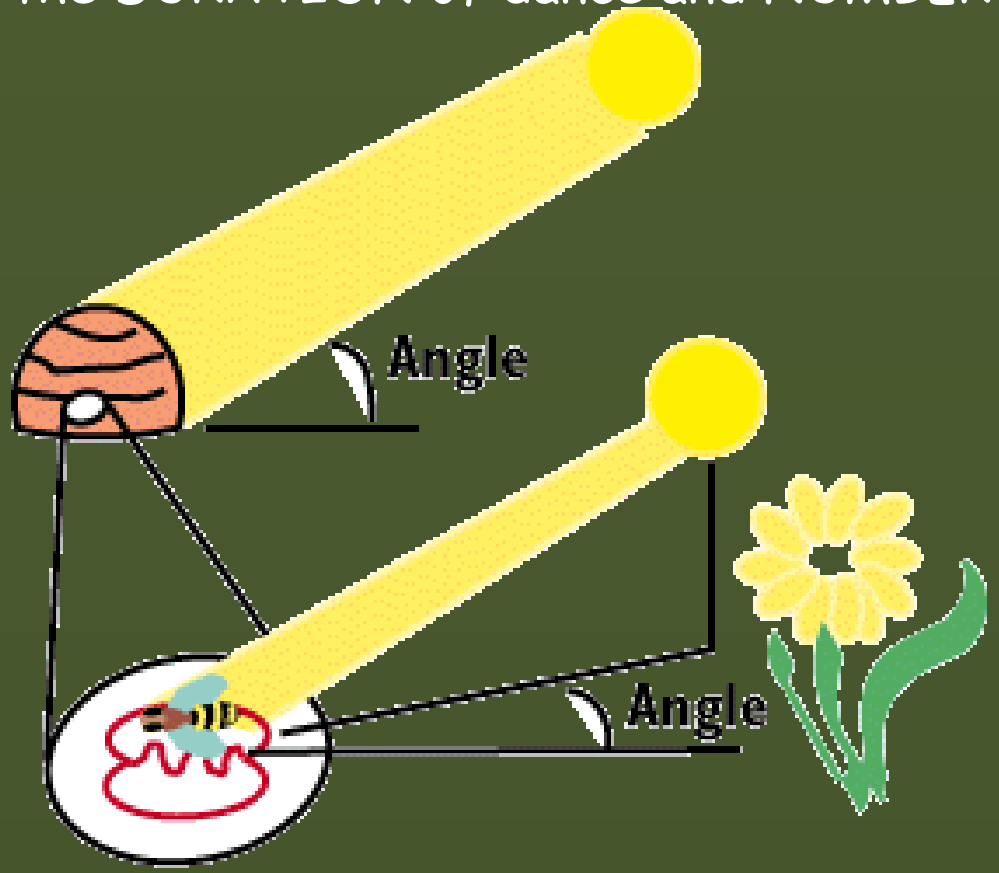
(2) Waggle Dance (food source is FAR from the hive, need directions)

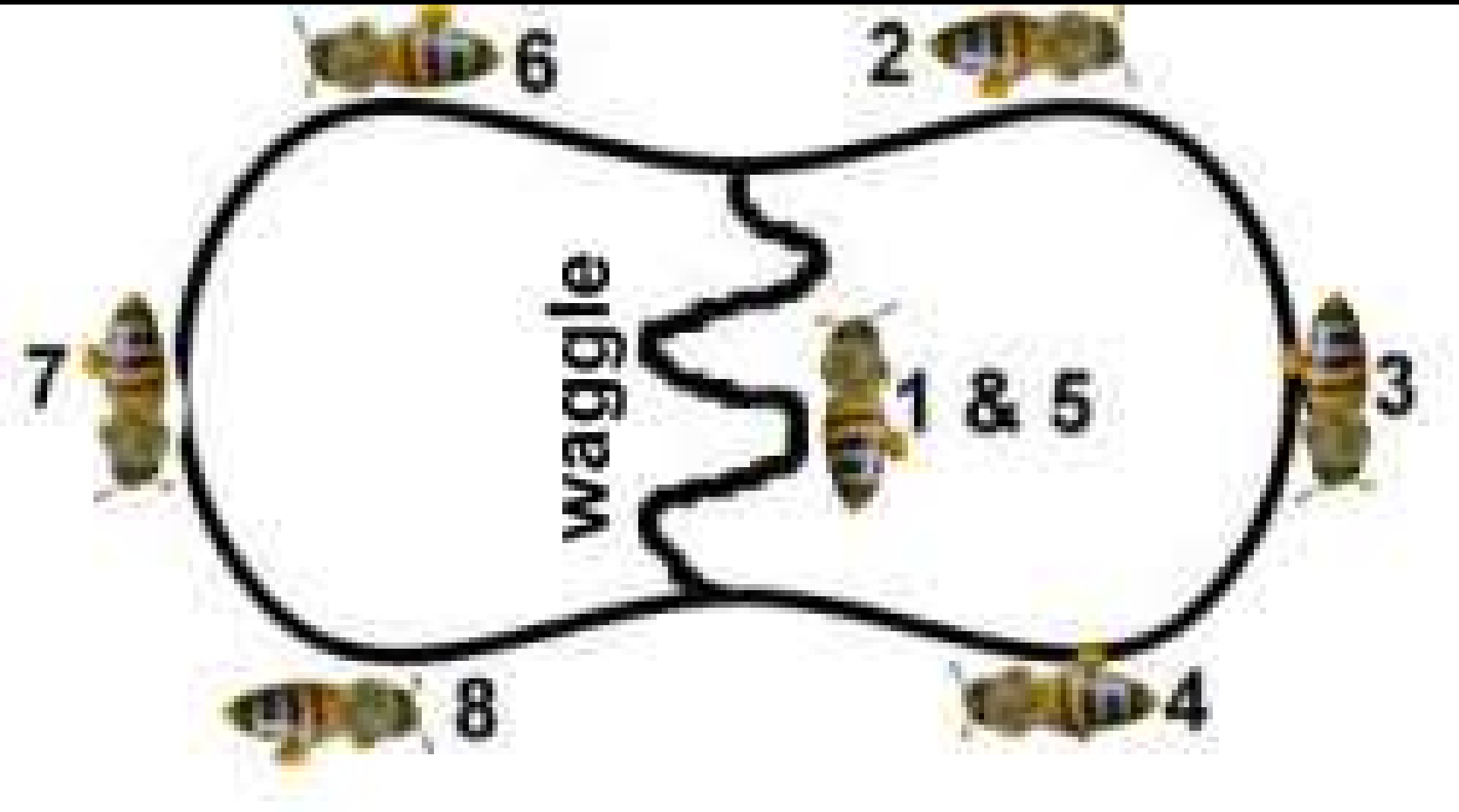
•SCOUT bee waggles ABDOMEN from side to side in a FIGURE-8; DIRECTION of food source is determined by ANGLE of the straight run on the vertical surface;

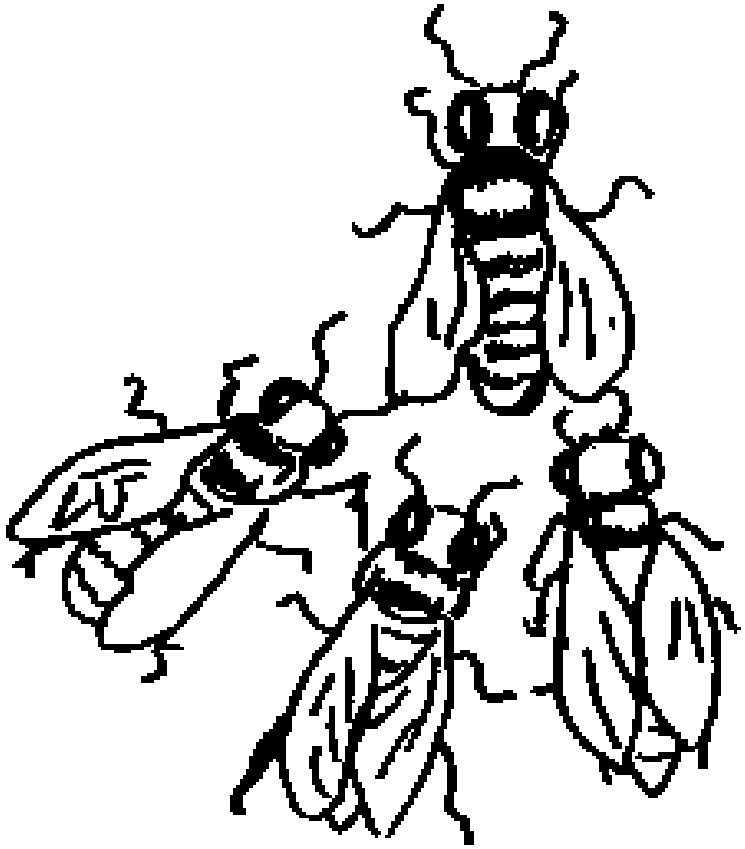
(Ex: Straight up, meant a DIRECTION towards the SUN; the DISTANCE to food source was determined by the DURATION of dance and NUMBER of waggles on each run)

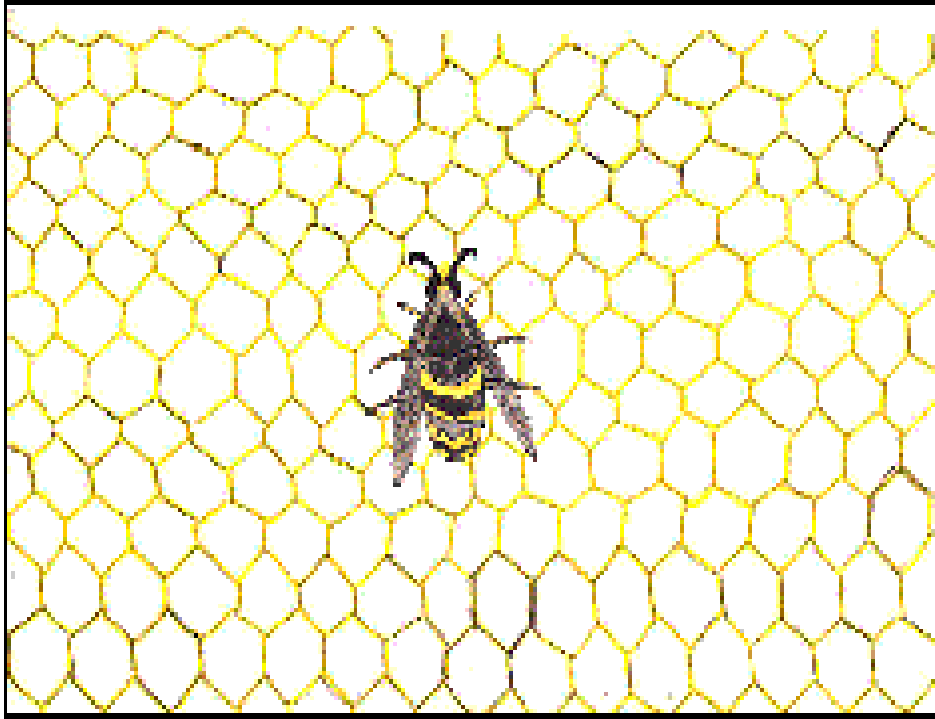


The (figure 8) Waggle Dance




6
2
7
waggle
1 & 5
3
8
4



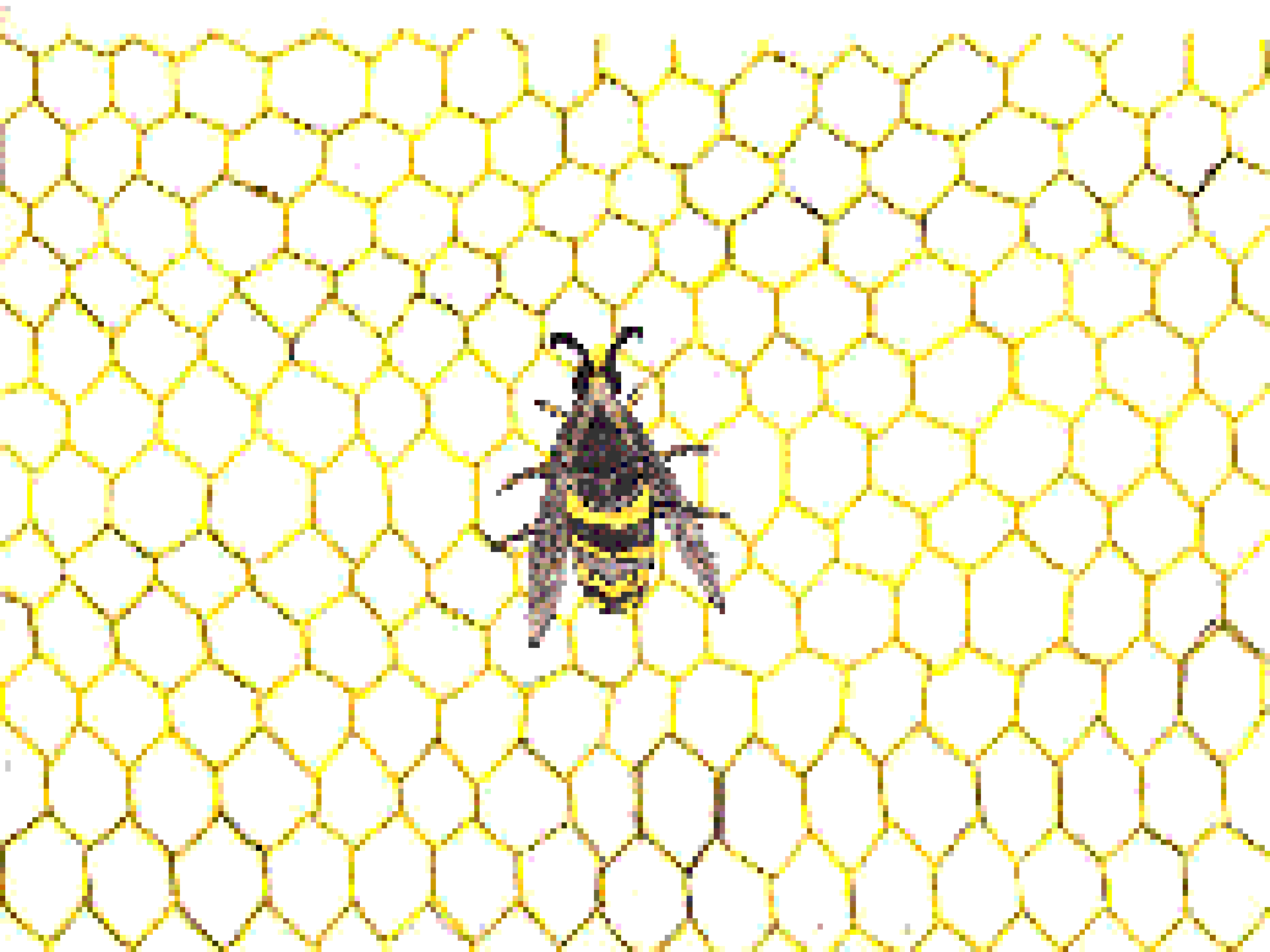


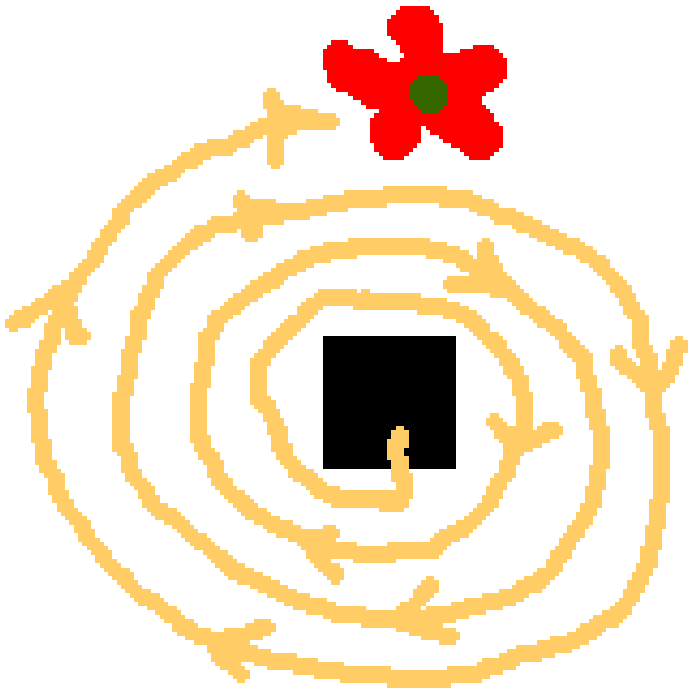
(D) Altruistic Behavior (WHEN worker bees DEFEND the colony)

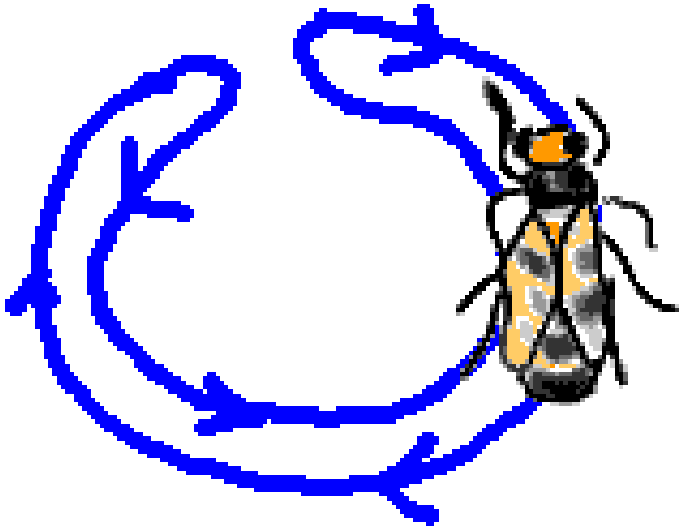
• Ultimate SACRIFICE of causing their OWN deaths—stinger and venom sac are BARBED, so they get pulled out (UNLIKE a wasp).

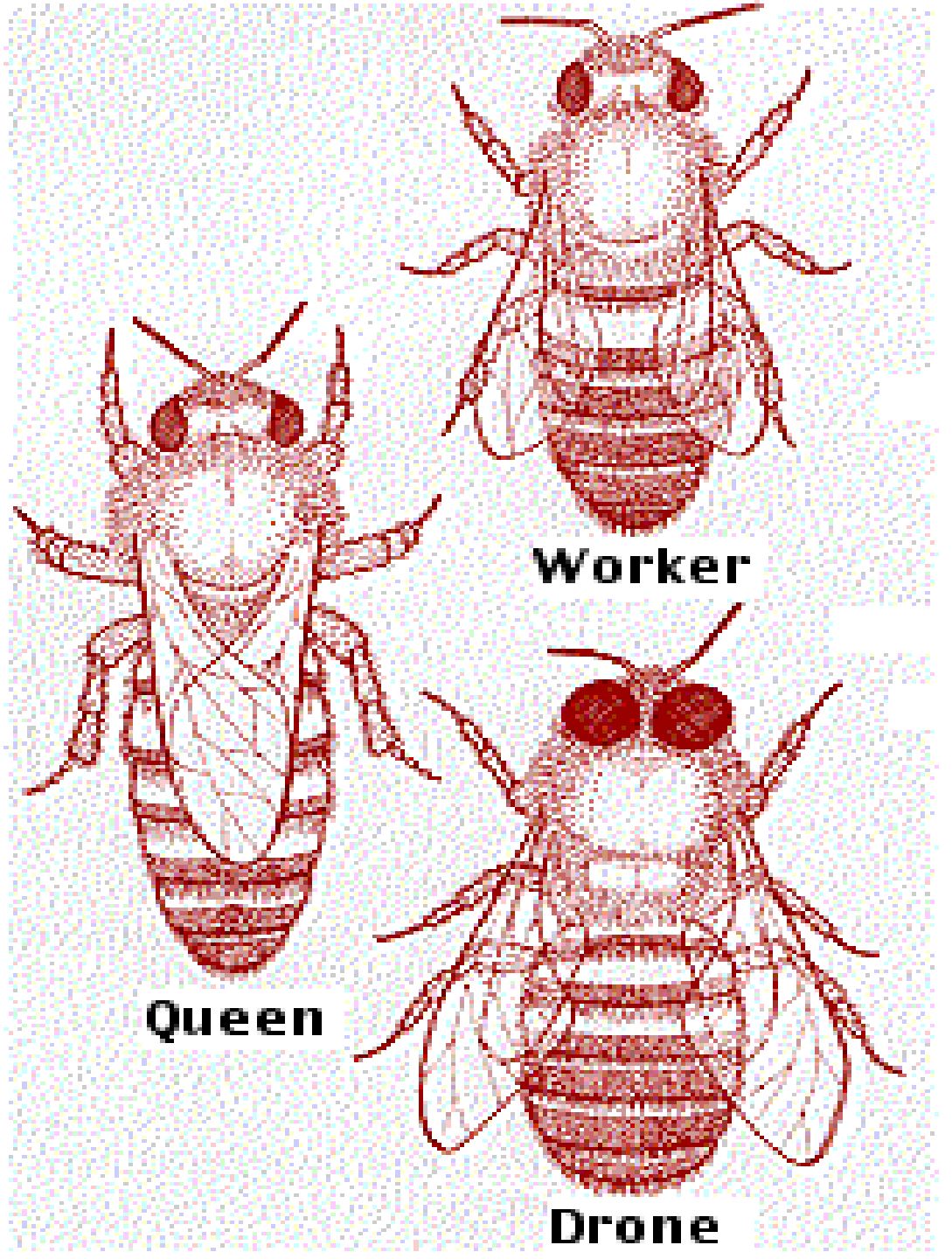
(1) Kin Selection (an EVOLUTIONARY behavior)

- Increasing propagation of one's OWN genes (WORKER bee) by HELPING a CLOSELY-RELATED individual reproduce (QUEEN bee).

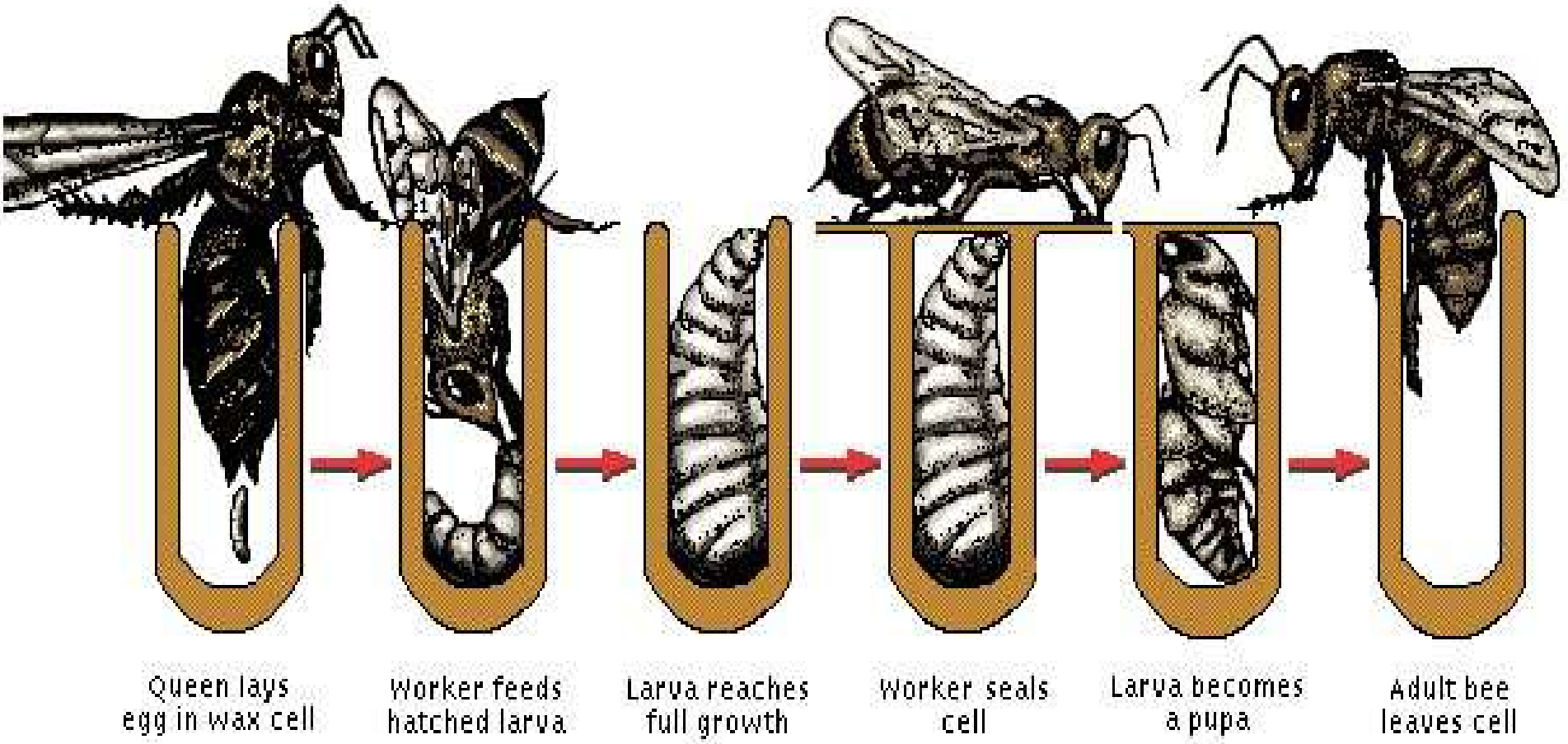







Worker
Queen
Drone


MicroAngela


Queen lays egg in wax cell
Worker feeds hatched larva
Larva reaches full growth
Worker seals cell
Larva becomes a pupa
Adult bee leaves cell

Parthenogenesis

"(pärthenojen´esis) [Gr.,virgin birth], in biology, a form of reproduction in which the ovum develops into a new individual without fertilization." www.encyclopedia.com

Charles Bonnet (1720-1793)

observed in many lower animals (e.g. rotifers, aphids)

Extra Slides AND Answers for Critical Thinking Questions

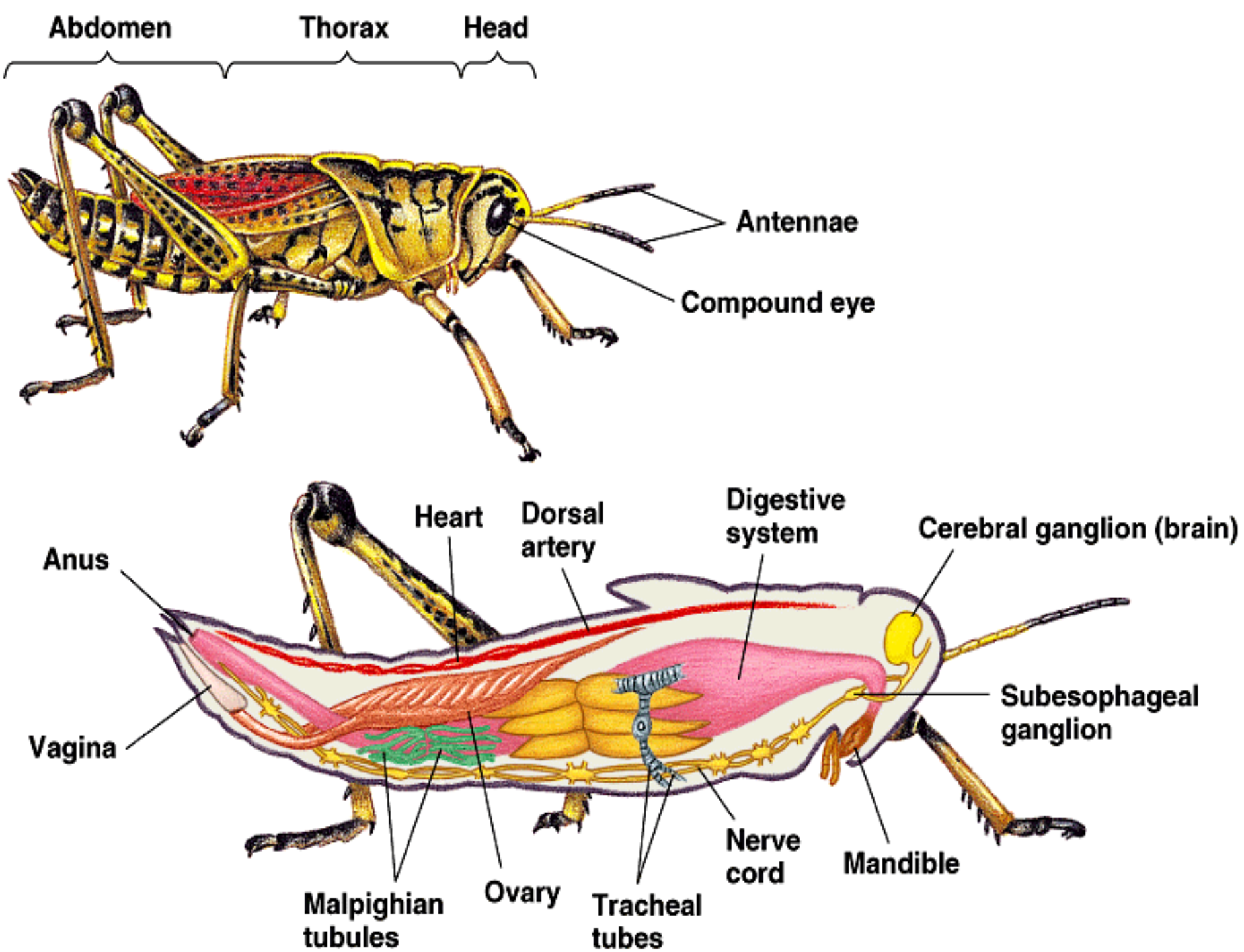
(1) Characteristics include insects' short life span, rapid reproduction with the production of many eggs, metamorphosis, and structural and behavioral adaptations.

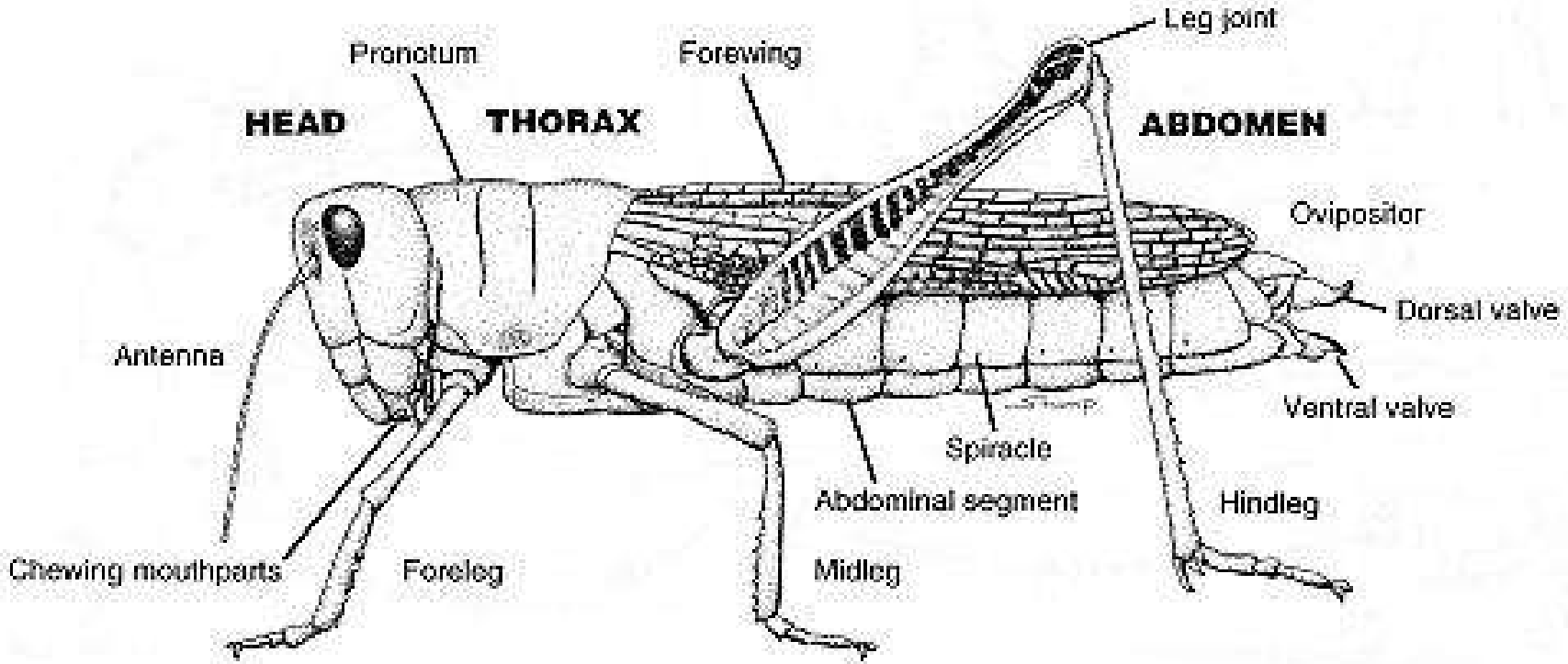
(2) Both have exoskeletons. Large crustaceans live underwater, and the water helps support their weight, taking some of the load off their exoskeleton. The largest insects are terrestrial, and the ability of their exoskeleton to support their body weight puts a much lower limit on their size.

(3) Insects with genes that confer resistance to an insecticide survive and reproduce in large numbers. Thus, they proliferate through natural selection (although the insecticide may be synthetic). This process occurs rapidly because insects have short life spans and produce large numbers of eggs.

(4) The circulatory system of a cephalopod carries oxygen to and carbon dioxide away from the animal's active cells. Insects use tracheae to transport these gases, so they can remain active with a less-efficient circulatory system.

(5) If a worker bee dies from losing its stinger while defending the hive, it will have already completed most of its other functions. It would be a greater loss to the hive if death occurred early in the worker's life.


Abdomen
Thorax
Head
Antennae
Compound eye
Anus
Heart
Dorsal artery
Digestive system
Cerebral ganglion (brain)
Subesophageal ganglion
Vagina
Malpighian tubules
Ovary
Tracheal tubes
Nerve cord
Mandible


Leg joint
Pronotum
Forewing
HEAD
THORAX
ABDOMEN
Ovipositor
Dorsal valve
Antenna
Ventral valve
Spiracle
Abdominal segment
Hindleg
Chewing mouthparts
Foreleg
Midleg