2013

COMPARATIVE ANIMAL PHYSIOLOGY

Structure & Function of Animals in Some Important Phyla

Laboratories 1, 2, 3, 4, 5, 6

Keep a detailed laboratory notebook on the animals you study. Be patient - look at the animals. Make drawings, write your observations in your notebook. Perform some of the simple experiments described in the lab book. You have a rare opportunity to become acquainted with a variety of animals. Before you can begin to ask physiological questions about these animals, you must understand the structures which mediate the different physiological functions. Know the features which distinguish the various phyla. Understand the relationships among the different phyla. In addition to specific questions which you may want to investigate in the different animals, consider the following topics as well:

1) modes of locomotion
2) modes of food acquisition
3) digestive tract properties
4) modes of excretion
5) modes of circulation of internal fluids
6) modes of respiration
7) modes of reproduction
8) types of sensory systems
9) types of coordinating systems
10) how the above adaptations allow the animals to exploit their environment

I. Protozoa - use live specimens and slides, Species?

Pay particular attention to

1) Modes of locomotion
2) Modes of food acquisition
3) Sensory systems
4) Reproduction

II. Cnidaria (Coelenterata) - use live specimens and slides, species?

1) Understand polymorphic life cycle (medusa, polyp)
2) Significance of gastrovascular cavity
3) Feeding mechanisms - nematocyst
4) Different cell layers

III. Platyhelminthes - live specimens and slides, Species?

1) Digestion in both forms
2) External anatomy
3) Internal anatomy

IV. Annelida - preserved specimens and slides; Species?

Note elaborate organ systems

1) External anatomy of marine and terrestrial forms
2) Internal anatomy - segmental septa
   - reproductive organs
   - digestive organs
   - excretory organs (difficult to see)
   - nerve cord
   - circulatory system

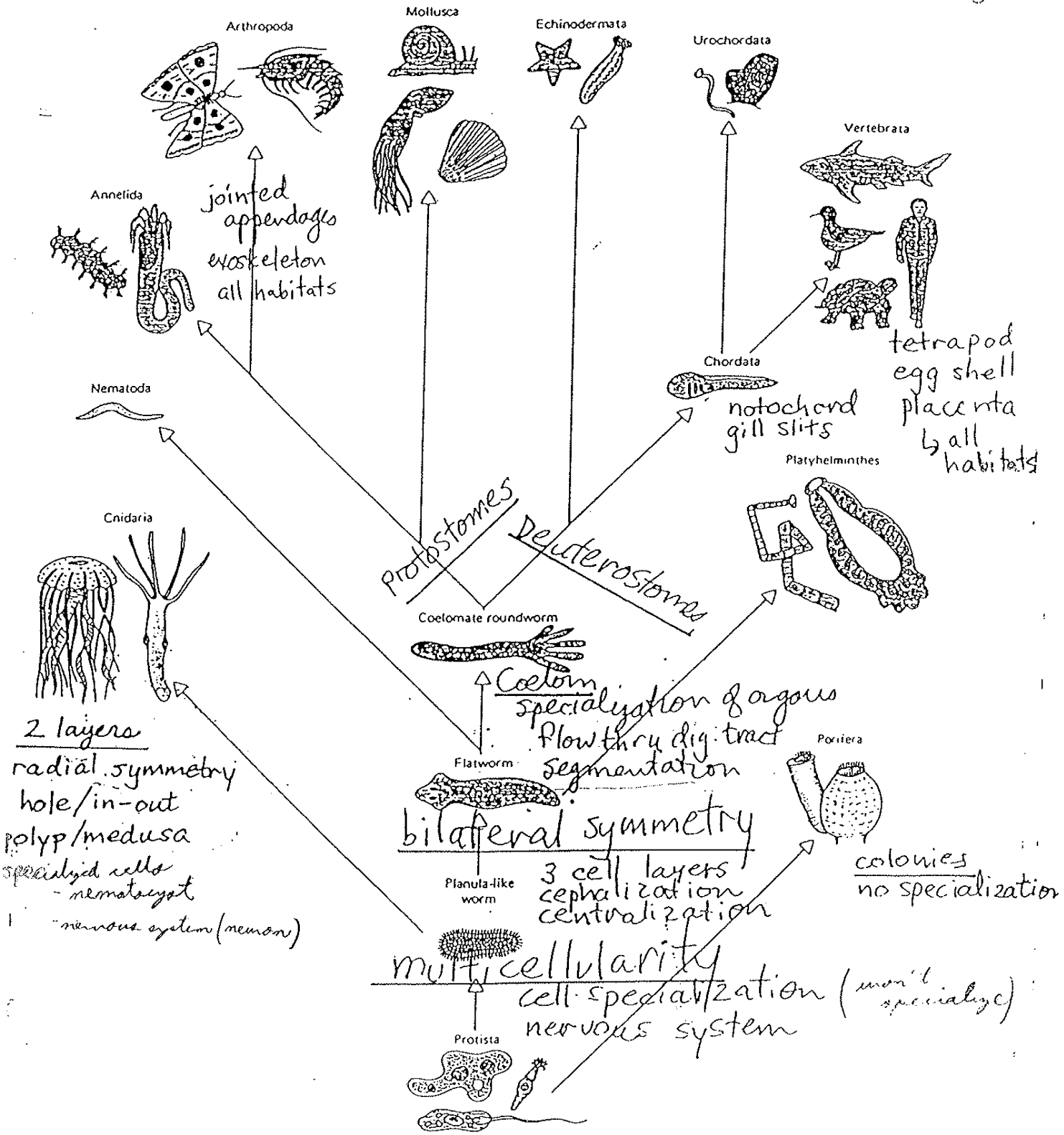
V. Arthropoda - preserved specimens and slides, species?

Note elaborate organ systems

1) External anatomy
2) Internal anatomy - digestive system
   - respiratory system
   - excretory system
   - nervous system
   - circulatory system

VI. Chordata - preserved specimens and models; a small but rather interesting phylum; Species?

1) Modes of locomotion
2) Sensory organs and senses
3) Internal anatomy - musculoskeletal system
   - digestive system
   - respiratory system
   - circulatory system/heart
   - excretory system
   - reproductive system
   - nervous system - locate the sciatic nerve
     brain



Evolution of different animals according to one widely held theory, based on the structure and development of modern animals.

homology analogy
convergence
divergence

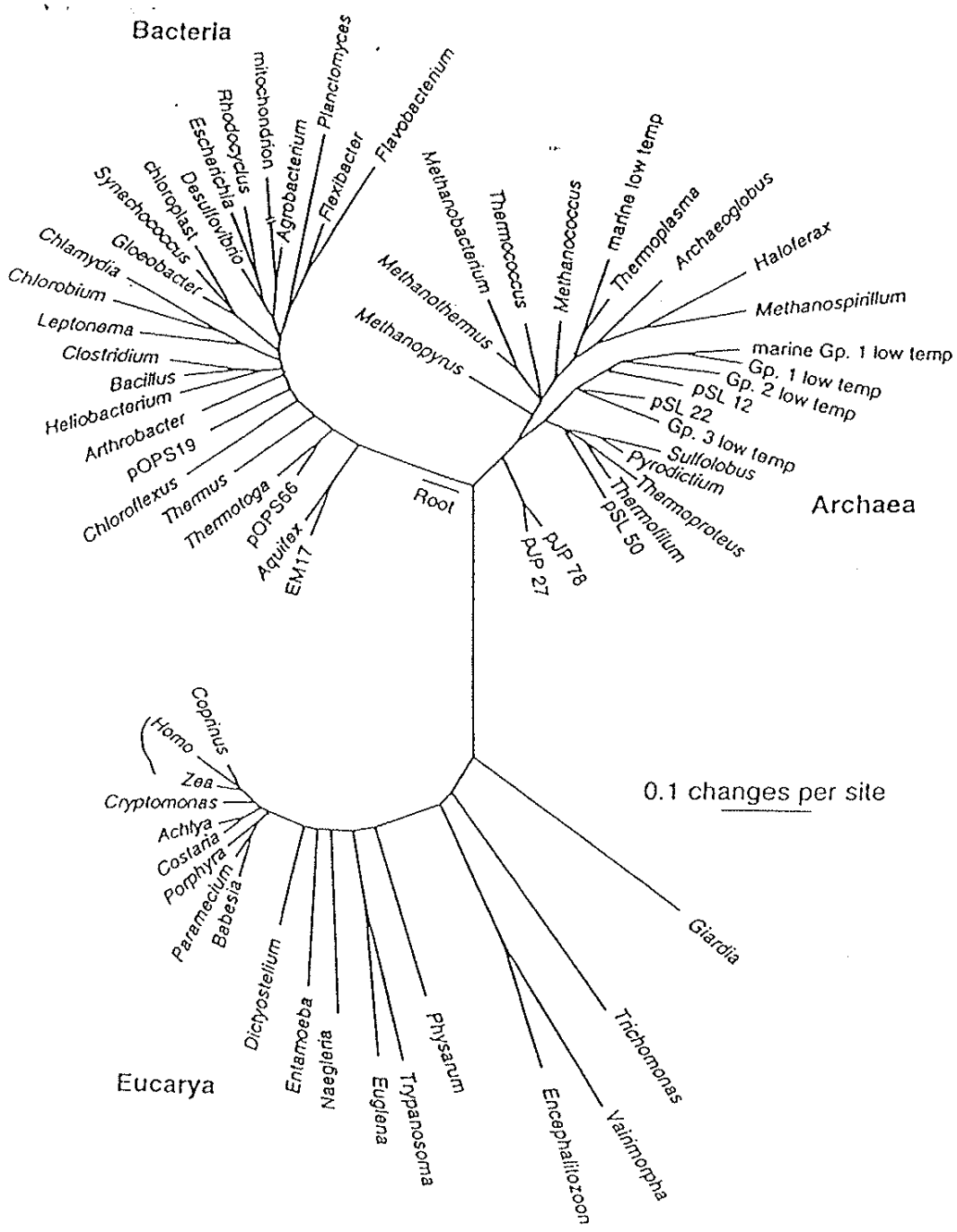


Fig. 1. Universal phylogenetic tree based on SSU rRNA sequences. Sixty-four rRNA sequences representative of all known phylogenetic domains were aligned, and a tree was produced using FASTDNAML (*43, 52*). That tree was modified, resulting in the composite one shown, by trimming lineages and adjusting branch points to incorporate results of other analyses. The scale bar corresponds to 0.1 changes per nucleotide.

CAP LAB 1: Protozoa (not a phylum), Rotifera (what is this?), Cnidaria

Living protozoa or protists
Paramecium (use methyl cellulose on slide to slow organisms)
Vorticella (use methyl cellulose on slide to slow organisms)
Blepharisma (use methyl cellulose on slide to slow organisms)
Amoeba

Living rotifers
What are the characteristics of these animals?
Make wet mounts of them with and without methyl cellulose)

Living Cnidaria
Hydra (with *Daphnia* for feeding; put in a small watch glass of water)
To what phylum do *Daphnia* belong?

Prepared slides
Hydra
Obelia (both polyp and medusa)
Various protists

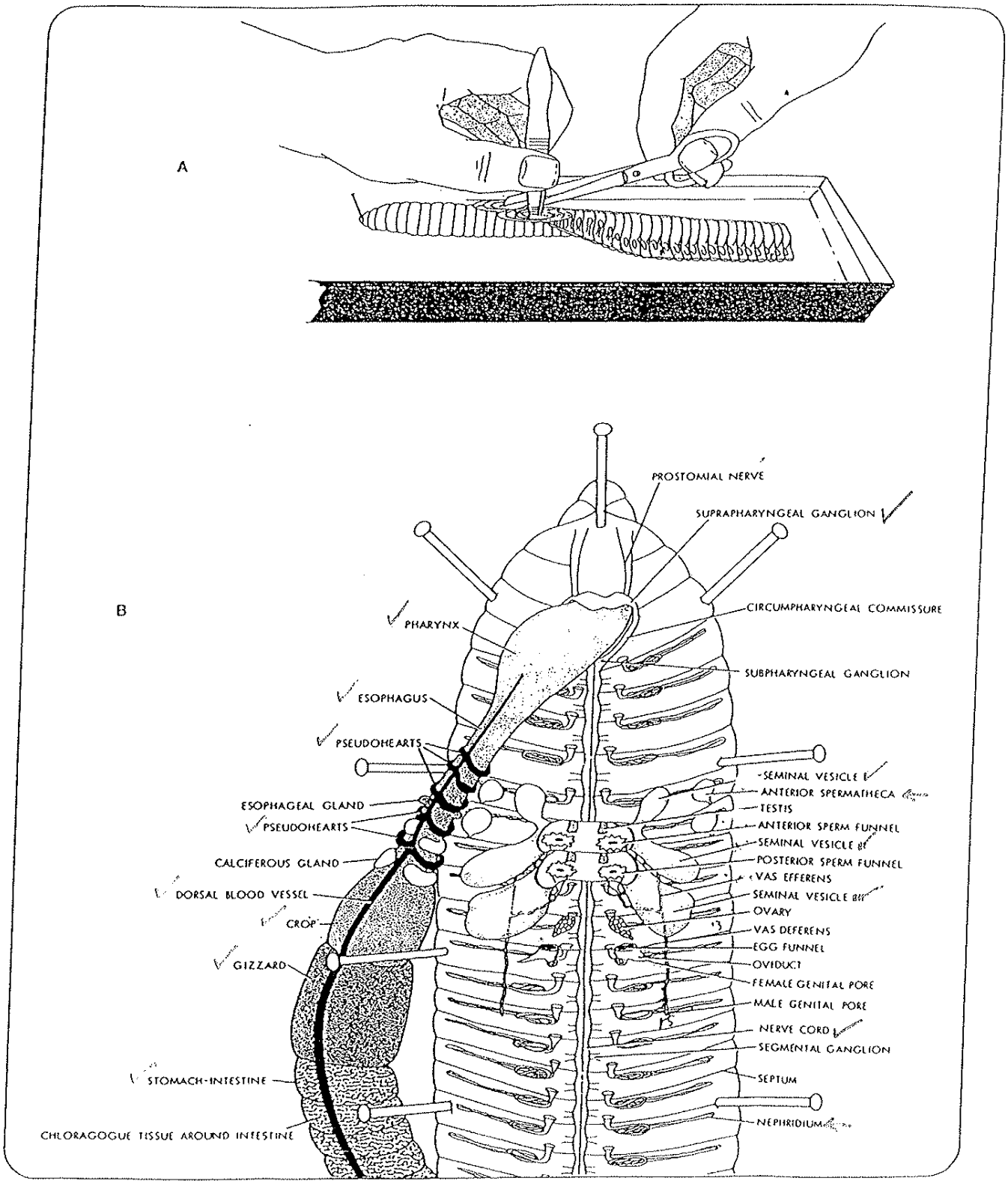
CAP LAB 2: Platyhelminthes, Annelida, Arthropoda, (Mollusca)

Phylum Platyhelminthes
Living *Planaria*
Prepared slides of *Planaria* and *Taenia* (tapeworm; how does it get food?)

Phylum Annelida
Living *Enchytraeus*
Preserved earthworms, *Lumbricus,* for dissection
Prepared slides of earthworms and polychaetes

Phylum Arthropoda
Living *Daphnia*
Living *Acheta* (crickets)
Preserved *Romalea* for dissection

Phylum Mollusca
Shells!


A
B
PROSTOMIAL NERVE
SUPRAPHARYNGEAL GANGLION
CIRCUMPHARYNGEAL COMMISSURE
PHARYNX
SUBPHARYNGEAL GANGLION
ESOPHAGUS
PSEUDOHEARTS
SEMINAL VESICLE I
ANTERIOR SPERMATHECA
ESOPHAGEAL GLAND
TESTIS
PSEUDOHEARTS
ANTERIOR SPERM FUNNEL
SEMINAL VESICLE II
CALCIFEROUS GLAND
POSTERIOR SPERM FUNNEL
VAS EFFERENS
DORSAL BLOOD VESSEL
SEMINAL VESICLE III
OVARY
CROP
VAS DEFERENS
GIZZARD
EGG FUNNEL
OVIDUCT
FEMALE GENITAL PORE
MALE GENITAL PORE
NERVE CORD
SEGMENTAL GANGLION
STOMACH-INTESTINE
SEPTUM
CHLORAGOGUE TISSUE AROUND INTESTINE
NEPHRIDIUM

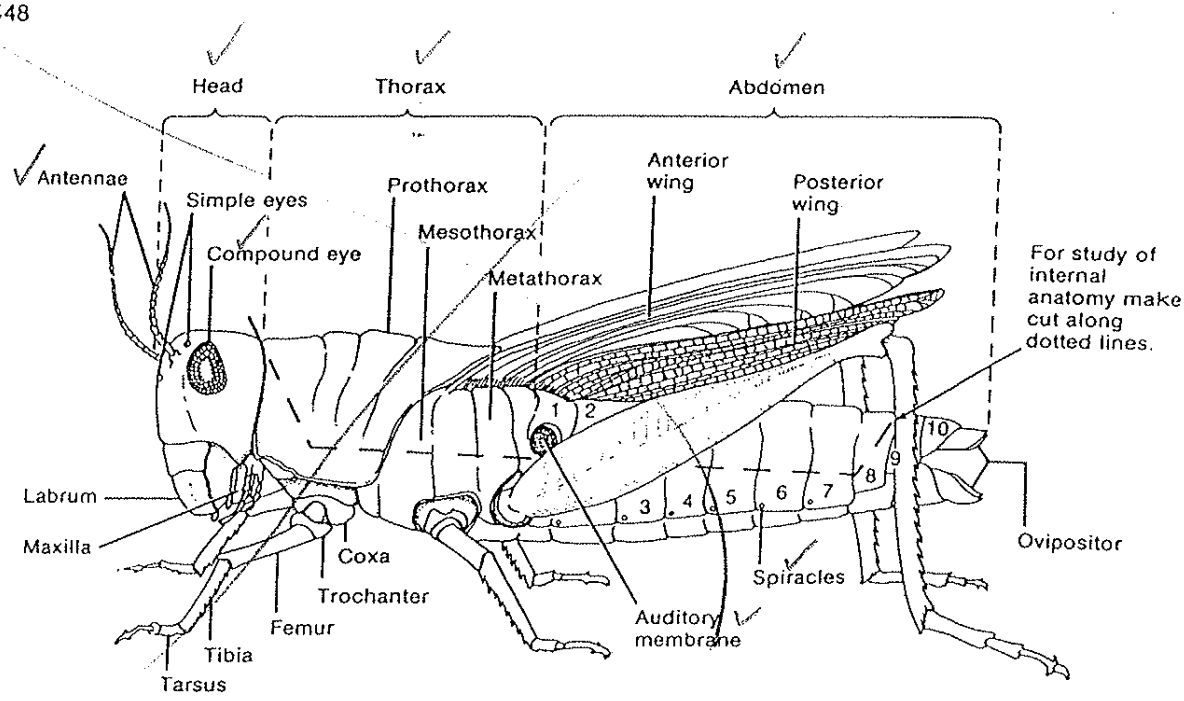


FIG. 36-7
External anatomy of a female grasshopper.

tify the leg segments indicated in Fig. 36-7. The meso- and metathorax each bear a pair of wings. The anterior wings of the grasshopper are thick and shield the larger pair of flight wings. Both pairs of wings are derived from the cuticle and have thick parts (veins) that strengthen them. Stretch out the wings, and examine the anterior protective wings and the flight wings.

The slender **abdomen** consists of 11 somites, the posterior ones being modified for reproduction. The male has a blunt terminal segment, whereas the female has four sharp conical prongs, the **ovipositors**, which are used in egg laying (Fig. 36-7). Along the lower sides of the thorax and abdomen are 10 pairs of **spiracles**, the small openings of elastic air tubes, or **tracheae**, that branch to all parts of the body and constitute the respiratory (**tracheal**) system of the grasshopper. This system of air tubes brings atmospheric oxygen directly to the cells of the body. The spiracles open and close to regulate the flow of air. The three most anterior pairs of spiracles are inhalatory, piping air directly to all body tissues. The other spiracles are exhalatory.

2. **Internal Anatomy.** It is difficult to preserve the internal organs of the grasshopper because the preservative often fails to penetrate the exoskeleton. Careful dissection is necessary to study the internal anatomy.

After removing the wings, start at the posterior end, and make two lateral cuts toward the head with a pair of scissors or fine scalpel as indicated in Fig. 36-7. Remove the dorsal wall. Locate the muscles on the inside of the body wall, and note their arrangement. What is their function?

A space between the body wall and digestive tract, the **hemocoel**, is filled with colorless blood.

Study the digestive tract and identify its parts (Fig. 36-9). Beginning at the anterior end, find the **mouth**, which is located between the mandibles and leads to a short **esophagus** followed by the **crop**. Next is the **stomach**, to which are attached six double finger-shaped digestive glands (**gastric caeca**); these glands produce enzymes that are secreted into the stomach to aid digestion. The digestive tract continues as the **intestine**, which consists of a tapered anterior part, a slender middle part, and an enlarged **rectum** that opens to the outside at the **anus**. During feeding, food held by the forelegs, labium, and labrum is lubricated by secretions from the salivary glands and chewed by the mandibles and maxillae. Chewed food is stored in the crop. Because most of the diges-

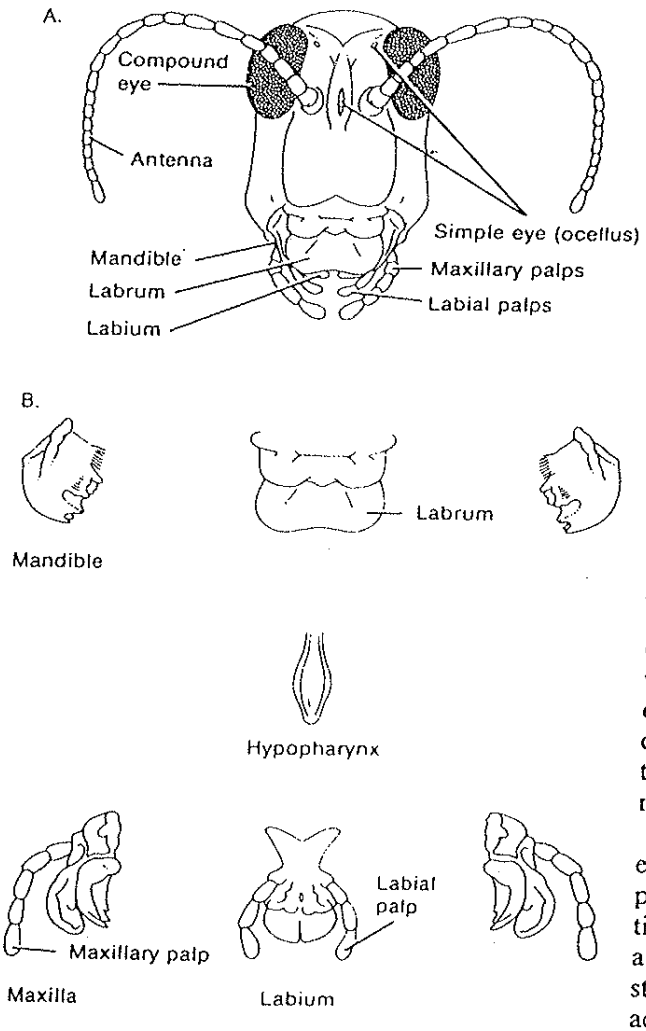


FIG. 36-8
Grasshopper (A) head and (B) mouth parts.

tive tract, except for the stomach and crop, is lined with chiton, which is impervious, digestion and absorption take place mainly in the stomach. Excess water is absorbed from any undigested food in the rectum.

The excretory system is made up of numerous tiny tubules—the excretory, or **Malpighian, tubules**—which empty their products into the anterior end of the intestine. These tubules remove urea and salts from the blood.

The sexes are separate, and their reproductive organs are in the terminal abdominal segments. In the male, each of the two testes is composed of a series of slender tubules, or follicles, and is located above the intestine; each testis is joined to a longitudinal **vas deferens** (Fig. 36-10). The vas deferens are joined to a single ejaculatory duct, to which accessory glands are attached. In the female, each **ovary** is composed of several tapering egg tubes (**ovarioles**), which produce the ova. Each ovary is joined to an **oviduct** leading to the **vagina**, to which a pair of accessory glands and a single **spermatheca** are attached. The latter organ is used to store sperm received at copulation.

The insect circulatory system can be studied by examining the wing veins of a living adult grasshopper or cricket. This can be done by preparing a plasticene or wax cell large enough to hold the insect on a microscope slide. Pin the animal down with two strips of paper, one across the thorax and the other across the body beneath the wings. Slip a piece of tinfoil or glazed white paper beneath the anterior

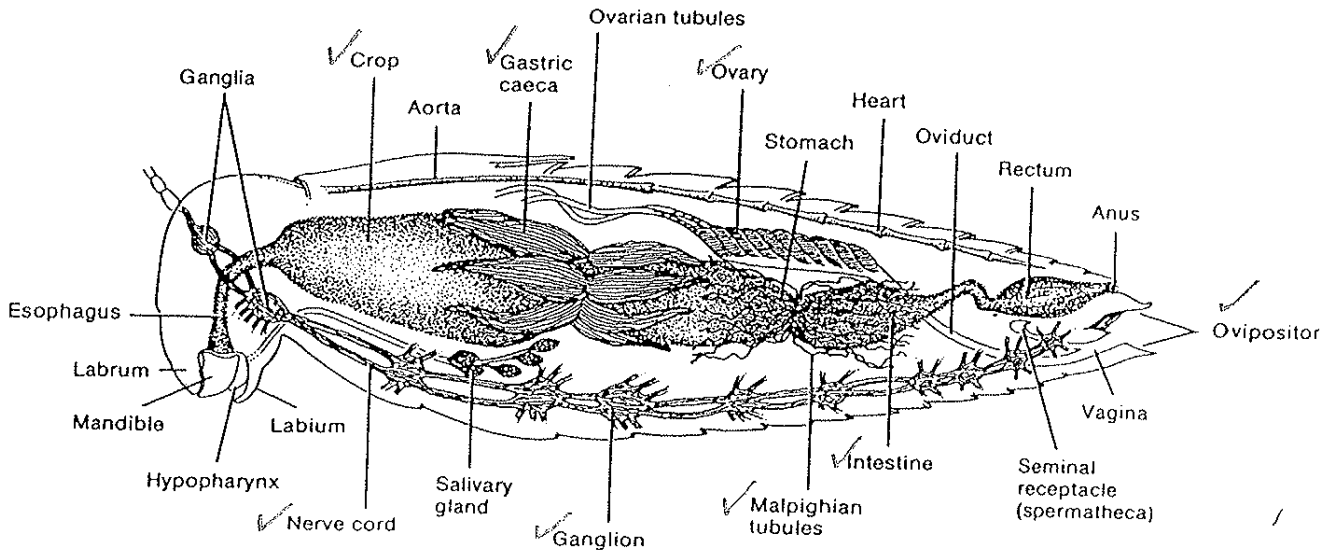


FIG. 36-9
Internal anatomy of a female grasshopper.

border of the lateral malleolus and down the dorsum of the fifth digit.

Peroneus brevis A short muscle just medial to the peroneus tertius. Its tendon runs with the tendon of the peroneus tertius over the lateral malleolus to its insertion on the fifth metatarsal.

Ventral Group (Figs. 3-17, 3-18)

Tibialis anterior A superficial muscle located on the dorsolateral border of the tibia. Its long tendon crosses the anterior surface of the tibia, then passes beneath a transverse ligament near the ankle joint and over the dorsal surface of the foot to its insertion on the first metatarsal.

Extensor digitorum longus A fusiform muscle located posterior to and partly covered by the tibialis anterior. After passing beneath the transverse ligament near the ankle joint, it divides into four tendons that pass down the dorsum of the foot to their insertion on the terminal phalanges. The tendons of this muscle join those of some of the intrinsic foot muscles, especially that of the extensor digitorum brevis, to form a common tendon.

The intrinsic muscles on the sole of the foot, which are arranged in five layers, are not discussed because they are quite small and difficult to dissect.

TABLE 3-1
Summary of the musculature of the cat.

Muscle	*Origin*	*Insertion*	*Action*
		Cutaneous Muscles	
Cutaneous maximus	Linea alba, latissimus dorsi	Dermis of skin	Moves skin of trunk
Platysma	Dorsal mid-cervical fascia	Dermis of skin	Moves skin of neck and face
		Shoulder Muscles	
Superficial Group			
✓Acromiotrapezius	Spines of cervical vertebrae	Spine of scapula	Draws scapula dorsally
✓Spinotrapezius	Spines of thoracic vertebrae	Fascia of scapular muscles	Draws scapula dorsally
✓Clavotrapezius	Lambdoidal crest of skull	Clavicle	Draws scapula craniodorsally
✓Clavobrachialis	Clavicle	Ulna beneath semilunar notch	Flexes forearm
✓Levator scapulae ventralis	Atlas and occipital bone	Metacromion process	Draws scapula cranially
✓Acromiodeltoid	Acromion of scapula	Outer surface of spinodeltoid	Flexes and rotates humerus
✓Spinodeltoid	Spine of scapula	Deltoid ridge of humerus	Flexes and rotates humerus
✓Latissimus dorsi	Thoracic and lumbar vertebrae	Shaft of humerus	Pulls arm caudodorsally
Deep Group			
✓Rhomboideus	Upper thoracic vertebrae	Medial border of scapula	Draws scapula dorsally
✓Rhomboideus capitis	Lambdoidal ridge of skull	Angle of scapula	Draws scapula cranially
✓Splenius	Mid-dorsal fascial line	Lambdoidal ridge	Turns and elevates head
✓Supraspinatus	Supraspinous fossa	Greater tubercle of humerus	Extends arm
✓Infraspinatus	Infraspinous fossa	Greater tubercle of humerus	Rotates humerus outward
✓Teres major	Axillary border of scapula	Medial surface of humerus	Flexes and rotates humerus
Teres minor	Lateral border of scapula	Greater tubercle of humerus	Rotates humerus
✓Subscapularis	Subscapular fossa	Lesser tubercle of humerus	Draws humerus medially

(continued on page 16)

TABLE 3-1 (*continued*)
Summary of the musculature of the cat.

Muscle	*Origin*	*Insertion*	*Action*
		Muscles of the Back	
✓ Serratus dorsalis superior	First nine ribs	Mid-dorsal raphe	Draws ribs cranially
✓ Serratus dorsalis inferior	Last four ribs	Lumbar spinous processes	Draws ribs cranially
Spinalis dorsi	Last four thoracic vertebrae	Thoraco-cervical vertebrae	Extends vertebral column
Longissimus dorsi	Sacral and caudal vertebrae	Trunk and cervical vertebrae	Extends vertebral column
Iliocostalis	As separate muscle bundles from lower thoracic ribs	Three ribs craniad to the origin of each bundle	Draws ribs together
Multifidus spinae	As separate muscle bundles from lumbar transverse processes	On spinous process one vertebra craniad to origin of each bundle	Extends from vertebral column
		Thoracic Muscles	
Pectoral Group			
✓ Pectoantebrachialis	Manubrium of sternum	Fascia of forearm	Adducts forelimb
✓ Pectoralis major	Cranial sternebrae	Pectoral ridge of humerus	Adducts forelimb
✓ Pectoralis minor	Body of sternum	Pectoral ridge of humerus	Adducts forelimb
✓ Xiphihumeralis	Xiphoid process of sternum	Proximal end of humerus	Adducts forelimb
Deep Thoracic Group			
✓ Serratus ventralis	First ten ribs	Medial surface of scapula	Draws scapula to thorax
Levator scapulae	Last five cervical vertebrae	Medial surface of scapula	Draws scapula craniovent
✓ Transversus costarum	Lateral border of sternum	First rib	Draws sternum cranially
✓ Scalenus	Ribs	Cervical transverse proc	Flexes the neck
✓ External intercostal	Border of rib	Border of adjacent rib	Protracts the ribs
✓ Internal intercostal	Border of rib	Border of adjacent rib	Retracts the ribs
		Abdominal Muscles	
✓ External oblique	Lumbodorsal fascia and ribs	Linea alba and pubis	Constricts abdomen
✓ Internal oblique	Lumbodorsal fascia	Linea alba	Compresses abdomen
✓ Transversus abdominis	Costal cartilages of lower ribs	Linea alba	Constricts abdomen
✓ Rectus abdominis	Pubis	Sternum and costal cartilages	Compresses abdomen
		Muscles of the Neck and Head	
Superficial Group			
Sternomastoid	Manubrium of sternum	Lambdoidal ridge of skull	Turns head
Sternohyoid	First costal cartilage	Body of the hyoid	Draws hyoid posteriorly
Digastric	Occipital bone of skull	Ventral border of mandible	Depresses lower jaw
Mylohyoid	Inner surface of mandible	Median raphe	Raises floor of mouth
Stylohyoid	Stylohyal bone of hyoid	Body of hyoid	Raises hyoid
Masseter	Zygomatic arch	Mandible	Elevates mandible
Temporalis	Surface of temporal fossa	Coronoid process of mandible	Elevates mandible
Deep Group			
Sternothyroid	First costal cartilage	Thyroid cartilage	Draws larynx caudally
Thyrohyoid	Thyroid cartilage	Posterior horn of hyoid	Raises larynx
Cricothyroid	Cricoid cartilage	Thyroid cartilage	Tensor of true vocal cords
Cleidomastoid	Mastoid process	Clavicle	Turns head
Geniohyoid	Medial surface of mandible	Body of hyoid	Draws hyoid cranially
Hyoglossus	Body of the hyoid bone	Dorsum of tongue	Retracts tongue
Styloglossus	Mastoid process of skull	Apex of tongue	Retracts tongue
Genioglossus	Medial surface of mandible	Root of tongue	Draws root of tongue forward

(*continued on page 18*)

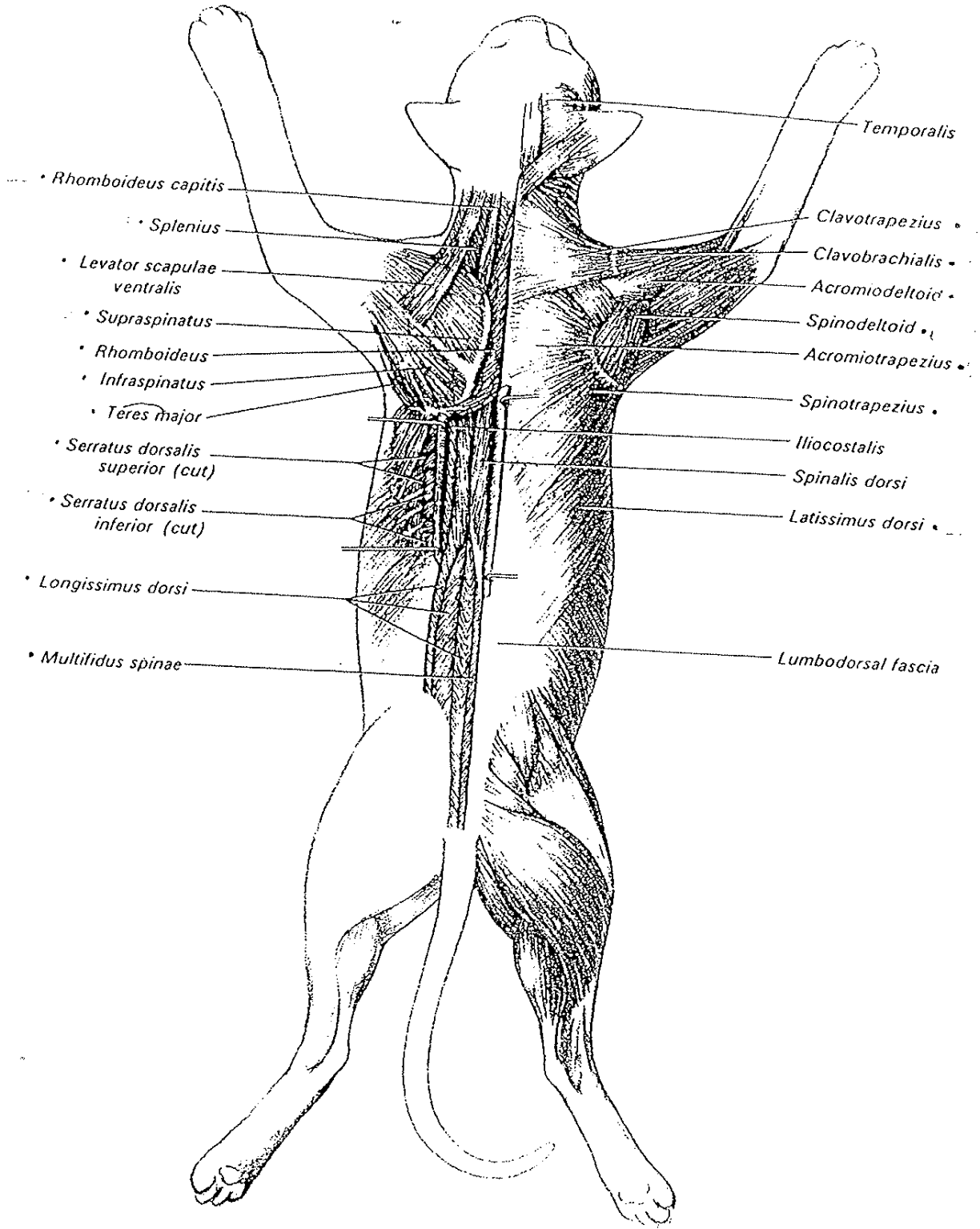


FIGURE 3-1
Muscular system (dorsal view)

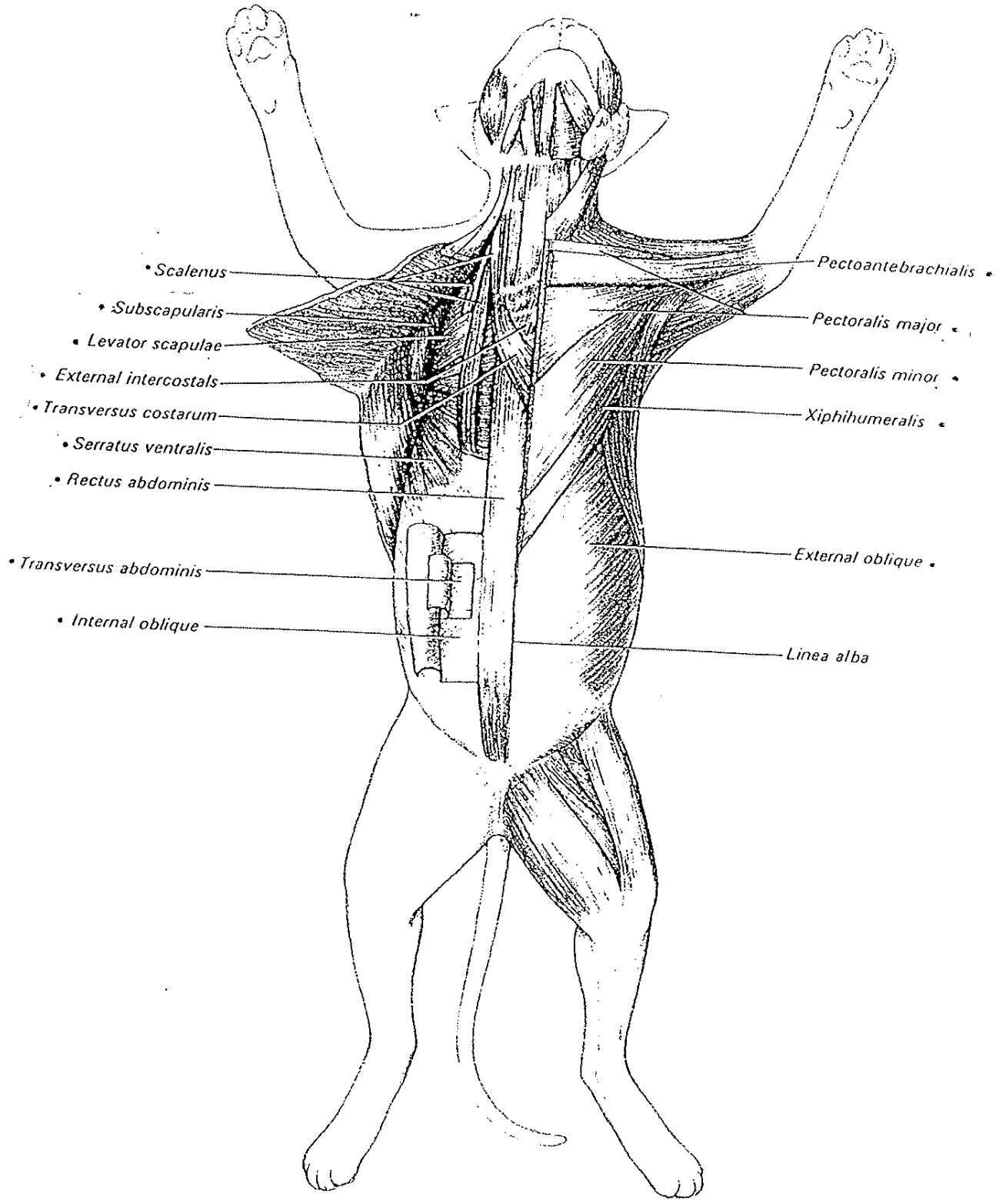


FIGURE 3-2
Muscular system (ventral view).

CAP LAB: Viscera

Salivary gland

Esophagus (it will be easier to see after thoracic dissection next week)
Lungs (wait until thoracic dissection next week)

Greater omentum (remove with professor), leave other mesenteries intact
Liver
Gall bladder
Stomach
Pancreas (note its extent)
Pyloric sphincter
Small intestine
Cecum
Large intestine
Kidney
Ovary
Oviduct (fallopian tube)
Uterine horns
Body of uterus
Urinary bladder
Ureters
Testis
Vas deferens

Comparative Animal Physiology
LAB: Circulatory system of cat

sections of the heart:

left and right atria
left and right ventricles
valves

blood vessels:

arch of aorta
abdominal aorta
brachiocephalic artery (inominate artery)
left & right subclavian arteries
left and right common carotid arteries
renal artery
pulmonary artery
anterior and posterior vena cavae
left and right subclavian veins
left and right jugular veins
brachiocephalic vein (inominate v.)
renal vein
hepatic portal vein
hepatic vein

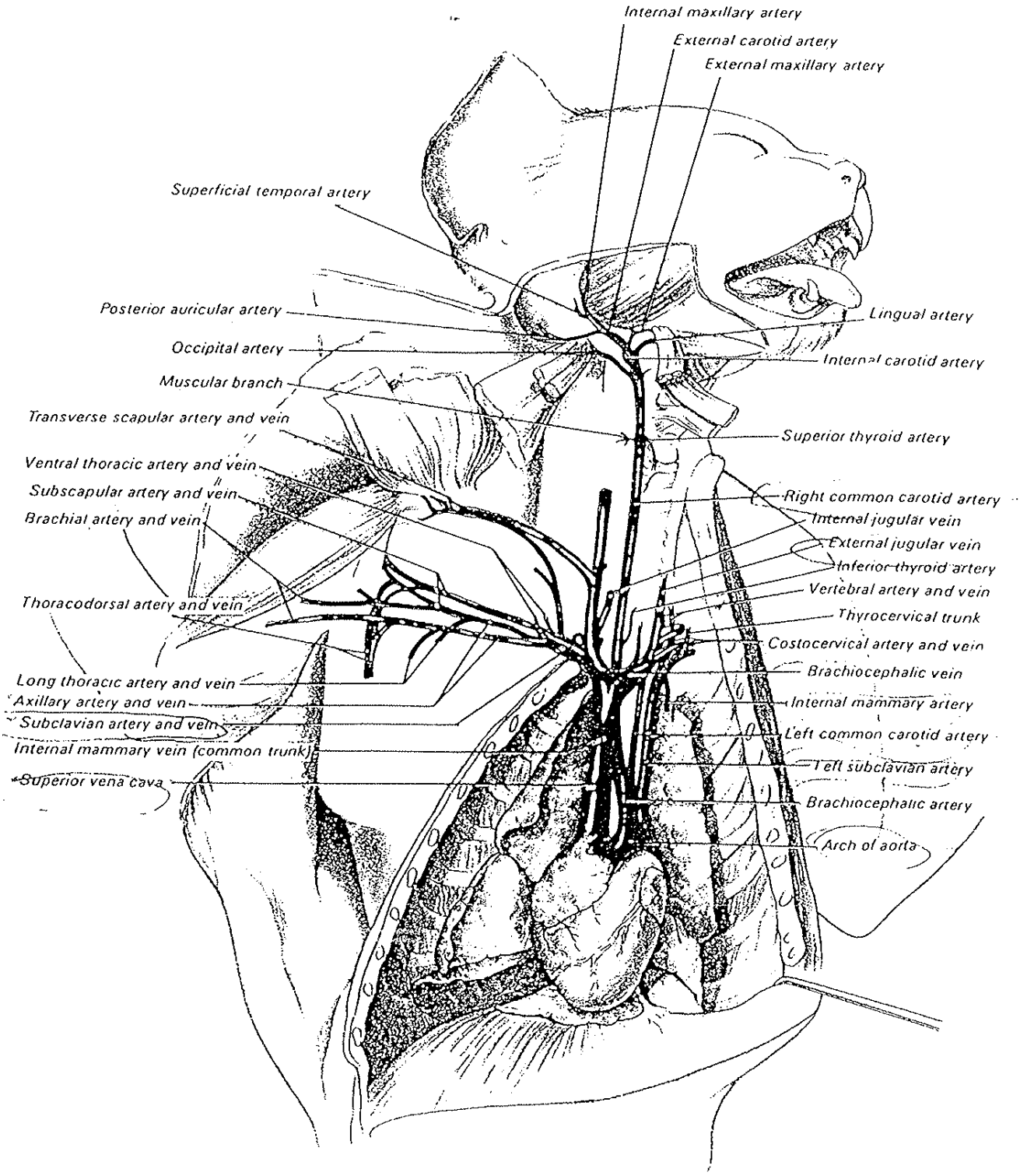


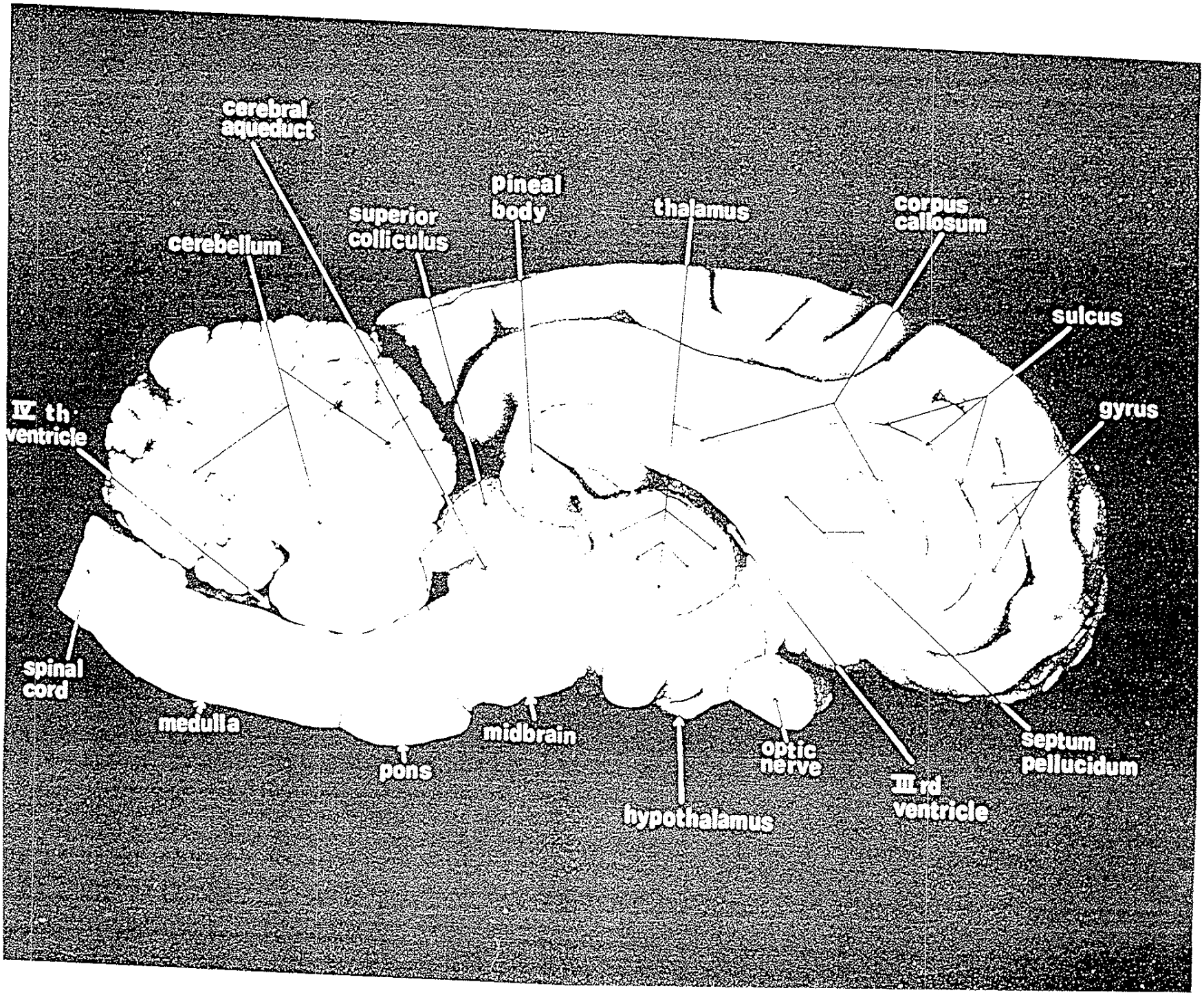
FIGURE 5-3
Arteries and veins of the neck, thorax, and upper arm.

Comparative Animal Physiology
LAB: Brain

Structures
cerebrum
cerebellum
medulla oblongata
spinal cord

olfactory bulb
optic chiasma
pituitary/hypophysis (if present)

corpus callosum
pineal body/epiphysis
location of hypothalamus


cerebral aqueduct
pineal body
thalamus
corpus callosum
superior colliculus
cerebellum
sulcus
IV th ventricle
gyrus
spinal cord
medulla
pons
midbrain
hypothalamus
optic nerve
III rd ventricle
septum pellucidum