EXERCISE: MULTICELLULAR ORGANIZATION - SPONGES

Materials: compound microscope; stereomicroscope; preserved specimens of sponge (Grantia or, Scypha) prepared slide of sponge (cs) (Grantia or Scypha); dissecting tray and instruments

Porifera; Background Information

The phylum Porifera includes the sponges, which display a simple multicellular level of organization with two cell layers that do not form "true" tissues. The sponges are described as the "simplest animals" with bodies characterized by pores and one central cavity and/or many internal canals. The body shape is supported by an internal skeleton formed by spicules composed of calcium or silica, and/or the protein spongin. These sessile animals display radial symmetry, or are asymmetrical. Some species are solitary while others form colonies in marine habitats with some freshwater forms as well.

The cells of the sponges show specialization. Epidermal cells and specialized pore cells or porocytes form an outer body cell layer. The pore cells form the characteristic pores that allow water inflow and connect the outside with the inner canals (spaces). Specialized collar cells (choanocytes), each characterized by a cytoplasmic collar and extending flagellum form an inner cell layer that line the canals. Between these inner and outer cell layer there is a gelatinous space with amoebocytes (moving amoeba-like cells), and embedded skeletal supports. As water enters the cavity and/or canals through the pores, it is circulated in the inner space by the beating action of the collar cells, which also ingest and digest food particles. The amoebocytes also ingest food, distribute nutrients, and collect wastes as they "wander" throughout the sponge. Water and wastes passes out of a typical sponge through an *opening* from the central cavity called the osculum. Sponges display variation in the arrangement of the inner cavities.

Sponges reproduce asexually by budding or by forming protected structures called gemmules, which develop into new sponges with favorable conditions. Sponges reproduce sexually as some collar cells differentiate into male and female gametes. Released sperm cells travel out the osculum and are then taken into other sponges through the pores where they enter collar cells. The collar cells absorb the sperm and become modified to "carry" the sperm nucleus to the eggs, which are amoeboid and found at the base of collar cells in the gelatinous middle layer. Fertilization results in an embryo that eventually forms a free-swimming larva called an amphiblastula. The larva leaves through the osculum and becomes attached to the sea floor to form a sessile adult sponge.

Representative Sponge, Grantia (Scypha):

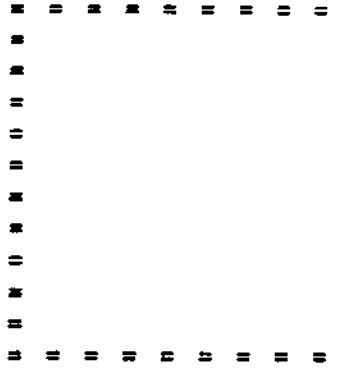
Grantia (Scypha) is a typical colonial marine sycon-type sponge commonly described as a vase sponge. In this sponge type, the body wall is folded, which results in the central cavity called the spongocoel with side extensions called radial canals. The single opening for water outflow is the osculum, which is fringed with spicules at the unattached end of the spongocoel.

1. Examination of Grantia (Scypha): Observe a whole specimen of this marine sponge and note the vase-like shape with the tapered base for substrate attachment and the opposite fringed osculum. Also note the pores through the body wall. DRAW a sketch of a single sponge body and LABEL the osculum, pores, and base.

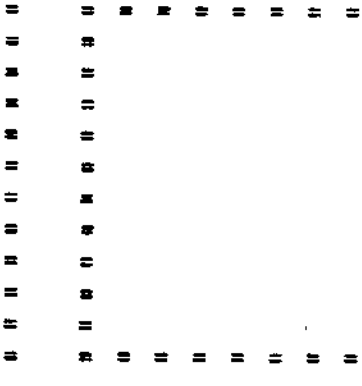
With a scissors, cut down the body lengthwise from the osculum to the base to make a longitudinal section through the sponge. With a stereoscope examine the section and note the overall inner foldings and design. Identify the osculum, central cavity (spongocoel) with its side branches (radial canals), and the pore openings (ostium). DRAW a sketch of the lengthwise inner section design and LABEL the osculum, spongocoel, a radial canal, and an ostium.

Examine a prepared slide of Grantia (Scypha) in cross section and note the relationship between the central spongocoel and the lateral radial canal. Note that body wall foldings also form infoldings between the radial canals called incurrent canals, and the opening to each incurrent canal is the "pore" opening or ostium. Water enters the ostium, then into the incurrent canal, then through inner openings to the radial canal, and then into the spongocoel before leaving through the osculum. Examine the body wall under the highest magnification and identify epidermal cells on the outermost cell layer, a middle layer with any spike-like angular spicules and amoeba-like amoebocytes. Also note the inner lining of the radial canals only to identify the collar cells with flagella. DRAW a section of the sponge in cross section, and LABEL the spongocoel, a radial canal, an incurrent canal, an ostium, a spicule, collar cells, epidermal cells, and amoebocytes (if identified).

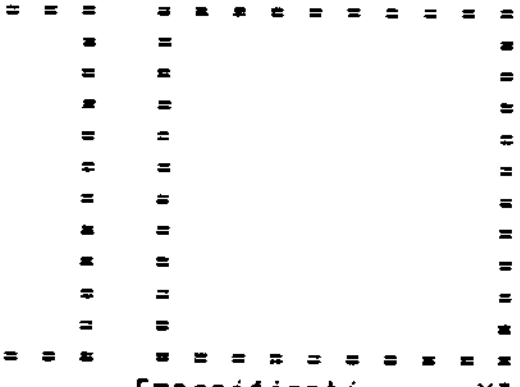
Grantia (Scypha)
Body Form:



Grantia (Scypha)
Longitudinal View:



Grantia (Scypha)
Body Slide (cs):

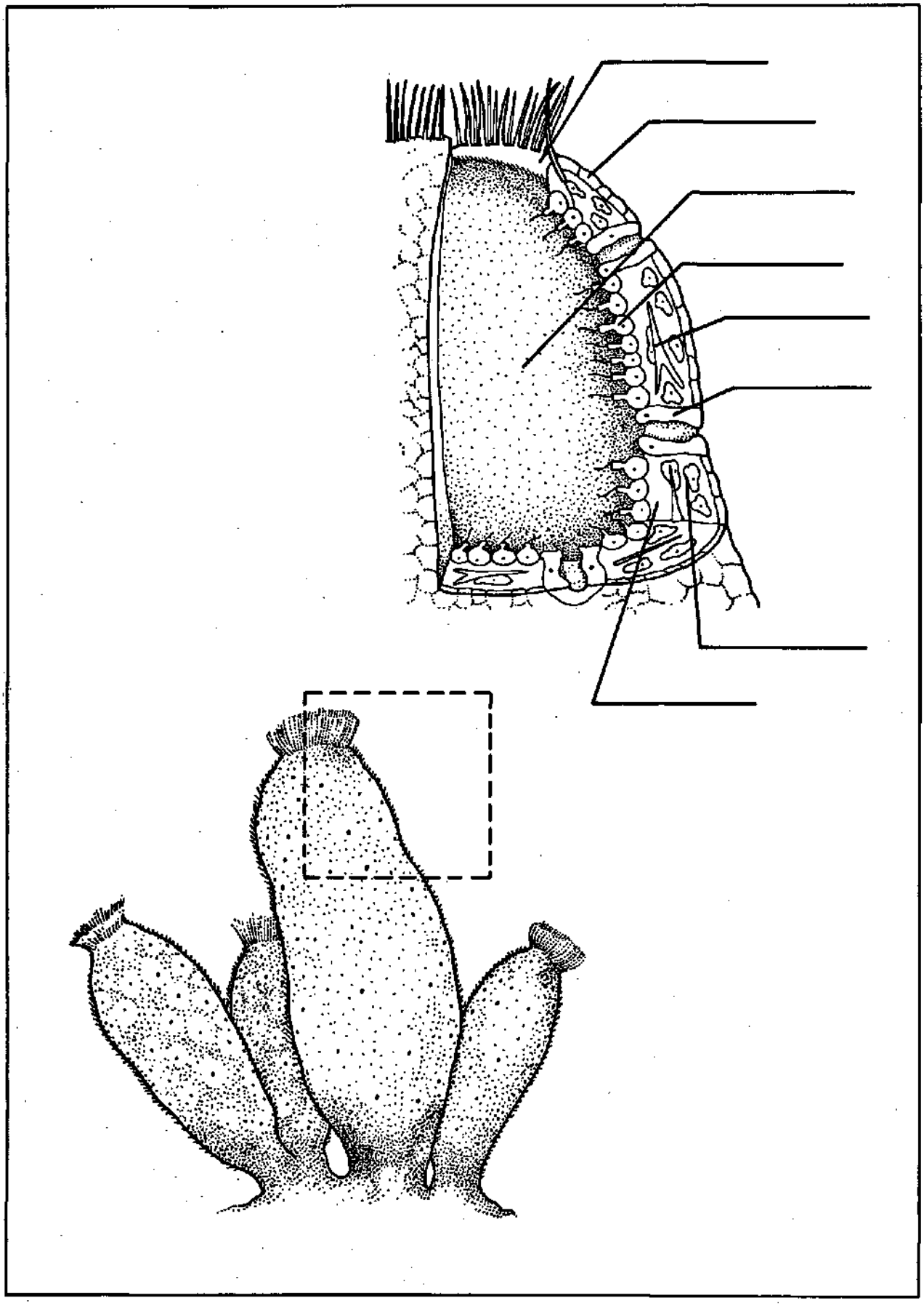


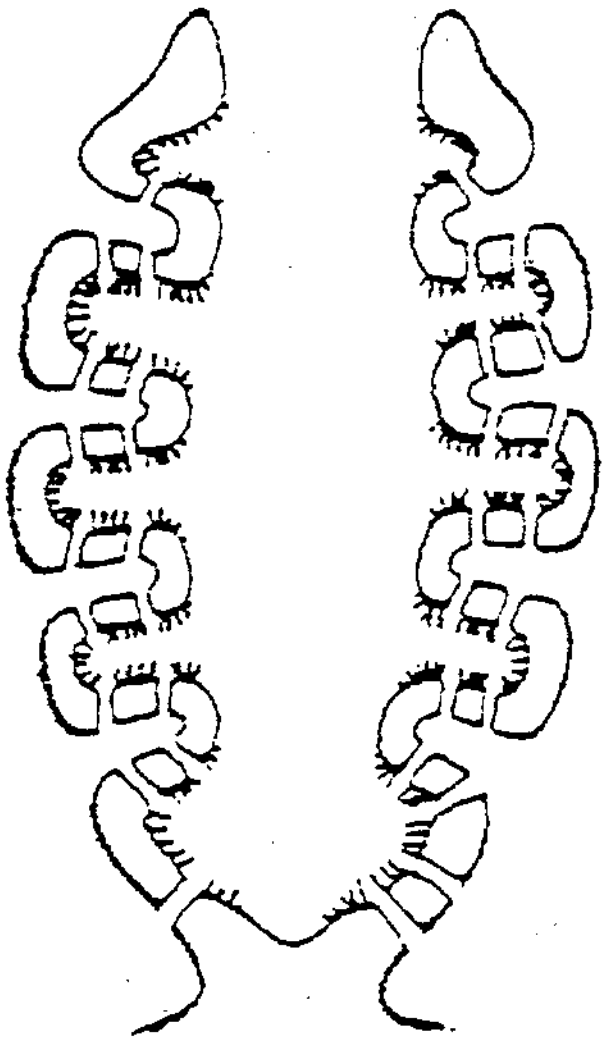
[magnification=___X]

Exercise Question:

1. How do sponges show a "simple" multicellular organization ?

Name _____ Date _____





CLASS SESSION: CELL DIVERSITY AND ANIMAL TISSUES

A. Epithelial Tissues (general characteristics) - found as coverings on surfaces of all body organs; found lining body's passageways and ducts; forms main mass of most glands; cells always appear in close contact and similar in shape/size; epithelial cells are modified to function in absorption, secretion, excretion, and protection; special functions are associated with reproduction (germinal epithelium) and sensory reception (neuroepithelium)

1. epithelial cells (description) -

Drawing: Basic Epithelial Cell Types (Simple) -

squamous cell | cuboidal cell | columnar cell

2. epithelial cell junctions (description) - the maintenance of strength and structure of epithelial tissues that form linings and coverings depends on cell to cell junctions defined as tight junctions and desmosomes

a. tight junctions (definition) -

b. desmosomes (description) -

Note: Squamous epithelium refers to simple or stratified cells that are flattened or spindle-shaped. Simple squamous epithelium lines structures where easy passage is necessary such as the air sacs of lungs and blood capillaries and forms membranes that line body cavities. Stratified squamous epithelium is associated with structures exposed to wear such as the linings of the mouth, anus, urethra, vagina, cornea, outer ear canal, and forms skin epidermis.

Cuboidal epithelium refers to simple or stratified cells that are cube-shaped and have a height approximately equal to their width. Simple cuboidal epithelium is found in organs where fluids are secreted or absorbed such as kidney tubules, ovary, surface of eye lens, and is found in many glands. Stratified cuboidal epithelium is found in ovarian follicles, and in the ducts of sweat and sebaceous glands.

Columnar epithelium refers to cells that are column-shaped and have a height greater than their width. Simple columnar epithelium is present where fluids are secreted or absorbed such as the linings of the stomach, intestines, gall bladder, uterus, oviduct (ciliated), and smaller respiratory passages. Stratified columnar epithelium is found usually where simple columnar meets stratified squamous such as in transition from larynx to trachea, from urethra to outer skin, and from eyeball surface to skin of eyelids.

Pseudostratified epithelium refers to a single layer of columnar cells that appear to be multilayered; the appearance is due to varying levels of nuclei in the single cell layer. This epithelial tissue functions to secrete and move fluids along a surface. It lines larger ducts of the respiratory, excretory, and male reproductive systems as well as lines the eustachian tube and occurs in the olfactory region.

B. General Connective Tissues (description) - makes up the framework of most body organs; basic connective tissue structure includes a ground substance (matrix adhesive material of organic molecules and inorganic salts), fibers (collagen, elastic, or reticular protein thread-like molecules that vary in thickness and composition), and cells which vary in quantity and type with the particular type of connective tissue; general descriptions include loose and dense forms

1. fibroblast cell (description) -

Drawing: Fibroblast Cell and General Connective Tissue

Note: Loose connective tissue is a general form in which the matrix is sparsely woven with fibers and there is a high ratio of fibroblast cells to fibers. In addition to fibroblasts, other cells include histiocytes (macrophages) and mast cells (source of histamine). Loose connective tissues are found in soft body areas such as the skin dermis, all glands, and organs of all body systems.

Dense connective tissue differs from loose tissue in that the matrix is compactly woven with many collagenous and/or elastic fibers with a high fiber to fibroblast cell ratio. Dense connective tissues may be found between or within layers of loose connective tissues and typically form ligaments, tendons, and fascia (wraps around muscle fibers and covers blood vessels and nerves as they pass through body structures).

C. Special Connective Tissues (description) - refers to particular types of connective tissues with specialized cells and modified forms that include adipose, blood, lymphoid, cartilage, and bony tissues

1. adipose cell (description) -

Drawing: Adipose Cells

Note: Adipose tissue formed by fat cells is found to a variable extent throughout most tissues (especially in skin, kidneys, bone marrow, armpit, groin, around muscles and nerves, and around heart). Adipose functions in protection, insulation and energy storage.

2. blood cells (description) - refers to cell types that form the "solid" component of blood tissue; includes red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes)

a. erythrocytes (description) -

b. thrombocytes (description) -

c. leukocytes (description) - general term for white blood cells that include granulocytes (with cytoplasmic granules) and agranulocytes (without cytoplasmic granules); descriptions based on Wright stain blood smear preparations

1. neutrophil (description) -

2. lymphocyte (description) -

Note: Lymphocytes together with fibroblasts or reticular cells form lymphoid tissue. This specialized connective tissue has cells densely packed into nodules or nodes. Lymphoid tissue is found in the tonsils, adenoids, lymph nodes, spleen, thymus gland, and patches in the digestive tract and skin. Lymphoid tissues function in filtration, immunity, and body defense reactions.

Drawings of Typical Blood Cells (Wright Stain):

Erythrocyte Neutrophil Lymphocyte

Note: Blood tissue is derived from connective tissues, and lacks ground substance and fibers. Blood consists of about 50% plasma and 50% cells, and is produced in bone marrow. Blood functions as a circulatory medium for general transport, gas transport, and the defense/immunity system.

3. chondrocyte (cartilage cell) (description) -

Drawing: Chondrocyte and Cartilaginous Tissue

Note: Cartilaginous tissue makes up "gristle" of the body, and is found in the trachea, larynx, bronchi, nose, outer ear, and in joints on the articulating bone surfaces and between vertebrae. Cartilage serves for support of the body framework.

4. osteocyte (bone cell)(description) -

Note: Bony tissue forms the bony layer of a bone (organ). Within this specialized connective tissue there is an elaborate communication network of haversian canal systems which form through the bony layer to supply nutrients to the living bone cells and remove wastes. Each haversian canal system includes a central haversian canal, which contains blood vessels and nerve supply, and concentric rings of the matrix ground substance called lamellae that form around the central canal. The lacunae refers to cavities or spaces within the lamellar ground substance that house the living bone cells or osteocytes. Throughout the system there are canaliculi, which are branching networks of "little canals" that radiate from the central canal to connect to lacunae throughout the lamellar ground substance.

Drawing: Bone Section

Haversian Canal System

D. Muscle Tissues (description) - refers to tissues formed by bundles of specialized muscle cells; distinguish basic types of muscle tissues as smooth, skeletal, and cardiac

1. myocyte (description) -

Note: Skeletal muscle is voluntary muscle associated with body movements. The fibers are striated and multinucleated with peripheral nuclei. Skeletal or striated muscles are located attached to bones, in the tongue, in the soft palate, beneath the scalp, in the larynx, in the eyelids, and on the eyeball surface.

Smooth muscle is involuntary muscle associated with the structure of internal organs. The spindle-shaped cells with single-central nuclei form fibers that are non-striated. Smooth muscles are located in the viscera (eg. digestive, respiratory, excretory, and reproductive tracts, in skin, blood vessels, eye iris, gall bladder, urethra, ureter, and ducts of glands (etc.).

Cardiac muscle is involuntary muscle composing the myocardium of the heart. The fibers are striated, branching with irregular cross bands called intercalated discs, and the nuclei are central.

Drawing: Muscle Tissue Types

Skeletal (Striated) Muscle

Smooth (Non-Striated) Muscle

E. Nervous Tissue (description) - refers to tissues formed by specialized nerve cells or neurons; neurons form neural tissue structures such as relay ganglia, and structures of central, peripheral, and autonomic nervous systems; organ structures include sense receptors, sense organs, nerves, spinal cord, and brain

1. neuron (description) -

a. cyton (description) -

b. fibers (description) -

1. axon (description) -

2. dendrite (description) -

Drawing: Neuron (Typical Multipolar)

EXERCISE: ANIMAL HISTOLOGY

Materials: compound microscope; prepared slides of vertebrate organs to include: lung (sec); frog small intestine (cs); trachea (cs); and frog skin (sec)

Refer to course notes and standard textbook for more detailed descriptions of tissues and cell types.

1. Examination of Lung: Observe a section of lung and note the overall "loose" organization of the organ. There are numerous spaces or air sacs that are characteristic of this organ. Note that each air sac has an alveolar wall formed by simple squamous epithelial tissue. In addition, there may be visible "circular" blood capillaries in between the air sacs. Using the highest magnification, DRAW a section of the lung and LABEL the air sac, alveolar wall, and simple squamous epithelial cells.

2. Examination of Small Intestine: Observe a cross section of frog small intestine and note the organization of this organ into four main tissue layers. The central space (lumen) is lined by simple columnar epithelium forming the mucosa layer. The second layer adjacent to the mucosa is the submucosa formed by loose connective tissue with blood vessels, nerve receptors, and glands. The third muscularis layer is formed by smooth muscle tissue, which is bordered by an outer layer of connective tissue. Using the highest magnification, DRAW a section of the intestine and LABEL the lumen, mucosa, submucosa, muscularis, columnar epithelial cells, loose connective tissues, and smooth muscle tissue.

Lung (section):

[magnification = ___X]

Frog Intestine (cross sec)

[magnification = ___X]

3. Examination of Trachea: Observe a cross section of the trachea and note the organization of the organ into several tissue sections. The innermost air space is lined by a ciliated pseudostratified epithelial tissue bordered by a layer of loose connective tissue with glands. The next tissue is a distinct layer of cartilage. Note the spaces (lacuna) with chondrocyte (cartilage) cells throughout the ground substance. The cartilage is also bordered by an outer connective tissue. using the highest magnification, DRAW a section of trachea and LABEL the ciliated epithelial cells, loose connective tissue, cartilage, lacuna, and chondrocyte.

4. Examination of Frog Skin: Observe a section of frog skin, and note the organization of the upper epidermis and the lower dermis layers. The upper epidermis is formed by stratified squamous epithelial tissue. There are distinct "vase-like" mucous glands that extend from the lower dermis up into the epidermis. Note that these glands are lined by a simple cuboidal epithelial tissue. The lower dermis is formed by loose connective tissue; there may be ring-like cross sections of blood vessels visible in the dermis as well as "patch-like" nerve receptors. Using high magnification DRAW a section of the skin and LABEL the epidermis, dermis, mucous gland, blood vessel, squamous epithelial cells, cuboidal epithelial cells, and loose connective tissue.

Trachea (cross section):

[magnification = ___X]

Frog Skin (section):

[magnification = ___X]

CLASS SESSION: CELL DIVERSITY AND PLANT TISSUES

A. Epidermal Tissues (description) - refers to the cell layer that provides an outer protective covering for the leaves, roots and stems; cell types include epidermal cells, guard cells, and root hair cells

1. epidermal cell (description) -

a. guard cell (description) -

1. stomate (definition) -

Drawing: Leaf Epidermis

b. root hair cell (description) -

Drawing: Root Hair Cell

8. Ground Tissues (description) - refers to the tissue components that form the support matrix and bulk of the leaves, stems, and roots; includes the cortex and pith in roots and stems; includes the mesophyll in leaves; plant cell types in ground tissues include parenchyma cells, collenchyma cells, and sclerenchyma sclereid cells

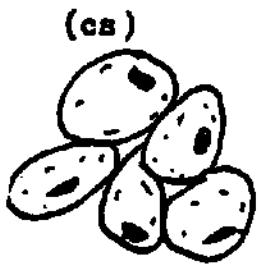
1. parenchyma cell (description) -

2. collenchyma cell (description) -

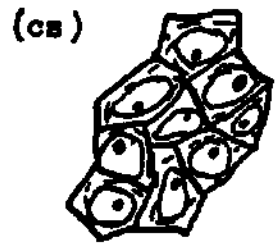
3. sclerenchyma sclereid cell (description) -

Drawing: Ground Tissue Cells (cross section)

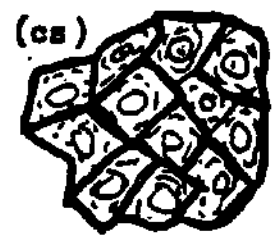
Parenchyma Cells



Collenchyma Cells

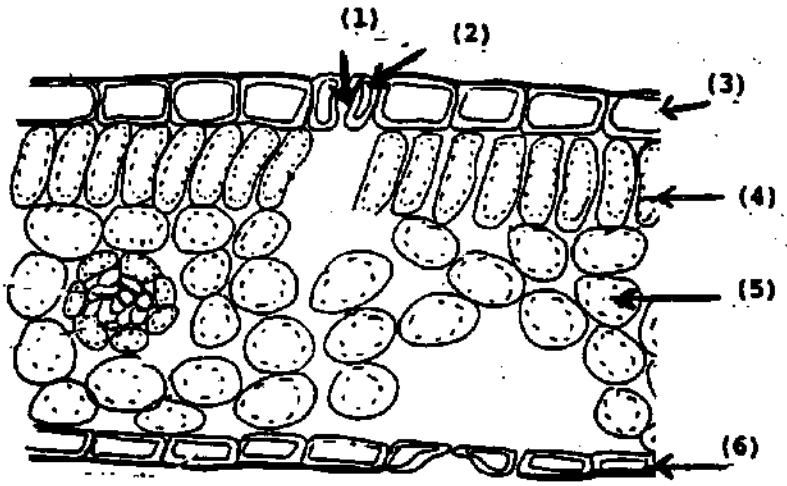


Sclerenchyma Cells



Note: The mesophyll ground tissue in a typical leaf includes the pallisade layer and the spongy layer. The pallisade layer is formed by column-shaped parenchyma cells found below the upper epidermis layer; these parenchyma cells have chloroplasts and are major sites in the leaf for photosynthesis. The spongy layer of a leaf lies below the pallisade layer and its parenchyma cells are loosely arranged to provide "spaces" for oxygen, carbon dioxide, and water vapor gases to accumulate. Vascular tissues in a typical leaf form a "vein-like" structure through sections of the leaf.

Diagram: Plant Cells and Tissues - Typical Leaf (cross sec)



C. Vascular Tissues (description) - refers to xylem and phloem tissues found in leaves, stems, and roots; vascular xylem transports water and minerals upward from the roots, through the stems, and into the leaves; vascular phloem transports food products downward from the leaves, through the stems, and into the roots; cell types that form the xylem and phloem include sclerenchyma fiber cells, vessel members, tracheid cells, sieve tube members, and companion cells

1. sclerenchyma fiber cell (description) -

2. vessel member (description) -

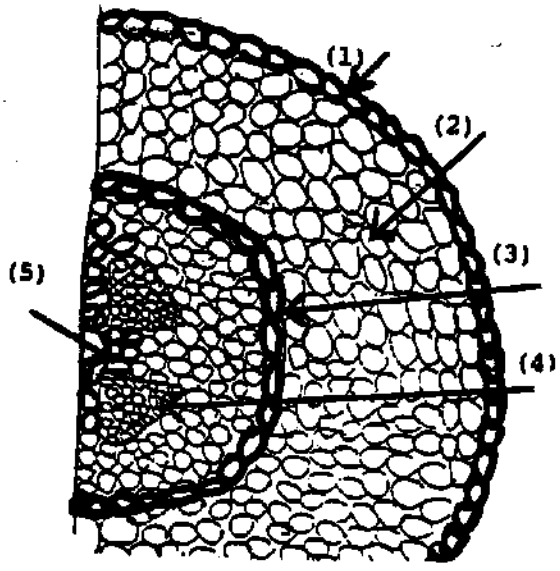
3. tracheid (description) -

4. sieve tube member (description) -

5. companion cell (description) -

Note: In typical roots the vascular tissue is arranged in a central cylinder that is continuous with the vascular tissues that run through the stem. The epidermis forms the outer cell layer of a typical root with the cortex forming the main mass of ground tissue. Specialized parenchyma cells form the innermost layer of the cortex called the endodermis, which borders the central vascular cylinder. Each endodermal cell has a wax-like Casparian strip within its cell wall that helps regulate the flow of water and dissolved substances into the vascular tissue of the root.

Diagram: Plant Cells and Tissues - Typical Root (cross sec)



Note: In typical stems, there is an outer epidermis with a bordering cortex ground tissue for support. In addition, there is a central mass of pith ground tissue for storage. The xylem and phloem arrangement varies in stems; there are differences noted between non-woody and woody stems.

Note: Vascular tissues in herbaceous (non-woody) stems form vascular bundles that are either scattered through the body of the stem (such as in corn, wheat, rye, oats, and grasses), or form vascular bundles that are arranged around the outer edge of the stem (such as in buttercup, celery, daisy, carrot, lettuce, tomato, sunflower, and potato).

Note: Vascular tissues in woody stems form distinct concentric rings of xylem and phloem separated by a lateral growth tissue layer (vascular cambium). The tissues form annual rings in woody plants (eg. typical trees), which are differences in the appearance of cells that grow to form new xylem tissue in the Spring season compared with cells that form new xylem in the Summer season; the annual growth pattern appears as a distinct "growth ring".

Diagram: Plant Cells and Tissues - Typical Herbaceous Stem

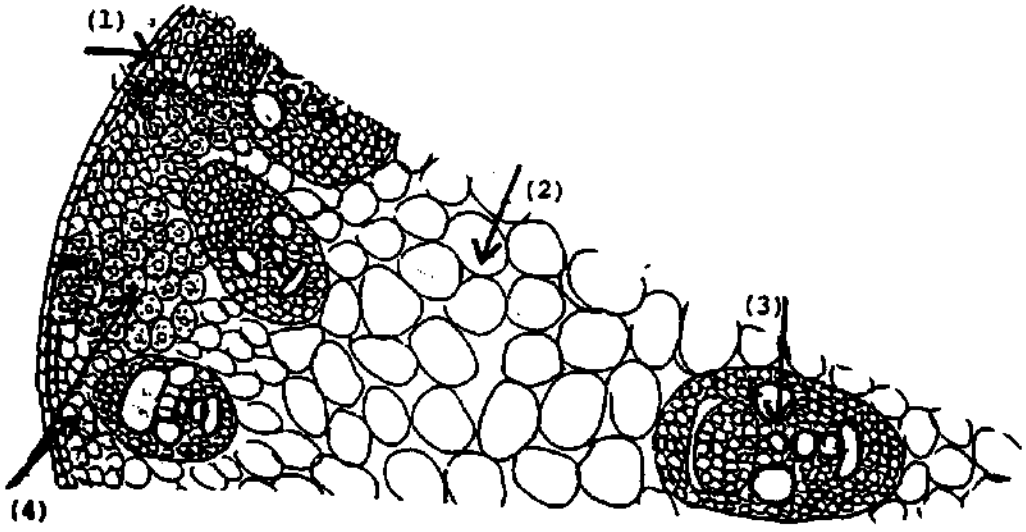
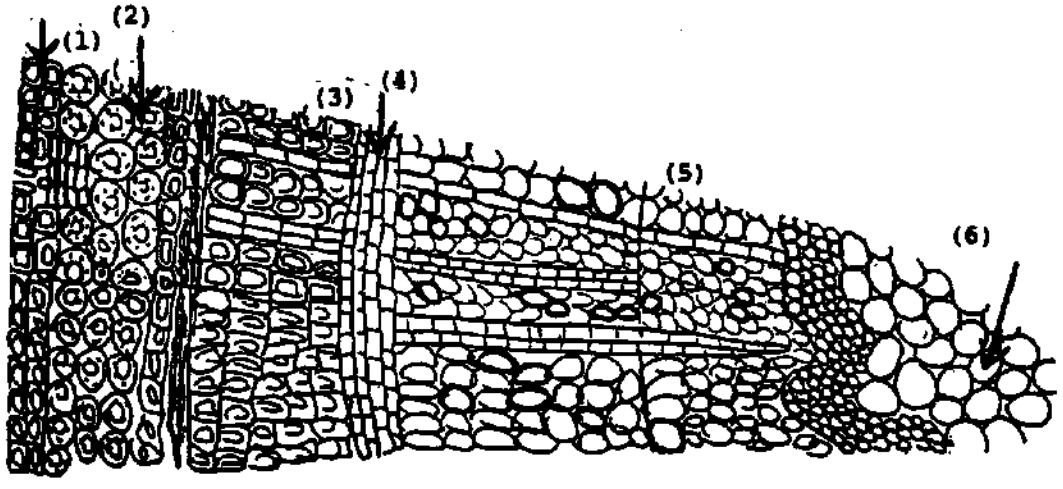


Diagram: Plant Cells and Tissues - Typical Woody Stem



D. Meristematic Tissues (description) - refers to primary and secondary growth tissues of the plant; includes apical meristems in the growing tips of roots and stems; includes lateral meristems (cambium) in stems and roots for growth in width

Note: Apical meristematic cells are embryonic, many-sided, thin-walled, and lack or have small vacuoles. These cells give rise to the mature tissues of the plant and cause stems and roots to grow longer. The lateral meristematic vascular cambium cells are elongate and spindle-shaped cells derived from parenchyma and primary meristematic tissue. In woody stems, these cells give rise to secondary xylem and phloem. The lateral meristematic cork cambium cells are flattened, compactly arranged cells derived from the cortex. These cells produce cork (phellem), which is a dead tissue at maturity that replaces the epidermis in woody stems and roots. The bark of some woody plants is an outer layer of "hard" dead tissue formed from cork, the cork cambium, and thin outer layer of phloem.

EXERCISE: PLANT HISTOLOGY

Materials: compound microscope; prepared slides of leaf (cs); root (cs); non-woody stem (cs); woody stem (cs). Note: Common preparations include Syringa leaf, Pinus (pine) stem; Zea (corn) leaf and stem; Lilium (lily leaf), Tilia (basswood) stem and root; and Ranunculus (buttercup) root;

Refer to course notes and standard textbook for more detailed descriptions of tissues and cell types.

1. Examination of Leaf: Observe a representative leaf cross section and note the tissue layers. Epidermal cells form the upper and lower epidermis tissues, and guard cells border the stomate openings. The main mesophyll layer is formed by the pallisade (column-shaped parenchyma cells) and spongy (loosely arranged parenchyma cells) layers. The vascular tissues of xylem and phloem form a "vein-like" structure through the mesophyll layer. Using low magnification, DRAW a section of the leaf and LABEL the epidermis, mesophyll, pallisade layer, spongy layer, vascular xylem & phloem, epidermal cell, guard cell, stomate, and parenchyma cell

2. Examination of Root: Observe a representative root cross section. The outer epidermis with root hair cells is bordered by the cortex (parenchyma cells) which forms the main ground tissue. An inner endodermis of specialized parenchyma cells borders a central vascular cylinder of xylem and phloem . DRAW a section of the root and LABEL the epidermis, cortex, endodermis, vascular xylem & phloem, epidermal cell, root hair cell, parenchyma cell.

Leaf (cross section):

[magnification = ___X]

Root (cross section):

[magnification = ___X]

3. Examination of Stems: Observe cross sections of a non-woody and woody stem. In both types of stems, epidermal cells form an outer epidermis tissue. Adjacent to the epidermis is a cortex tissue layer formed by parenchyma and collenchyma cells. In non-woody stems the pith tissue formed by parenchyma cells fills the main ground tissue of the stem. The vascular xylem and phloem form "bundles" that are loosely arranged through the pith (in monocots) or are arranged around the outer edge of the cortex and pith (in dicots). In the woody stems, the pith forms the innermost central tissue layer and the vascular xylem and phloem form distinct "rings". The vascular "rings" of xylem are separated from "rings" of phloem by a vascular cambium (lateral meristem) tissue layer. Using low magnification, DRAW a section of a non-woody stem and a woody stem, and LABEL the epidermis, cortex, pith, vascular bundle (non-woody); vascular xylem (woody), vascular phloem (woody), vascular cambium (woody), epidermal cell, parenchyma cell, and collenchyma cell (location).

Non-woody Stem (cross sec):

[magnification = ___X]

Woody Stem (cross sec):

[magnification = ___X]

Note: The cell types that form vascular xylem (sclerenchyma fiber cells, vessel members, and tracheids), and vascular phloem (sclerenchyma fiber cells, sieve tube members, and companion cells) were not distinguished in this exercise.

Plant Histology
Supplement

In addition to the histology drawings and labeling for the root, leaf and stem, include the following:

Locate and observe the prepared slides for:

- Root Hairs
- Leaf Epidermis

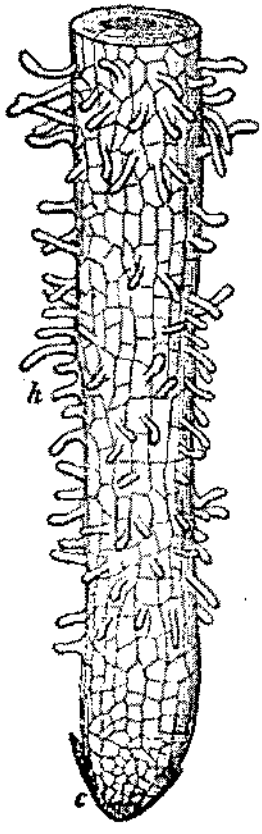
Research descriptions of these tissues and cells:

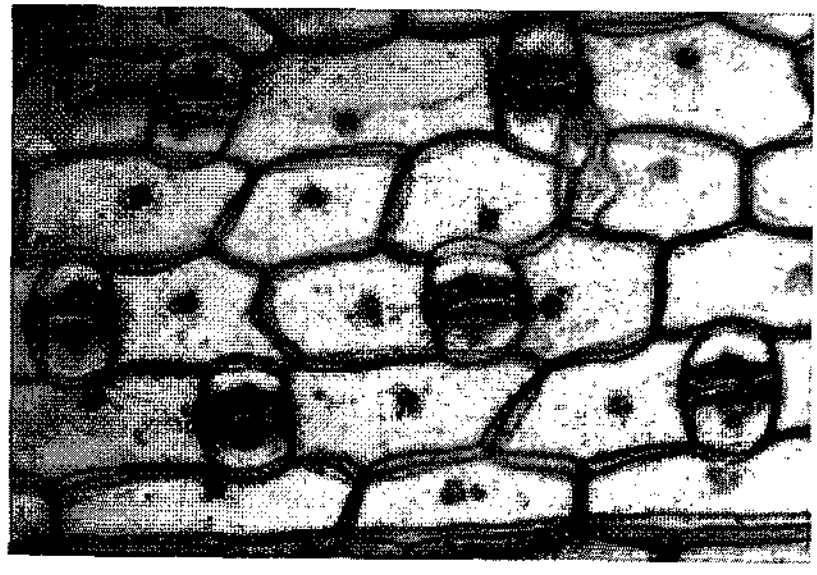
Label on the Root Hair:

- epidermal cell
- root hair

Label on the Leaf Epidermis:

- epidermal cell
- guard cell
- stomata





VOCABULARY REVIEW: CELL STRUCTURE AND DIVERSITY

Class Sessions: ----->

heterotroph hypothesis	anaerobic	aerobic
primitive "soup"	aggregation	fermentation
anaerobic heterotroph	anerobic autotroph	photosynthesis
aerobic heterotroph	aerobic autotroph	respiration

cell doctrine	eukaryote	prokaryote
nucleus	nucleoplasm	nuclear envelope
chromatin material	nucleolus	organelle
ctyoplasm	cytosol	plasma membrane
fluid mosaic model	ribosome	vacuole
endoplasmic reticulum	smooth ER	rough ER
vesicle	Golgi complex	lysosome
peroxisome	mitochondrion	cytoskeleton
actin filament	cyclosis	microtubule
cilia	flagella	basal body
centriole	chloroplast	plastid
chlorophyll	chromoplast	leucoplast
cell wall	middle lamella	pectins
cellulose	lignin	plasmodesmata
prokaryotic cell	nucleoid	flagellin
pili	endosymbiosis	

unicellular	specialized cell	tissue
multicellular	organ	system
epithelial tissue	squamous	cuboidal
columnar	simple	stratified
tight junction	desmosome	pseudostratified
connective tissue	ground substance	fibers
fibroblast	loose connective	dense connective
mast cell	histiocyte	macrophage
ligament	tendon	fascia
adipose	blood tissue	erythrocyte
thrombocyte	leukocyte	neutrophil
lymphocyte	lymphoid tissue	plasma
cartilaginous tissue	bony tissue	haversian system
chondrocyte	lacuna	osteocyte
haversian canal	lamella	canaliculi
muscle tissue	smooth muscle	skeletal muscle
cardiac muscle	intercalated disc	nervous tissue
neuron	cyton	neuron fibers
axon	telodendria	myelin sheath
dendrite	multipolar neuron	

epidermal cell
cutin
ground tissue
mesophyll
sclerenchyma cell
spongy layer
vascular phloem
tracheid cell
endodermis
woody
meristematic tissue
cork cambium

guard cell
cuticle
cortex
parenchyma cell
sclerenchyma sclereid
vascular tissue
sclerenchyma fiber
sieve tube member
Casparian strip
vascular cambium
apical meristem
cork (phellem)

root hair cell
stomate
pith
collenchyma cell
pallisade layer
vascular xylem
vessel member
companion cell
herbaceous
annual ring
lateral meristem
bark

Exercises: ----->

archaebacteria
bacillus
capsule
obligate aerobe
binary fission
transduction
phycocyanin
concave cell
Escherichia coli

eubacteria
spirillum
plasmid
obligate anaerobe
conjugation
cyanobacteria
phycoerythrin
apical cell
Oscillatoria

coccus
colonial form
endospore
facultative aerobe
transformation
filamentous form
heterocyst
Nostoc

sponges
spongin
choanocyte
amphiblastula
Grantia

spicules
porocytes
osculum
spongocoel
sycon-type sponge

sessile
amoebocytes
gemmules
radial canal
ostium

air sac
lumen
muscularis layer
dermis

alveolar wall
mucosa
ciliated epithelium
mucous gland

simple squamous
submucosa
epidermis
cross section

leaf structure
xylem cells
endodermis cells
pith cells

epidermis cells
phloem cells
cortex cells
cambium cells

mesophyll cells
root structure
stem structure