

EPITHELIAL

Introduction

A. Concept and occurrence

1. Cellular covering
2. Free surfaces -- exposed to air or body fluids
 - a. Outer surfaces
 - internal (e.g. lungs)
 - external (e.g. skin)
 - b. Lining spaces
 - smaller (e.g. blood vessels)
 - larger (e.g. abdominal cavity)
3. Exceptions
 - a. Joint cavities
 - b. Brain ventricles
 - c. Spinal cord central canal

B. Classification

1. Cell types
 - a. Classic (based on shapes)
 - squamous (flattened)
 - cuboidal (square in vertical sections)
 - columnar (long rectangular in vert. sect.)

b. Modern

- variety in each of 3 classic types
- more than three shapes in reality
- variability in any one shape type
- individual cell can vary during life
- solve the riddle

2. Layering

- a. Simple -- one layer deep
- b. Pseudostratified -- illusion of > 1 layer
- c. Stratified -- more than one layer deep

Characteristics and Features

A. Essentially cellular

- Slight intercellular material
- To prevent or control passage between cells
- Inherent problems -- [reason for remaining features]

B. Cellular interconnections (junctions)

- Necessitated by lack of intercellular material ("cement")
- Junction types
 - a. Jigsaw puzzle effect
 - complementary surface irregularities
 - no specialized intercellular modifications

b. Tight (occludens)

- "ZipLoc"-like zone around cell
- cooperating zones between cells
- seals between cells for transport barrier
- absolute (e.g. intestine)
- leaky (e.g. capillaries, moderate; kidney tubules, extreme)

c. Desmosomes (adherens)

- intercellular bonding
- not transport barrier, structural only
- several components (stitched seam analogy)
- hemidesmosomes – between epithelial/non-epithelial (eg. basement membrane)

d. Gap junctions (communicans; nexuses)

- gap between cells (2 nm.)
- intercellular passageway
- for chemical communication (metabolic cooperation)
- NO EPITHELIAL EXAMPLES; intercalated discs (cardiac muscle)

C. Stabilization of epithelial layer(s)

- Necessitated by lack of intercellular material
- To bind with adjacent connective tissue

-- Basement membrane (lamina propria)

a. Basal lamina

- amorphous protein/polysaccharide
- secretion of epithelium
- always present

b. Reticular lamina

- fibrous
- secretion of underlying connective tissue
- sometimes absent (e.g. capillaries)

D. Avascularity

- Lack of intercellular blood vessels
- Due to lack of intercellular space
- Diffusion to/from nearby vessels in connective tissue
- Limiting factor in thickness

E. Replacement

- Short cell lifetimes
- Due to vulnerability from locations
- Active mitotic cell division

Functions *[no epithelium will have all of these]*

A. Protection

1. Mechanical

- Physical protection

-- Most epithelia have this function

2. Chemical
3. Osmotic -- semipermeable barrier
4. Microbial
5. Ultraviolet radiation

B. Transport

1. Secretion -- glandular
2. Excretion -- waste elimination
3. Absorption -- incoming materials
4. Movement
 - Cilia
 - Flagella

C. Lubrication

1. Mucus [sometimes stickiness (e.g.) is its prime function]
2. Serous -- watery

D. Sensory reception

- Sense organs (receptors)
- Neuroepithelial cells
 - Highly specialized
 - Both epithelial and nervous

E. Reproduction

- Cell types
 - Sperm

- Ova (eggs)
- Technically epithelial
 - Unique function
 - Special role for entire body

Simple Epithelia

A. General

1. One layer of cells, unambiguously
2. Cell type possibilities
 - a. All identical
 - b. Similar, but variable size/shape
 - c. More than one distinct type (structural/functionl)
3. Naming
 - Based on one of 3 basic shape classifications
 - Not always reliable -- e.g. low columnar; tall cuboidal

B. Simple squamous

1. Functions
 - a. No mechanical protection
 - b. Dialyzing membrane -- transport function
 - type of filtration (diffusion under pressure)
 - separation of different sized particles
 - reason for extreme thinness
 - virtually 2 semipermeable membranes

-- transport between cells (leaky tight junction)

c. Secretion -- serous

2. Variations

a. Thickness

b. Degree of permeability

3. Locations

a. Endothelium -- blood vessel lining

b. Mesothelium (serous layers)

-- lining thoracic & abdominal cavities

-- covering most thoracic & abdominal organs

c. Alveoli (air sacs) -- lungs

d. Kidney tubules (some)

e. Glandular ducts (many) -- smallest glands

C. Simple cuboidal

1. Functions

-- Only slight mechanical protection

-- Mostly various transport functions [*details later*]

2. Variations

a. Size -- in section, from square to rectangular

b. Features

-- microvilli (surface area increase)

-- ciliated

-- goblet

3. Locations & functional details

a. Relatively unspecialized

- glandular ducts (some); e.g. bile in liver
- ovarian covering
- eye lens covering

b. Secretory

- thyroid
- liver (hepatic cells)
- sweat glands

c. Dialysis & absorption -- kidney tubules (some)

d. Respiratory

- smallest bronchioles
- with cilia and goblet cells

e. Pigmented -- retina and iris of eye

D. Simple columnar

1. Functions

- More mechanical protection
- Varied functions [*details later*]

2. Variations

a. Size & shape

- low to tall
- rectangular

- square at one end & tapered at the other
- triangular (pyramidal 3-dimensionally)

b. Features [*same as cuboidal*]

3. Locations & functional details

a. Relatively unspecialized -- gallbladder lining

b. Secretory (majority of glands)

- gastric glands
- pancreatic glands
- intestinal glands
- salivary glands

c. Digestive linings

-- Organs

- stomach
- small & large intestines

-- Cell Types

- absorptive cells with microvilli
- goblet cells (except stomach)

d. Excretory (some kidney tubules)

e. Respiratory

- smaller bronchi
- larger bronchioles

f. Reproductive (ciliated)

-- fallopian tubes

-- uterine lining

Pseudostratified Epithelium

A. Functions

1. Increased protection compared with simple columnar
2. Several respiratory roles
 - a. Sensory -- smell
 - b. Humidification -- mucous
 - c. Dust trapping & elimination -- mucous & cilia
3. Others [*details later*]

B. Structure

1. Illusion of multiple layers -- due to varying cell heights
 - a. Columnar
 - b. Fusiform
 - c. Basal
2. Variations
 - a. Fusiform sometimes absent
 - b. Cilia
 - c. Goblet

C. Locations

1. Respiratory

a. General

-- most abundant

-- cilia and goblet cells

b. Nasal lining -- with olfactory receptors

c. Pharynx

d. Larynx

e. Trachea

f. Larger bronchi

2. Relatively unspecialized

a. Larger glandular ducts -- e.g. salivary

b. Urethra (part)

Stratified Epithelia

A. General

1. Offer the most mechanical protection

2. Structure

-- Two or more complete cell layers

-- Usually more than one cell type in different layers

-- Basal layer

-- farthest from free surface

-- cell type variable

-- most active cell division

3. Naming

- Based on cell type at free surface
- Other layers not considered

B. Stratified squamous

1. General

- a. Several to many squamous layers at free surface
- b. Several to many cuboidal layers next
- c. Basal layer of columnar

2. Non-keratinized (wet)

- a. Squamous layers living
- b. Mucous glands
 - below epithelium in connective tissue
 - ducts empty moisture onto free surface
- c. Locations

- mouth
- pharynx (part)
- esophagus
- anal canal
- urethra (near opening)
- vagina

3. Keratinized (dry)

- a. Dead cells at free surface
 - dry & hardened with keratin (protein)

-- provides maximum mechanical protection

b. Remainder similar to non-keratinized

c. Locations

-- epidermis

-- hard palate (anterior part)

-- anterior tongue

C. Stratified cuboidal

1. Structure

-- Most layers are cuboidal

-- Basal layer usually columnar

2. Locations

a. Seminiferous tubules -- meiotic sperm production

b. Ovarian follicle walls -- nourish ova (eggs)

c. Glandular ducts -- e.g. sebaceous & sweat

D. Transitional (Uroepithelium)

1. Structure

-- Unique transitional cells

-- Sometimes termed modified cuboidal

-- Free surface layer has largest cells

-- Gradual size reduction towards basal layer

2. Locations

a. Lining urinary bladder

b. Lining ureters

c. Urethra – first part, joining bladder

3. Function

-- Rapidly undergo radical shape transitions

-- Accomodation to varying urine amounts

-- When filling

-- cells flatten to squamous-like

-- cells move into fewer layers

-- When emptying -- filling changes reversed

E. Stratified columnar

1. Most mechanical protection offered by living cells

2. Structure

-- Usually two columnar layers

-- free surface

-- basal

-- Most layers cuboidal

3. Variations/locations

a. With cilia and goblet cells

-- pharynx (part)

-- larynx (part)

b. With goblet cells

-- urethra (part)

-- conjunctiva (folds)

-- largest glandular ducts (e.g. mammary)

CONNECTIVE

Introduction

A. Concept and occurrence

1. Maintains body
 - a. Form (shape)
 - b. Functionally
2. Holds body together
3. Occurrence
 - Most widespread tissue
 - All organs -- except central nervous tissue

B. Characteristics and features

1. Essentially noncellular
 - By volume, mostly intercellular material (matrix)
 - Matrix variable for each specific type
 - Exception -- adipose mostly cellular
2. Cells inconspicuous
 - Important, though
 - Responsible for forming matrix
 - Exception -- adipose
3. Function(s) performed by matrix
 - Not by cells, as in other 3 tissue types
 - Exception -- adipose

C. Functions

1. Maintenance of form (anatomical)

a. Connection

- joining other tissues
- most basic function
- all other functions related
- ex. tendon

b. Anchorage

- stabilization (holding fast)
- ex. basement membrane

c. Support

- hold shape and position
- ex. skeleton

d. Protection

- physical
- ex. skeleton

e. Space-filling

- prevent collapse/position changes
- ex. areolar

2. Physiological Processes

a. Transport

- diffusion medium

-- ex. areolar

b. Movement

-- provide flexible stability

-- ex. tendon; ligament; areolar

c. Storage

-- nutrients

-- ex. skeleton; adipose (fat)

d. Protection

-- functional

-- immunity

-- ex. reticular; areolar

Components

A. Matrix (intercellular substance or material)

1. Amorphous components

a. Ground substance

-- proteoglycans

- also termed mucopolysaccharides

- also termed glycosaminoglycans

- polysaccharide + protein

-- various proteins

-- other, minor substances

-- variable composition forms various types

-- functions

- main contributor to firmness
- holds all other components
- binds tissue fluid for diffusion

-- secretion of special cells (fibroblasts)

b. Tissue (interstitial) fluid

-- 1/3 of body fluid volume

-- functions

- exchanges with blood plasma
- exchanges with intracellular fluid

--composition

- water (about 80%)
- electrolytes (e.g. Na, Cl, HCO₃)
- proteins (e.g. albumins)
- misc. organics (e.g. glucose, lipids)
- metabolic wastes (e.g. CO₂)

2. Fibers

a. Collagenous

- composed of protein collagen
- smaller parallel fibrils
- great tensile strength

- formed by fibroblasts
 - subcomponents secreted
 - assembled extracellularly

b. Elastic

- composed of protein elastin
- branched, form network
- elasticity, so stretch and recoil
- formed by fibroblasts

c. Reticular

- composed of protein reticulin
- found only in immune related tissues/organs
- formed by reticular cells

B. Cells

1. Mesenchymal

- Embryonic cell type
- Undifferentiated -- unspecialized
- Can differentiate into any specific cell type
- Present throughout life
- Needed for:
 - development (embryo and immature)
 - repair (regeneration)
 - replacement (turnover of old)

2. Fibroblast

- Most numerous and important
- Secretes ground substance
- Fiber formation
 - secretes components & causes assembly
 - collagenous & elastic only
- Fibrocyte
 - mature form
 - maintenance cell
 - some phagocytosis

3. Fibroblast-related

a. Chondroblast

- fibroblast role in cartilage
- chondrocyte mature form

b. Osteoblast

- fibroblast role in bone
- osteocyte mature form

4. Reticular cell (reticulocyte)

- Secretes ground substance in reticular tissue
- Forms reticular fibers
- Phagocytic

5. Adipose cell (adipocyte)

- Fat storage
- *Not unique to adipose tissue
- Possibly a variant type of fibrocyte

6. Immune related

a. Macrophage (histiocyte)

- related to monocyte of blood circulation
- phagocytic (very important)

b. Mast cell

- related to basophil of blood circulation
- releases histamine, heparan, serotonin
- responsible for allergic reactions

c. Plasma cell

- related to lymphocyte of blood circulation
- central role in all immune aspects, as controller

d. Other types

- sometimes present, entering from blood
- phagocytic
- eosinophil (acidophil) & neutrophil

7. Others

- Variable, not always present
- Ex. chromatophore -- pigment-containing

C. Blood vessels

- Present in most connective tissues
- Only on surface of cartilage
- Considered as tissues (or organs) in their own right
- Organ/Tissue conundrum

Classification

A. No scheme agreed upon by all authorities

- Disagreement about status of some tissues
- Ex. adipose or blood

B. Variability

- Much greater than any of other 3 tissue types
- Custom types of specific category in different organs
- Ex. dense irregular of gland capsule vs. skin's dermis

Connective Tissues Proper

A. Concept

1. Also termed ordinary connective tissues
2. Overall tissue variable in shape or even amorphous
3. Usually characterized, & sometimes named, by fibers
 - a. Density of spacing
 - b. Size
 - c. Predominant type
4. Cells vary with function of particular tissue type

B. Loose (Areolar)

1. Structure
 - a. Most variable of any connective tissue
 - b. All three fiber types
 - c. All possible cell types
 - d. Amorphous -- semi-liquid gel

2. Functions

- a. Limited support
- b. Mobility
 - provides freedom of movement (mobility)
 - elasticity
- c. Space-filling (-packing)
- d. Transport
 - abundant tissue fluid
 - diffusion medium
 - cellular nourishment & wastes
- e. Immunity -- [*note immune-related cells above*]

3. Locations

- Most widespread of all tissues -- in all sections
- Under basement membrane of most epithelia
- Between most non-epithelial tissues
- Surround muscle cells
- Surround peripheral nerve fibers
- Surround blood vessels -- especially capillaries
- Subcutaneous

C. Reticular

1. Structure

- a. Reticular cells (reticulocytes)
- b. Reticular fibers
- c. No other components, except required amorphous

2. Functions -- all immune related

3. Locations -- all part of immune (reticuloendothelial) system

- a. Lymph nodes
- b. Spleen
- c. Liver
- d. Thymus
- e. Tonsils
- f. Lymphatic nodules (patches)
- g. Bone marrow (red)

D. Adipose

1. Structure

- a. Mostly cellular -- adipocytes
- b. Limited matrix
 - some fibers and other cell types
 - blood vessels

2. Functions

- a. Fat (triglyceride) storage
- b. Protection -- padding
- c. Insulation -- thermal

3. Locations

- a. Only absent in following
 - nervous tissue
 - lungs
 - dorsal hand
 - penis
- b. Subcutaneous
- c. Kidney
- d. Serous membranes
- e. Bone marrow (yellow) -- most

E. Dense

1. General

- a. Fibers predominate
 - more numerous
 - densely arranged
 - thicker
- b. Less space for amorphous matrix
- c. Fewer cells

2. Irregularly arranged (Interwoven)

- a. Can withstand tension from various directions
- b. Collagenous predominating
 - glandular capsules and trabeculae
 - non-glandular sheaths
 - epimysium & perimysium

- epineurium & perineurium
- perichondrium & periosteum
- dura mater

-- dermis

c. Elastic predominating -- arterial wall membranes

3. Regularly arranged (Parallel-fibered)

a. Take tension in only one plane

b. Collagenous predominating

-- tendon (attach muscles)

-- ligaments (limit joint mobility)

-- fascia (deep fascia) [*debated status*]

c. Elastic predominating

-- vocal cords

-- stylohyoid ligament

-- suspensory ligament

Blood

A. Plasma

-- Equivalent to matrix -- no ground substance

-- Liquid

-- No fibers

B. Cells

1. Erythrocytes (red blood cells) -- oxygen transport
2. Leukocytes (white blood cells) -- immunity
3. Thrombocytes (platelets) -- clotting

C Uncertain status

- Sometimes considered as unique 5th tissue type
- Mesenchymal origin, however

Cartilage

A. Matrix

1. Firm gel -- unique ground substance
2. Variable fibers -- basis for 3 types
 - a. Hyaline -- delicate collagenous
 - b. Fibrous -- dense, thick collagenous predominate
 - c. Elastic -- dense, thick elastic predominate
3. No blood vessels
 - Located on surface
 - Diffusion of nutrients & wastes through tissue fluid

B. Cells

- Only chondrocytes
- Trapped in lacunae (spaces) of firm matrix

Bone (Osseous) Tissue

A. Matrix

1. True solid -- mineralized
2. Tissue fluid confined to minute tunnels (canaliculi)
3. Blood vessels within separate tunnels
4. Collagenous fibers

B. Cells

1. Osteocytes -- trapped in lacunae
2. Osteoclasts -- involved in tissue remodeling