Protist Coloring Sheets

NAME: ______________________________ DATE: ______________

INTRODUCTION TO PROTOZOANS

Phylum Protozoa (*Proto* = first, *Zoa* = animal) consists of about 50,000 species. Structural characteristics make it possible to segregate protozoans into the four primary groups shown here.

Color the flagellate protozoans (A through C) and read the paragraph below.

Flagellate protozoans are characterized by one or more whip-like processes called flagella. Used for locomotion or capturing prey, a flagellum is a cable of microtubules surrounded by an extension of the cell membrane. The arrangement of these microtubules is identical to flagella (and cilia) seen in cells throughout the animal kingdom, including cells of the human respiratory and reproductive tracts.

Flagellates may be individuals with one flagellum (as in *Euglena*) or several flagella (as in *Trichomonas*). They may also exist as colonies of thousands of cells, as in *Volvox,* where interconnected organisms are enclosed within a transparent, gelatinous sphere which moves by the synchronous beating of thousands of flagella. Certain flagellates (e.g., *Euglena*) may contain chlorophyll, an important pigment in photosynthesis. In this respect, *Euglena* may be more plant-like than animal. Certain flagellates are parasitic (*Trichomonas* is responsible for infection of parts of the human reproductive and urinary tracts; *Trypanosomes* are responsible for a kind of African Sleeping Sickness). Many of the incredibly populous marine microorganisms (plankton), which are such an important food for practically all marine animal life, are flagellates. Occasionally, the density of flagellates in coastal waters multiplies so as to sharply color the ocean surface by day (so called "red tides") and generate an eerie luminescence by night. Rarely, this concentration has a severe, toxic effect on neighboring marine and bird life.

Color the ameboid protozoans (D and E) and then read the paragraph below.

Ameboid protozoans are capable of forming projections of their body mass (pseudopodia) to encircle prey or as a means of locomotion. Such "ameboid movement" can be seen in cells throughout the Animal Kingdom, including certain human connective tissue cells. The best known member of this group is the amoeba (*Amoeba*), whose form seems everchanging. Other members secrete a multichambered skeleton or shell, often creating a magnificent geometric pattern. As chambers are formed, the organism flows by ameboid movement into the various chambers and extends its pseudopodia outward. *Radiolarians* produce a round, lattice-like, silica skeleton. The spherical body of the *radiolarian* is divided by a capsule into inner and outer regions from which pseudopodia project radially among its skeletal spines. *Radiolarians* are tiny individual or colonial microorganisms contributing prominently to plankton, as well as to untold acres of ocean floor where their skeletal remains form a thick layer, called "radiolarian ooze."

Color the ciliated protozoans (F and G) and read the paragraphs below.

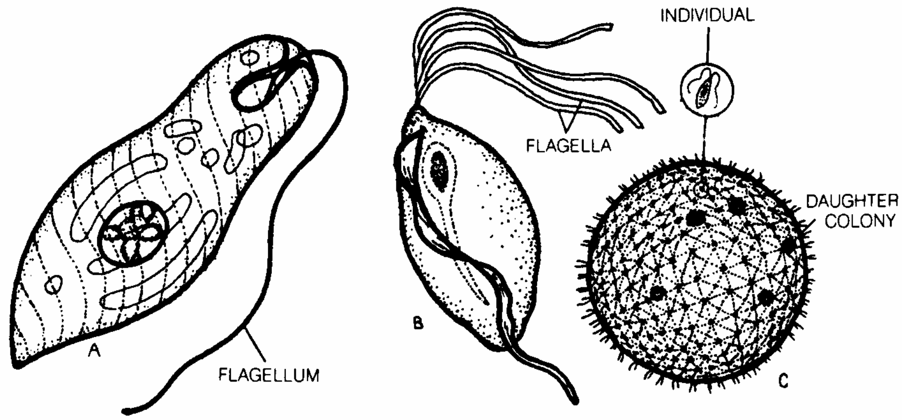
The *ciliated protozoans* make up the largest group within the phylum. The frequently rapid locomotion of these ciliates is made possible by the synchronous power strokes of great numbers of cilia (as in *Paramecia*), which may, in some, have an additional sensory function. Certain ciliates are sessile and are fixed to the underlying substrate by long stalks. Some of these, the Suctorians, of which *Tokophyra* is an example, lose their cilia during maturity and develop hollow tentacles which help to capture prey. Once captured, the prey is sucked into the tubular tentacles and digested in the central cavity.

Color the spore-forming protozoans (H) and read the paragraph below.

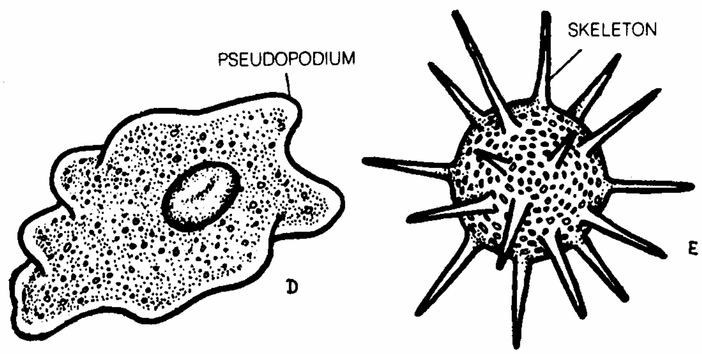
This parasitic group of *spore-forming protozoans* bears infective spores (reproduced batches of nuclei and surrounding cytoplasm sometimes encased in a rigid sheath) which invade the intestinal cells, blood vessels and other ducts of the host. The resultant cellular destruction by expanding numbers of spores (such as those of *Plasmodium*) gives rise to the signs and symptoms of disease in both vertebrates and invertebrates alike.

PHYLUM PROTOZOA.

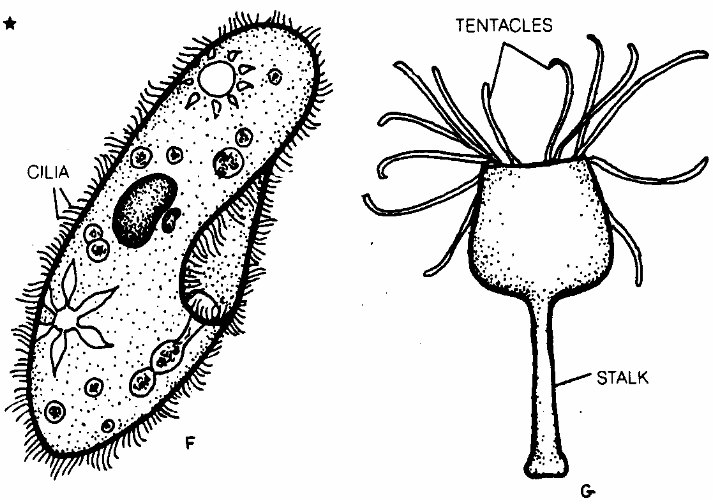
FLAGELLATE PROTOZOANS★
EUGLENA A
TRICHOMONAS B
VOLVOX C



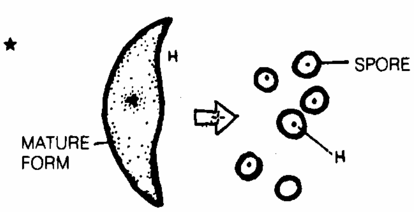
AMEBOID PROTOZOANS★
AMOEBA D
RADIOLARIAN E



CILIATED PROTOZOANS★
PARAMECIUM F
TOKOPHYRA G



SPORE-FORMING PROTOZOANS★
PLASMODIUM H



PARAMECIUM

Paramecium, perhaps the best-known of the ciliated protozoans, due to its frequent appearance in college zoology laboratories, is generally found free-living (independent of a host organism) in fresh water and in close proximity to decaying plant matter. Although visible to the naked eye under ideal conditions, paramecium structure is best seen with the aid of a light microscope. In the evolutionary sense, Paramecia are important as fairly specialized, single celled animals under the command of two (and frequently more) nuclei.

Color the structures A through D and their companion titles, then read below. Choose a light color for B. Color the locomotion diagram below.

The paramecium is held together by an external, flexible, elastic covering (pellicle) surrounding the clear, thin *ectoplasm.* Arising within the *ectoplasm,* cilia project out through the pellicle like a thousand oars, providing a mechanism for combined forward and rotary movement. The organism rotates while moving in the desired direction, blunt (anterior) end first (see lowest illustration labeled *Locomotion*). Between the bases of cilia in the ectoplasm, tapered, bottle-like bodies called *trichocysts* can be found, which can be fired as long, whip-like threads. Such threads may be used for capturing smaller organisms for food, for defense against attack, or possibly for anchoring to other structures while feeding in rapid currents. The ground (basic) substance of the paramecium is the *endoplasm*—a granular, somewhat viscous fluid in which the other organelles are situated. The administrative centers for functional activity are the *macronucleus* and *micronucleus.* These contain the genetic material—the blueprints for all functional processes. The *macronucleus* oversees all metabolic processes; the *micronucleus* supervises reproductive activity.

Color structures E through J, and their respective titles, and read below. The arrows for direction of food vacuole movement may be left blank or colored black/gray.

On the ventral or oral surface of the paramecium can be found an extended depression in the shape of a funnel—this is the *oral groove.* Within this groove there is an opening (*mouth pore* or cytostome) leading into a tubular *gullet* (cytopharynx) which terminates as a rounded membrane. Food (smaller organisms such as other protozoans, bacteria, and algae often associated with decaying vegetation) is whipped into the *mouth* and *gullet* by the beating cilia surrounding the *oral groove.* Under such pressure, a small spherical vacuole is formed from the membrane at the end of the *gullet.* This swollen, *developing food vacuole* breaks off from the membrane and circulates through the *endoplasm (circulating food vacuole)* in a predetermined or set pattern consistent with the movement of all *food vacuoles* (arrows). As nutrients diffuse through the *vacuole* into the *endoplasm,* the *vacuole* becomes smaller and drifts toward the *anal pore* just below the *gullet.* There, certain waste materials and undigested remains are expelled to the outside. Other wastes simply diffuse outward through the *ectoplasm* and pellicle.

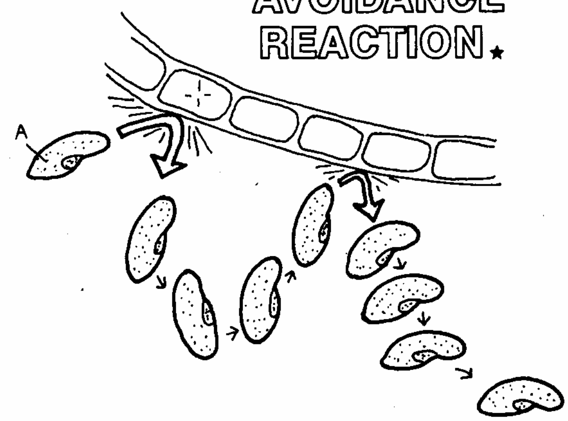
Color structures K through M and their related titles and read below. Color the avoidance reaction above.

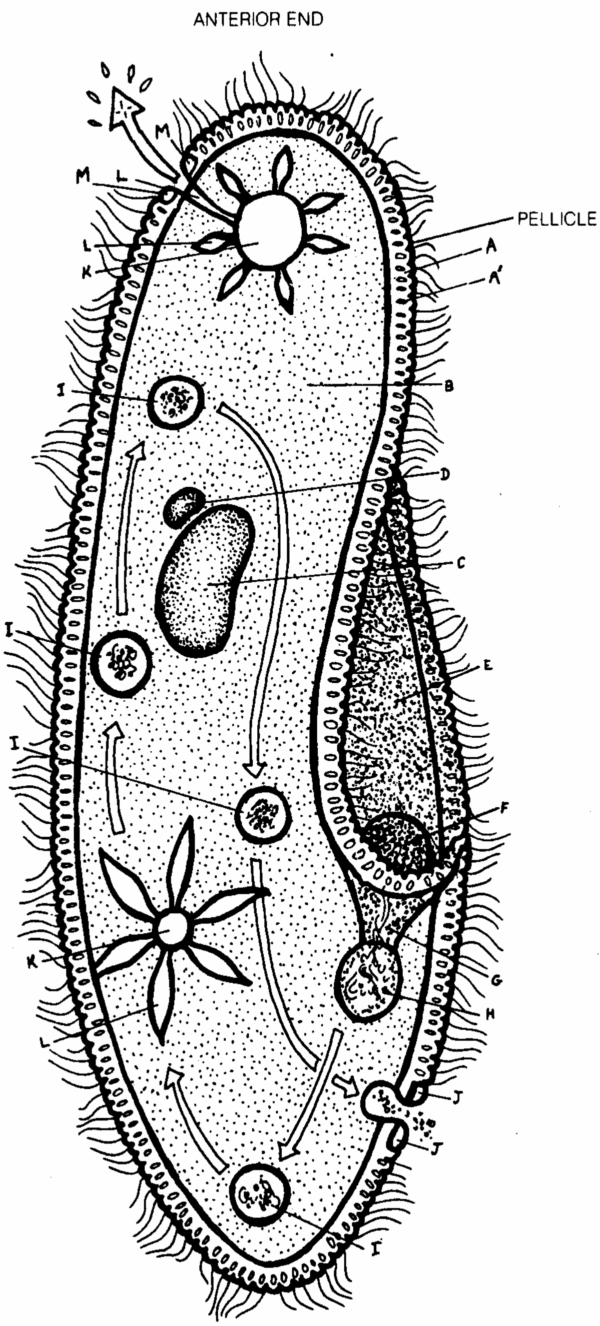
As water diffuses into the *endoplasm* from the outside, excess concentrations of it are directed into *contractile vacuoles* by several *feeder canals.* When full, the *vacuole* rapidly contracts, emptying the water through an *excretory pore.* In this way, the paramecium adjusts its water volume, maintains a proper balance of salts and water, and rids itself of undesired water-soluble chemicals.

Paramecia demonstrate an interesting reaction to objects in their path of movement, or to other undesirable (negative) stimuli. Note in the *avoidance reaction,* how one backs off after initial contact with a foreign object, swings/rotates on its pointed posterior end, and tries again. Depending on the object, the paramecium may remain attached to the object (food), or it may simply take up another track. The reproductive activity of the paramecium will be described in Plate 10.

PARAMECIUM.

AVOIDANCE REACTION.★

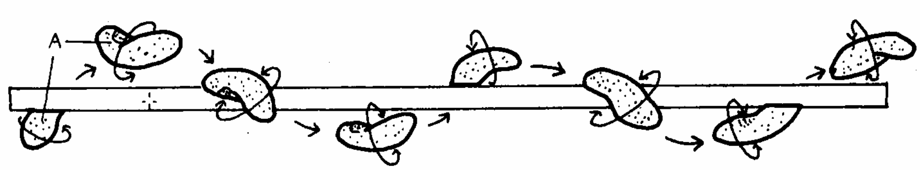




ECTOPLASM A
  TRICHOCYST A'
ENDOPLASM B
MACRONUCLEUS C
MICRONUCLEUS D

ORAL GROOVE E
MOUTH PORE F
GULLET G
DEVELOPING FOOD VACUOLE H
CIRCULATING FOOD VACUOLE I
ANAL PORE J

CONTRACTILE VACUOLE K
  FEEDER CANAL L
  EXCRETORY PORE M



LOCOMOTION.★

AMOEBA

The genus *Amoeba* of the Phylum Protozoa consists of single-celled organisms with free flowing cytoplasm which forms processes called *pseudopodia* ("false feet") when capturing food and when in motion. Amoebae (ah-*mee*-bee) are found in fresh and salt water and are of microscopic size (.01–.5mm). Certain amoebae are normally found in the intestines of animals, including humans. Another parasitic species finds its way into the human body through contaminated food or water. By penetrating and causing injury to the intestinal wall it causes a condition called amoebic dysentery (amebiasis), characterized by weight loss, mild fever, and diarrhea. Cells capable of amoeboid-like movement are found throughout the animal kingdom, including humans. Such cells often have the potential to form (differentiate into) a variety of other cells. The amoeba is an excellent example of a fundamental living unit with several complex functions.

Start at the top of the page (amoeba) and work down, coloring both title and related structure. Darker colors are recommended for the smaller structures; lighter colors for larger areas. After coloring F, stop briefly, then read the paragraph below.

The *plasma membrane* is the limiting, flexible wall of the amoeba; permeable to the ingestion of water, oxygen and salts, it is capable of pronounced stretching during movement and the ingestion/ejection process. Immediately within the *plasma membrane* is a clear, viscous (gel) layer called *ectoplasm.* It contains no vacuoles or other functional structures.

The primitive organelles of the cell (*vacuoles, lysosomes,* etc.) are dispersed in the *endoplasm,* which has an inner, watery phase (plasmasol), as well as an outer, gelatinous phase (plasmagel) shared with the ectoplasm. Transformation from ectoplasm (gel) and outer endoplasm (gel) to inner endoplasm (sol) is believed to be responsible for formation of pseudopodia and their flowing movement. *Movement of the sol-state endoplasm* is depicted here by arrows (E). As the plasmasol moves up into the developing *pseudopod,* it is diverted away like a fountain to become plasmagel (see split arrow). This process, as well as the reverse process at the hind end of the amoeba, is believed to be the principal mechanism for movement. The *nucleus* is the "administrative center" for the cell's activity and contains the genetic material (DNA).

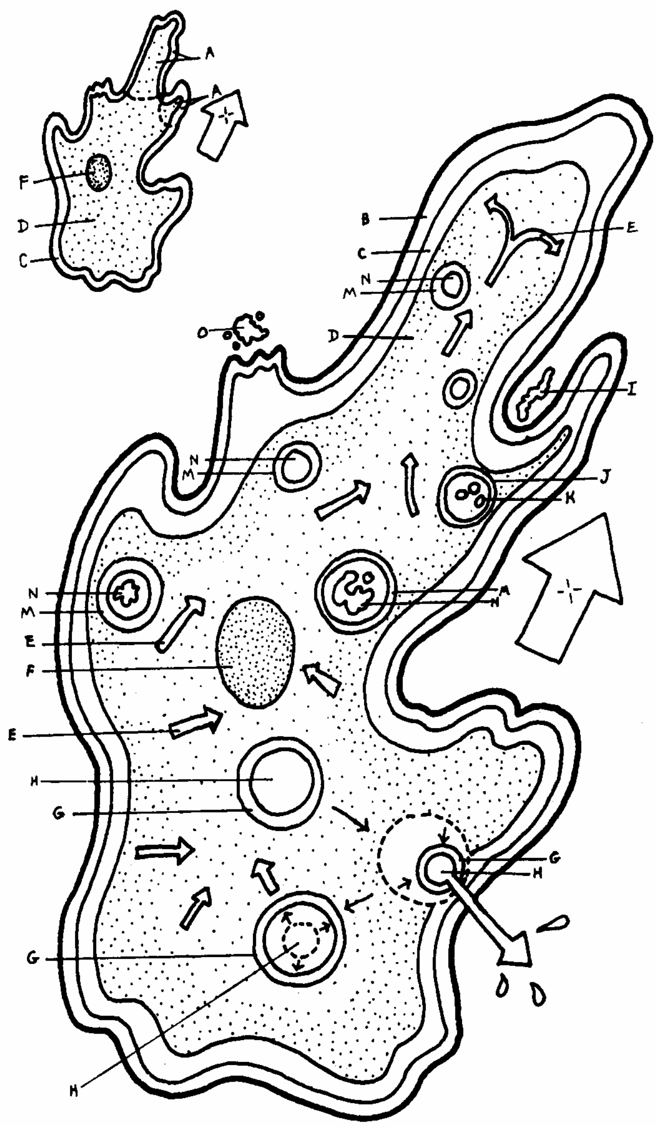
Now color structures G and H, and their titles. The small arrows depict movement of contractile vacuoles alternately taking on and releasing water.

Contractile vacuoles contain *water.* These vacuoles take up excess water as it is brought into the cell, either through diffusion or in the process of *phagocytosis.* This occurs primarily in fresh water amoebae. Because the intake of fresh water tends to dilute the salt solution (salinity) of the protoplasm, the offending water has to be removed. In marine environments, where the salinity of the protoplasm is high and no need exists for removing water, *contractile vacuoles* are quite small or even non-existent. The *contractile vacuole* increases in size by fusion of small vacuoles, migrates to the plasma membrane and discharges its content to the outside. The residual *vacuole* returns to the *endoplasm* and begins to fill once again.

Color, in order, the title phagocytosis and structures I through O with their respective titles. Then read below.

Nutrient *food* is ingested by the process of *phagocytosis* (*phago,* I eat; *cyte,* cell; *-osis,* condition of). As you can see in the series of illustrations below, *food* (a bacterium, in this case) is drawn into a cavity being formed by the *plasma membrane* as it forms a *pseudopod* (see upper right side of larger amoeba). The *plasma membrane* completely encircles the food and, as it does so, separates away from the rest of the cell membrane, forming a *food vacuole.* A *lysosome* with its powerful *enzymes* comes into contact with the *food vacuole;* the membranes of the two *vacuoles* fuse; the center of the fused membrane breaks open, allowing the contents of the *lysosome* to mix with the contents of the *food vacuole.* The *food* is then digested by the *enzymes* into units which can be used by the amoeba as energy or as material for cell repair or replacement. Several *food* or *digestion vacuoles* can be seen in the amoeba after feeding. The residual *waste* is ultimately expelled to the outside of the cell through a process of reverse *phagocytosis.*

AMOEBA.



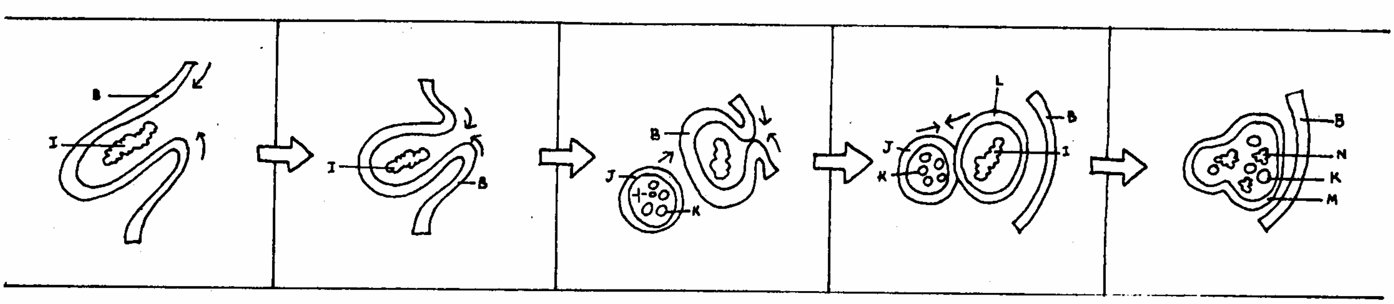
PSEUDOPODIA A

PLASMA MEMBRANE B
ECTOPLASM C
ENDOPLASM D
PLASMASOL MOTION E
NUCLEUS F

CONTRACTILE VACUOLE G
WATER H

FOOD I
LYSOSOME J
ENZYME K
FOOD VACUOLE L
DIGESTION VACUOLE M
DIGESTED FOOD N
EXPELLED WASTE O

PHAGOCYTOSIS ★



EUGLENA

Euglena is a genus of microscopic, single celled, free-living aquatic organisms, characterized as much by their motile flagella as by masses of green pigment in their cytoplasm. In fact, populations of pigment-carrying euglenids can reach such proportions as to color green the pond water in which they exist.

Color structures A through F and their respective titles and then read below.

The *pellicle* is the cell membrane of this unicellular organism. It is an organic, flexible, fibrous membrane which, as you can see, is grooved in a spiral fashion about the body. It permits *absorption of nutrients* as well as diffusion to the outside of *waste products* of metabolism. The inner substance *(cytoplasm)* appears as an outer, less dense ring of gelatinous *ectoplasm* and an inner, granular *endoplasm.* Within the *endoplasm,* in addition to the more obvious structures, tiny water vacuoles (products of metabolism and vacuoles of nutrients under varying degrees of digestion) can be found. The *nucleus* contains the genetic material, DNA, and can generally be found at the center or toward the anterior (flagellated) end of the organism. Like most nuclei of cells throughout the kingdoms of living things, the *nucleus* functions as an administrative center for all operational activities of the organism.

Color structures G through J and their respective titles and then read below.

The *pellicle* is permeable to the fresh water environment in which the euglena finds itself, and this water tends to dilute the more saline water of the cytoplasm, creating potentially harmful osmotic conditions. However, as the hypotonic fresh water becomes absorbed by the euglena, vesicles are formed and the water is kept apart from the cytoplasmic fluid. At the anterior end of the organism, several of these vesicles form a larger *contractile vacuole.*

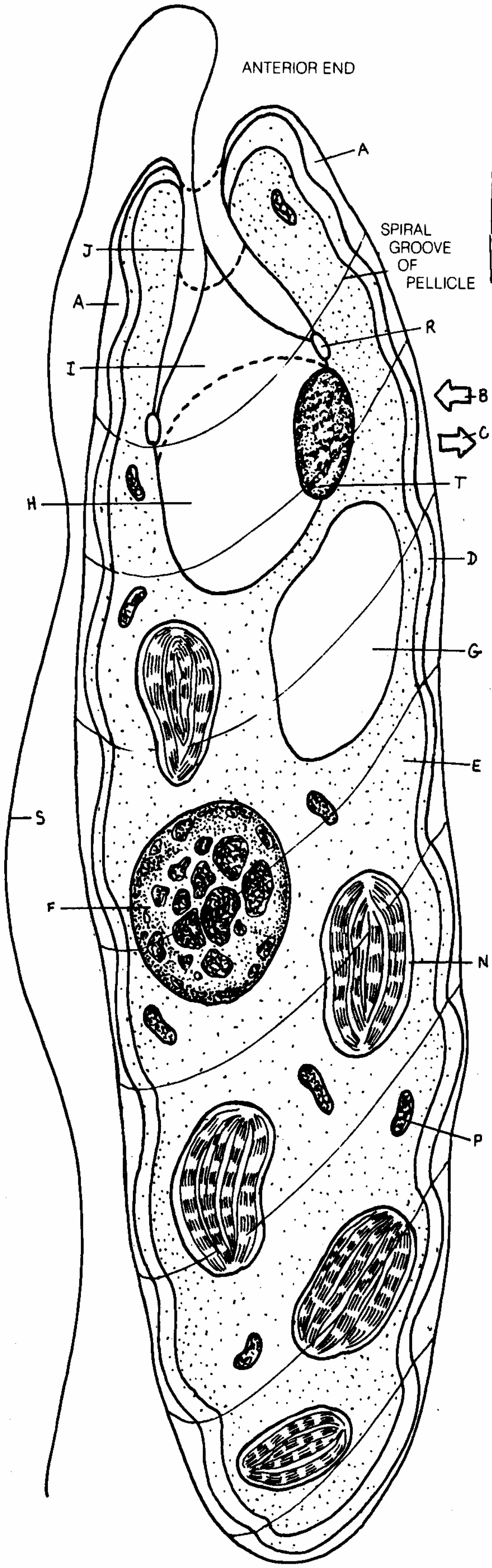
Periodically, the *contractile vacuole* fuses with the permanent *reservoir* and water is passed into it and on into the tubular *cytopharynx,* through the opening *(cytostome)* to the outside. Compare this mechanism for water and salt balance with that of the paramecium (Plate 4).

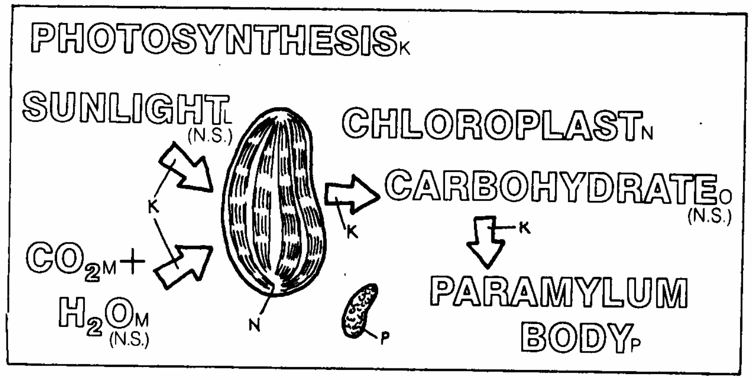
Color the rest of the titles (J through T) and their respective structures and then read below. If you wish to use true-to-life colors, the chloroplasts should be green and the stigma red. Color over the lines representing the flagellum in the large drawing as well as the smaller drawings at lower right.

Euglena is capable of producing organic materials *(carbohydrates)* from inorganic sources *(carbon dioxide, water),* provided there is *sunlight,* which activates the enzymes in the chlorophyll (green pigment)-laden *chloroplasts.* This process is called *photosynthesis.* The *carbohydrates* thus produced (providing energy for all living activities) are utilized directly or stored in the *paramylum bodies* (pyrenoids) as complex (starchy) *carbohydrates.* Under conditions of little or no light the *chloroplasts* diminish or disappear, and the euglena takes to *absorbing nutrients* from decayed organic matter (saprozoic nutrition), and *discharging wastes* through its body wall.

Locomotion in the euglena is created by the whiplike action of the *flagellum.* The *flagellum* beats from one side of the body to the other. This beating action moves the organism forward (in the direction of the anterior end), spiralling about the long axis of the body. *Flagella* develop from *basal bodies* which are located at the edge of the *reservoir.* Throughout the animal kingdom *flagella* and cilia share a largely identical microstructure. Near the *basal bodies* is the light-sensitive *stigma* or eyespot, made red by a pigment. The pigment serves to block light coming into the stigma, except along one thin axis. The euglena is capable of orienting (anterior end first) in the direction of this thin stream of light and of moving toward it, like an aircraft following a navigational radio beam. This behavior is vital for operation of the photosynthetic process.

EUGLENA.





PELLICLE A
NUTRIENT ABSORPTION B
WASTE EXCRETION C

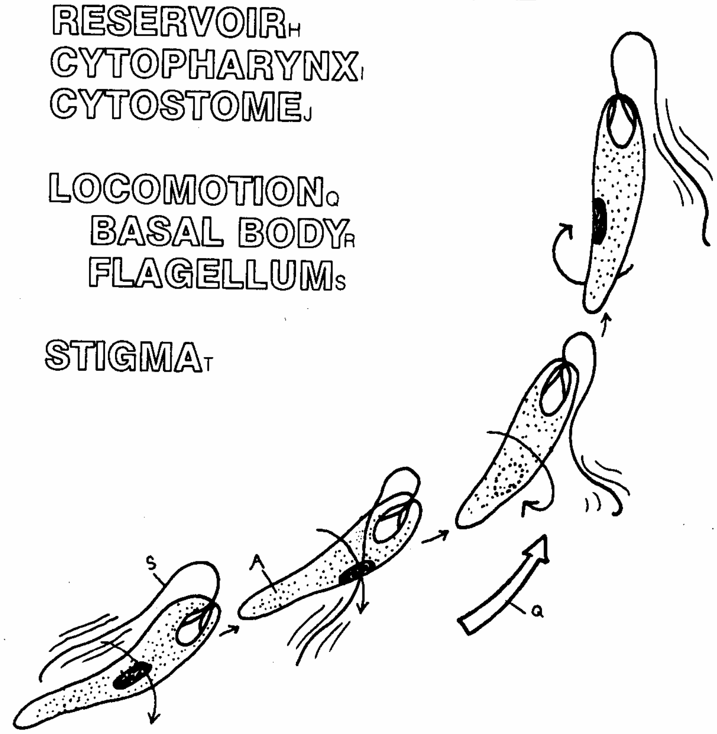
CYTOPLASM ★
ECTOPLASM D
ENDOPLASM E

NUCLEUS F

CONTRACTILE VACUOLE G
RESERVOIR H
CYTOPHARYNX I
CYTOSTOME J

LOCOMOTION Q
BASAL BODY R
FLAGELLUM S

STIGMA T



MALARIA

Malaria is an ancient disease of human beings, and is characterized by high fever, chills and rigidity, enlarged spleen, anemia, and general feelings of poor health. The course of this disease may last indefinitely if not treated, such course being marked by periods of remission and relapses of signs and symptoms. Malaria can often be cured by chemotherapy; it can at least be suppressed by such treatment. There are data showing that over 1 million people in India die annually from malaria.

Malaria is diagnosed by blood tests in which any one of four infective species of *Plasmodium* (see Plate 3) can be identified. The carrier (final or definitive host) of the *Plasmodium* parasite is the *Anopheles mosquito,* where the *sexual* part of the parasite's life cycle takes place. *Humans* are the intermediate host, where the *asexual* part of the life cycle occurs. Humans are a prerequisite to completion of the *Plasmodium* life cycle. Wherever high populations of people and *Anopheles* mosquitos exist together, barring appropriate control measures by public health officials, malaria tends to appear in a significant part of the human population.

Color the events of the human-carried asexual cycle of *Plasmodium* (A through E) and related titles and then read the paragraph below. Start with A.

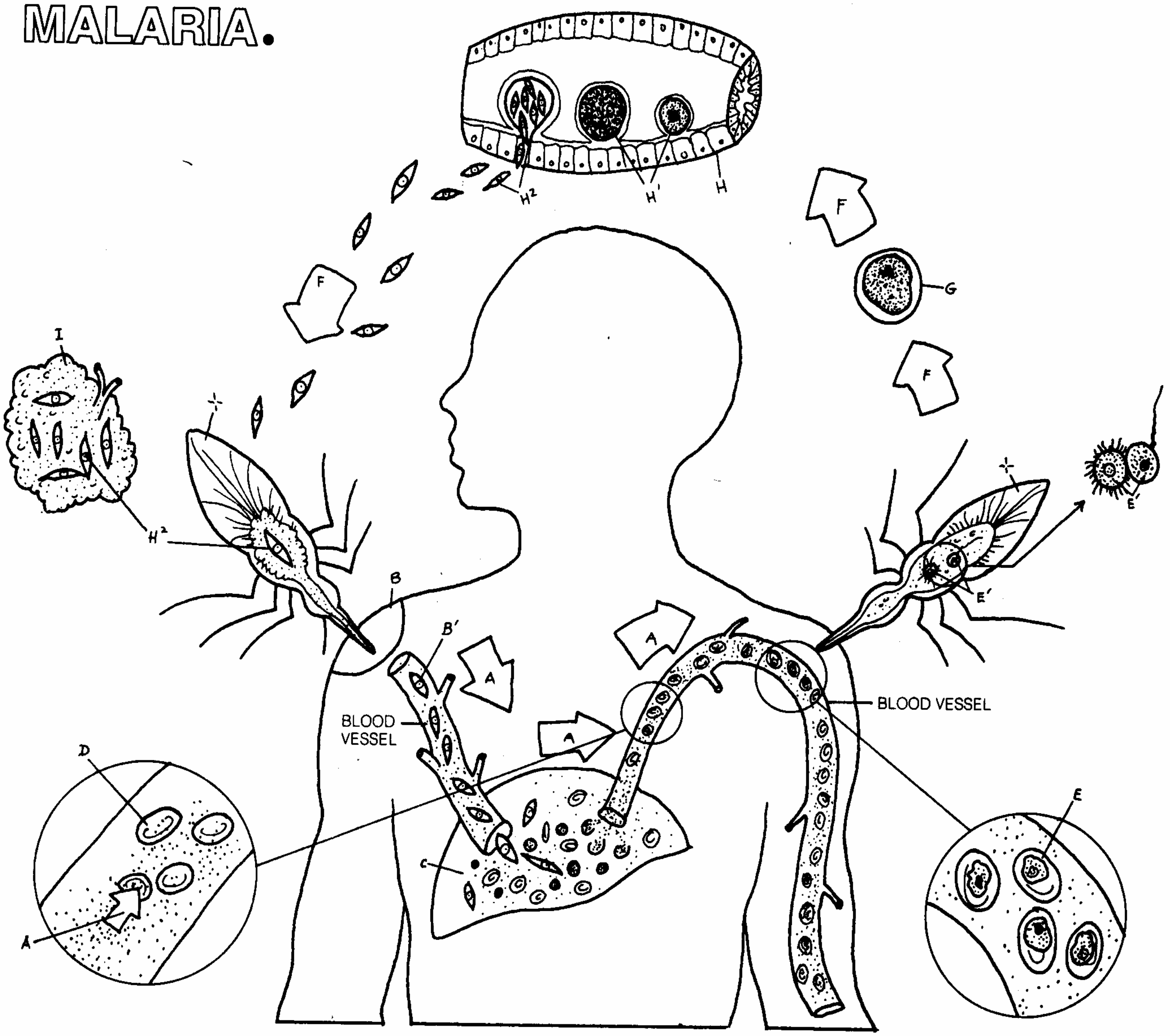
The human skin is pierced by the mouth parts of the mosquito and salivary secretions laden with young *Plasmodium spores* (sporozoites) are *injected* into the blood. Traveling through the circulatory vessels, the *spores* arrive at the liver and undergo a series of multiple divisions in the cells of that gland. The liver is quite vascular (many blood vessels) and the cells are in close proximity to the small veinlike channels (sinusoids). The *offspring* (merozoites) of these multiple divisions are released into the circulation where they *infect* the *red blood cells.* The time from initial injection to release of the *spore offspring* from the liver is the incubation period (about 2 to 6 weeks, depending on the species of *Plasmodium*). The signs and symptoms of malaria begin to appear as the merozoites enter the *red blood cells.* Continuous division of the *spores* cause the *red blood cells* to rupture, releasing new *spores* to infect new *red blood cells.* Reduction of healthy *blood cells* and the toxic products from sporozoan metabolism give rise to the signs of anemia and fever, and an enlarged spleen probably relates to the increased destruction of *red blood cells* there. The cyclic rate of signs and symptoms (every 24–72 hours) corresponds to the cyclic release of merozoites *(spore offspring)* from the liver.

After numerous *asexual divisions* in the human *red blood cells,* some *spores* beget sexual forms called *gametes.* These forms remain quiescent in the blood cells without rupturing them. At this point, the *Anopheles* mosquito is required to complete the life cycle of the *Plasmodium* parasite. For a mosquito to carry malaria-causing *Plasmodium spores,* it must have received the *gametes* from the blood cells of an already infected human.

Color the events of the mosquito-carried sexual cycle (F through I) and related titles and then read the paragraph below. Use a light color for H.

By piercing the human skin, the mosquito withdraws *gamete*-laden *red blood cells* from the blood of the human host into its foregut (stomach). The *red blood cells* are ruptured, allowing the male and female *gametes* to fuse (fertilization). The fertilized *gametes* form single cells *(zygotes)* which attach to the wall of the *stomach* and form *cysts* where multitudes of new *spores* (sporozoites) are formed. After a time, the new *spores* break through the cysts and wall of the *stomach* to enter the blood-carrying cavities of the mosquito. Traveling throughout the body of the insect, the *spores* reach the *salivary glands,* as well as other tissues and organs. When once again the mosquito pierces the skin of a human with its mouth parts, *Plasmodium*-laden salivary secretions are injected into the blood, and the transmission of malaria continues.

MALARIA.



HUMAN CYCLE (ASEXUAL)A
SITE OF INFECTIONB
PLASMODIUM SPORES IN BLOODB1
INFECTION OF LIVER BY SPORE OFFSPRINGC
INFECTION OF RED BLOOD CELLSD
FORMATION OF GAMETES IN RED BLOOD CELLSE

MOSQUITO CYCLE (SEXUAL)F
FUSION OF GAMETESE1
FORMATION OF ZYGOTEG
STOMACH (WALL)H
GROWING SPORESH1
MATURE SPORESH2
INFECTION OF SALIVARY GLANDI