106
CORRELATIVE EXCRETORY MECHANISMS

The excretory system (urinary system in amniotes) has two major functions: conservation of water and maintenance of chemical equilibrium in the body fluids. In accomplishing these missions, "wastes" are excreted. Frequently, what is "waste" at one moment (for instance, excess salts) may be highly desirable the next. Aquatic animals in a marine environment, freshwater organisms, and terrestrial animals have unique problems with respect to water conservation. The limiting membrane of an organism, the epidermis or skin, gills and lungs, as well as excretory structures all play a role in water conservation and excretion of "wastes."

Color the excretory structures of the invertebrates on the left side of the plate and related titles. After coloring, read below.

Paramecia possess *contractile vacuoles* whose membranes are permeable to water. As water is absorbed through the cell membrane, the appropriate osmotic pressure within the cell may be adversely altered. The *vacuole* takes up the water through the central portion and excretes it to the outside via feeder canals.

In many other invertebrates with relatively small surface areas and volumes, wastes in the form of ammonia or urea, carbon dioxide, and so forth are simply excreted by diffusion pressure through the cell membrane. In roundworms and many insects, urea and other waste products are absorbed by *excretory canals* or *tubules* and delivered to the outside through a pore or are excreted into the intestine for discharge through the anus. In flatworms and proboscis worms a network of ciliated cells or nests of cells (flame cells or bulbs) absorb waste products from the body cavity. These wastes are conducted by ducts to one of several pores along the length of the body. Such a closed tubular system, derived from ectoderm, is called a *protonephridial* system.

Other worms and certain molluscs possess nephridial tubules that are open directly into the coelom or remnants of the coelom (for example, the pericardial cavity). These constitute *metanephridia* and are often located segmentally throughout the length of the organism or are enclosed in a single unit that opens into a bladder (as seen in the clam). The *metanephridium* consists of a convoluted, ciliated tubule open to the coelom at the nephrostome and open to the outside at the nephridiopore. Derived from ectoderm, the *metanephridia* filter waste products from the coelomic fluid and reabsorb necessary water and other chemicals required at the moment.

Color the structures of the vertebrate kidneys and read below.

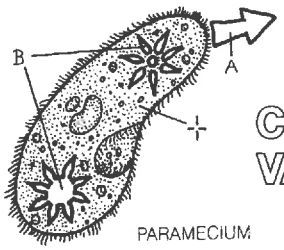
The vertebrate *kidney* is formed from mesoderm. The embryonic vertebrate *kidney* lies along the length of the dorsal body wall. Its head end (head *kidney, pronephros*) survives for only a short period during embryonic development and is represented, in part, by convoluted, ciliated tubules that open into the coelom at one end and form an *archinephric duct* at the other end. These are not homologous with the *metanephridia* of invertebrates. The rest of the *kidney (opisthonephros)* consists of ciliated convoluted tubules, arranged segmentally, forming large capsules at one end (which are in contact with blood vessels) and emptying into the *archinephric duct* at the other end. Such an *opisthonephric kidney* is characteristic of a jawless fish (hagfish).

The *kidney* of the shark, bony fishes, and amphibians is located along the dorsal body wall of the abdominal cavity and is somewhat shorter than that seen in the agnates. The pronephros does not exist in the adult but survives long enough embryologically to form the archinephric duct. In the male the ducts of the testes make connection with the nephric ducts in the anterior part of the opisthonephros (not shown). The archinephric duct is thus a urogenital duct. The anterior part of the opisthonephros is often degenerated to one degree or another. The tubules of the main *kidney* are compacted together and are no longer arranged segmentally. The adult *kidney* (functional opisthonephros) of jawed fishes and amphibians is often called the *mesonephros* and the archinephric duct is called the *mesonephric duct.*

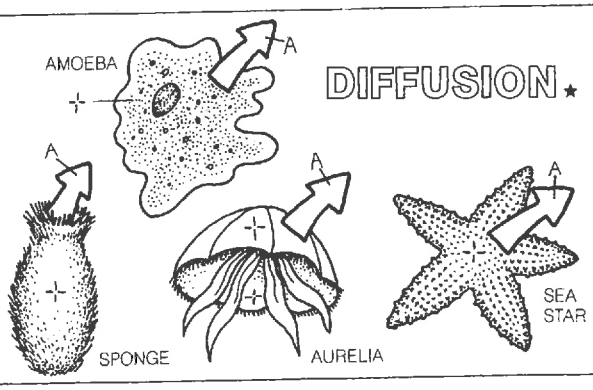
In the mammalian *kidney* the posterior part of the opisthonephros (metanephros) persists while the remainder largely degenerates in embryonic development. In males the archinephric duct retains its connection to the testis and becomes the epididymis and ductus deferens. The metanephros becomes a bean shaped mass lateral to the gonads on the dorsal body wall. It consists of a million or so highly compacted *nephrons* connected to *collecting ducts* and intimately associated with tufts and networks of blood vessels. Tiny branches of the renal arteries form convoluted tufts (glomeruli) invaginated into hollow capsules of the *nephrons.* The blood plasma is filtered into the capsule, and the filtrate passes through the nephric tubule, where 99 percent of it is reabsorbed by the tubule cells. Only undesired materials of the moment, dissolved in a small amount of water, form urine, which is discharged into the calyces of the *kidney* from the collecting ducts. Urine passes through the *ureter* (a specific urinary duct associated only with the metanephros) into the urinary *bladder* and out the *urethra.*

CORRELATIVE EXCRETORY/URINARY MECHANISMS.

INVERTEBRATE — EXCRETION$_A$ — VERTEBRATE

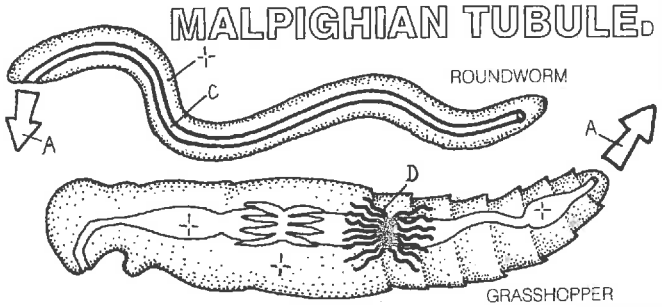


CONTRACTILE VACUOLE$_B$

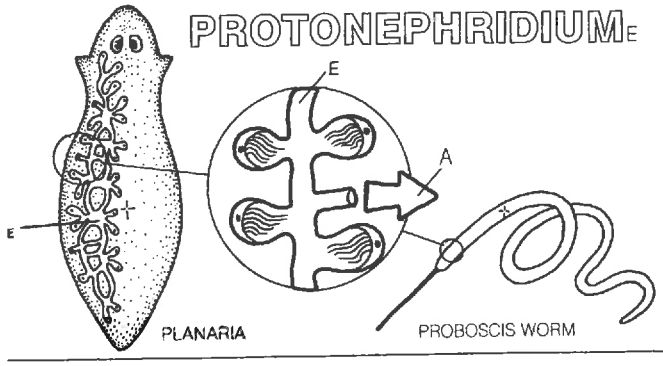


DIFFUSION★

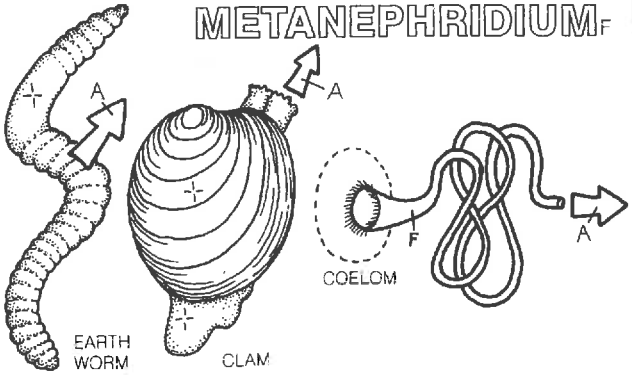
EXCR. CANAL$_C$
MALPIGHIAN TUBULE$_D$



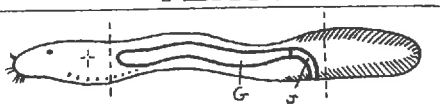
PROTONEPHRIDIUM$_E$

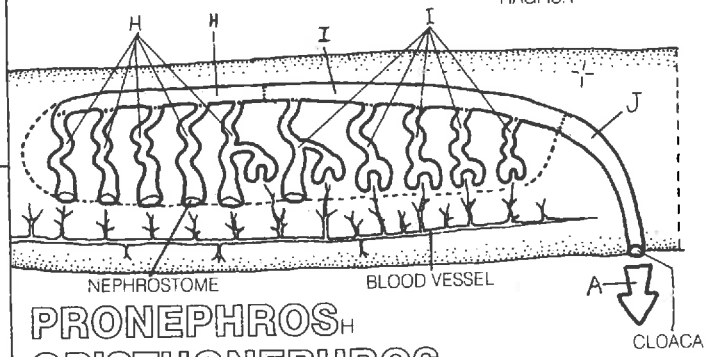


METANEPHRIDIUM$_F$



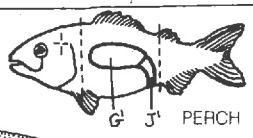
KIDNEY$_G$

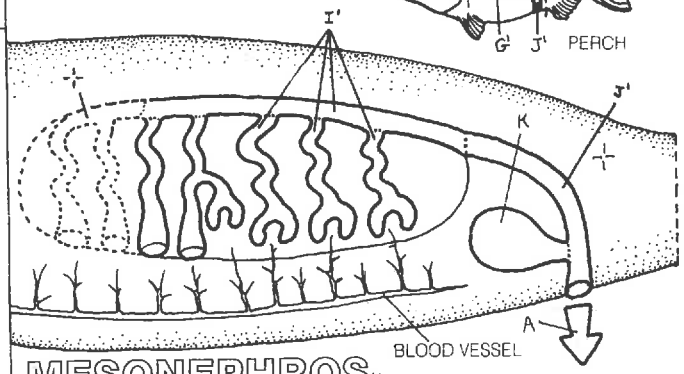




PRONEPHROS$_H$
OPISTHONEPHROS$_I$
ARCHINEPHRIC DUCT$_J$

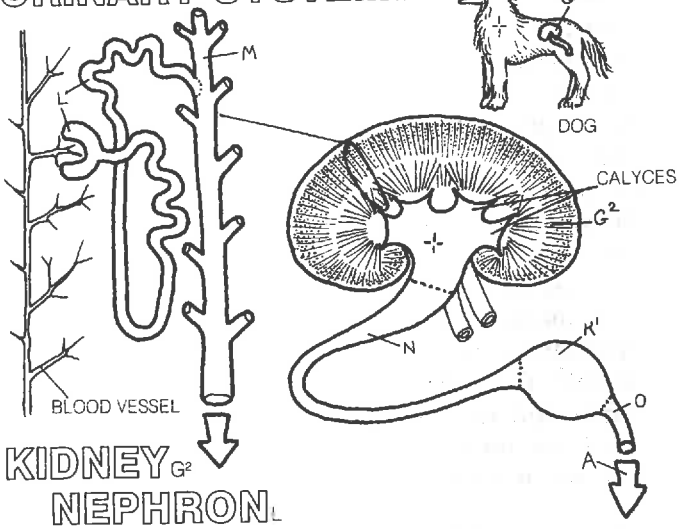
KIDNEY$_{G'}$





MESONEPHROS$_{I'}$
MESONEPHRIC DUCT$_{J'}$
BLADDER$_K$

URINARY SYSTEM★



KIDNEY$_{G^2}$
NEPHRON$_L$
COLLECT. DUCT$_M$
URETER$_N$
BLADDER$_{K'}$
URETHRA$_O$