The Tissue Level of Organization

• Group of similar cells
  – common embryonic origin
  – common function

• Histology
  – study of tissues

• Pathologist
  – looks for tissue changes that indicate disease

4 Basic Tissues

• Epithelial Tissue
  – covers surfaces because cells are in contact
  – lines hollow organs, cavities and ducts
  – forms glands when cells sink under the surface

• Connective Tissue
  – material found between cells
  – supports and binds structures together
  – stores energy as fat
  – provides immunity to disease

• Muscle Tissue
  – cells shorten in length producing movement

• Nerve Tissue
  – cells that conduct electrical signals
  – detects changes inside and outside the body
  – responds with nerve impulses

Origin of Tissues

• Primary germ layers within the embryo
  – endoderm
  – mesoderm
  – ectoderm

• Tissue derivations
  – epithelium from all 3 germ layers
  – connective tissue & muscle from mesoderm
  – nerve tissue from ectoderm

Biopsy

• Removal of living tissue for microscopic examination
  – surgery
  – needle biopsy
• Useful for diagnosis, especially cancer
• Tissue preserved, sectioned and stained before microscopic viewing

Cell Junctions
• Tight junctions
• Adherens junctions
• Gap junctions
• Desmosomes
• Hemidesmosomes

Tight JUNCTIONS
• Watertight seal between cells
• Plasma membranes fused with a strip of proteins
• Common between cells that line GI and bladder

Adherens Junctions
• Holds epithelial cells together
• Structural components
  – plaque = dense layer of proteins inside the cell membrane
  – microfilaments extend into cytoplasm
  – integral membrane proteins connect to membrane of other cell

Desmosomes
• Resists cellular separation and cell disruption
• Similar structure to adherens junction except intracellular intermediate filaments cross cytoplasm of cell
• Cellular support of cardiac muscle

Hemidesmosomes
• Half a desmosome
• Connect cells to extracellular material
  – basement membrane
Gap Junctions

- Tiny space between plasma membranes of 2 cells
- Crossed by protein channels called connexons forming fluid filled tunnels
- Cell communication with ions & small molecules
- Muscle and nerve impulses spread from cell to cell
  - heart and smooth muscle of gut

Epithelial Tissue -- General Features

- Closely packed cells forming continuous sheets
- Cells sit on basement membrane
- Apical (upper) free surface
- Avascular---without blood vessels
  - nutrients diffuse in from underlying connective tissue
- Good nerve supply
- Rapid cell division
- Covering / lining versus glandular types
  
  **Basement Membrane**

- Basal lamina
  - from epithelial cells
  - collagen fibers
- Reticular lamina
  - secreted by connective tissue cells
  - reticular fibers
- holds cells to connective tissue
- guide for cell migration during development

**Types of Epithelium**

- Covering and lining epithelium
  - epidermis of skin
  - lining of blood vessels and ducts
  - lining respiratory, reproductive, urinary & GI tract
- Glandular epithelium
  - secreting portion of glands
  - thyroid, adrenal, and sweat glands
Classification of Epithelium

- Classified by arrangement of cells into layers
  - simple = one cell layer thick
  - stratified = many cell layers thick
  - pseudostratified = single layer of cells where all cells don’t reach apical surface
    - nuclei at found at different levels so it looks multilayered

- Classified by shape of surface cells
  - squamous = flat
  - cuboidal = cube-shaped
  - columnar = tall column
  - transitional = shape varies with tissue stretching

Simple Squamous Epithelium

- Single layer of flat cells
  - lines blood vessels (endothelium), body cavities (mesothelium)
  - very thin --- controls diffusion, osmosis and filtration
  - nuclei centrally located

- Cells in direct contact with each other

Examples of Simple Squamous

- Surface view of lining of peritoneal cavity
  - Section of intestinal showing serosa
Simple Cuboidal Epithelium

- Single layer of cube-shaped cells viewed from the side
- Nuclei round and centrally located
- Lines tubes of kidney
- Absorption or secretion

Example of Simple Cuboidal

- Sectional view of kidney tubules

Nonciliated Simple Columnar

- Single layer rectangular cells
- Unicellular glands = goblet cells secrete mucus
  - lubricate GI, respiratory, reproductive and urinary systems
- Microvilli = fingerlike cytoplasmic projections
  - for absorption in GI tract (stomach to anus)

Ex. Nonciliated Simple Columnar

- Section from small intestine
Ciliated Simple Columnar Epithelium

- Single layer rectangular cells with cilia
- Mucus from goblet cells moved along by cilia
  - found in respiratory system and uterine tubes

Ex. Ciliated Simple Columnar
- Section of uterine tube

Stratified Squamous Epithelium

- Several cell layers thick
- Surface cells flat
- Keratinized = surface cells dead and filled with keratin
  - skin (epidermis)
- Nonkeratinized = no keratin in moist living cells at surface
  - mouth, vagina

Example of Stratified Squamous
- Section of vagina
**Stratified Cuboidal Epithelium**
- Multilayered
- Surface cells cuboidal
  - rare (only found in sweat gland ducts & male urethra)

**Stratified Columnar Epithelium**
- Multilayered
- Surface cells columnar
- Rare (very large ducts & part of male urethra)

**Transitional Epithelium**
- Multilayered
- Surface cells varying in shape from round to flat if stretched
- Lines hollow organs that expand from within (urinary bladder)
Pseudostratified Columnar

- Single cell layer
- All cells attach to basement membrane but not all reach free surface
- Nuclei at varying depths
- Respiratory system, male urethra & epididymis

**Glandular Epithelium**

- Derived from epithelial cells that sank below the surface during development
- Exocrine glands
  - cells that secrete---sweat, ear wax, saliva, digestive enzymes onto free surface of epithelial layer
  - connected to the surface by tubes (ducts)
  - unicellular glands or multicellular glands
- Endocrine glands
  - secrete hormones into the bloodstream
  - hormones help maintain homeostasis

**Structural Classification of Exocrine Glands**

- Unicellular are single-celled glands
  - goblet cells
- Multicellular glands
  - branched (compound) or unbranched (simple)
  - tubular or acinar (flask-like) shape

**Examples of Simple Glands**

- Unbranched ducts = simple glands
- Duct areas are blue
Examples of Compound Glands

- Sweat gland duct
- Stratified cuboidal epithelium

Methods of Glandular Secretion

- Merocrine -- most glands
  - cells release their products by exocytosis---saliva, digestive enzymes & sweat
- Apocrine
  - smelly sweat & milk
– upper part of cell possibly pinches off & dies (perhaps—see EM data)

• Holocrine -- oil gland
  – whole cells die & rupture to release their products

Connective Tissues
• Cells rarely touch due to extracellular matrix
• Matrix(fibers & ground substance secreted by cells
• Consistency varies from liquid, gel to solid
• Does not occur on free surface
• Good nerve & blood supply except cartilage & tendons

Cell Types
• Blast type cells = retain ability to divide & produce matrix (fibroblasts, chondroblasts, & osteoblasts)
• Cyte type cells = mature cell that can not divide or produce matrix (chondrocytes & osteocytes)
• Macrophages develop from monocytes
  – engulf bacteria & debris by phagocytosis
• Plasma cells develop from B lymphocytes
  – produce antibodies that fight against foreign substances
• Mast cells produce histamine that dilate small BV
• Adipocytes (fat cells) store fat

Connective Tissue Ground Substance
• Supports the cells and fibers
• Helps determine the consistency of the matrix
  – fluid, gel or solid
• Contains many large molecules
  – hyaluronic acid is thick, viscous and slippery
– condroitin sulfate is jellylike substance providing support
– adhesion proteins (fibronectin) binds collagen fibers to ground substance

Types of Connective Tissue Fibers

• Collagen  (25% of protein in your body)
  – tough, resistant to pull, yet pliable
  – formed from the protein collagen

• Elastin  (lungs, blood vessels, ear cartilage)
  – smaller diameter fibers formed from protein elastin surrounded by glycoprotein (fibrillin)
  – can stretch up to 150% of relaxed length and return to original shape

• Reticular  (spleen and lymph nodes)
  – thin, branched fibers that form framework of organs
  – formed from protein collagen

Mature Connective Tissue

• Loose connective tissue
• Dense connective tissue
• Cartilage
• Bone
• Blood
• Lymph

Loose Connective Tissues

• Loosely woven fibers throughout tissues
• Types of loose connective tissue
  – areolar connective tissue
  – adipose tissue
  – reticular tissue

Areolar Connective Tissue

• Cell types = fibroblasts, plasma cells, macrophages, mast cells and a few white blood cells
• All 3 types of fibers present
• Gelatinous ground substance
Areolar Connective Tissue

- Black = elastic fibers,
- Pink = collagen fibers
- Nuclei are mostly fibroblasts

Adipose Tissue

- Peripheral nuclei due to large fat storage droplet
- Deeper layer of skin, organ padding, yellow marrow
- Reduces heat loss, energy storage, protection
- Brown fat found in infants has more blood vessels and mitochondria and responsible for heat generation

Reticular Connective Tissue

- Network of fibers & cells that produce framework of organ
- Holds organ together (liver, spleen, lymph nodes, bone marrow)
Dense Connective Tissue

• More fibers present but fewer cells
• Types of dense connective tissue
  – dense regular connective tissue
  – dense irregular connective tissue
  – elastic connective tissue

Dense Regular Connective Tissue

• Collagen fibers in parallel bundles with fibroblasts between bundles of collagen fibers
• White, tough and pliable when unstained (forms tendons)
• Also known as white fibrous connective tissue

Dense Irregular Connective Tissue

• Collagen fibers are irregularly arranged (interwoven)
• Tissue can resist tension from any direction
• Very tough tissue -- white of eyeball, dermis of skin

Elastic Connective Tissue

• Branching elastic fibers and fibroblasts
• Can stretch & still return to original shape
• Lung tissue, vocal cords, ligament between vertebrae
Cartilage
- Network of fibers in rubbery ground substance
- Resilient and can endure more stress than loose or dense connective tissue
- Types of cartilage
  - hyaline cartilage
  - fibrocartilage
  - elastic cartilage

Hyaline Cartilage
- Bluish-shiny white rubbery substance
- Chondrocytes sit in spaces called lacunae
- No blood vessels or nerves so repair is very slow
- Reduces friction at joints as articular cartilage

Fibrocartilage
- Many more collagen fibers causes rigidity & stiffness
- Strongest type of cartilage (intervertebral discs)

Elastic Cartilage
- Elastic fibers help maintain shape after deformations
- Ear, nose, vocal cartilages
Growth & Repair of Cartilage

- Grows and repairs slowly because is avascular
- Interstitial growth
  - chondrocytes divide and form new matrix
  - occurs in childhood and adolescence
- Appositional growth
  - chondroblasts secrete matrix onto surface
  - produces increase in width

Other Tissues
- Bone (Osseous) Tissue
- Blood
- Lymph
- Membranes
- Muscle
- Nerve Tissue

Tissue Engineering
- New tissues grown in the laboratory (skin & cartilage)
- Scaffolding of cartilage fibers is substrate for cell growth in culture
- Research in progress
  - insulin-producing cells (pancreas)
  - dopamine-producing cells (brain)
  - bone, tendon, heart valves, intestines & bone marrow

Tissue Repair: Restoring Homeostasis
- Worn-out, damaged tissue must be replaced
- Fibrosis = replacement with stromal connective tissue cells (scar formation)
- Regeneration = replacement with original cell types (parenchymal cells)
  - some cell types can divide (liver & endothelium)
  - some tissues contain stem cells that can divide
    - bone marrow, epithelium of gut & skin
  - some cell types can not divide & are not replaced
    - muscle and nervous tissue

Important Clinical Terminology
- Regeneration versus fibrosis
- Granulation tissue
  - very actively growing connective tissue
- Adhesions
  - abnormal joining of tissue
  - occurs after surgery or inflammation
Conditions Affecting Tissue Repair

- Nutrition
  - adequate protein for structural components
  - vitamin C production of collagen and new blood vessels
- Proper blood circulation
  - delivers O2 & nutrients & removes fluids & bacteria
- With aging
  - collagen fibers change in quality
  - elastin fibers fragment and abnormally bond to calcium
  - cell division and protein synthesis are slowed