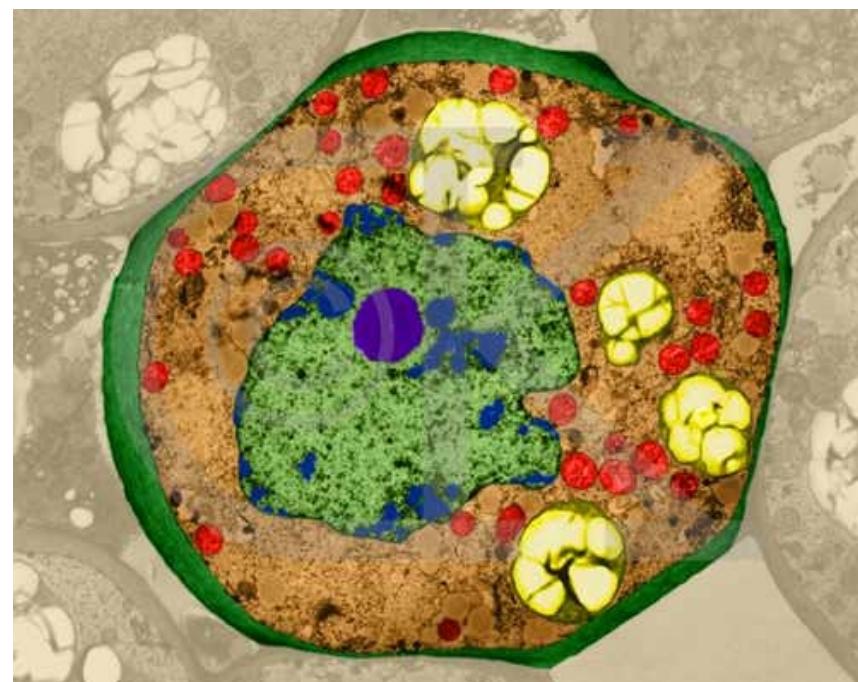


Introduction to Molecular and Cellular Biology

LECTURE 9:

Cell organization II



LECTURE 9: CELL ORGANIZATION II

➤ Cell types and organization in tissues

➤ Stem cells

➤ Connective tissue:

- bone (osteoblasts, osteoclasts)

- cartilage

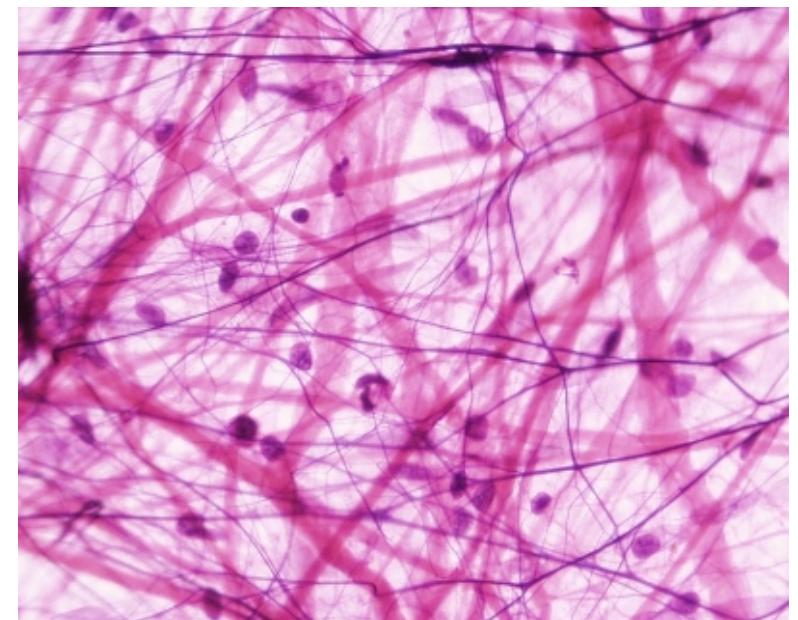
- blood

➤ Muscle tissue (myocytes)

➤ Nervous tissue (neurons)

➤ Epithelial tissue (epithelial cells)

➤ Skin



HISTOLOGY

Histology: microscopic anatomy of cells and tissues

- Anatomy at microscopic level
- Cell => tissues => organs => organ systems

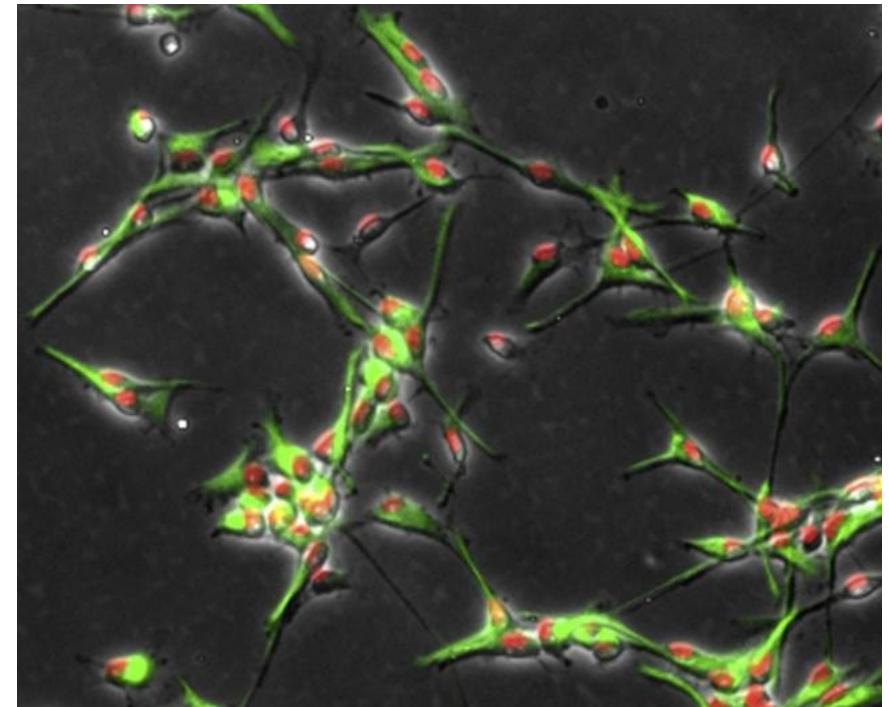
➤ 10^{15} cells in human body

➤ > 200 types of cells

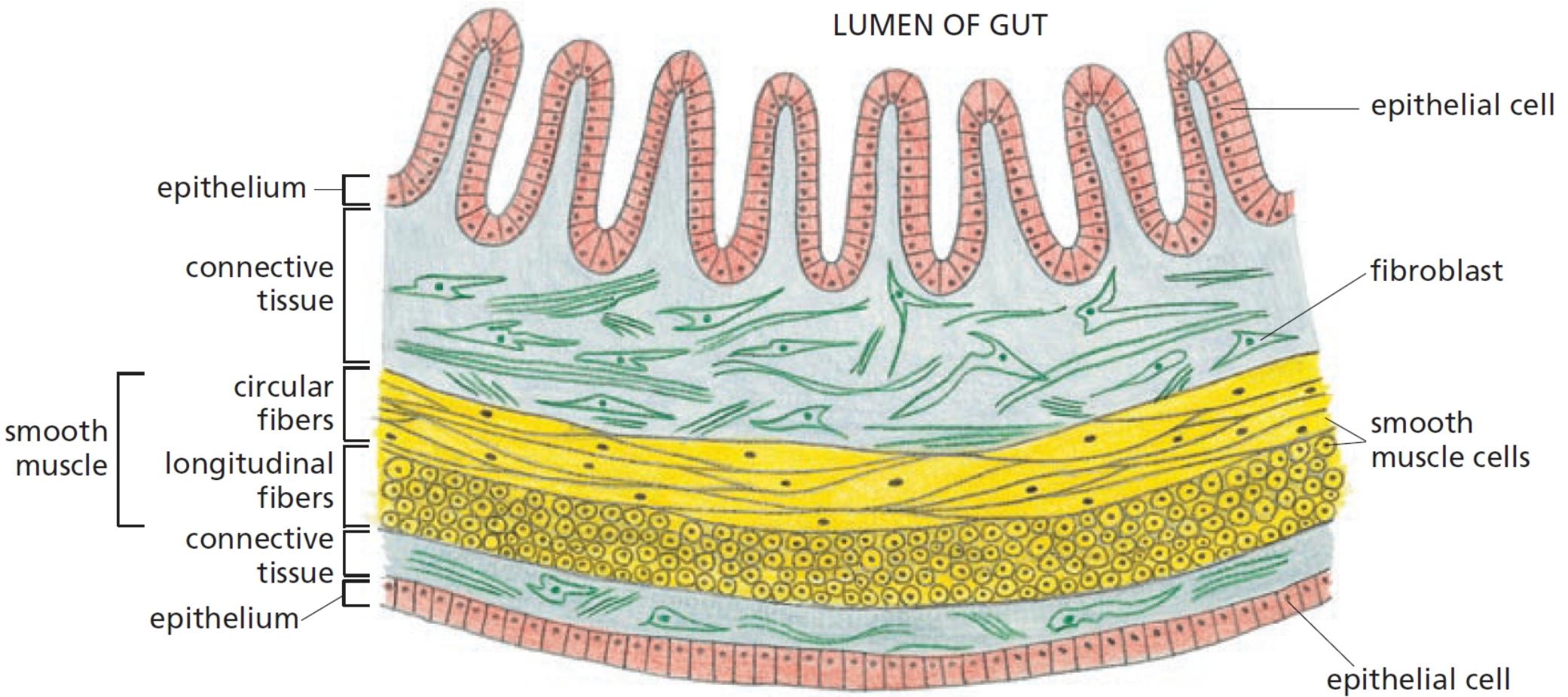
➤ Techniques:

- light microscopy (up to 10^{-7} m)

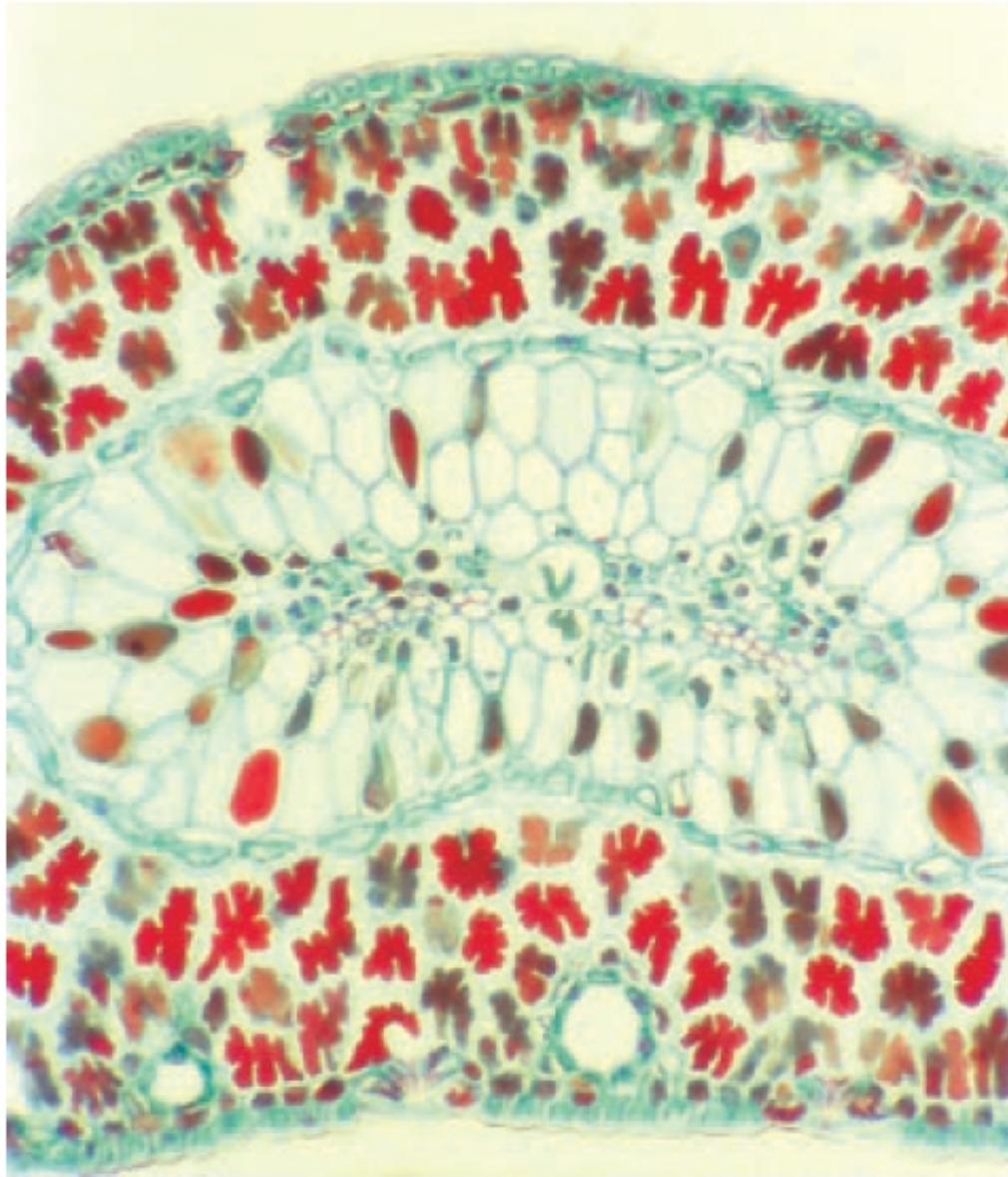
- electron microscopy (up to 10^{-11} pm)



EXAMPLE OF CELLS ORGANIZED INTO TISSUES: ANIMAL GUT

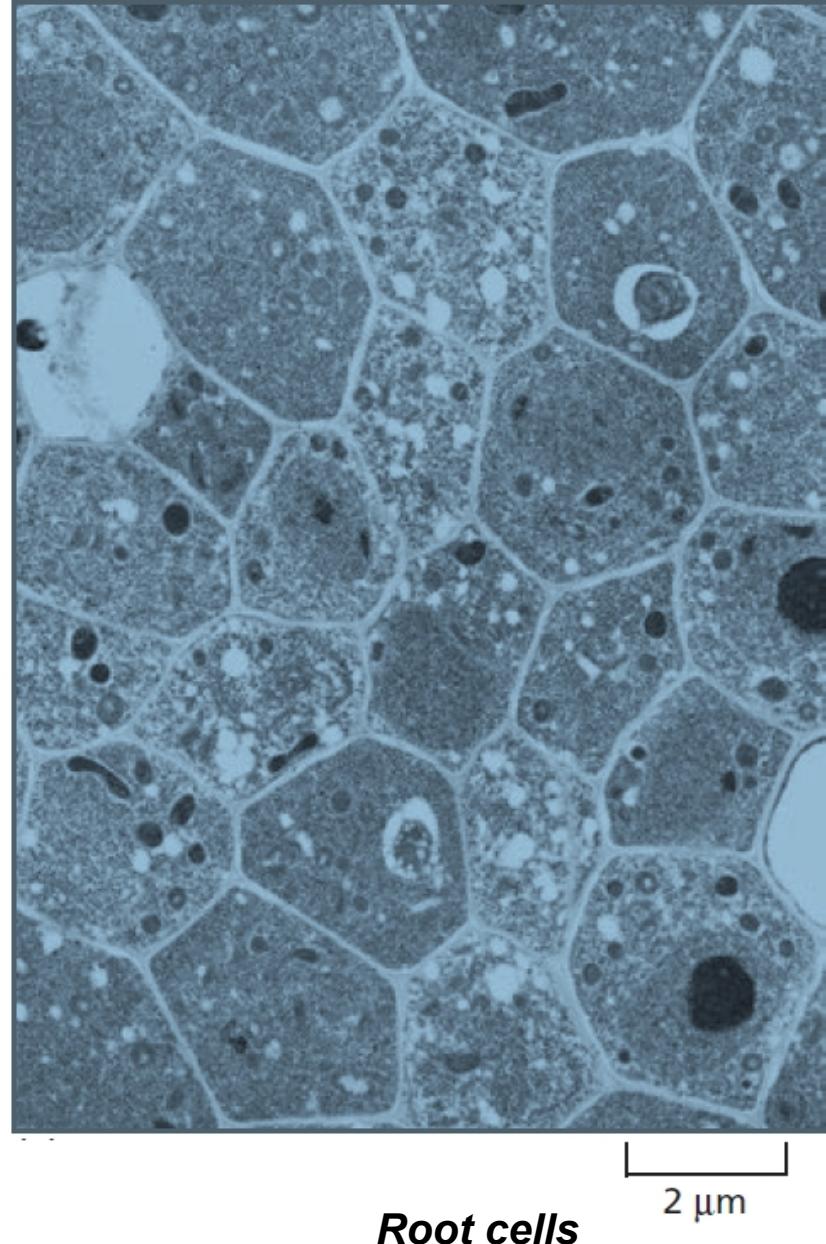
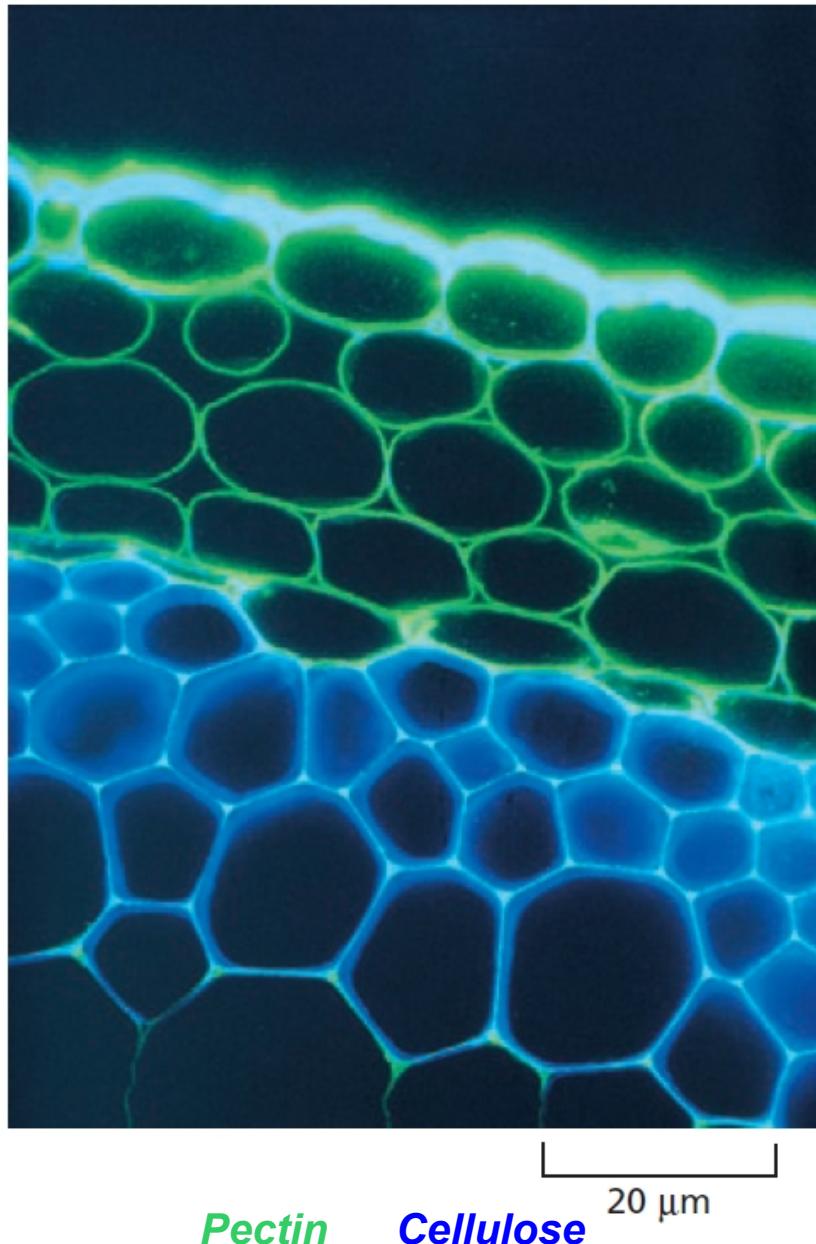


EXAMPLE OF CELLS ORGANIZED INTO TISSUES: PINE NEEDLE



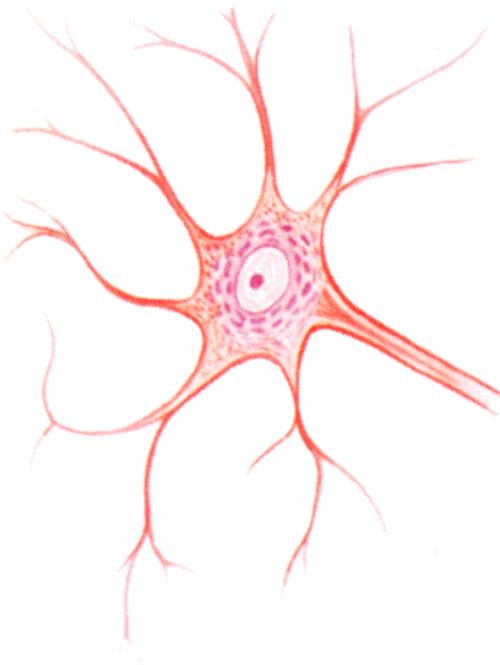
500 μm

EXAMPLE OF CELLS ORGANIZED INTO TISSUES: PLANT (ARABIDOPSIS)



CELL TYPES DIVERSITY

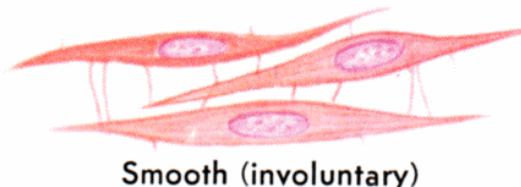
NERVE CELL



MUSCLE CELLS



Striated (voluntary)

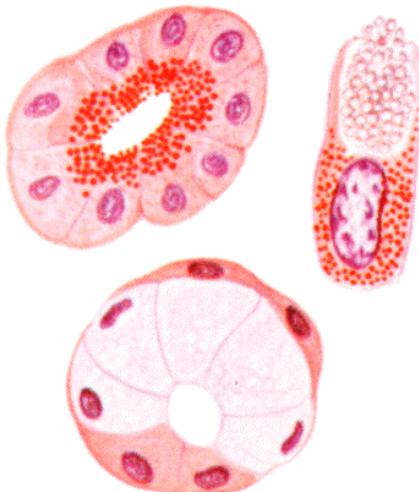


Smooth (involuntary)



Cardiac

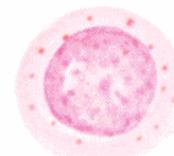
GLAND CELLS



BLOOD CELLS



Red blood cells



Lymphocyte



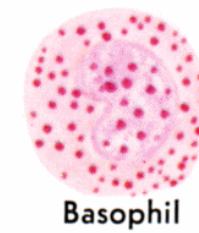
Monocyte



Neutrophil

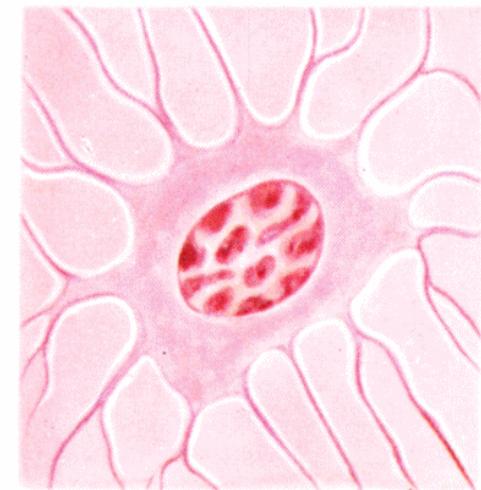


Eosinophil

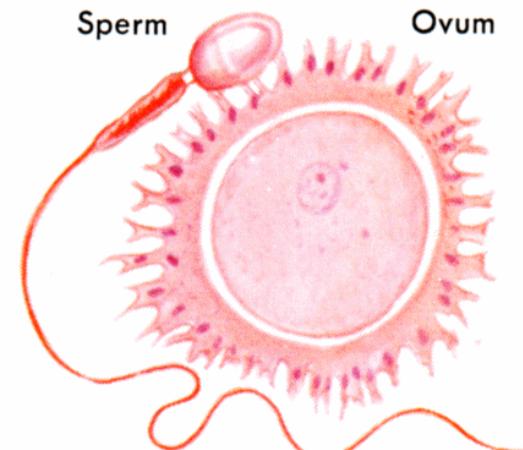


Basophil

BONE CELL



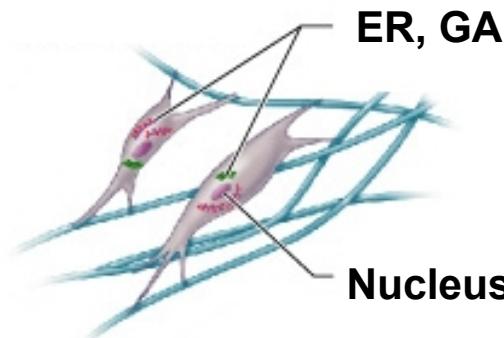
Sperm  Ovum



REPRODUCTIVE CELLS

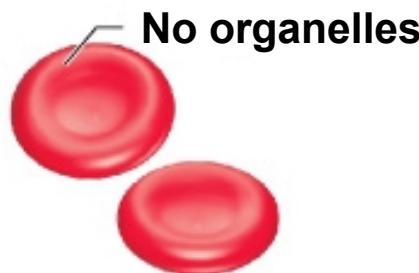
CELL TYPES DIVERSITY

Fibroblasts



Connecting body parts

Erythrocytes



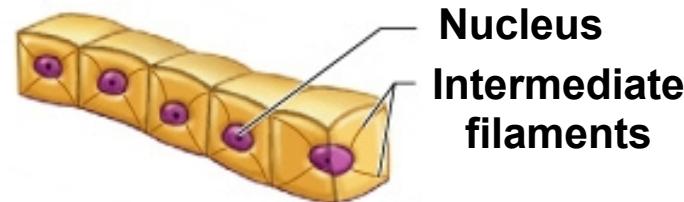
Skeletal muscle cells



Smooth muscle cells

Move organs and body parts

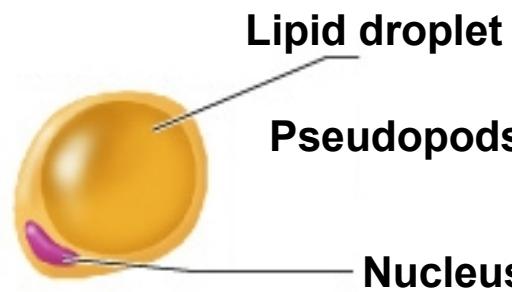
Epethelial cells



Cover organs

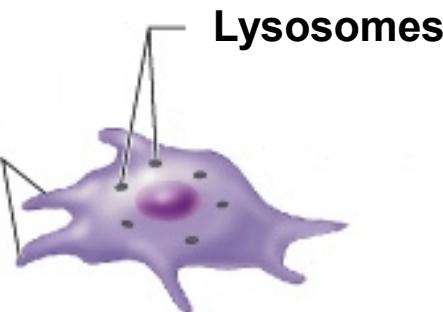
CELL TYPES DIVERSITY

Fat cells



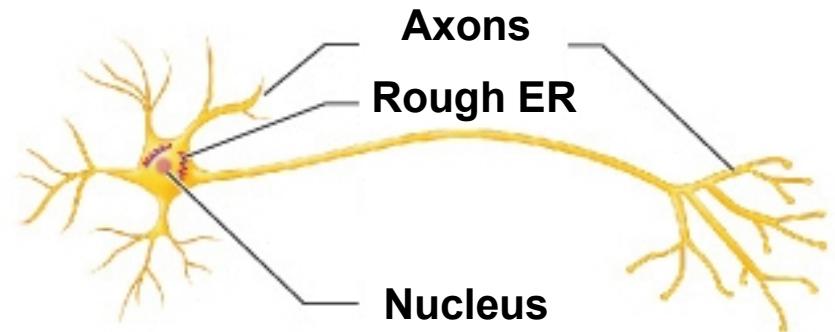
Store nutrients

Macrophages



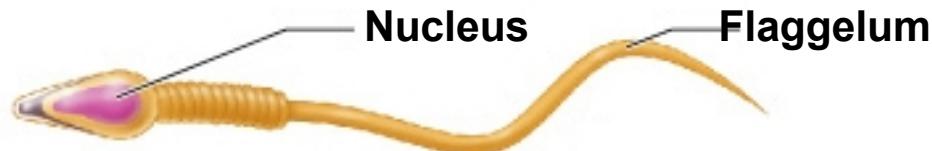
Fight diseases

Nerve cells



Controls body functions

Sperm cells



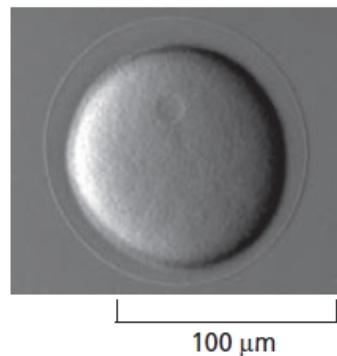
Involved in reproduction

CELL DIFFERENTIATION

Process of changing of one cell type to an another

➤ The same DNA => > 200 types of cells

➤ Signals is a key

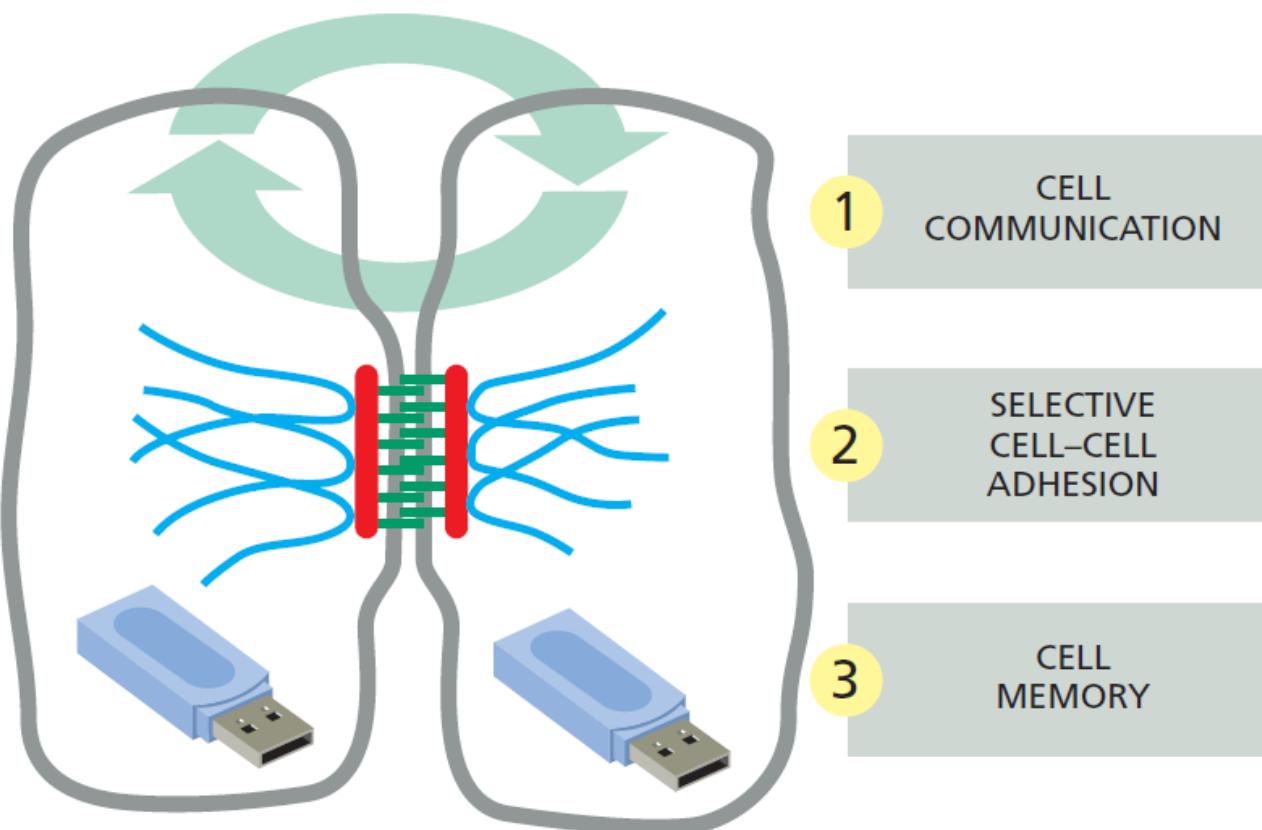


SIGNAL PRINCIPLE

➤ Communication between cells (L19-20)

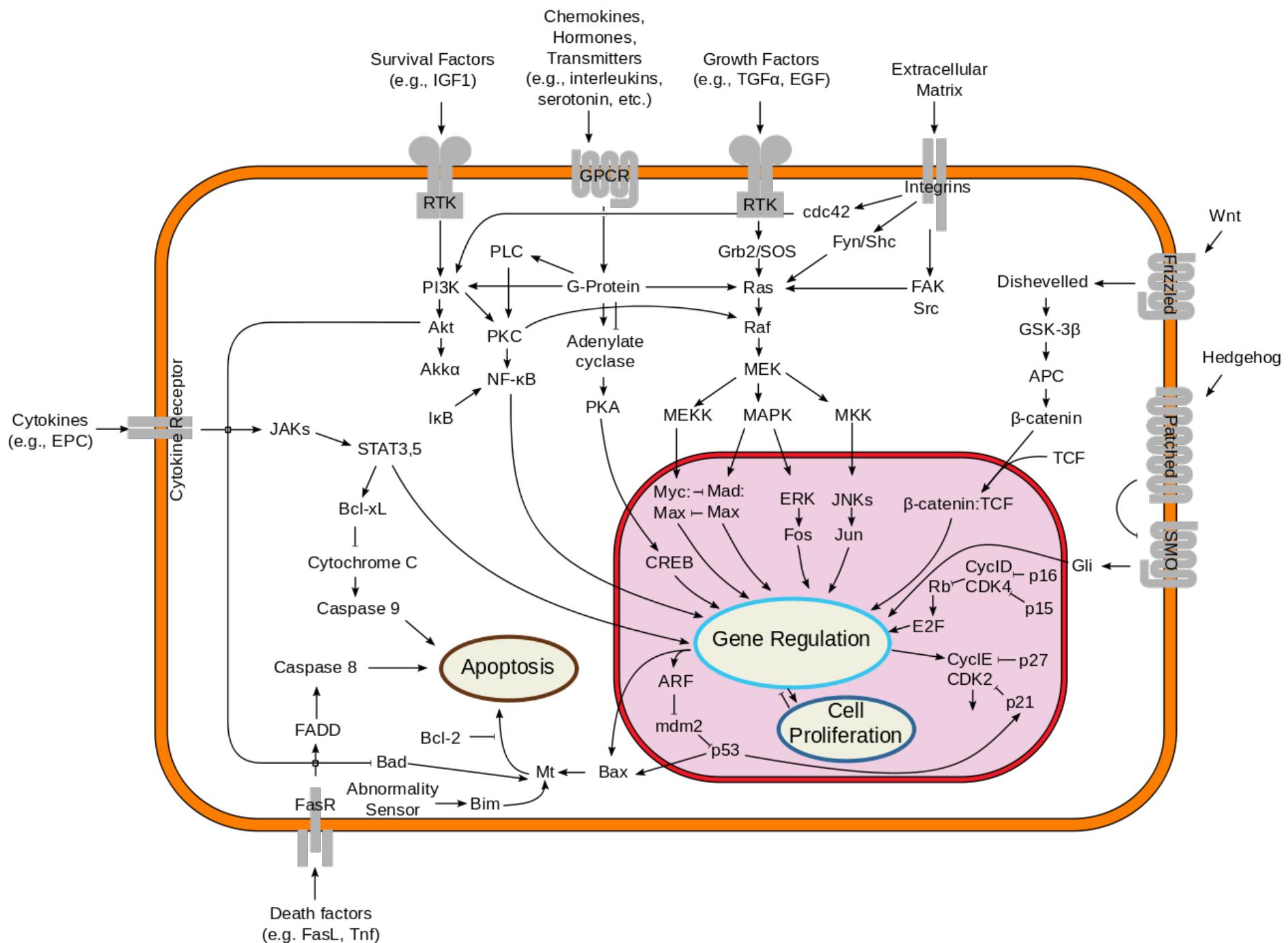
➤ Selective cell adhesion (L25-26)

➤ Memory of the cells

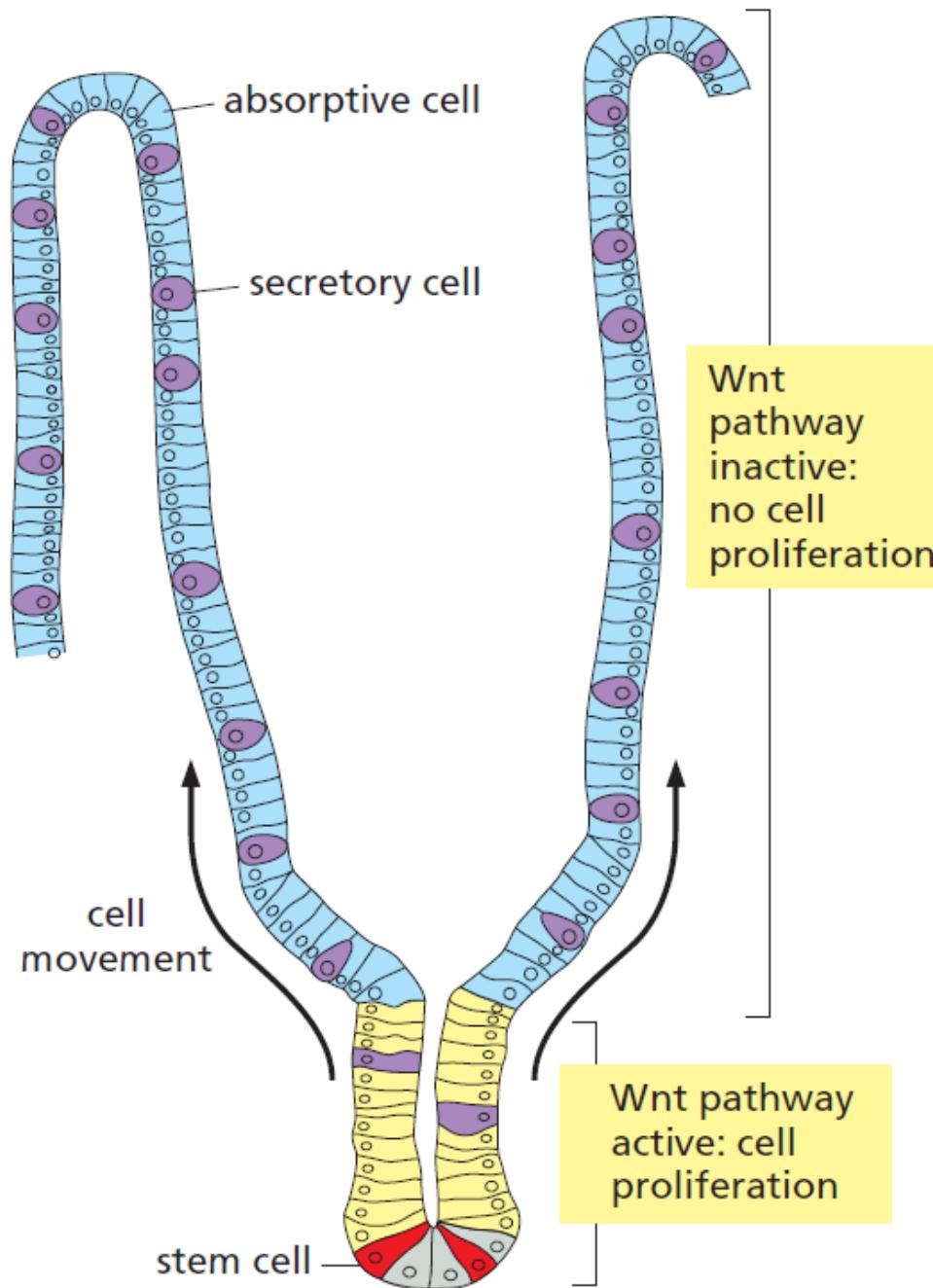


Cells are renewd constantly: new appear, old die

COMPLEXITY OF SIGNAL TRANSDUCTION



WNT: ONE OF THE CRUCIAL PATHWAYS



CELLS TURNOVER

➤ **Different speeds:**

- neurons are not renewed a lifetime
- intestine cells are renewed each few days
- bone: ~ 10 years cycle involving osteoblasts and osteoclasts
- Red blood cells (from bone marrow): 120 days
- Epidermis: ~ months

➤ **Unbalancing the rate**

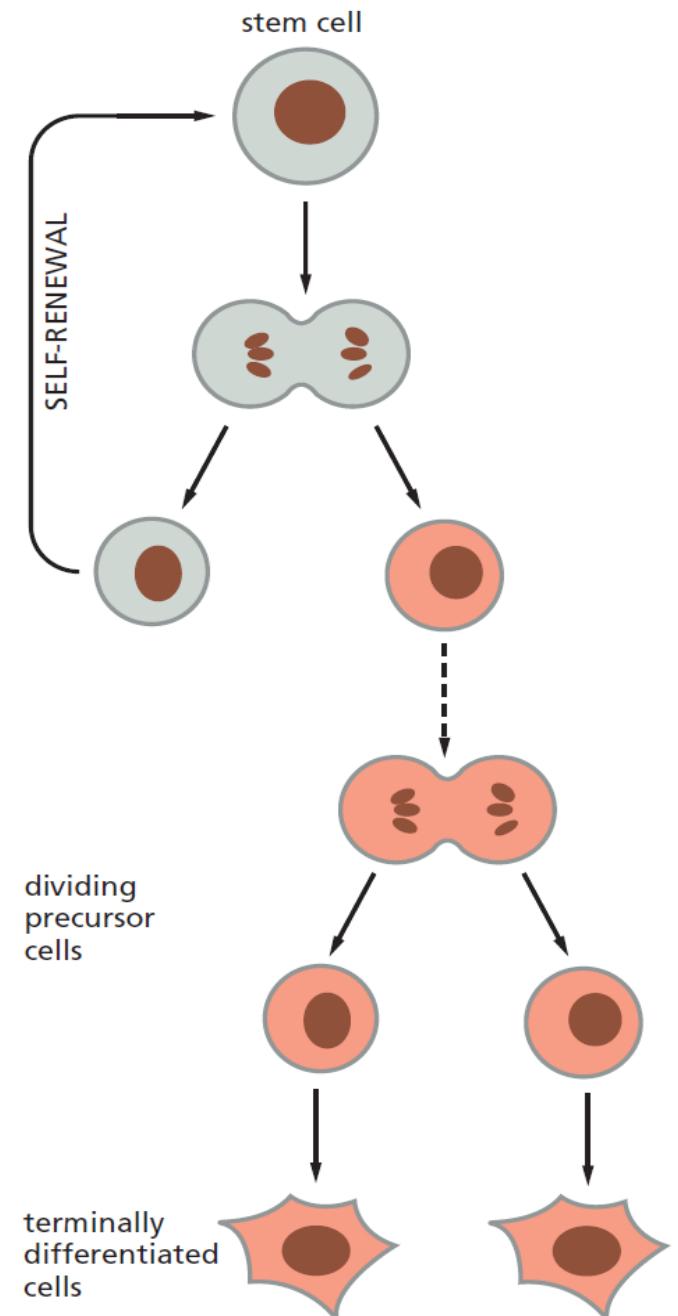
- ionizing radiation
- cancer

TERMINALLY DIFFERENTIATED CELLS AND STEM CELLS

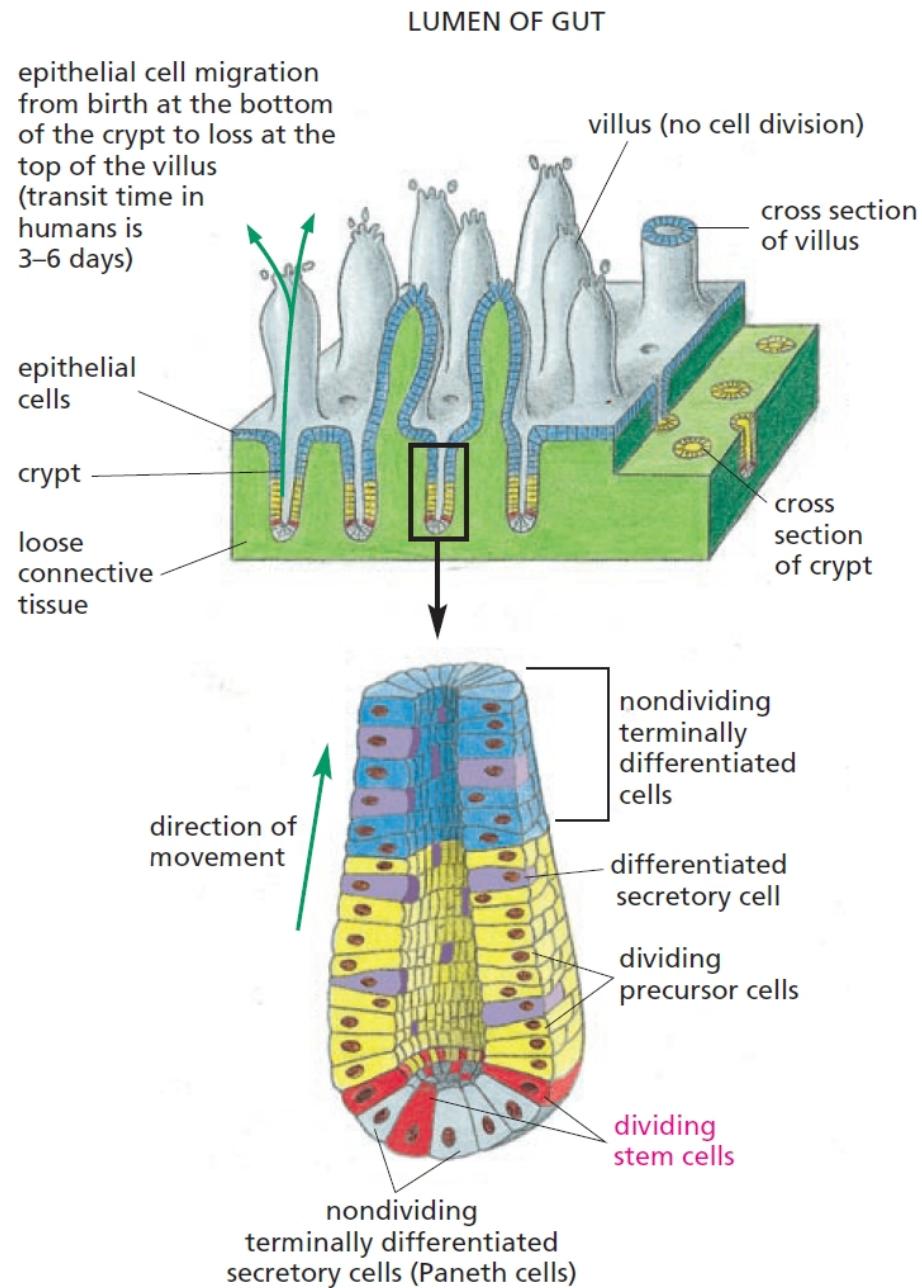
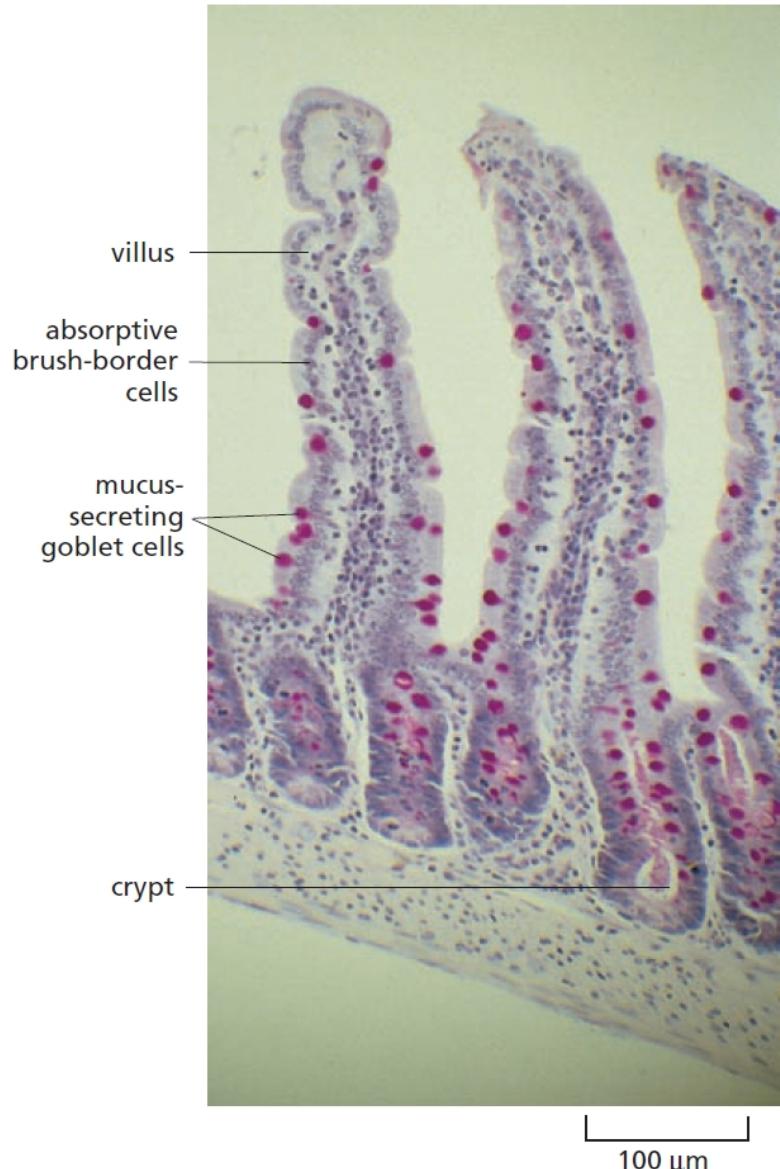
Terminally differentiated cells:
the differentiated cells unable to divide

Stem cells: not differentiated and can
divide without limit

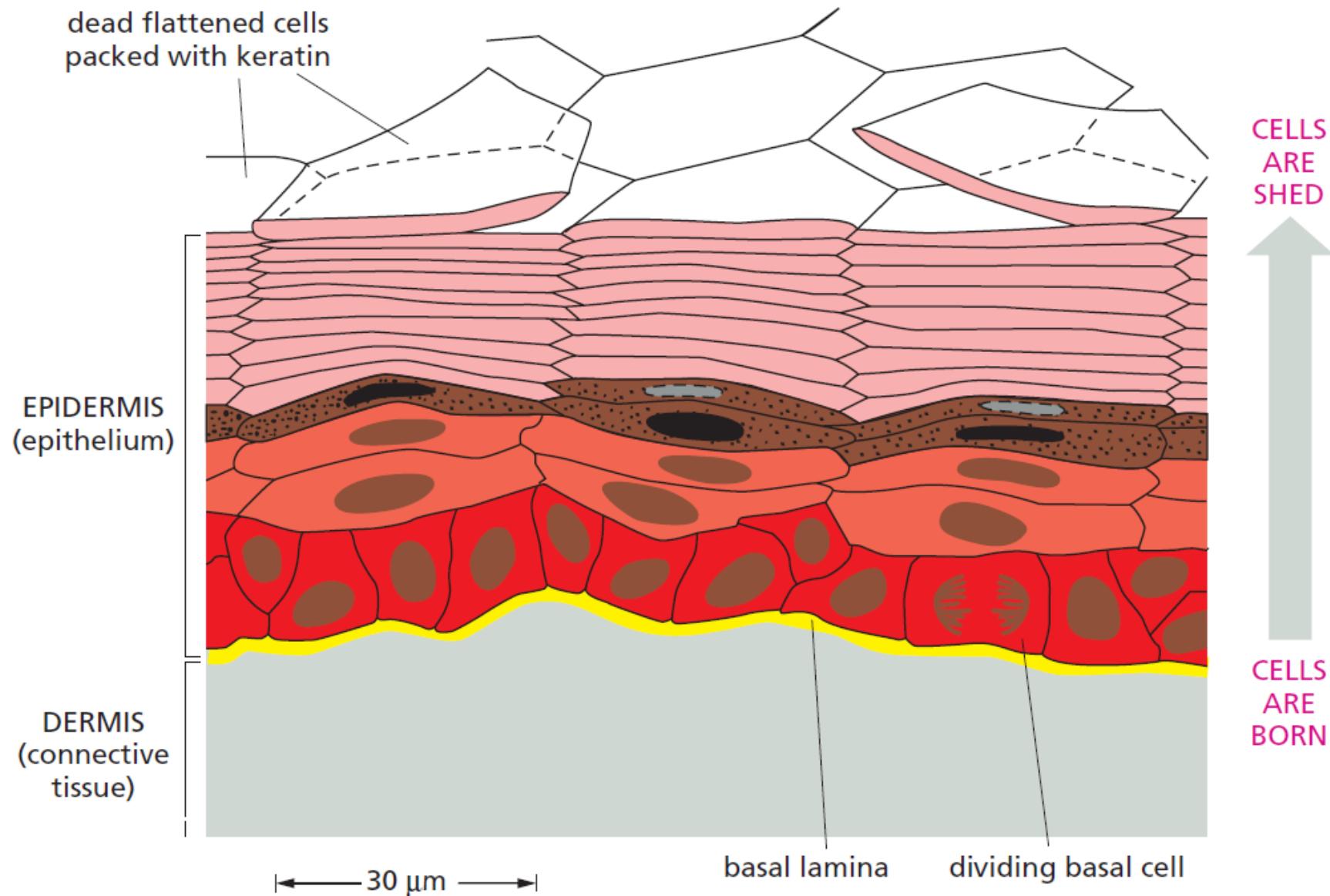
Stem cells => proliferating precursor cells



DIFFERENTIATION IN INTESTINE: FIRST DIFFERENTIATION, THEN MOVEMENT

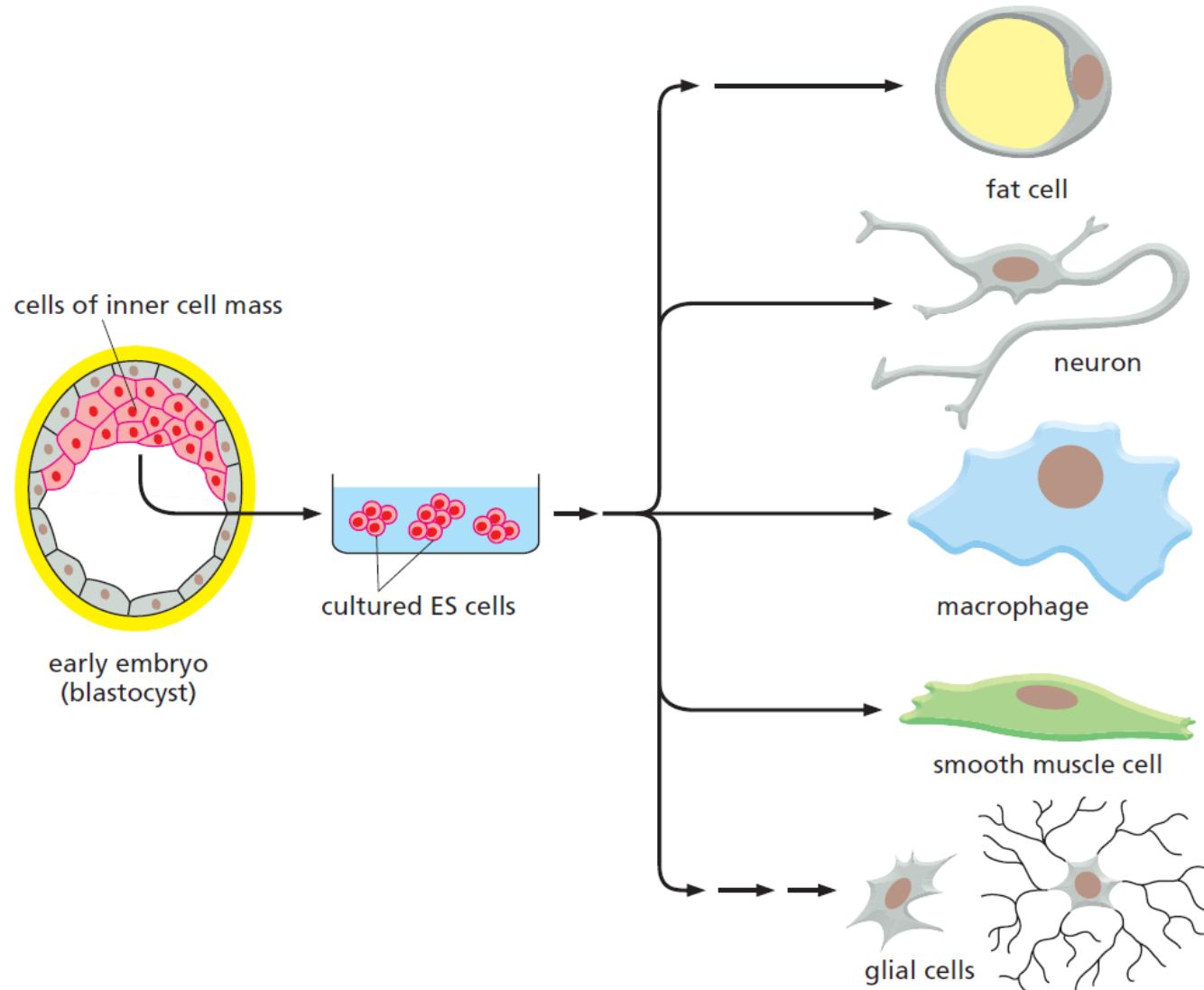


DIFFERENTIATION IN EPIDERMIS: SIMULTANEOUSLY WITH THE MOVEMENT



EMBRYONIC STEM CELLS

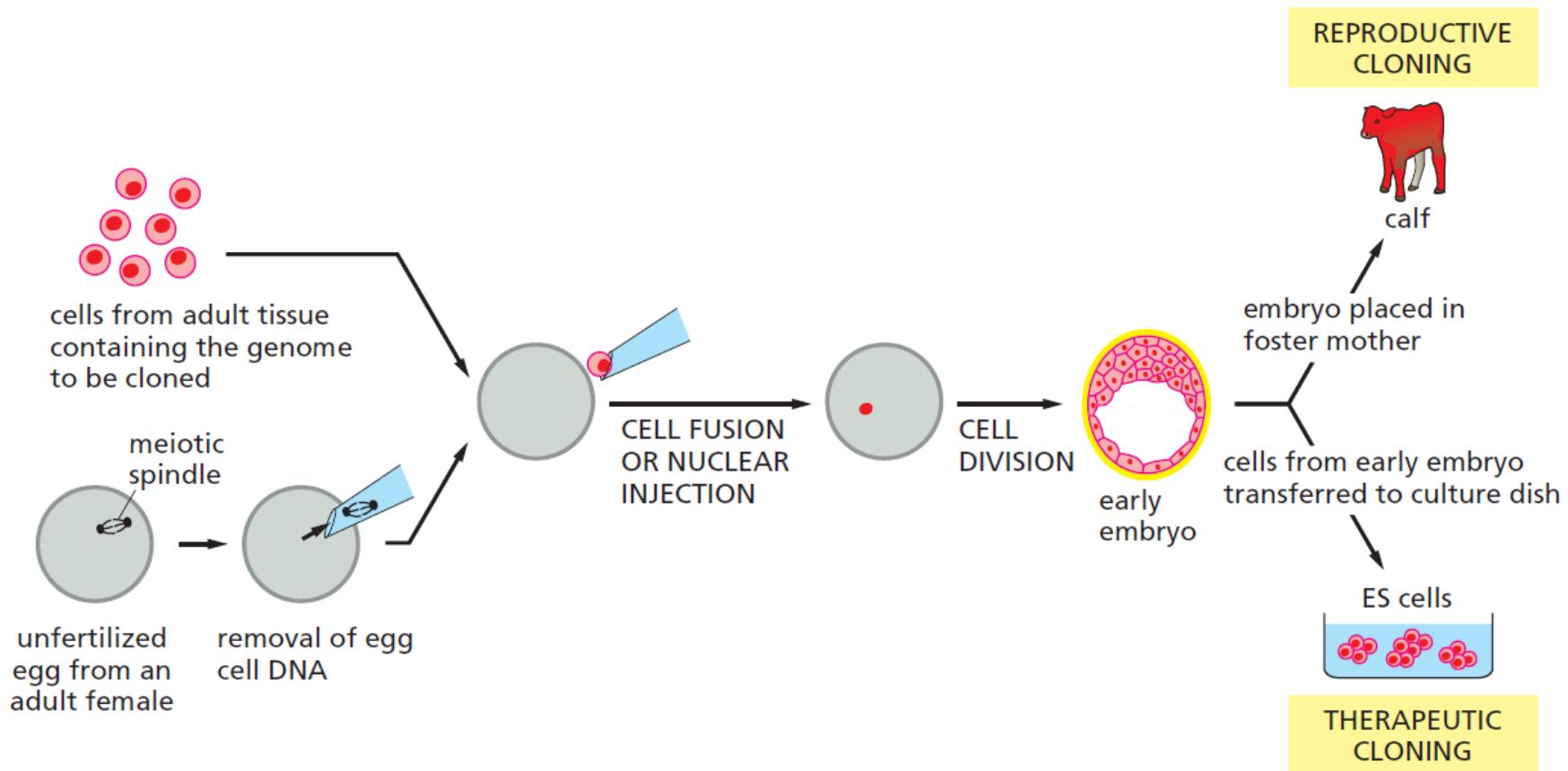
Embryonic stem cells:
proliferate indefinitely in a culture under certain conditions



CLONING

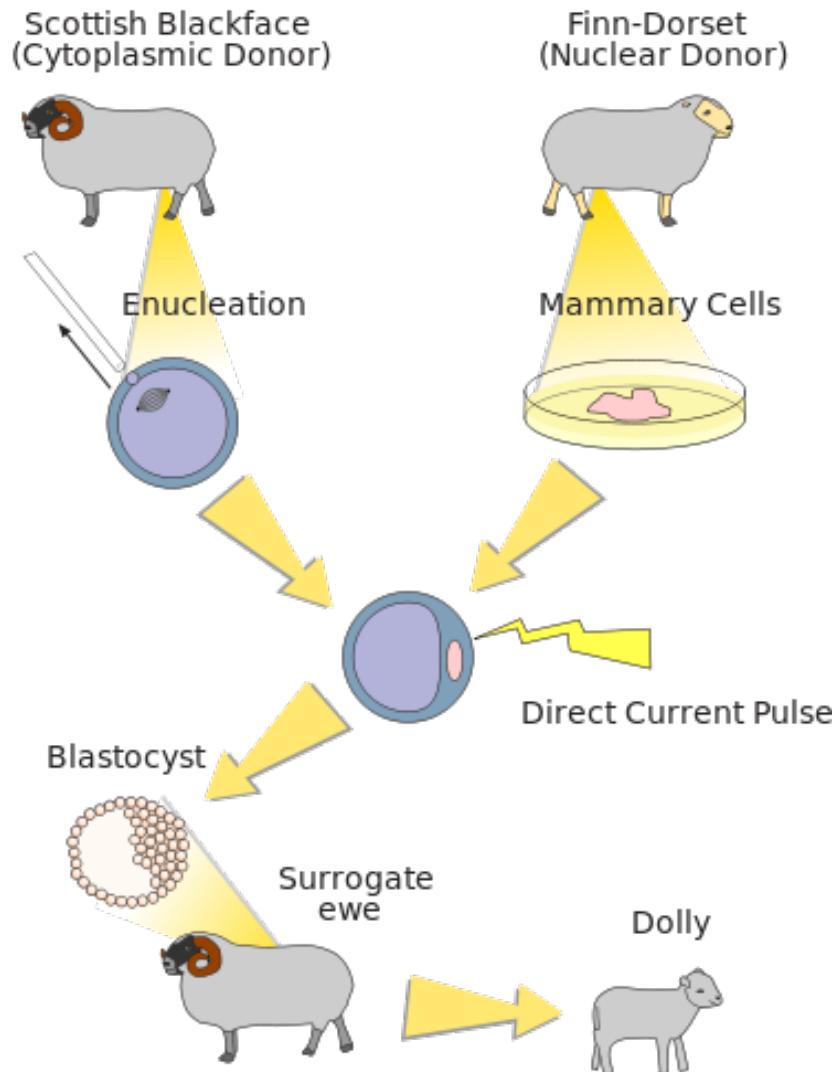
➤ Therapeutic

➤ Reproductive

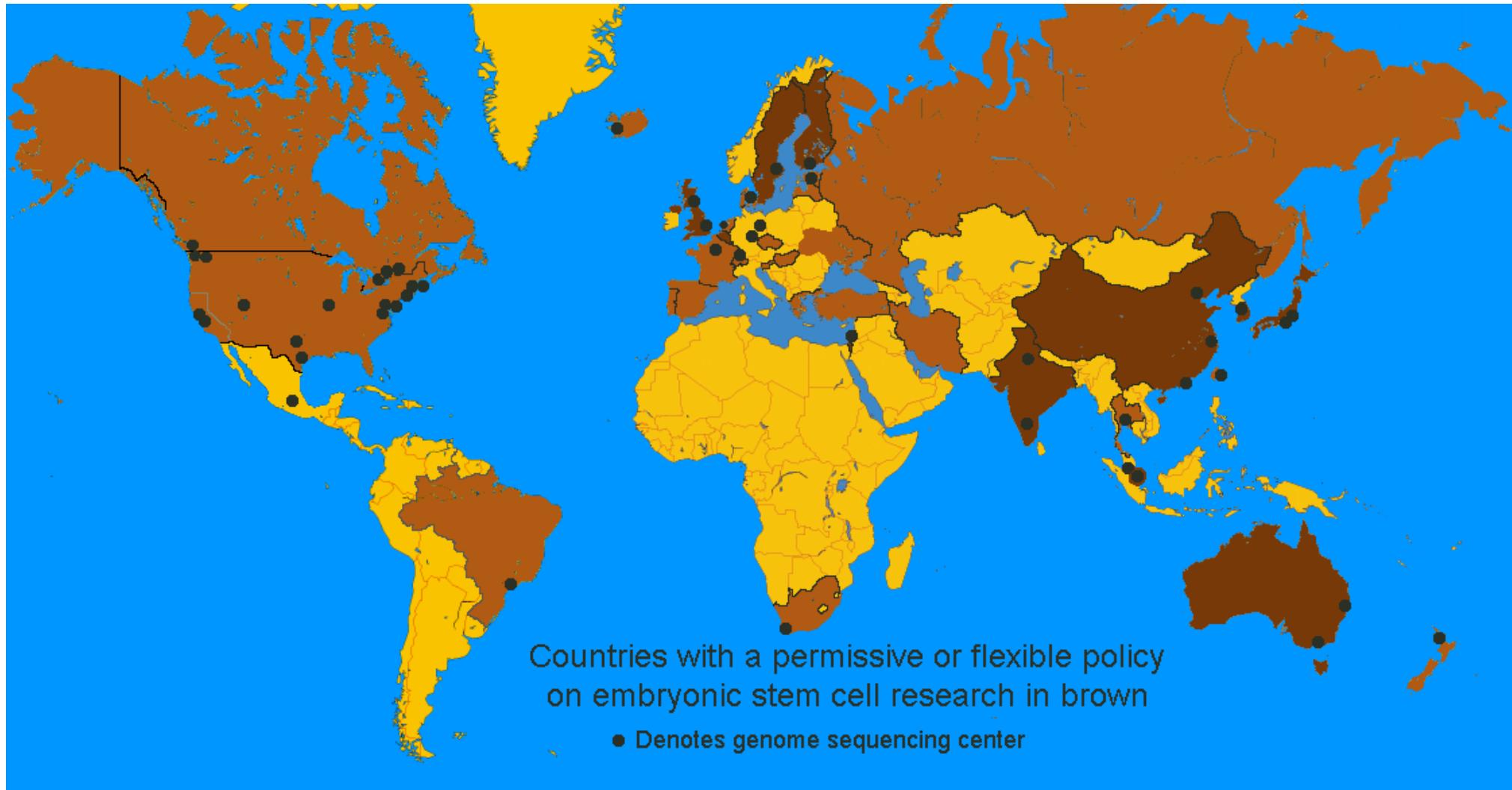


REPRODUCTIVE CLONING

Sheep dolly (1996-2003)

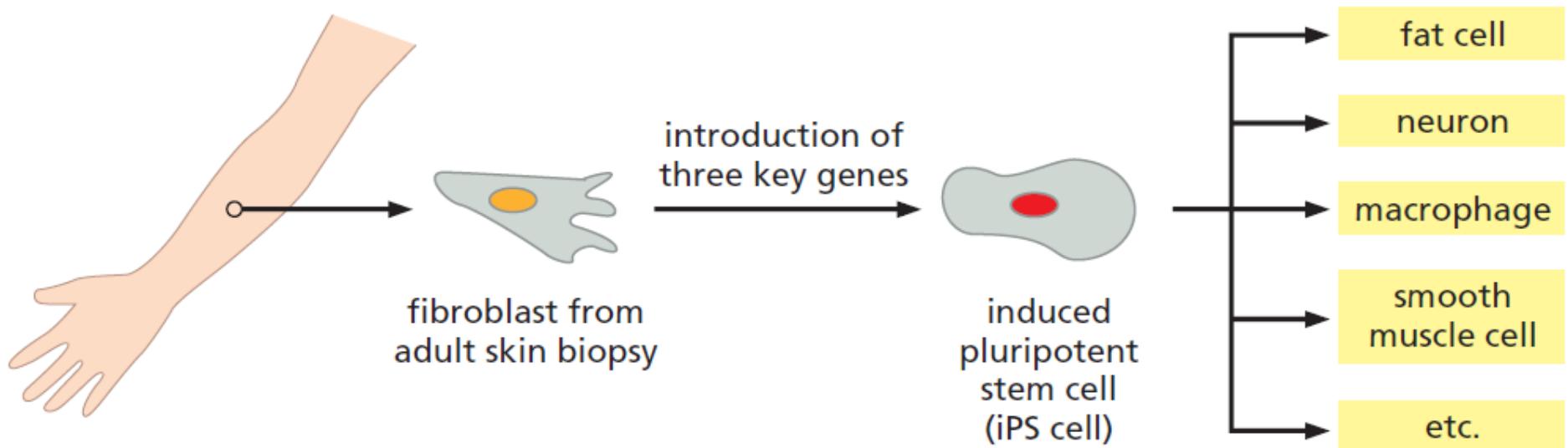


CLONING RESEARCH BY COUNTRIES: WORK WITH EMBRYONIC STEM CELLS

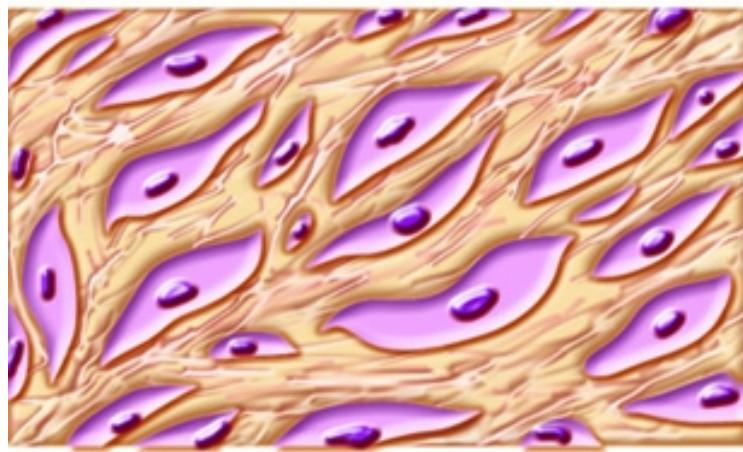


INDUCED PLURIPOTENT STEM CELLS

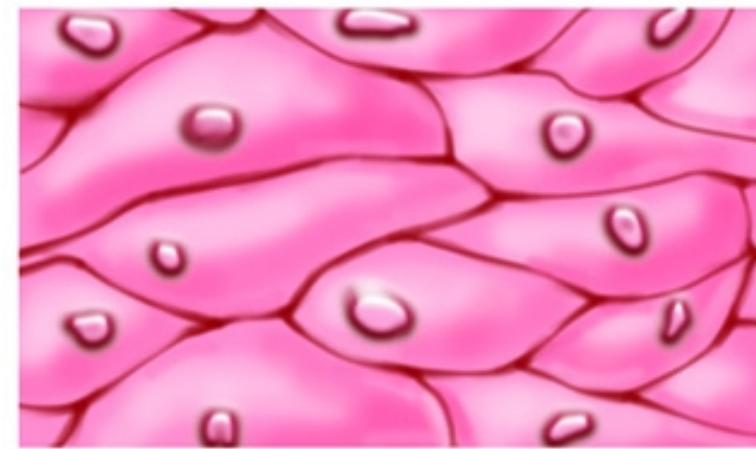
- Fibroblasts => embryonic stem cells (iPS cells)
- Genes involved Oct3/4, Sox2, Klf4



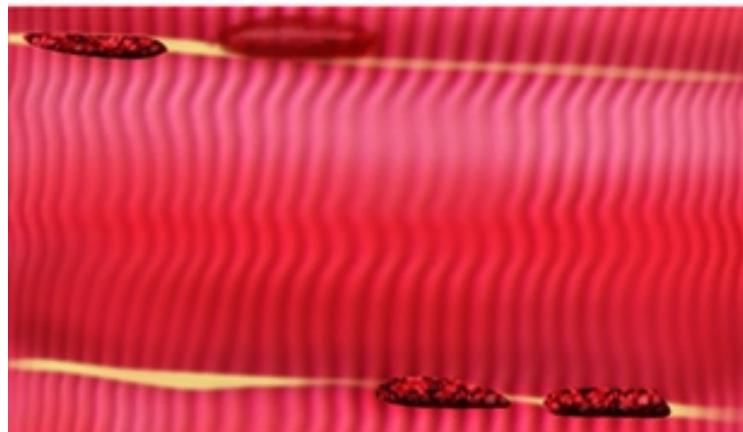
FOUR PRIMARY TISSUES



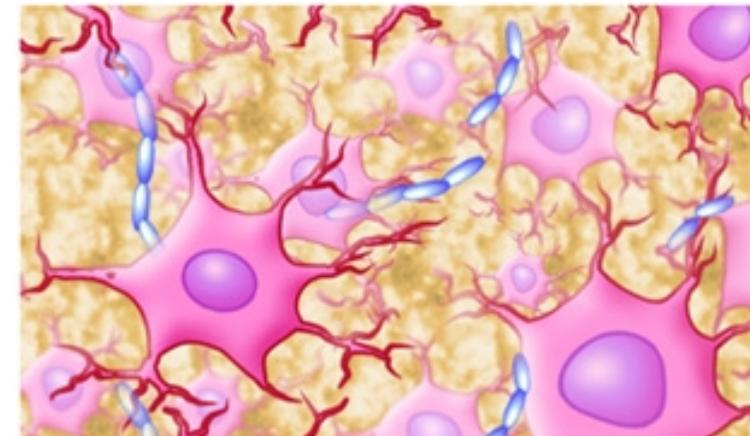
Connective tissue



Epithelial tissue

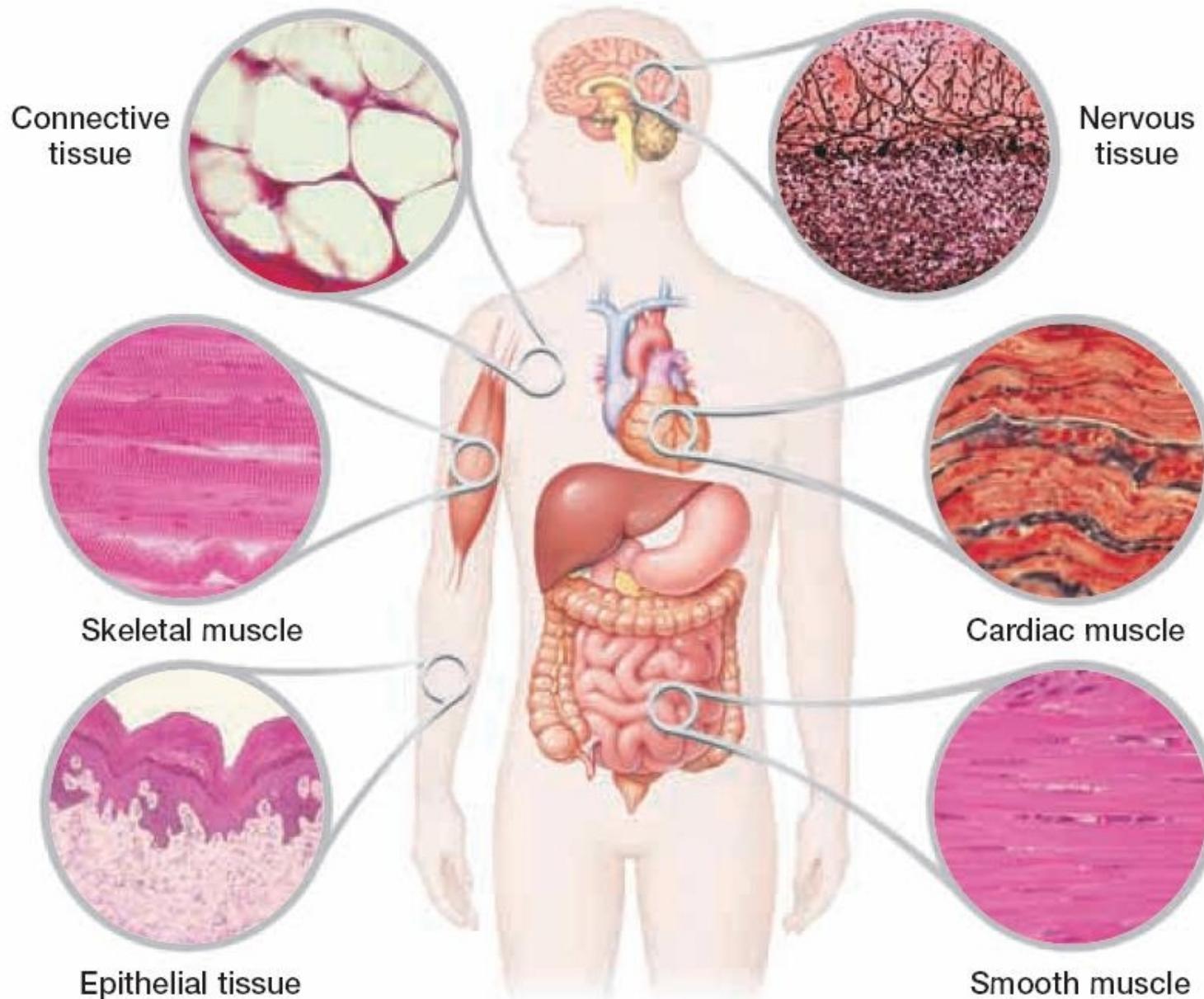


Muscle tissue



Nervous tissue

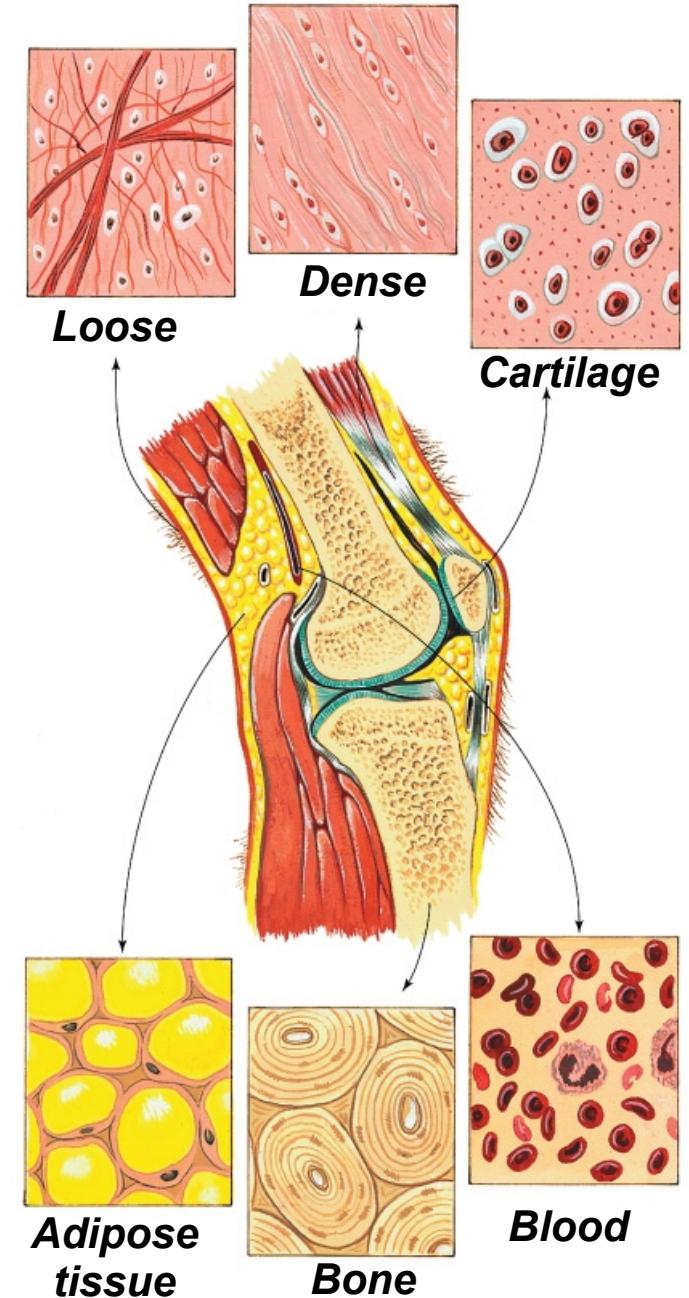
FOUR PRIMARY TISSUES IN HUMAN BODY



CONNECTIVE TISSUE

Supports, connects and separates other types of tissues in the body

- Found everywhere in the body
- The most abundant and widely distributed
- Functions: connective, supporting, protective
- Classifications:
 - dense/loose (fibroblast and collagen fibers)
 - vascularized/avascular
 - proper/specialized (cartilage, bone, blood)

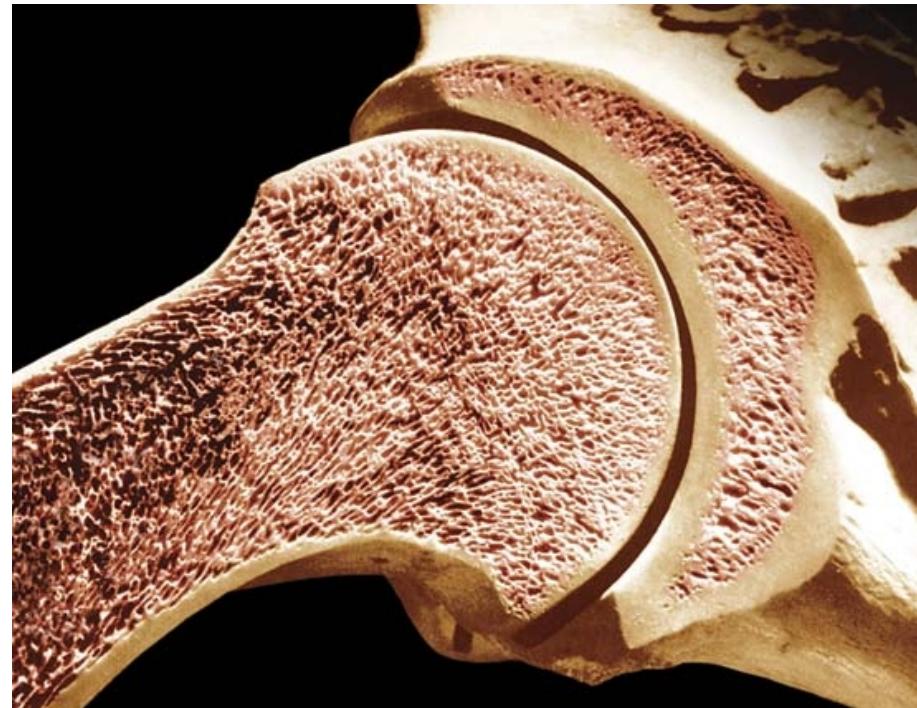


BONE

Bone (osseous tissue): constitutes vertebral skeleton

➤ **Composition:**

- cells
- hard Ca-salts
- collagen fibers



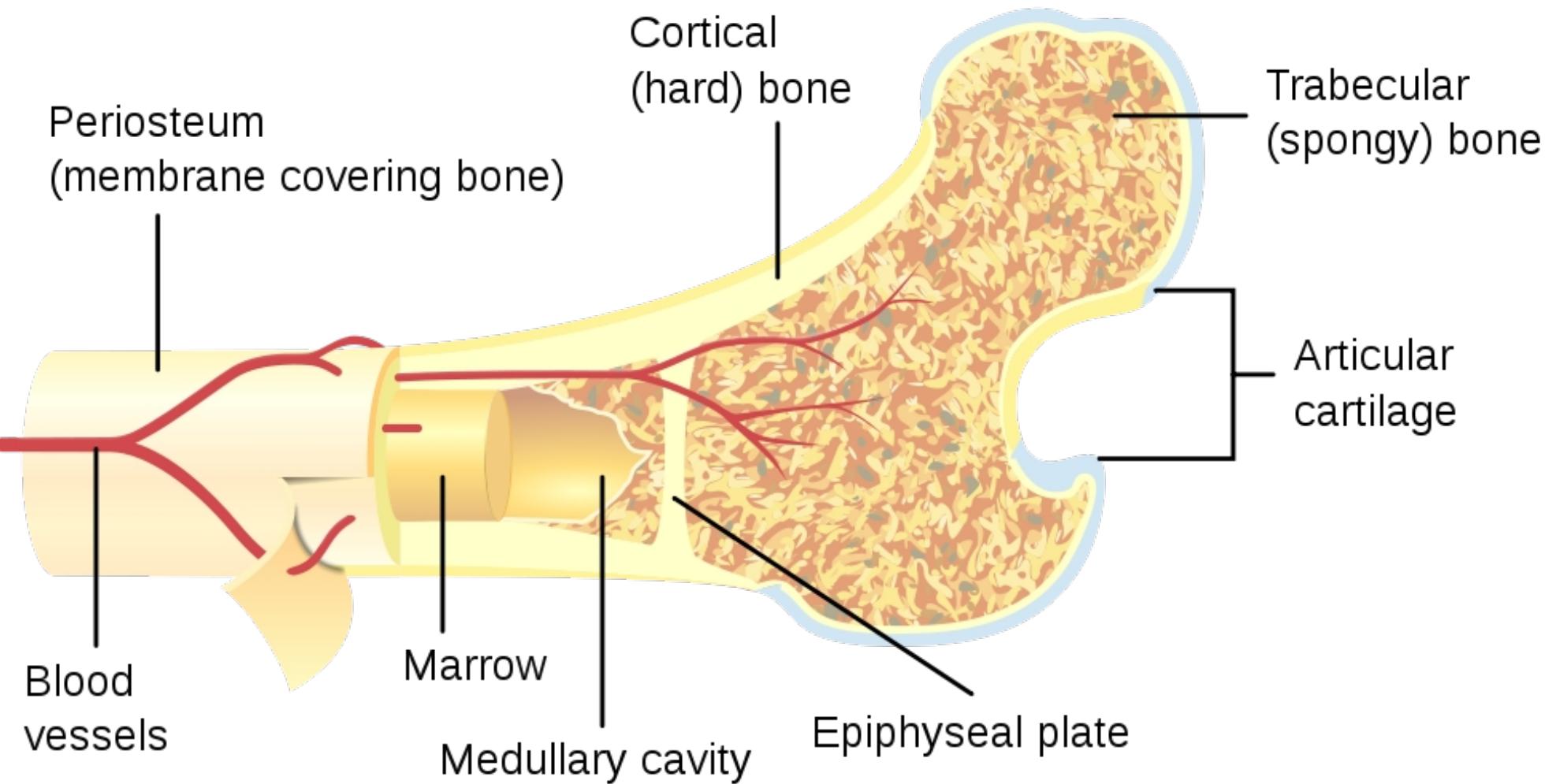
➤ **Function:**

- protective
- supportive

➤ **Classification:**

- spongy/compact

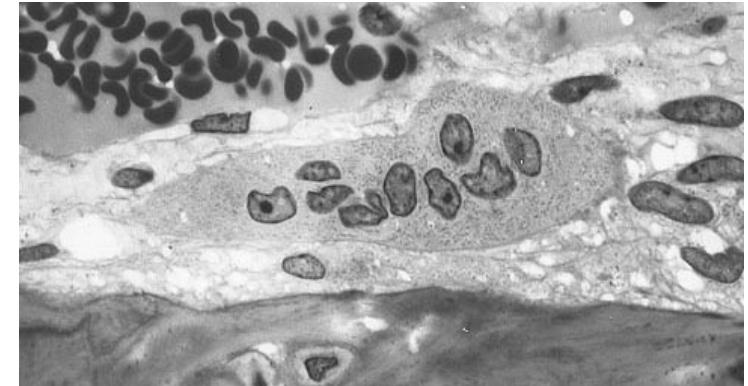
BONE STRUCTURE



BONE CELLS

➤ **Osteoclasts (destructive):**

- multinucleate
- Howships Lacunae enzyme breaks the bone



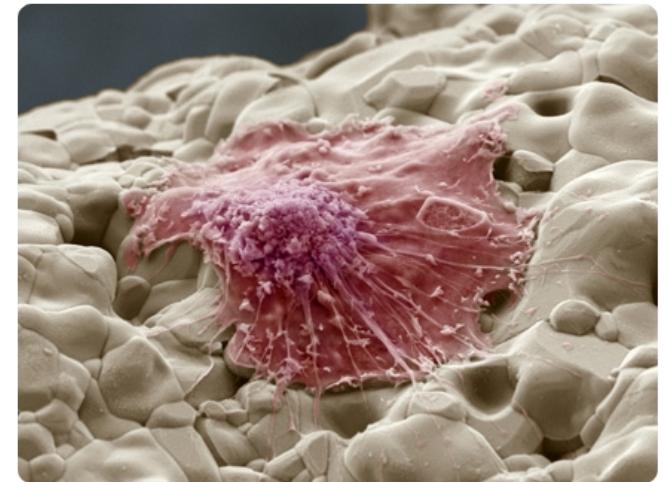
Osteoclasts

➤ **Osteoblasts (constuctive):**

- mononuclear
- very small
- construction of collagen=>Ca²⁺ salts=>trapping=>osteocyte

➤ **Osteocytes (holding):**

- lose of many organelles
- establishment of lacuna



Osteoblasts

➤ **Lining cells (protecting):**

- maintenance bone fluid
- gap junctions
- Ca²⁺ release to the blood

BONE DIFFERENTIATION REGULATION

➤ Growth factors:

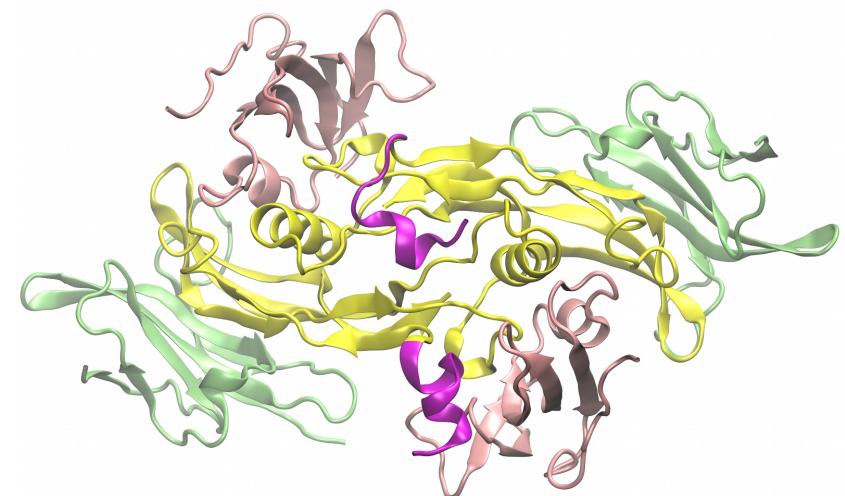
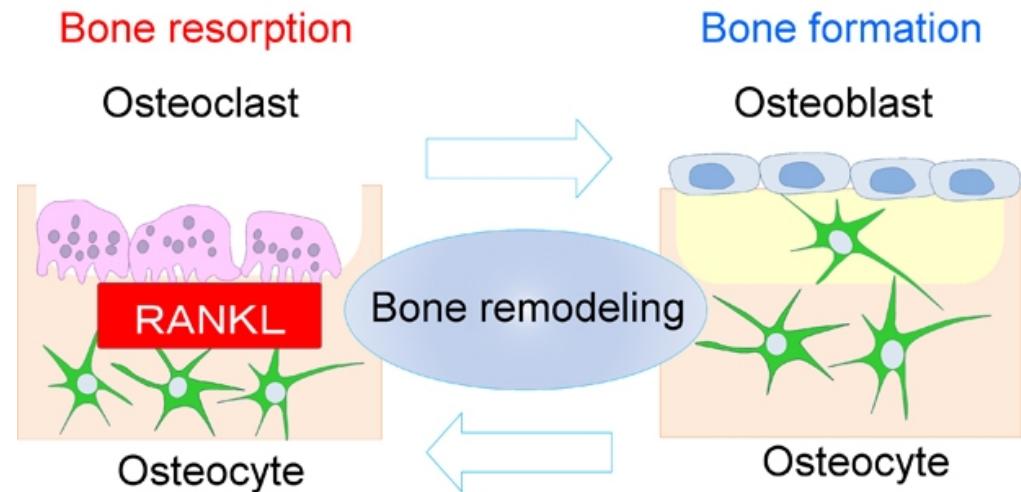
- bone morphogenic proteins (11) => osteoblasts

- insulin-like => osteoclasts

➤ Cytokines:

- IL-1, IL-6, necrosis factors

- RANKL

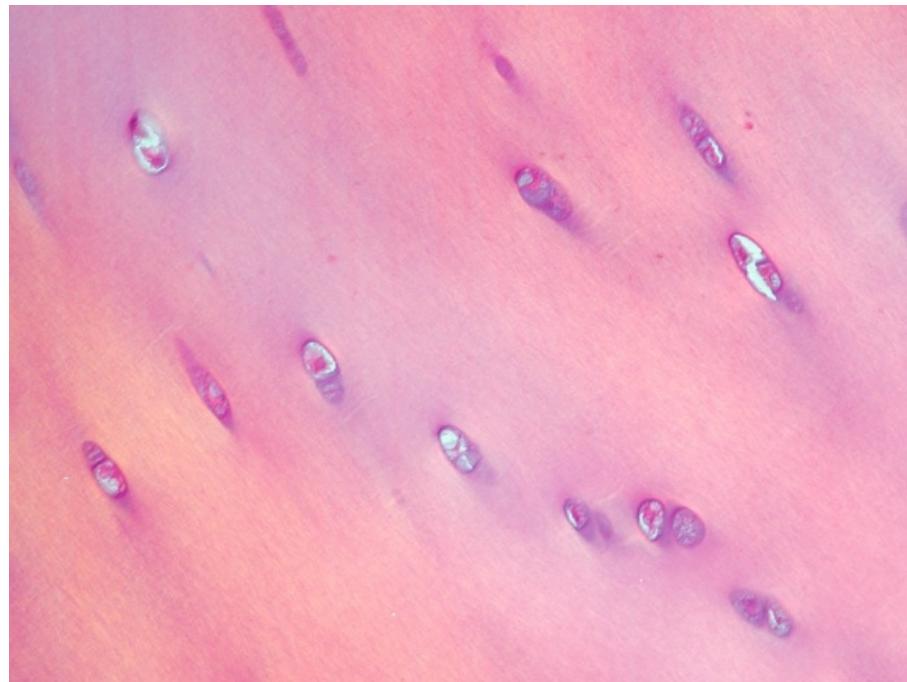


BMP-2 with receptors

CARTILAGE

Flexible connective tissue connecting joints and bones, ear, nose etc.

- Cells: chondrocytes (produce collagen, proteoglycans)
- Classification:
 - Hyaline (most common)
 - Elastic (outer ear)
 - Fibrocartilage (cushion-like discs between vertebrae)



Hyaline cartilage

BLOOD

Blood cells + fluid matrix (plasma)

➤ Blood cells:

- erythrocytes (oxygen transport) $\sim 10^6/\text{ml}$
- leukocytes (immune system) $\sim 10^3\text{-}10^4/\text{ml}$
- thrombocytes (coagulation) $\sim 10^5/\text{ml}$

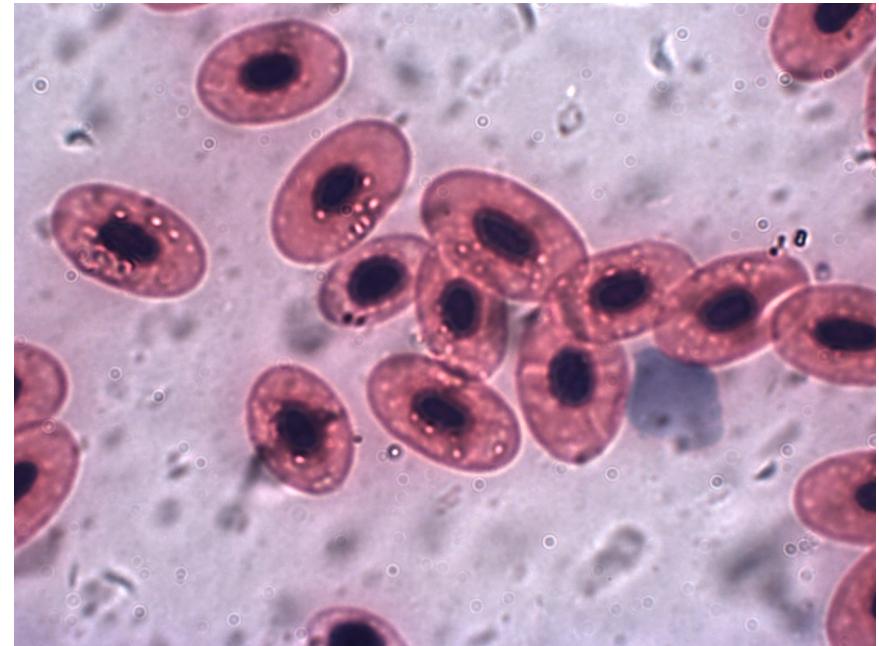
➤ Plasma:

- serum albumin
- blood clotting factors
- immunoglobulins
- electrolytes

➤ Function:

- transport (O_2 , CO_2 , H^+)
- thermoregulation
- hydraulic functions

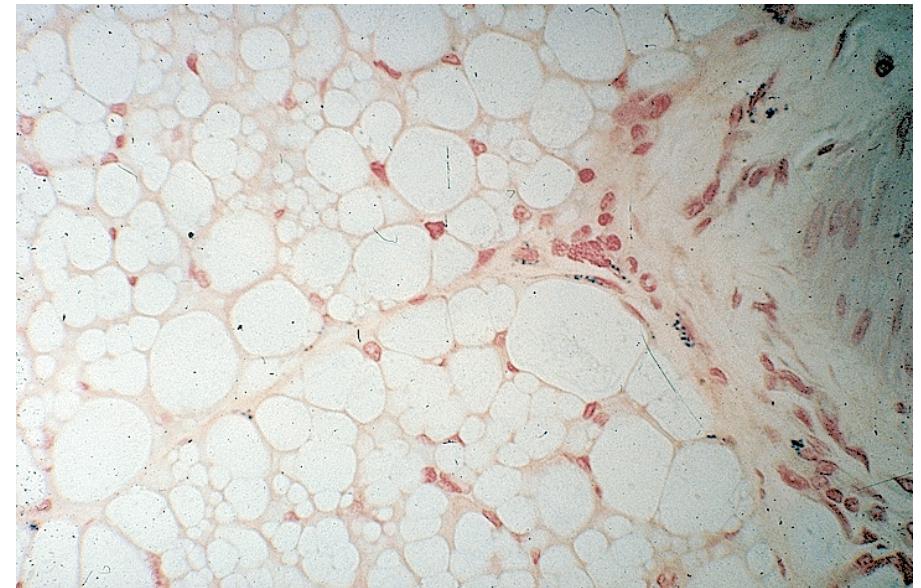
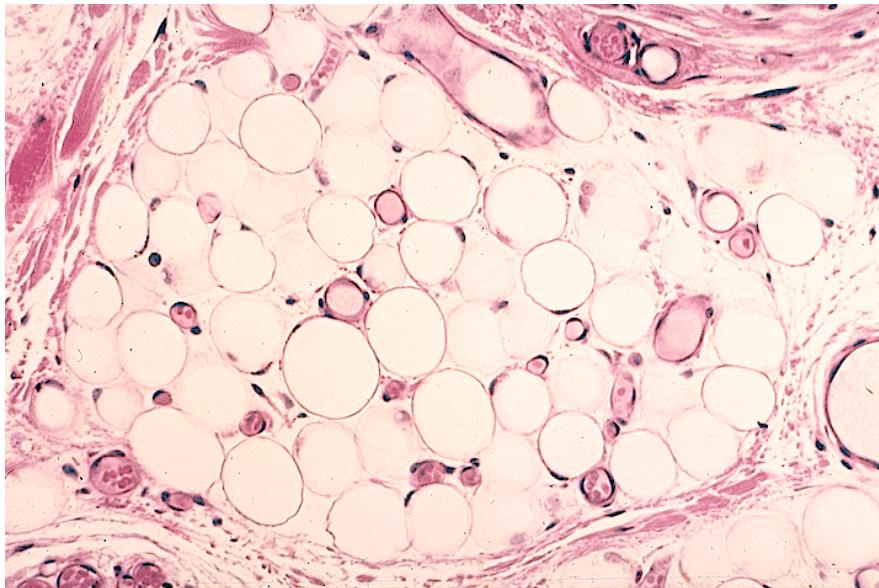
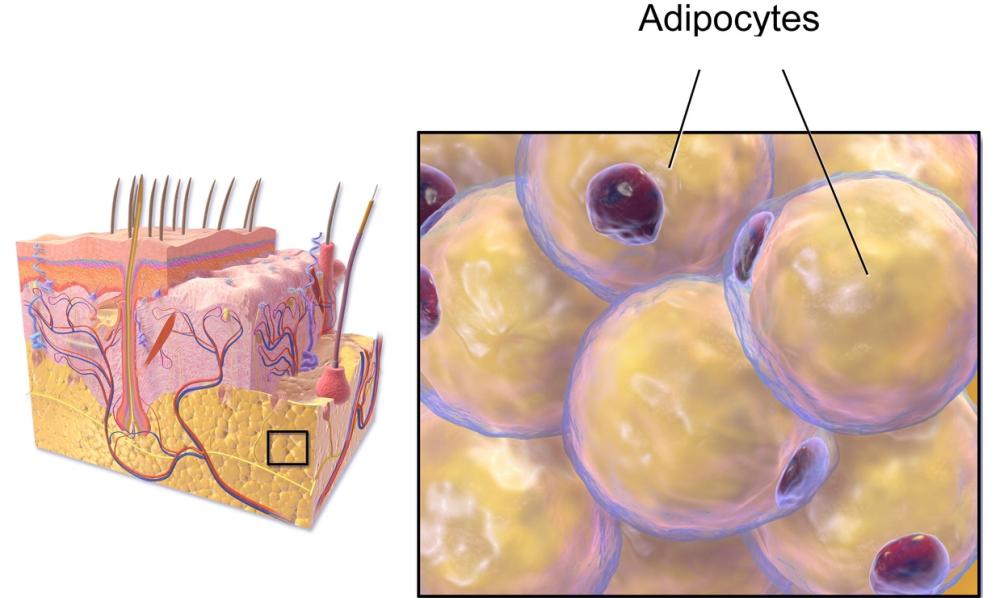
➤ pH 7.35-7.45



Erythrocytes

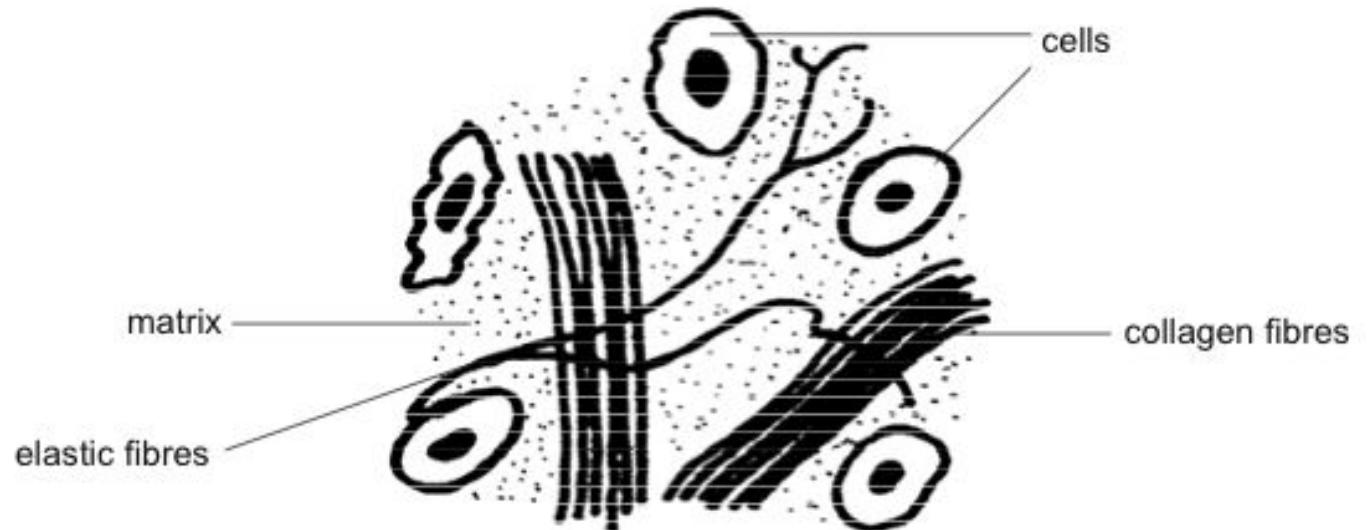
ADIPOSE TISSUE

- Adipocytes: fat globules
- Functions:
 - lipids storage (white and brown)
 - protection
 - isolation



AREOLAR TISSUE

- Most common loose connective tissue
- Soft
- All fiber types
- Functions:
 - supporting
 - soaking excess of fluid
 - soaks salts

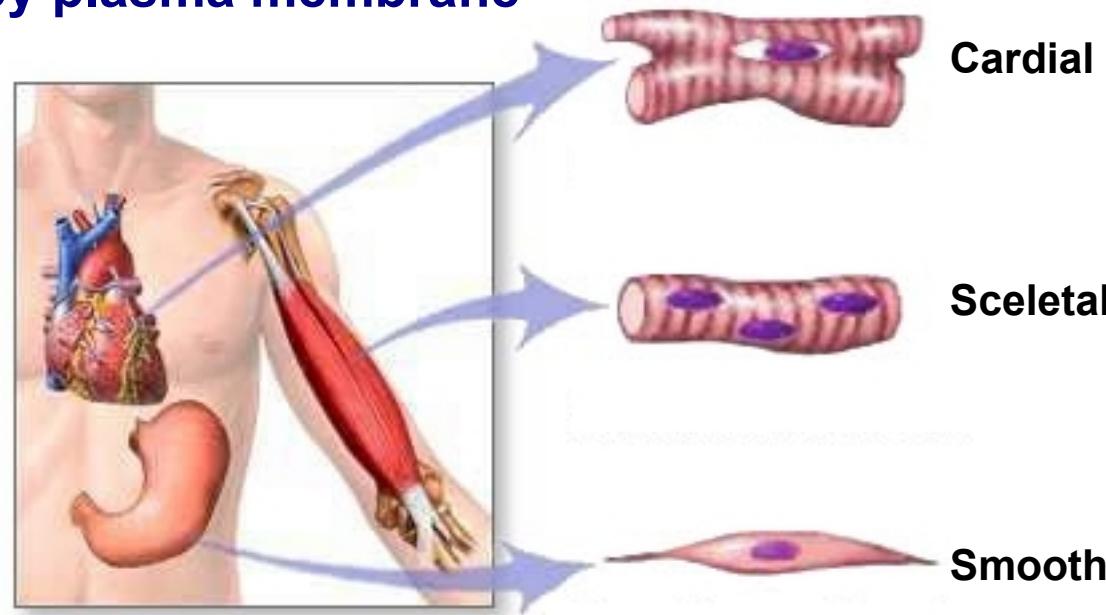


MUSCLE TISSUE

Composes muscles and provides their ability to contract

➤ Cardial

- branched, striated cells, fused by plasma membrane
- heart wall
- involuntary contractions
- functions: blood pumping



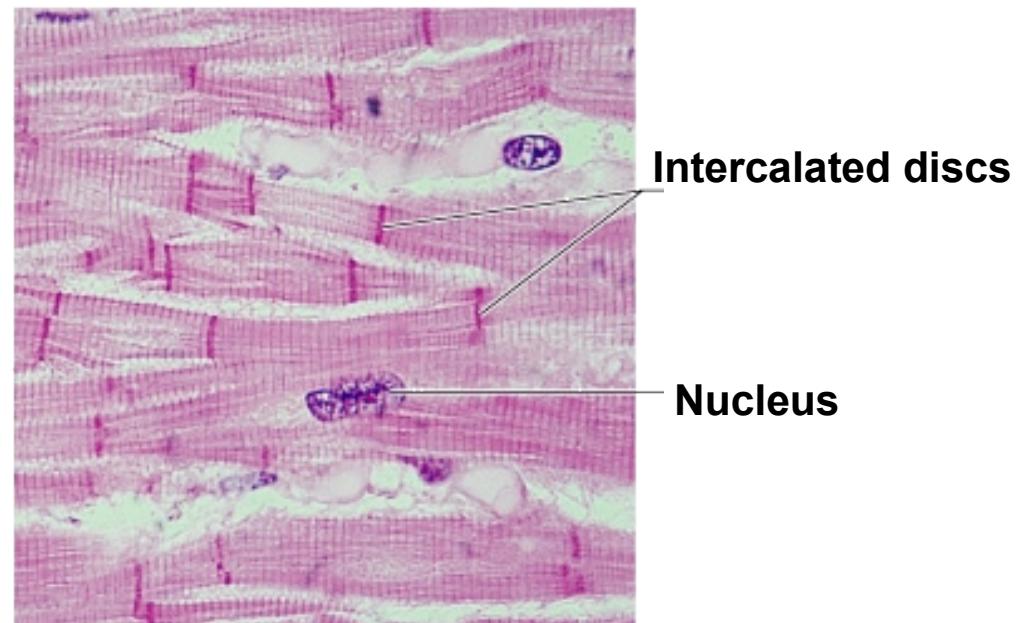
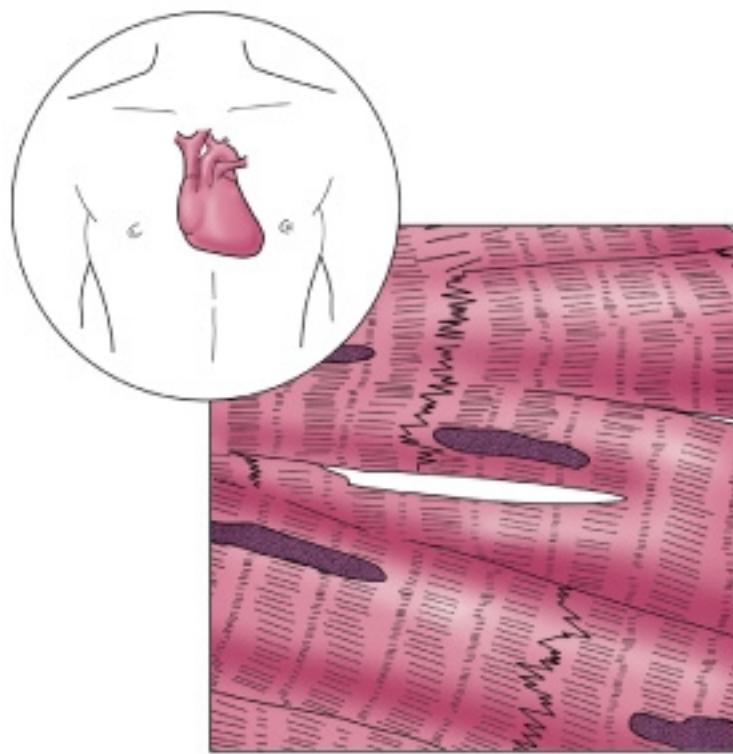
➤ Sceletal

- long striated multinuclear cells
- in sceletal muscles
- voluntary contractions
- functions: supporting, posturing, motive

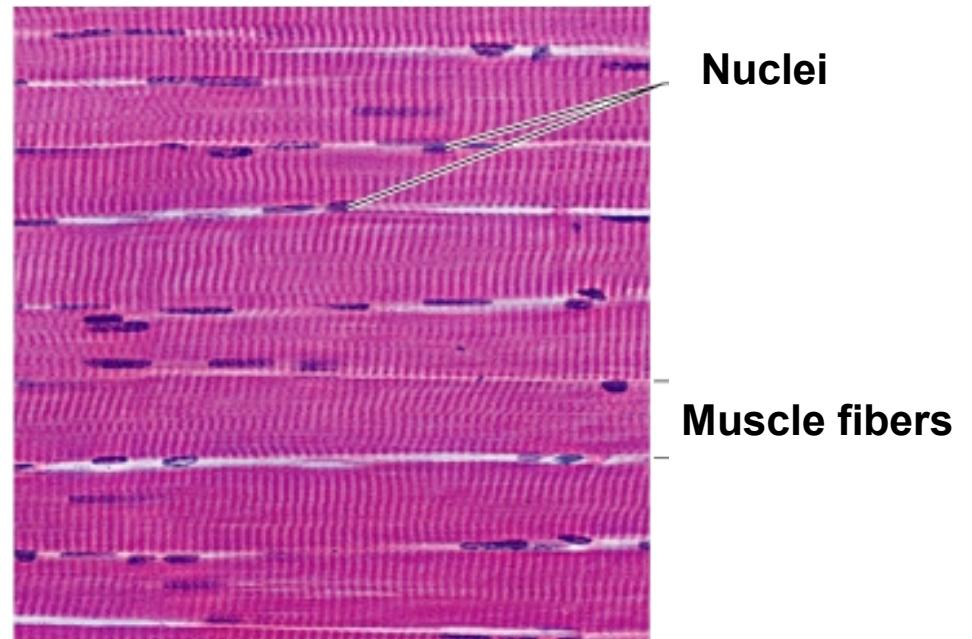
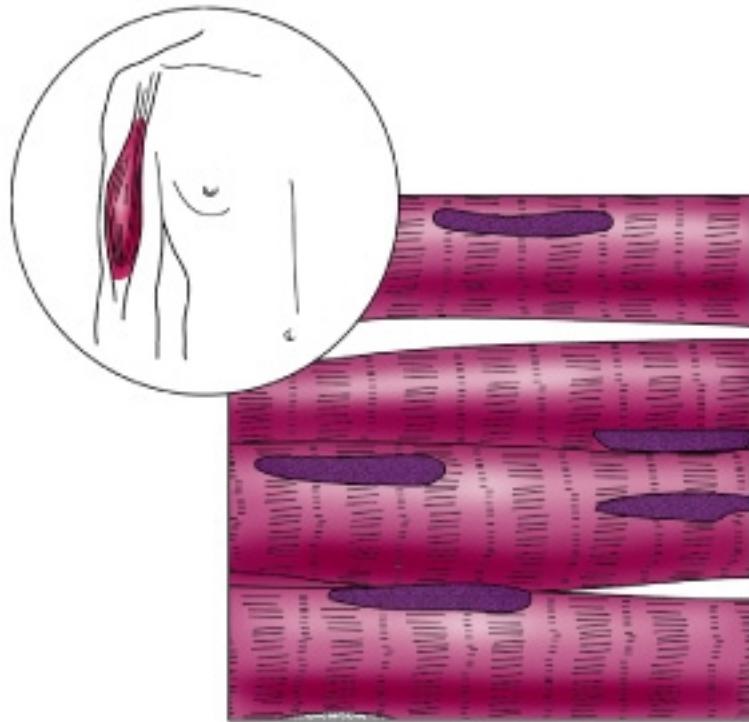
➤ Smooth

- long spindle-shaped mononuclear cells
- in hollow organs (f.i.: stomach, vessels)
- involuntary contractions
- functions: contractivity of hollow organs

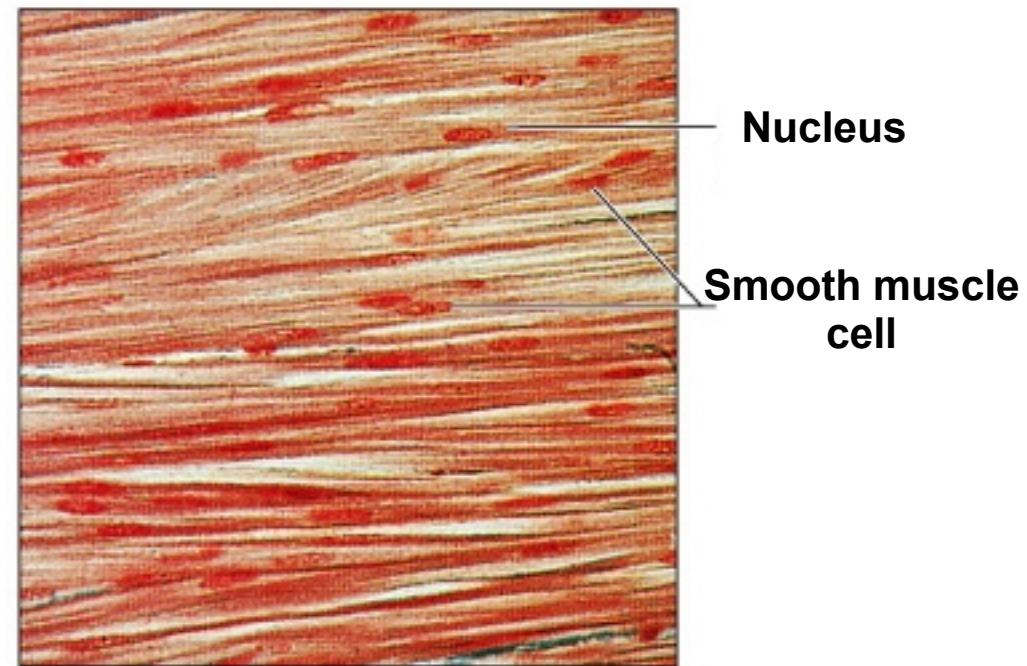
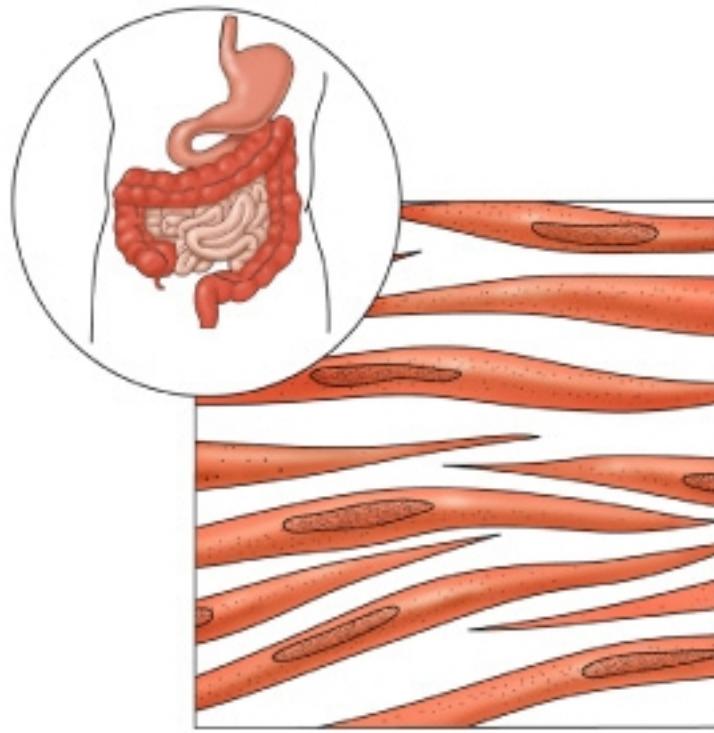
CARDIAC MUSCLE



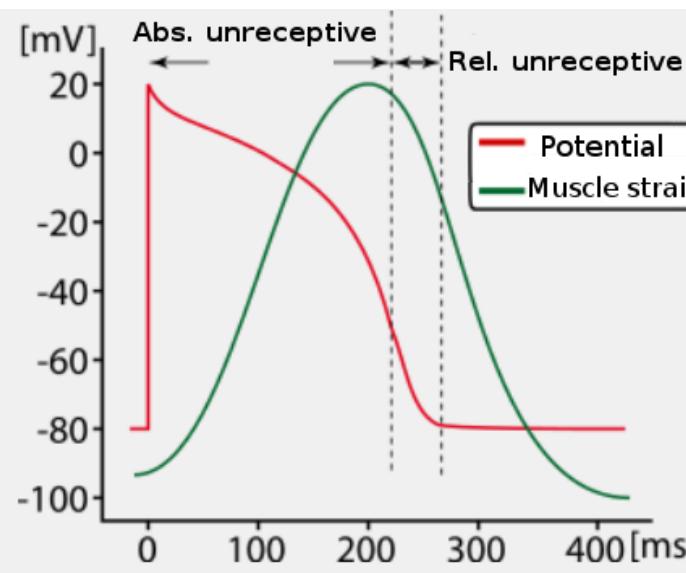
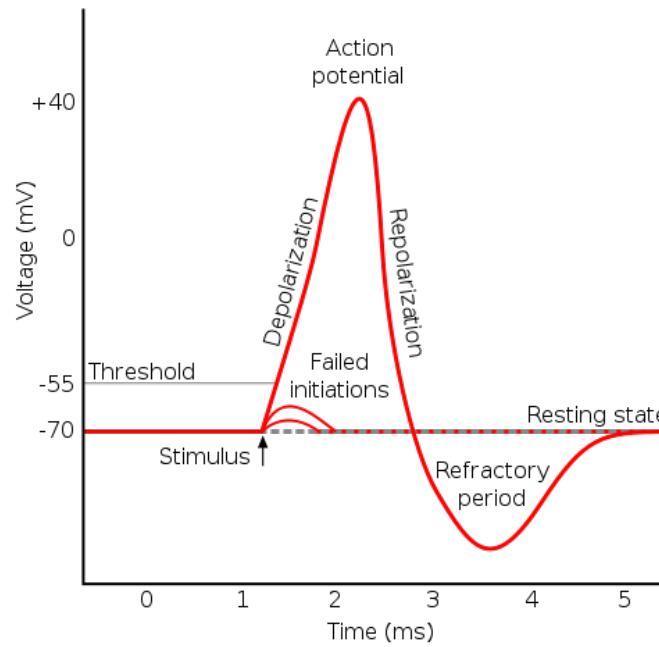
SKELETAL MUSCLE



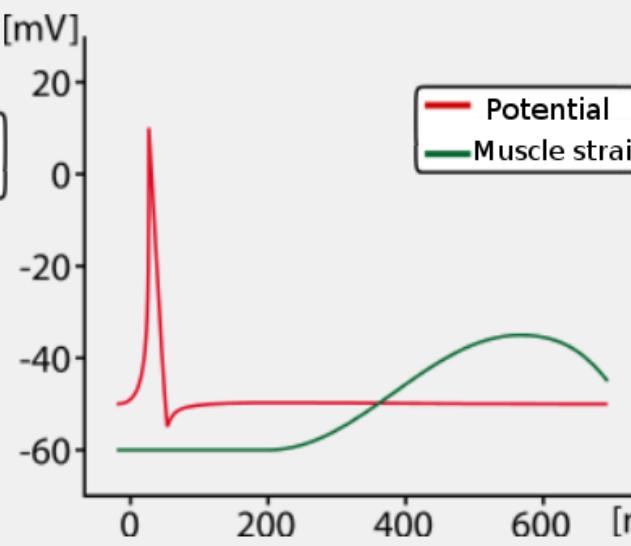
SMOOTH MUSCLE



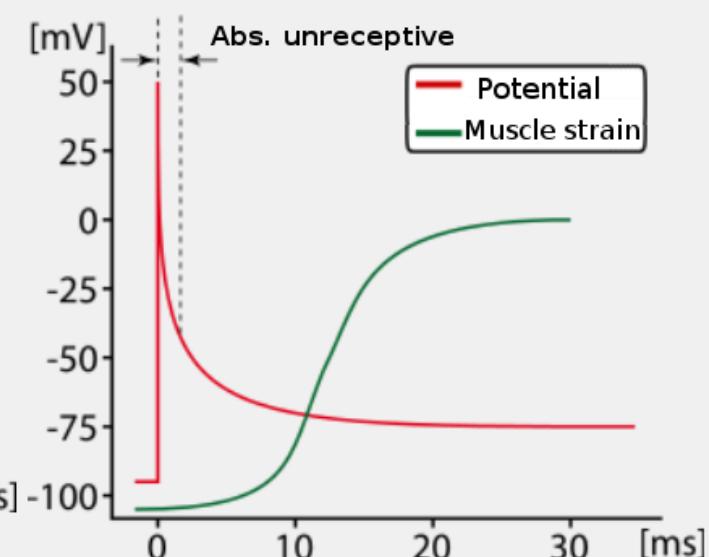
REACTION TO THE ACTION POTENTIAL



Cardial



Sceletal



Smooth

MYOFIBRILS

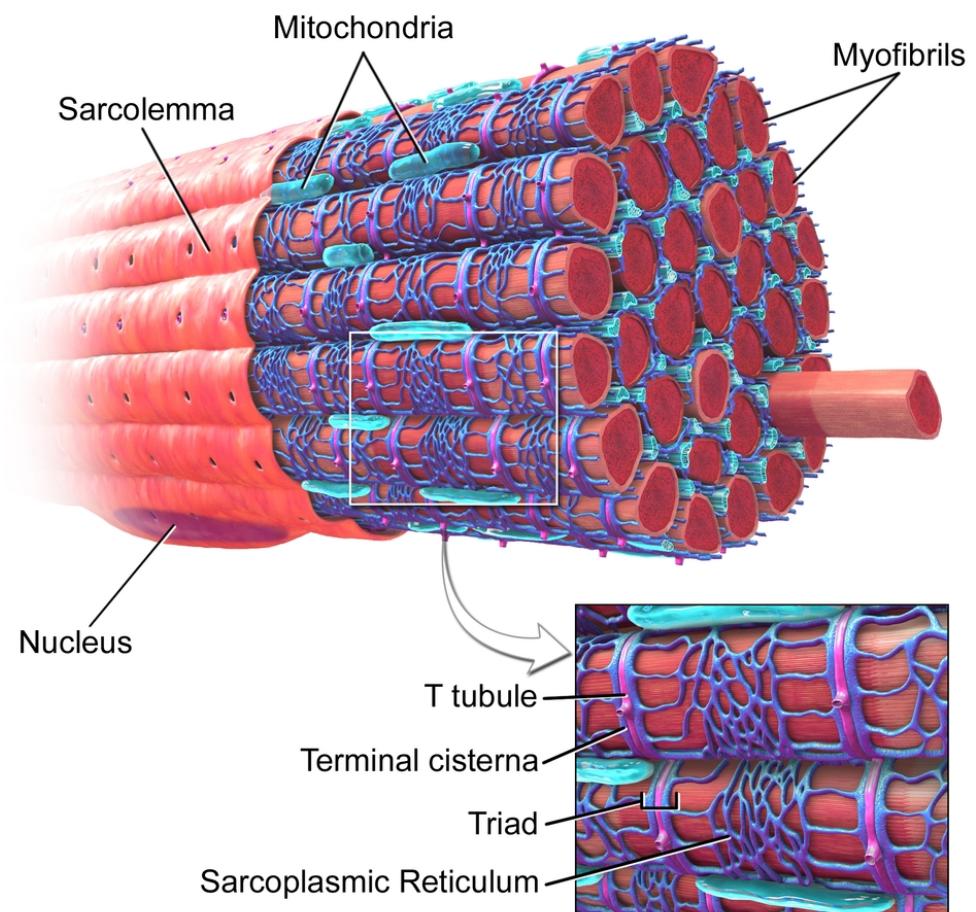
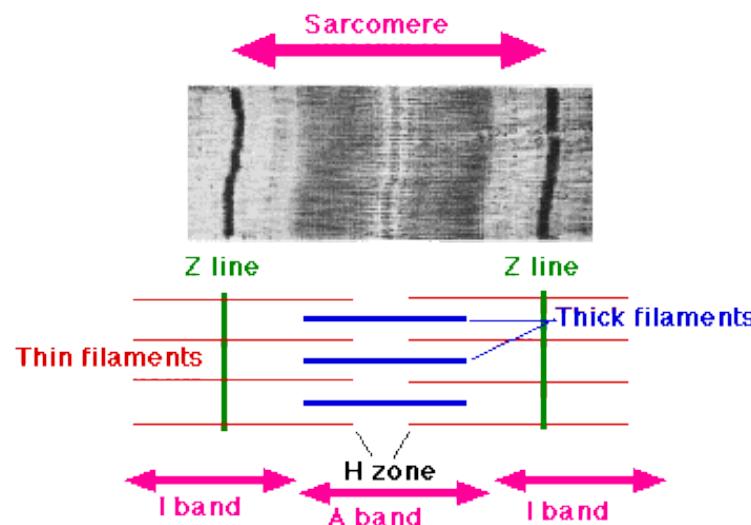
Myofibrils: basic rod-like muscle unit made up of myocytes (muscle cells)

➤ Proteins: actin, myosin, titin

➤ Myofilaments:

- thin (actin, titin): “ladder”

- thick (myosin, nebulin): $ATP \Rightarrow ADP$



NERVOUS TISSUE

Composes central nervous system (CNS) and peripheral nervous system (PNS)

➤ Cells: neurons, supporting cells (neuroglia)

➤ Functions: irritability, conductivity

➤ Classification:

- white and grey matter (CNS)

- nerves and ganglia (PNS)

➤ Impulse is conducted to:

- other neurons

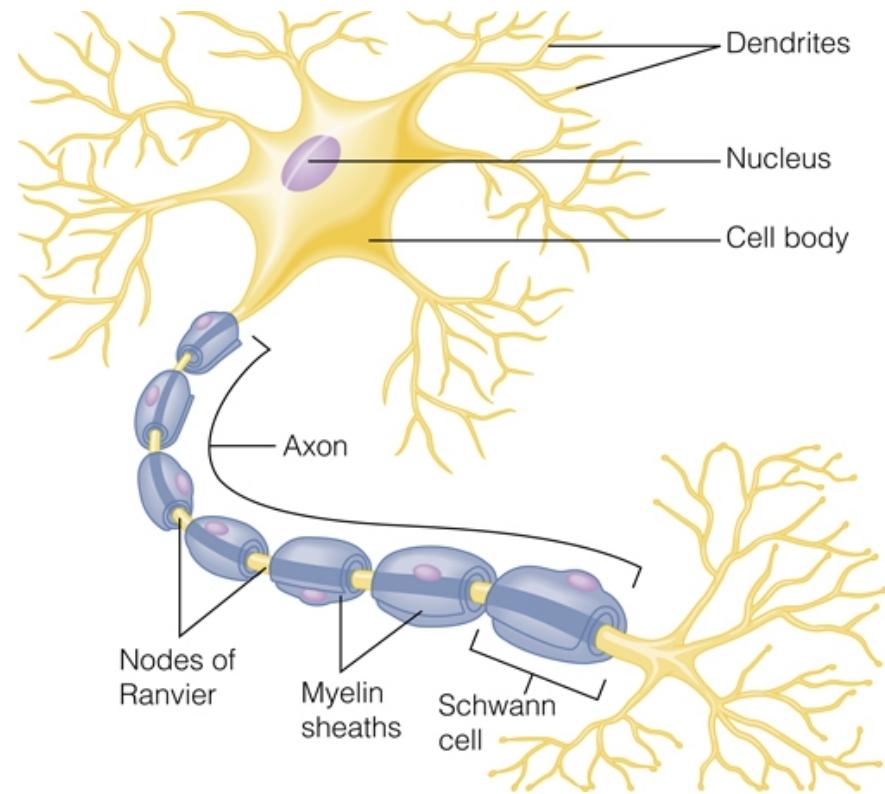
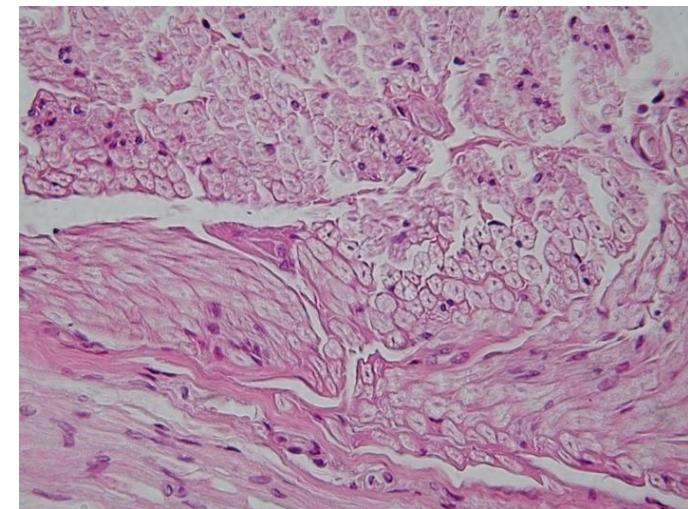
- muscles

➤ Impulse conduction is mediated by:

- Na^+ , K^+ , Ca^{2+} , Cl^-

- neuromediators

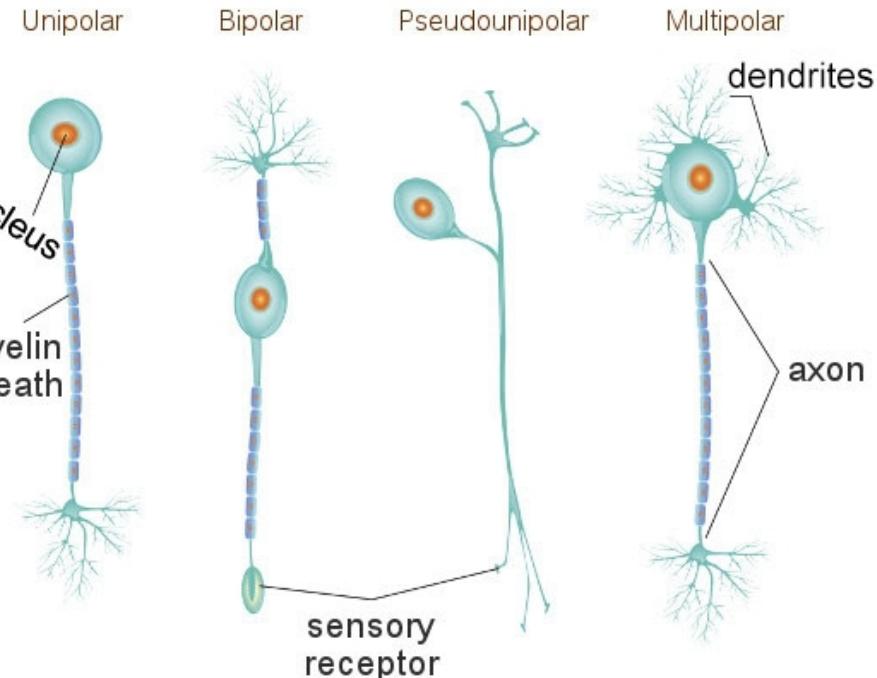
- myelin



NEURONS CLASSIFICATION

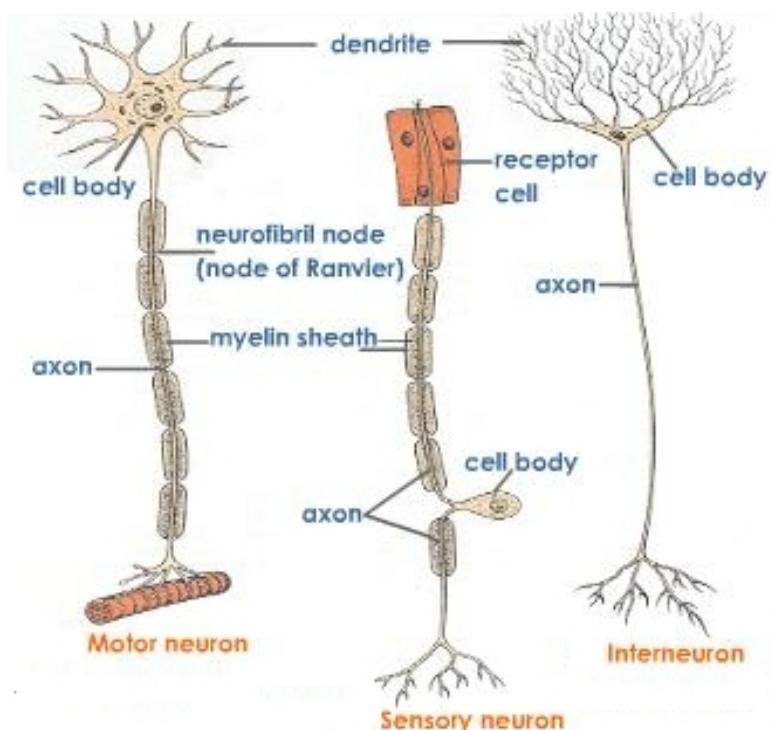
➤ Structural:

- unipolar
- bipolar
- pseudounipolar
- multipolar



➤ Functional:

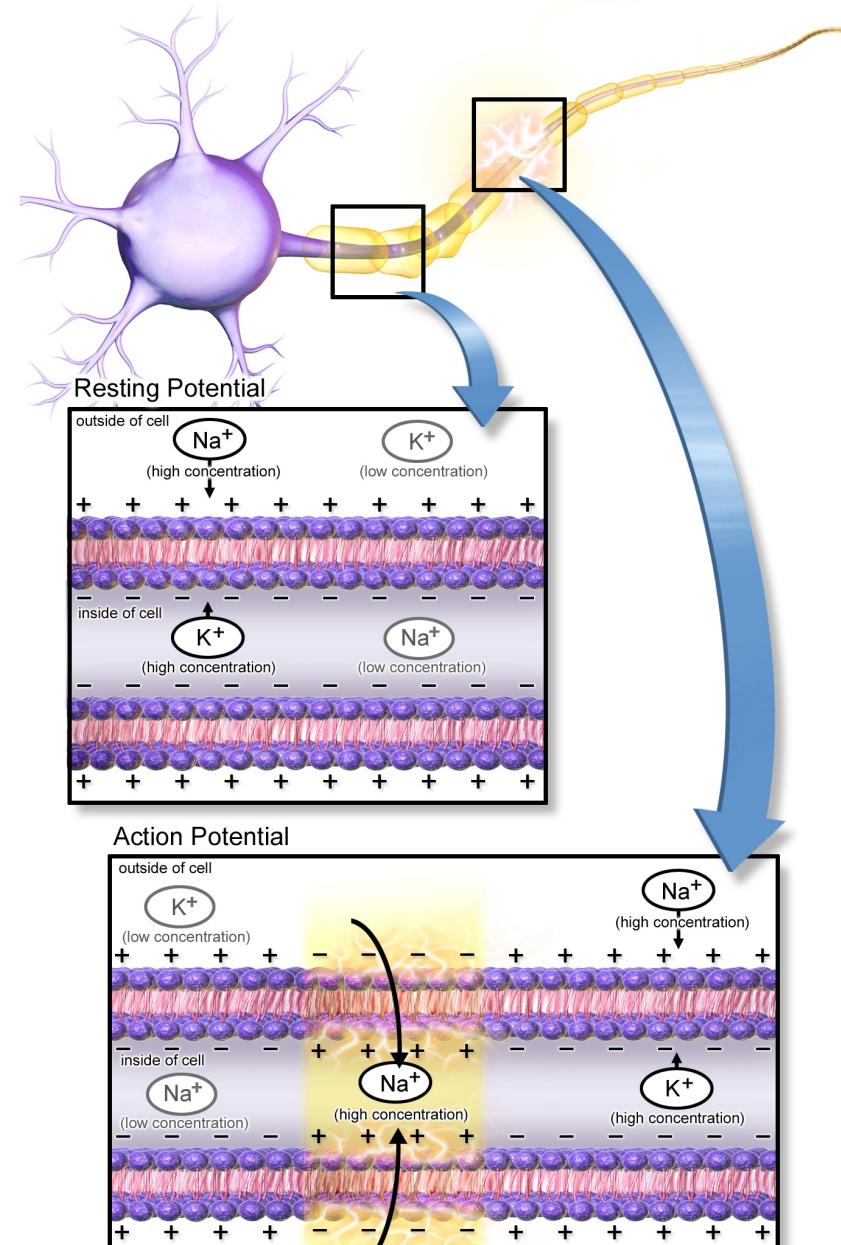
- motor (efferent): CNS=>PNS
- sensory (afferent): PNS=>CNS
- interneurons: local action



POTENTIAL CONDUCTION IN NEURONS

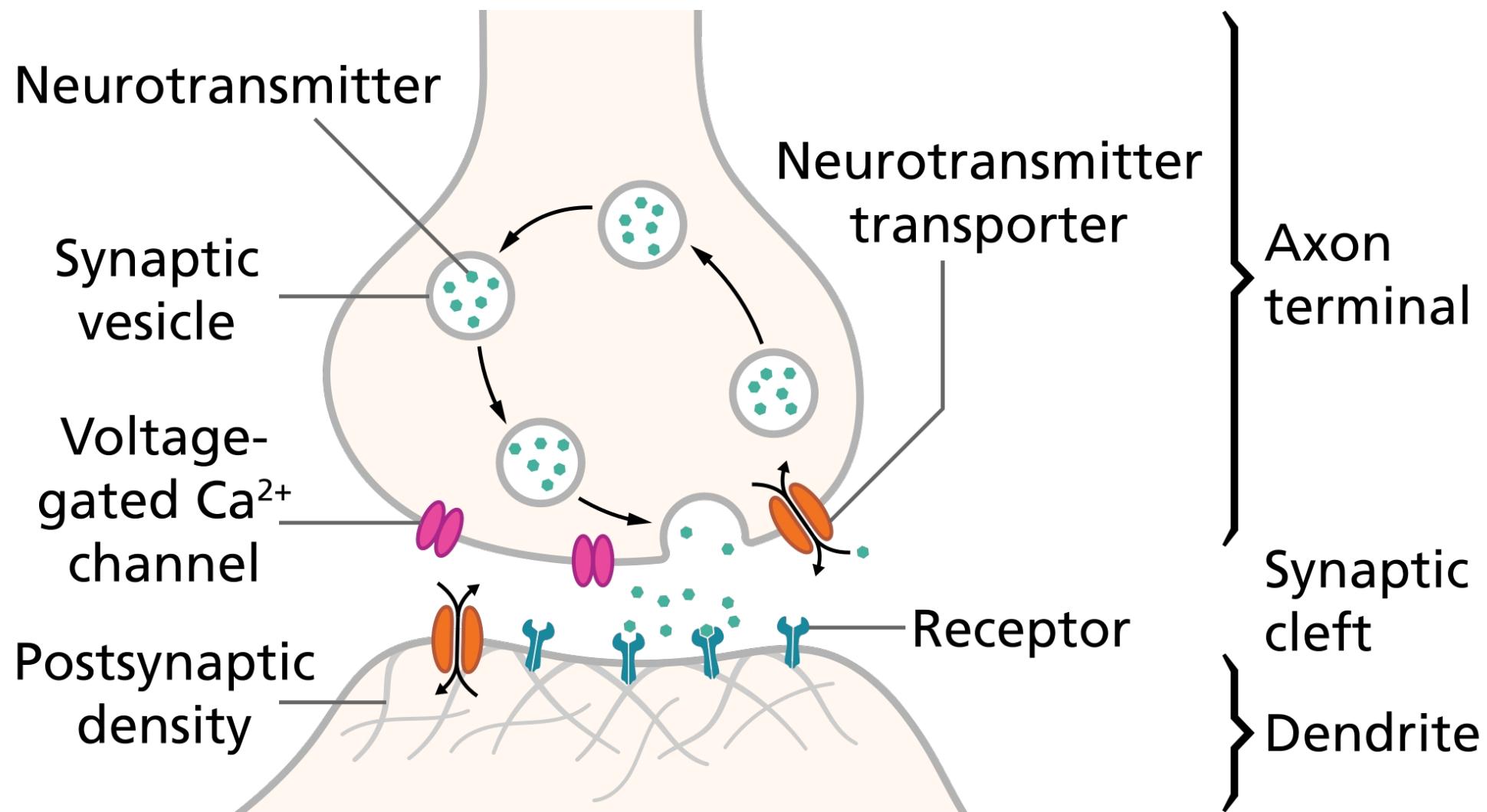
➤ Voltage-gate ion channels:

- Several conformations
- One of them is permeable
- Conformational change = $f(\Phi_{\text{membrane}})$
- Feedback mechanism
- “All-or-nothing” property



SYNAPSE

Structure that provides conducting a signal from one neuron to another one



- Electric signal
- Chemical signal

EPITHELIUM

Composes covering of organs and forms glands

➤ Localization:

- body coverings
- body linings
- glandular tissue

➤ Functions:

- protection
- absorption
- filtration
- secretion

➤ Classifications:

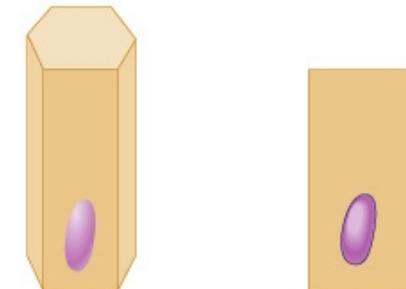
- cell shape (squamous, cuboidal, columnar)
- simple/stratified



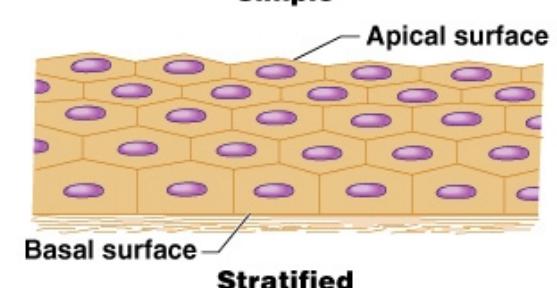
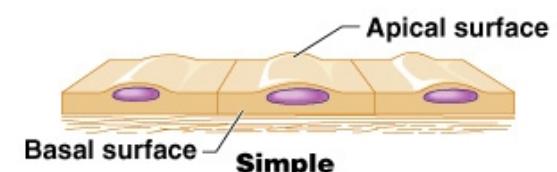
Squamous



Cuboidal

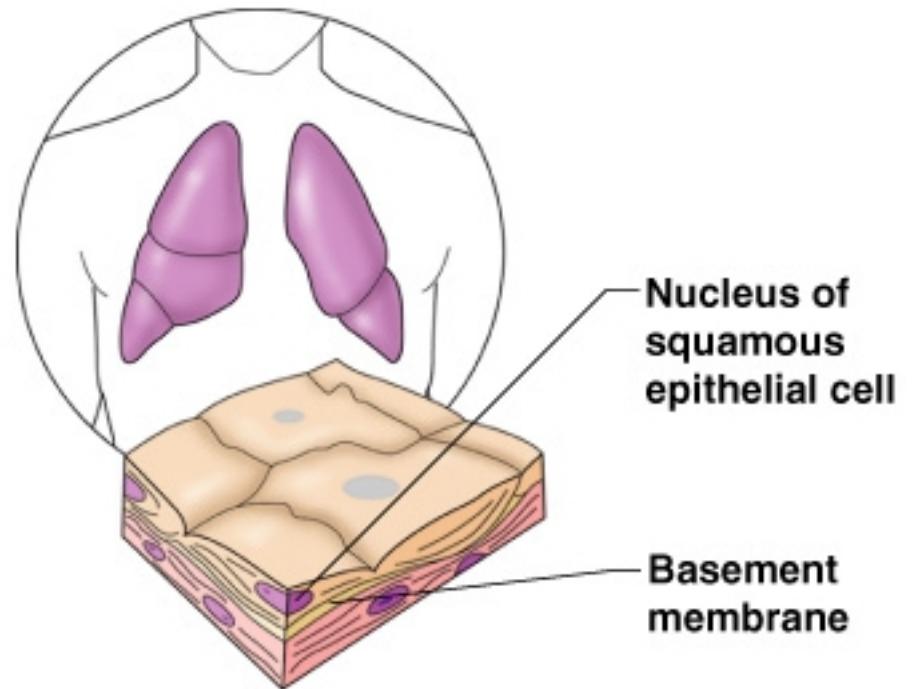


Columnar



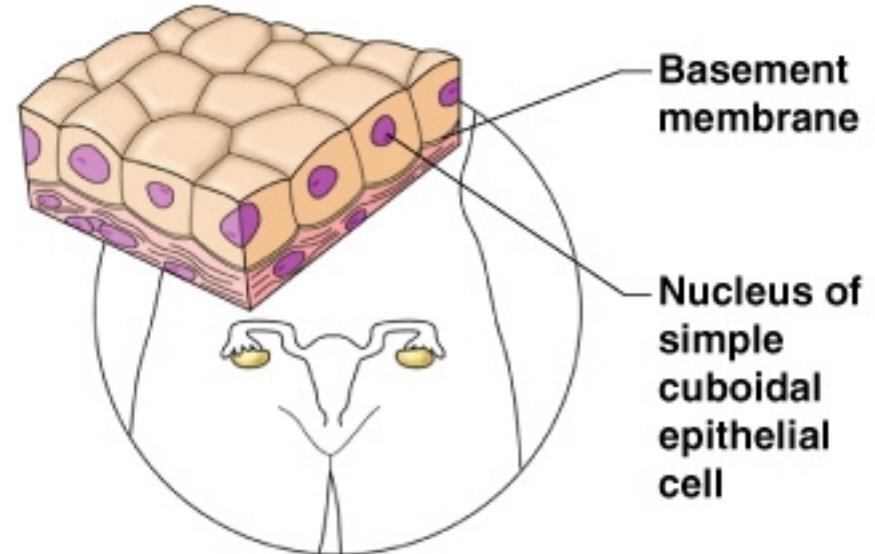
SIMPLE SQUAMOUS

- Single flat layer
- Function:
 - lines body cavities
 - lines lungs and capillaries



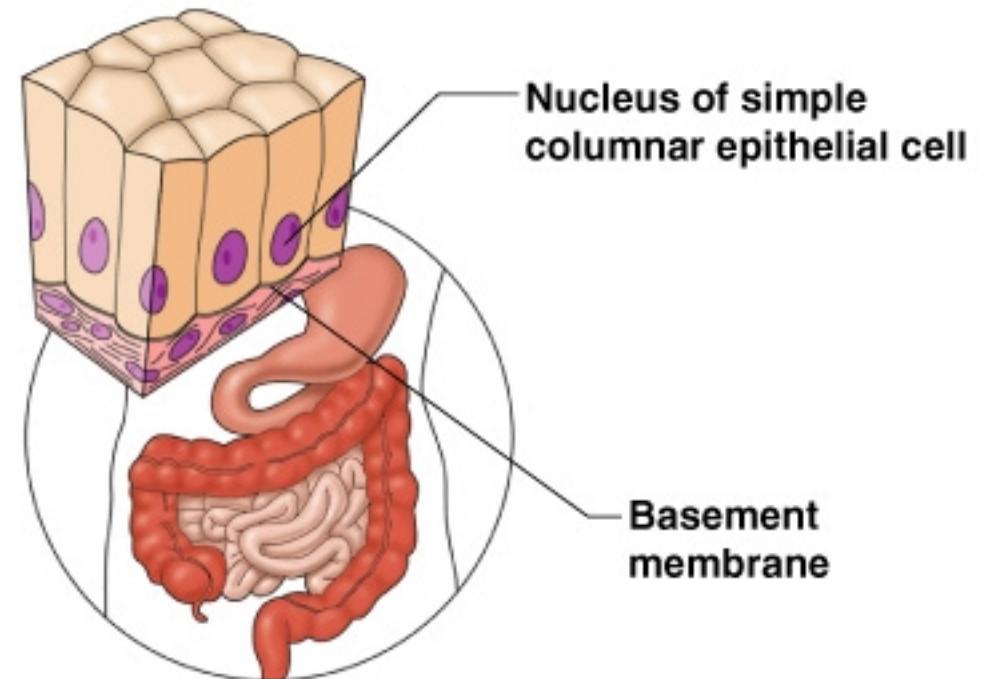
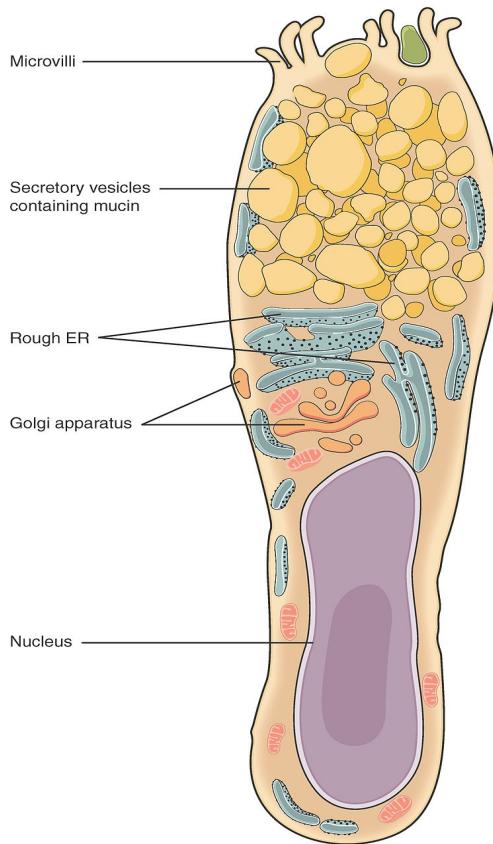
SIMPLE CUBOIDAL

- Single layer of cubic cells
- Function:
 - common in glands and their ducts
 - forms walls of kidneys
 - covers ovaries

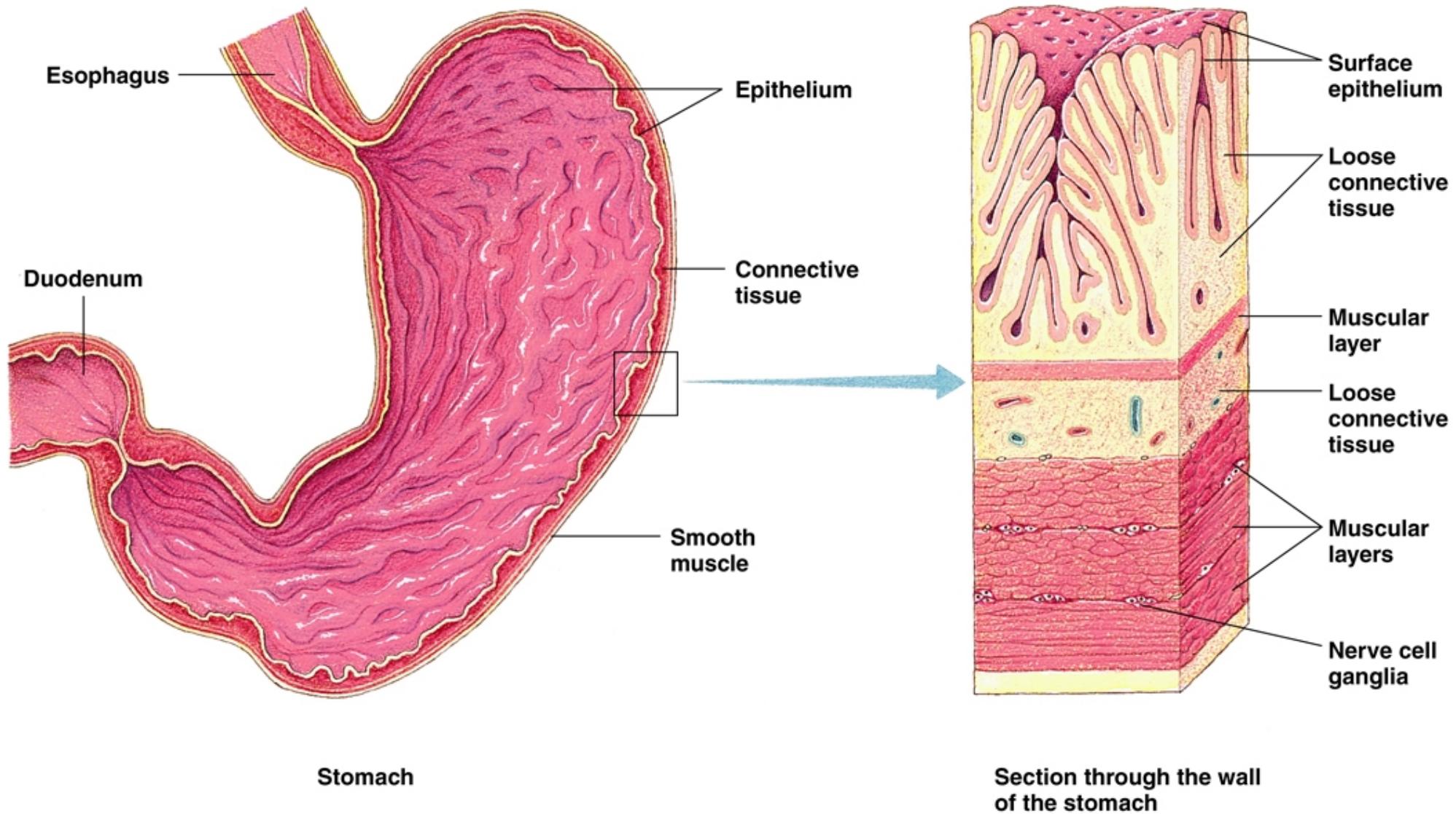


SIMPLE COLUMNAR

- Single tall layer
- Function:
 - includes goblet cells (mucus)
 - lines digestive tract

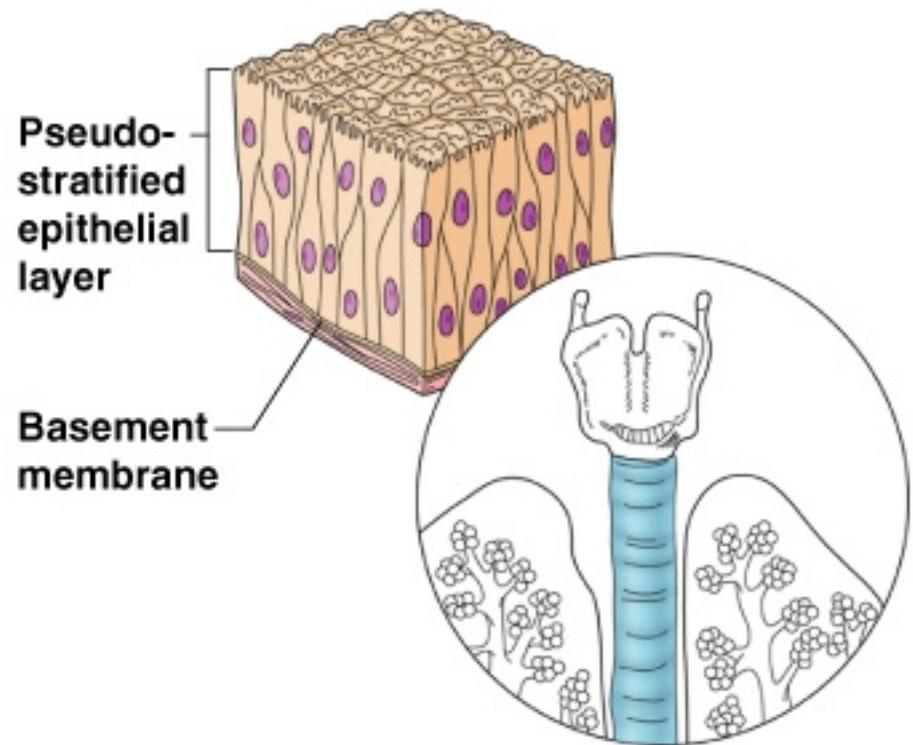


STOMACH



SIMPLE PSEUDOSTRATIFIED

- Single layer of cells of different length
- Looks like a double layer
- Function:
 - respiratory tract
 - absorption/secretion

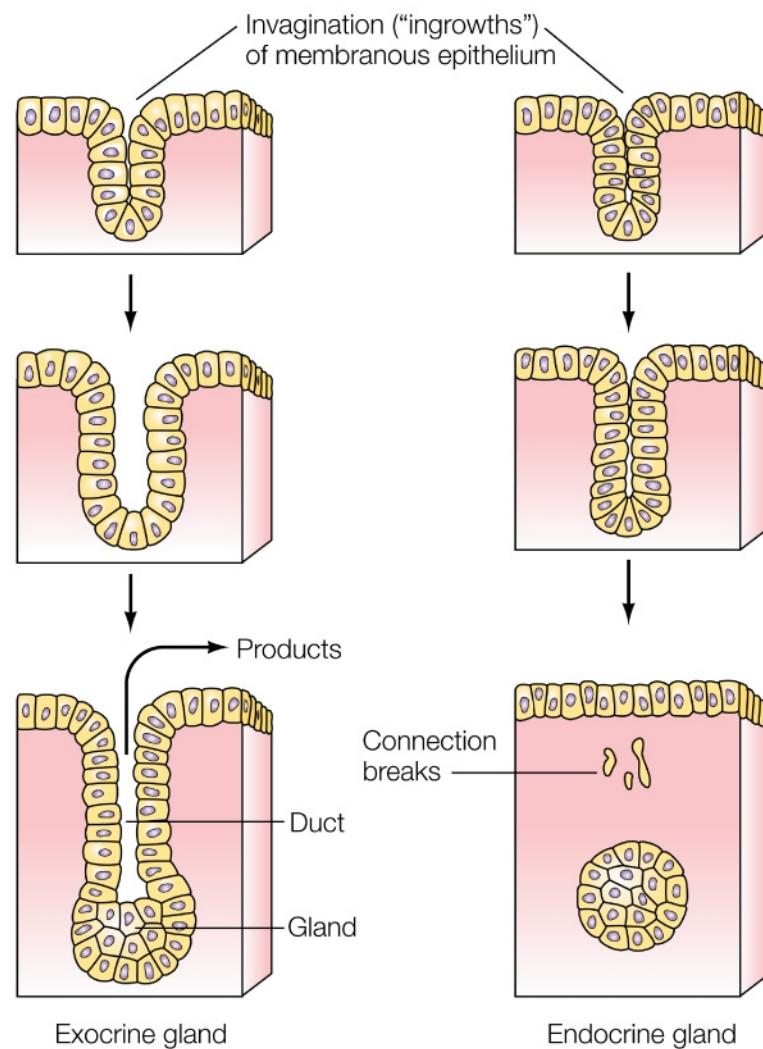


GLANDULAR EPITHELIUM

➤ Glands

- exocrine

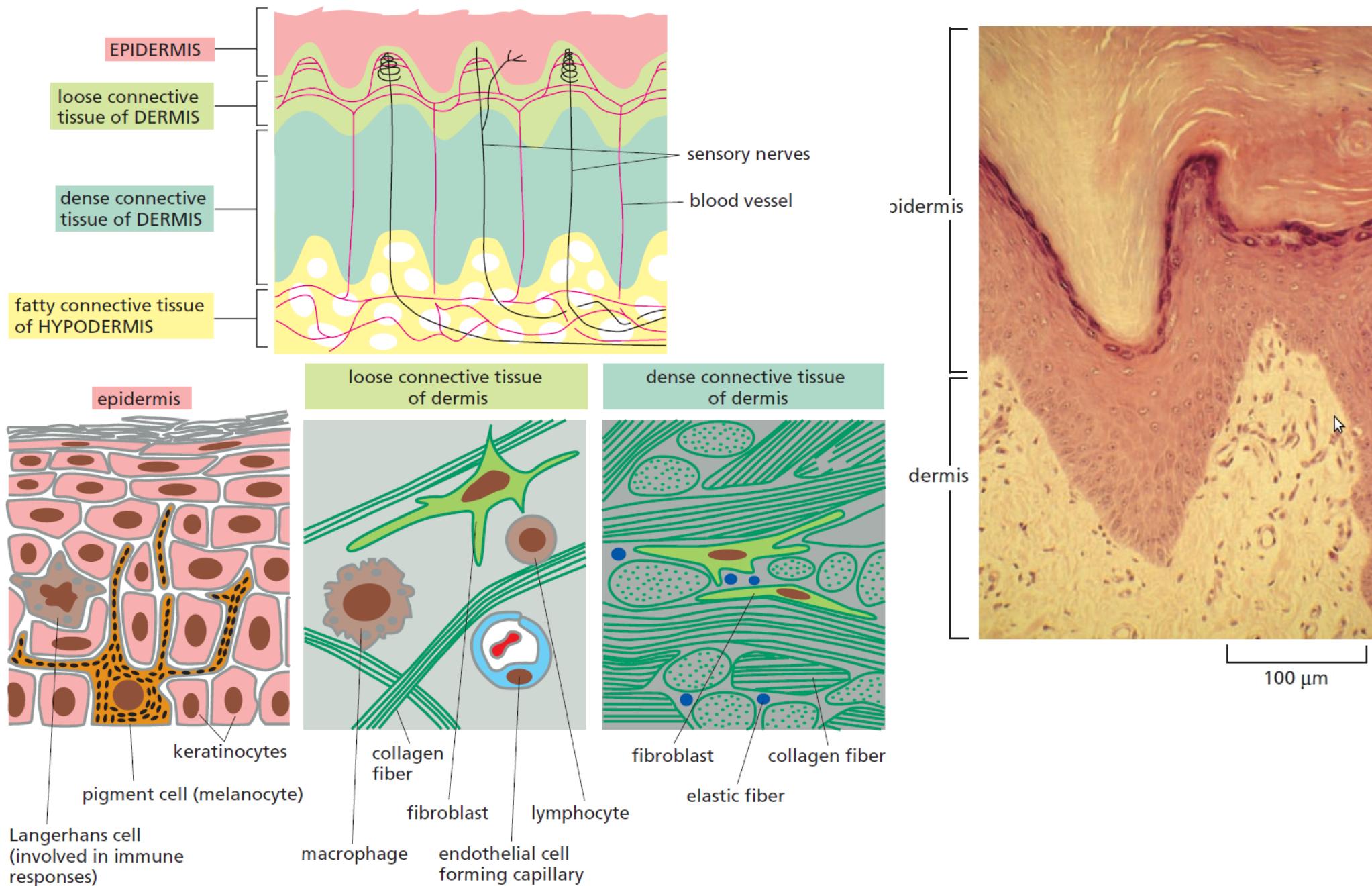
- endocrine



SKIN

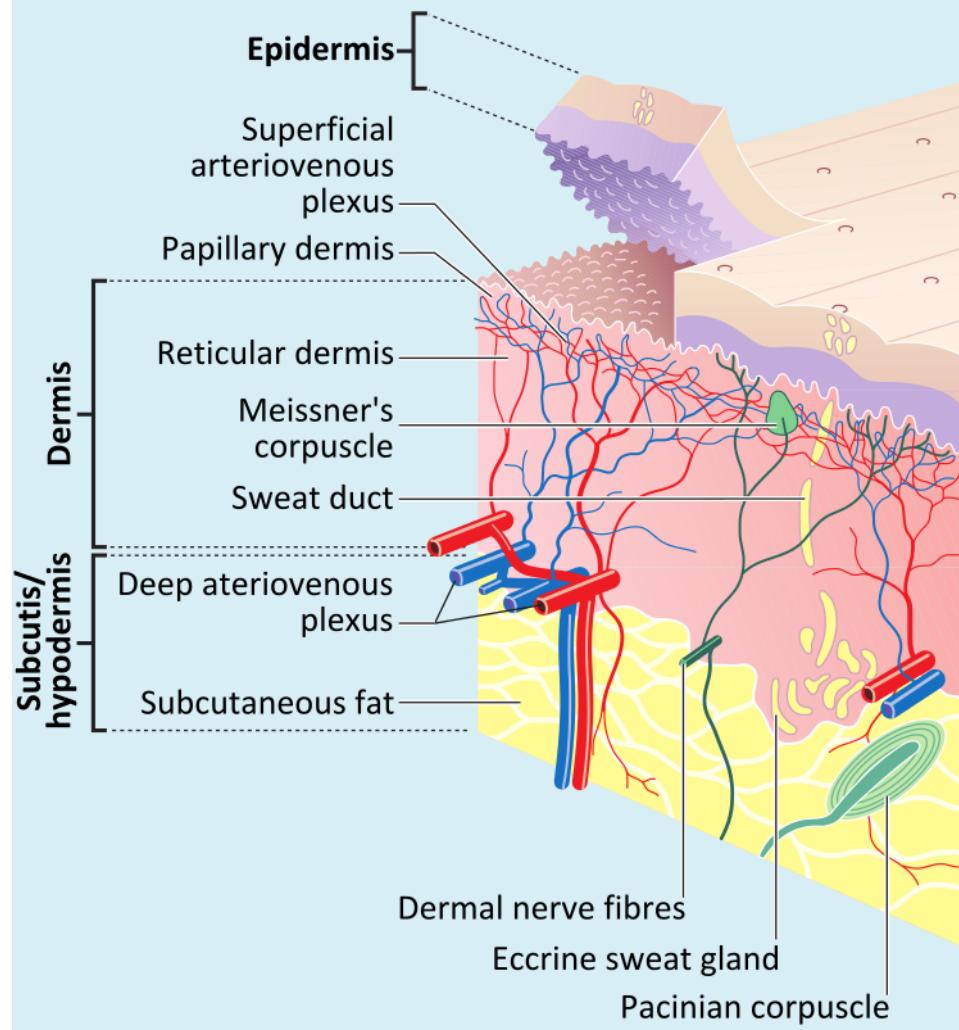
- **Epidermis:**
 - epithelial tissue (stratified squamous epithelium)
 - functions: protection, thermal regulation
 - differentiating keratinocytes (structural proteins, proteases, defensins)
- **Basement membrane:**
 - membrane between epidermis and dermis
 - rich in cytokines and growth factors
- **Dermis:**
 - connective tissue
 - functions: strain and elasticity
 - glands, vessels
 - cells: fibroblasts, macrophages, adipocytes
- **Hypodermis:**
 - connective tissues, elastin
 - functions: connection with bones/muscles, nerves/vessels
 - cells: fibroblasts, macrophages, adipocytes

TISSUE IS A MIXTURE OF CELL TYPES: SKIN

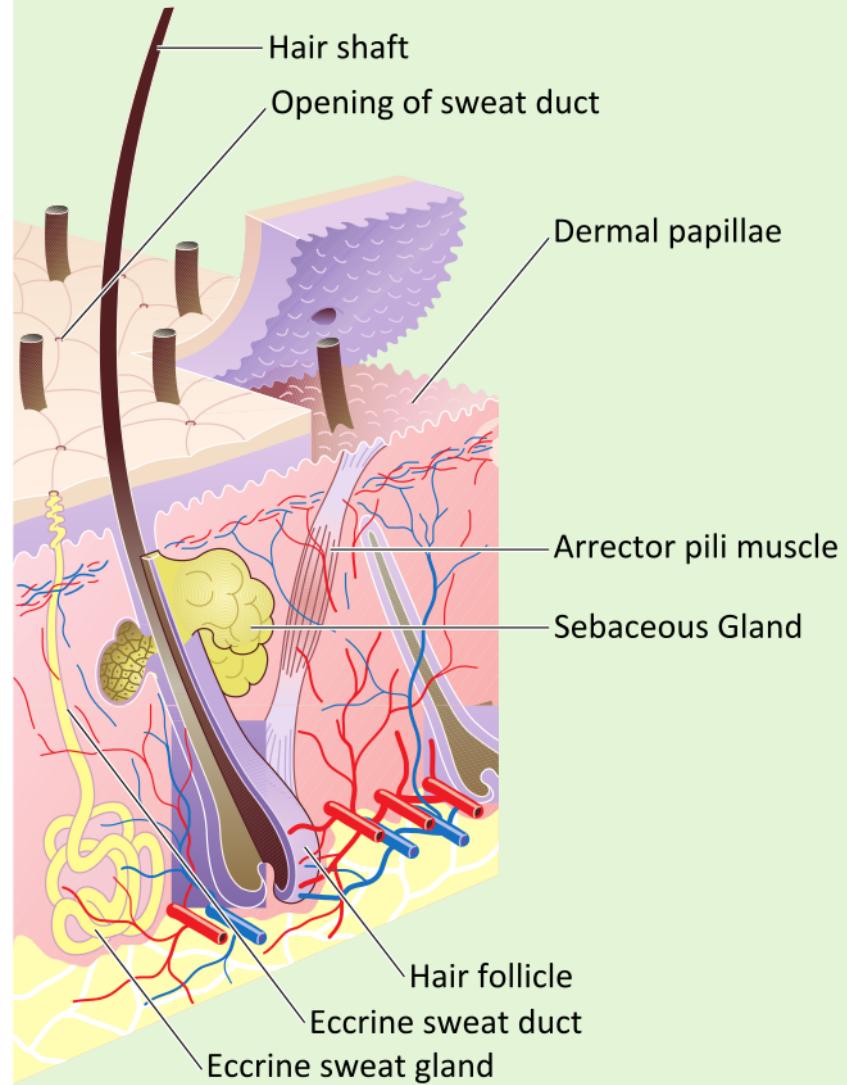


SKIN

Thick skin (hairless)



Thin skin (hairy)



TISSUES REGENERATION

➤ Tissues which regenerate easily:

- Epithelial
- Fibrous connective tissues
- Bone

➤ Tissues which regenerate with scar tissue:

- cardiac muscle
- nervous tissue (brain, spinal cord)

➤ Tissues which regenerate poorly:

- skeletal muscle



Scar

LECTURE 9: CELL ORGANIZATION II

➤ Cell types and organization in tissues

➤ Stem cells

➤ Connective tissue:

- bone (osteoblasts, osteoclasts)

- cartilage

- blood

➤ Muscle tissue (myocytes)

➤ Nervous tissue (neurons)

➤ Epithelial tissue (epithelial cells)

➤ Skin

