

HISTOPATHOLOGY

1

CELLULAR ADAPTATIONS OF GROWTH AND DIFFERENTIATION



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Third Stage

المرحلة الثالثة

محاضرة رقم 7

الجانب النظري

Lecture No. 7

Theoretical

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OBJECTIVE

- What is Cell Adaptation.
- What are the Forms of Cellular Adaptation and types.
- What is the Mechanism of each of types with Examples.

Cell Adaptation

- **Definition** : Reversible change in size, number, phenotype, metabolic activity, or functions of cells in response to change in their environment.
- a state that lies intermediate between the normal, unstressed cell and the injured, overstressed cell.

Environmental changes:

- **Physiologic Adaptation** : In response to normal stimulation by hormones or endogenous chemical substances
- **Pathologic Adaptation** : provide the cells with the ability to survive in their environment and perhaps escape injury.

Forms of Cellular Adaptation

SIZE & NUMBER:

- Atrophy
- Hypertrophy
- Hyperplasia

DIFFERENTIATION OF CELLS:

- Metaplasia
- Dysplasia

Hypertrophy

- Increase in the size of cells, resulting in an increase in the size of the organ, Can be physiologic & pathologic
- No new cells, just larger cells
- Due to increase functional demand or by stimulation of hormones & growth factors.

Examples of Hypertrophy:

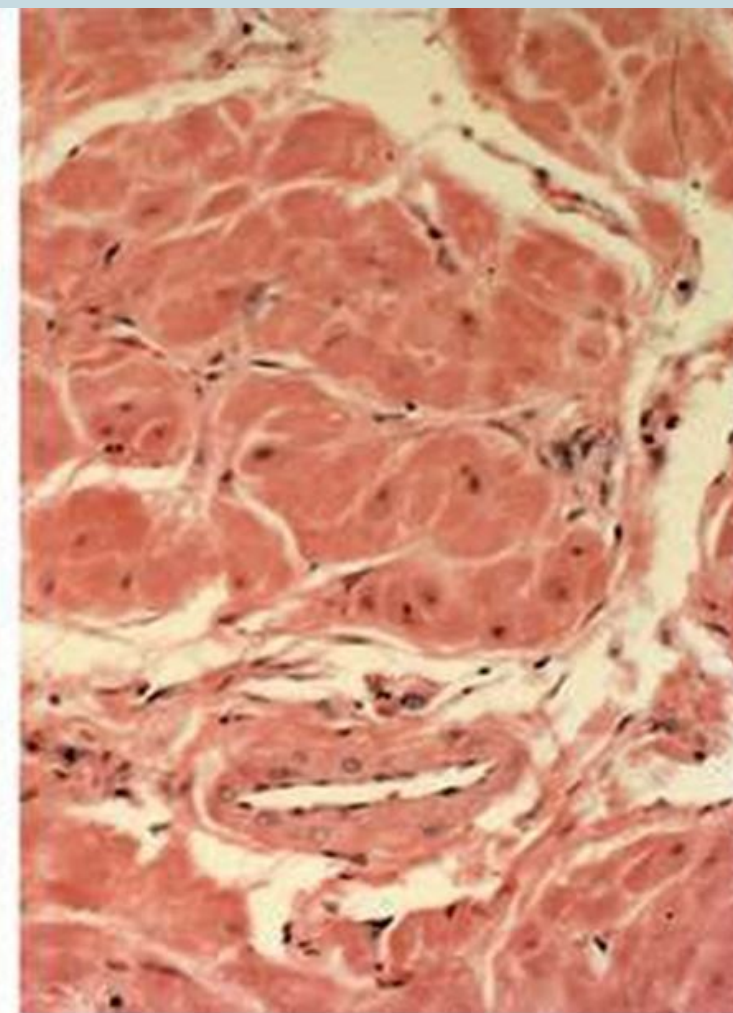
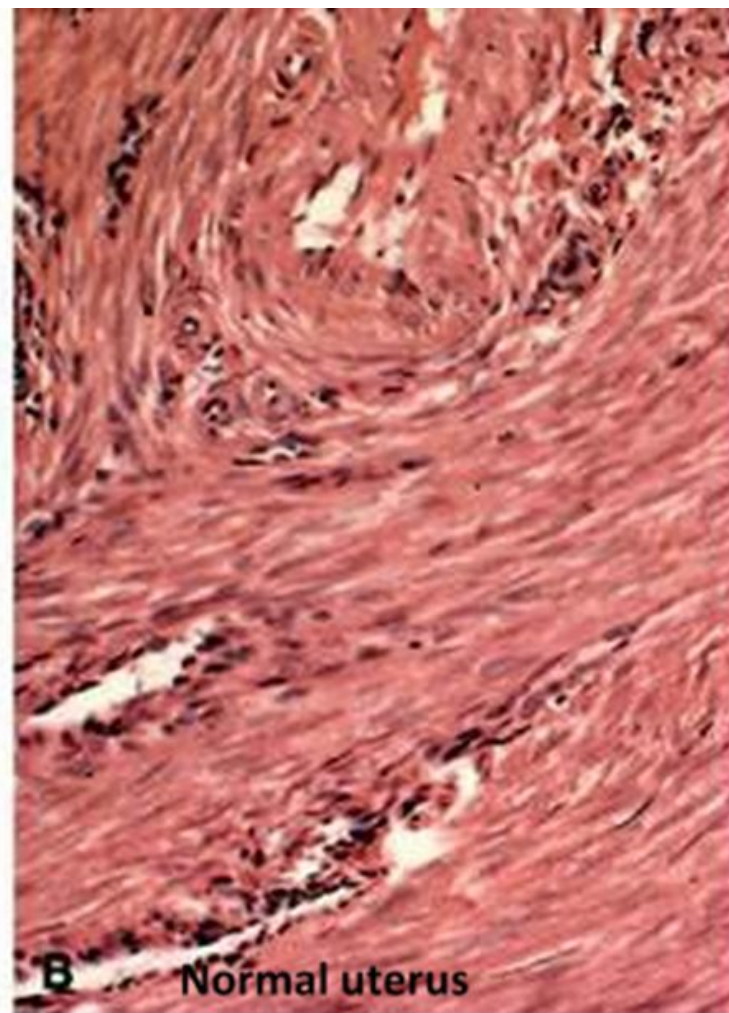
1. Increase workload :

- Physiologic : Skeletal muscle hypertrophy in response to exercise
- Pathologic : Myocardium in hypertensive heart disease due to stimulus is chronic hemodynamic overload

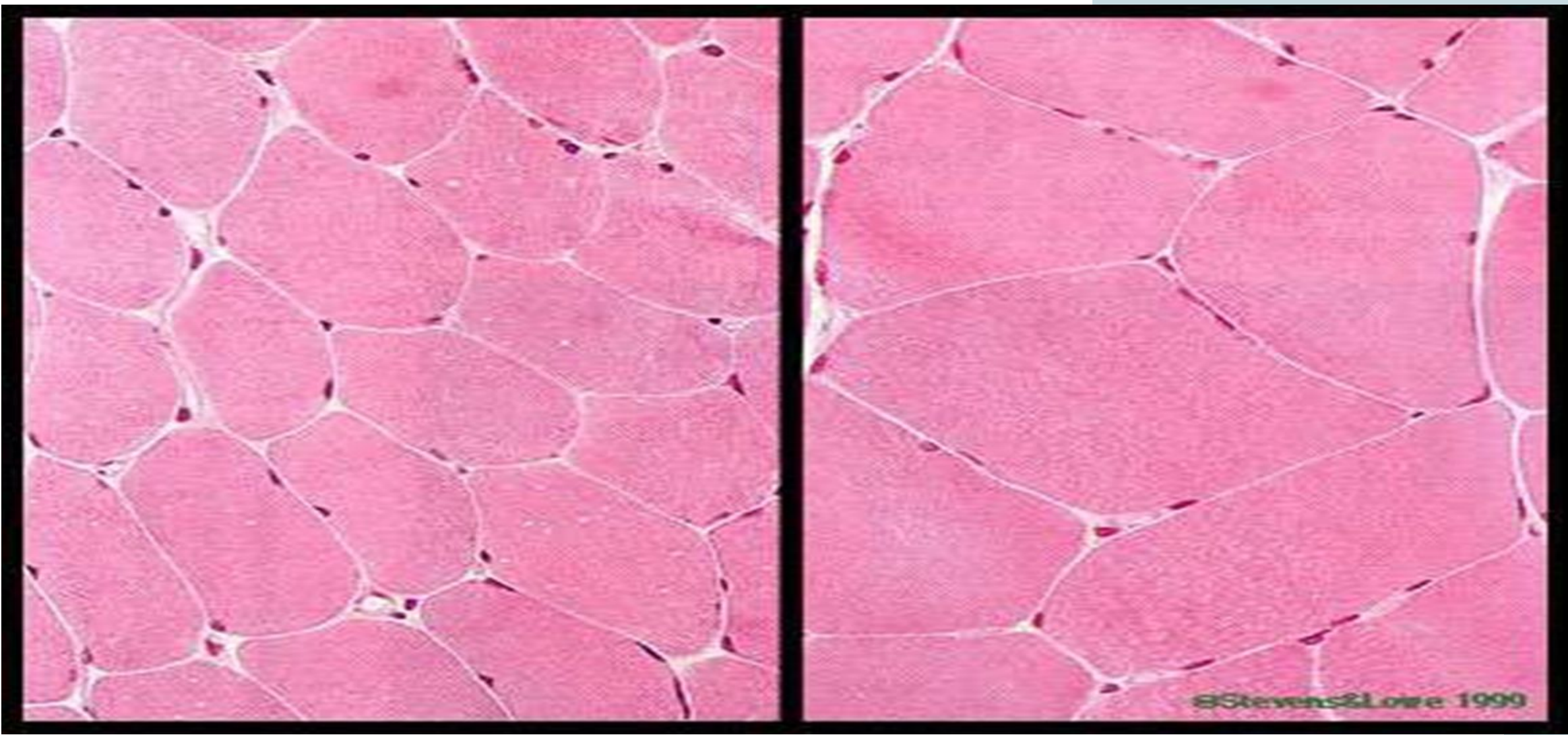
2. Hormone induced :

- Physiologic : uterus during pregnancy stimulated by estrogenic hormones
- Pathologic : Prostatic hypertrophy due to excessive androgenic stimulation

⁵3. Compensatory hypertrophy: Renal compensatory hypertrophy(tubular epithelial cells)



Physiologic hypertrophy of the uterus during pregnancy. A, gross appearance of a normal uterus (right) and a gravid uterus (left) that was removed for postpartum bleeding,



Skeletal muscle hypertrophy in response to exercise
(Physiological hypertrophy)

Mechanism of hypertrophy

- Due to increase production of cellular proteins
- By the actions of
 - Growth factors : TGF- β , IGF-1, FGF
 - Vasoactive agents : α -adrenergic, angiotensin –II
- Expression of contractile proteins of fetal & neonatal forms
- Selective hypertrophy : hypertrophy of SER of hepatocytes in patients treated with barbiturates

Hyperplasia

- Definition : increase in number of cells in an organ or tissue, usually resulting in increased mass of organ or tissue
- Hyperplasia is also an important response of connective tissue cells in wound healing, in which proliferating fibroblasts and blood vessels aid in repair.

Types of hyperplasia:

1. **Physiologic:** Response to need, e. g. Hyperplasia uterus during pregnancy.
2. **Compensatory:** Response to deficiency, e. g.
 - Hyperplasia following surgical removal of part of liver or of one kidney
 - hyperplasia of the bone marrow in anemia.

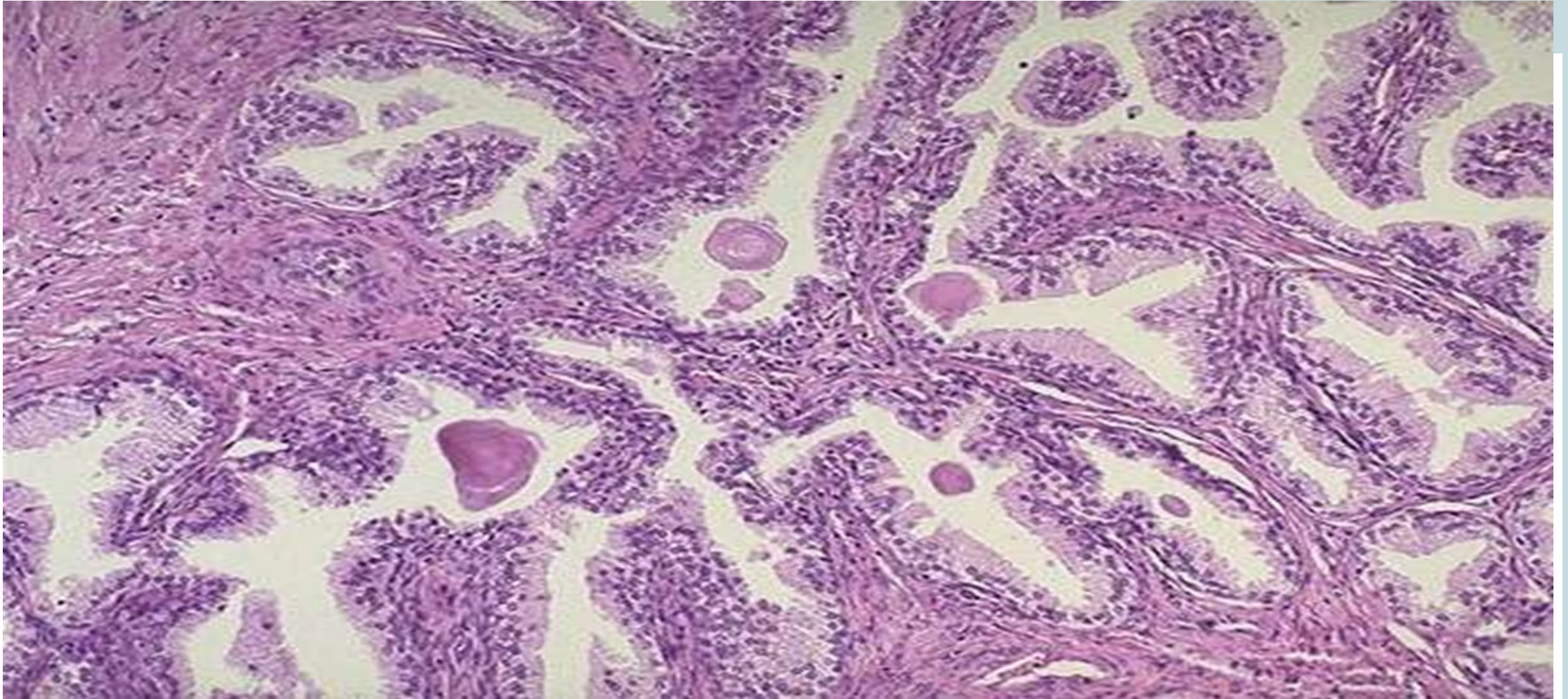
3. Excessive stimulation: Pathologic:

Hormonal :

- as in ovarian tumor producing estrogen and stimulating endometrial hyperplasia
- androgen mediated enlargement of prostate in benign prostatic hyperplasia

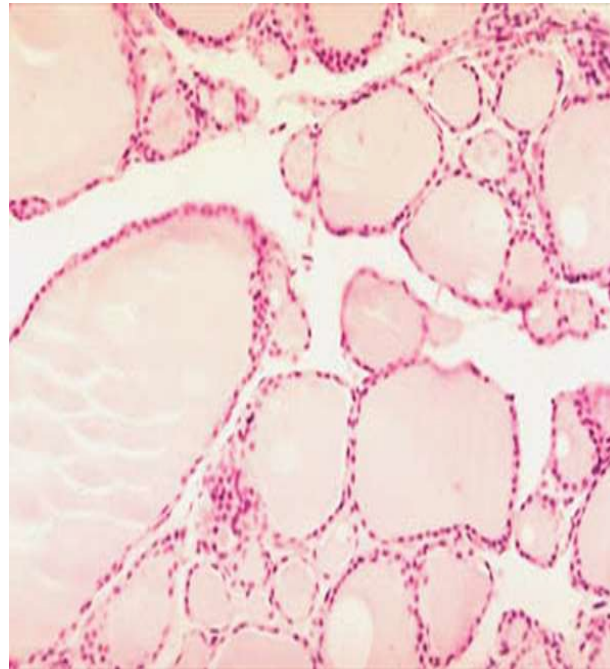
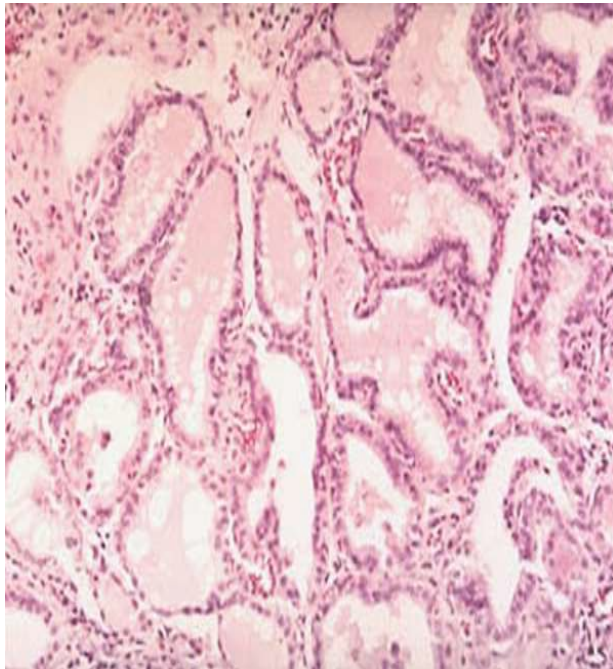
Other chemicals

- pancreatic islet hyperplasia in infants of a diabetic mother (stimulated by high glucose level)



Microscopic view of prostatic hyperplasia

4. Viral infection : pathologic: e.g. papilloma viruses
5. Failure of regulation: Pathologic: e.g.
 - Hyperplasia of thyroid in Grave's disease
 - Hyperparathyroidism resulting from renal failure or vitamin D deficiency.
6. Neoplastic: Total loss of normal control mechanism. Should not be termed hyperplasia



Thyroid hyperplasia

Mechanism of hyperplasia

- Result of
 - Growth factor driven proliferation of mature cells
 - In some cases, increase output of new cells from tissue stem cells

Relationship between hyperplasia & hypertrophy

- These may occur independently or together.
- Often triggered by same stimulus
- Reflected by an increase in size and weight of an organ
- Cells capable of dividing : undergo both Hypertrophy & hyperplasia
- Non-dividing cells : undergo hypertrophy (myocardial fibres)
- Examples : gravid uterus during pregnancy

Atrophy

- **Definition** : reduced size of an organ or tissue resulting from a decrease in cell size & number
- **Types** :
- **A. Physiologic atrophy** :
 - Embryonic structures during Fetal development : thyroglossal duct, notochord
 - Involution :
 - Uterus shortly after parturition
 - breast after cessation of lactation

B. Pathologic Atrophy

1. **Diminished blood supply**: - **Ischemic atrophy** : Due to arterial occlusive disease leading to atrophy of brain in patients with cerebrovascular diseases.

2. **Loss of nerve stimulus**: - **Denervation atrophy** : Atrophy of muscle nerves fibers due to damage to nerves

3. Loss of endocrine stimulation:

- In hormone responsive tissues such as breast & reproductive organs

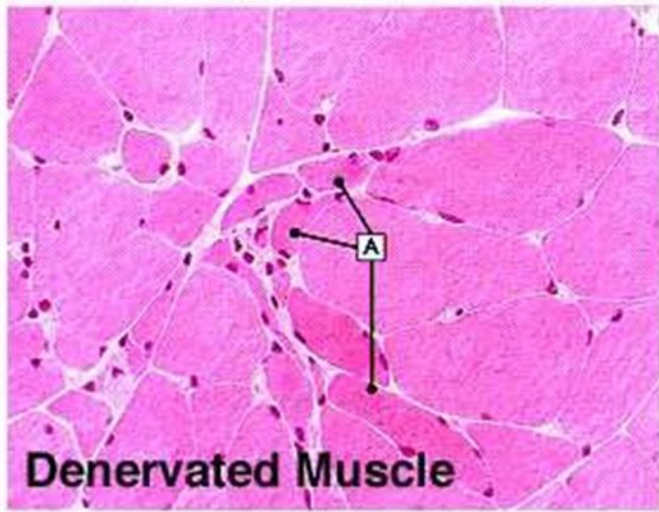
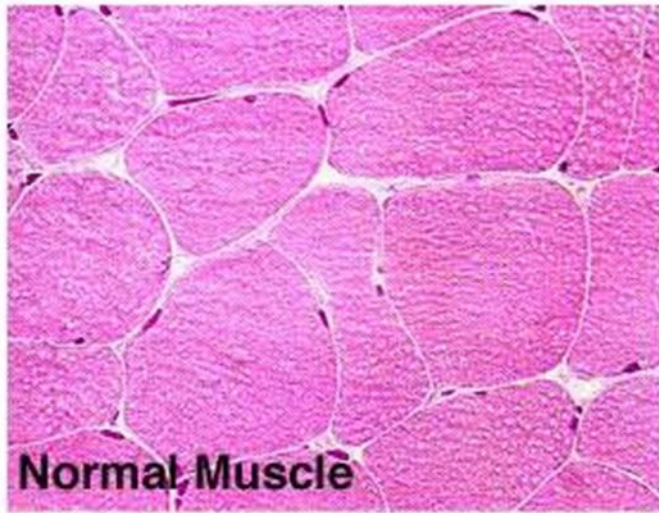
4. Inadequate nutrition: **Muscle wasting in protein-energy malnutrition (marasmus)**

, Cachexia in patients with chronic inflammatory diseases & cancer.

5. Pressure atrophy: **Atrophy of surrounding tissue by benign tumor**

6. Decreased workload : **Disuse atrophy** : Skeletal muscle atrophy immobilized by cast.

7. Aging: **Senile atrophy** : Decrease in body fat, muscle mass, brain size seen with aging



Denervation atrophy



DISUSE ATROPHY (Poliomyelitis)

Other causes of a small organ other than atrophy

- **Hypoplasia:** incomplete growth of an organ
- **Agenesis:** complete failure of development of an organ in embryogenesis

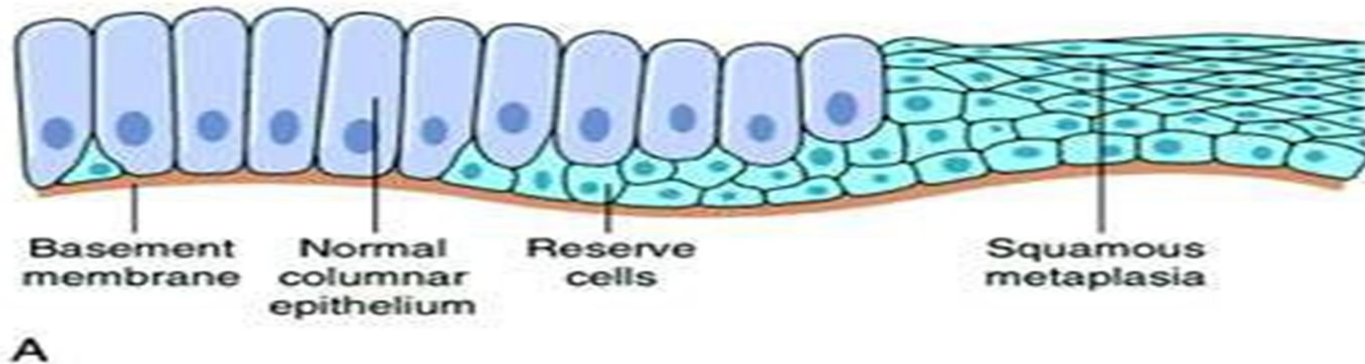
Metaplasia

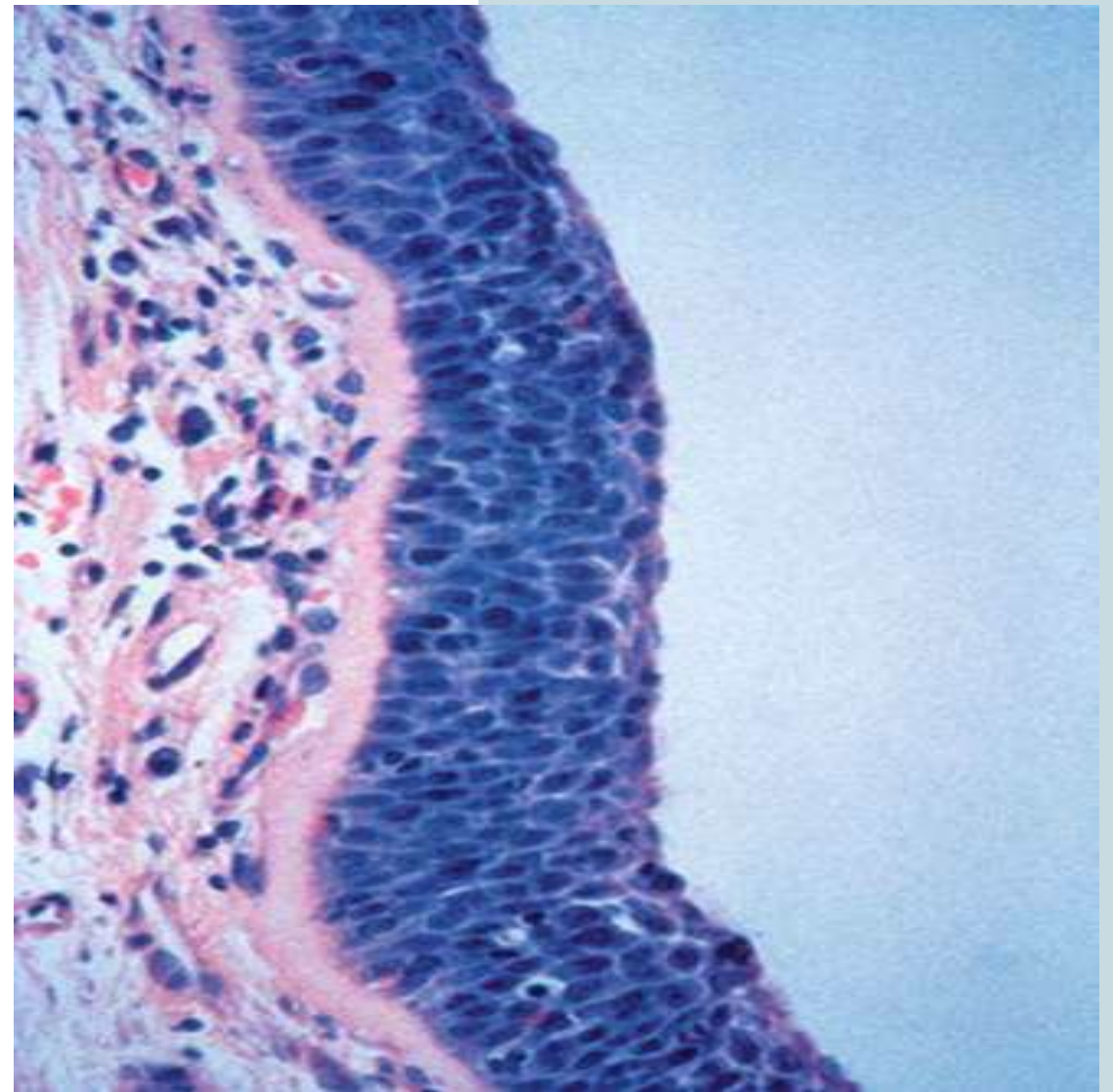
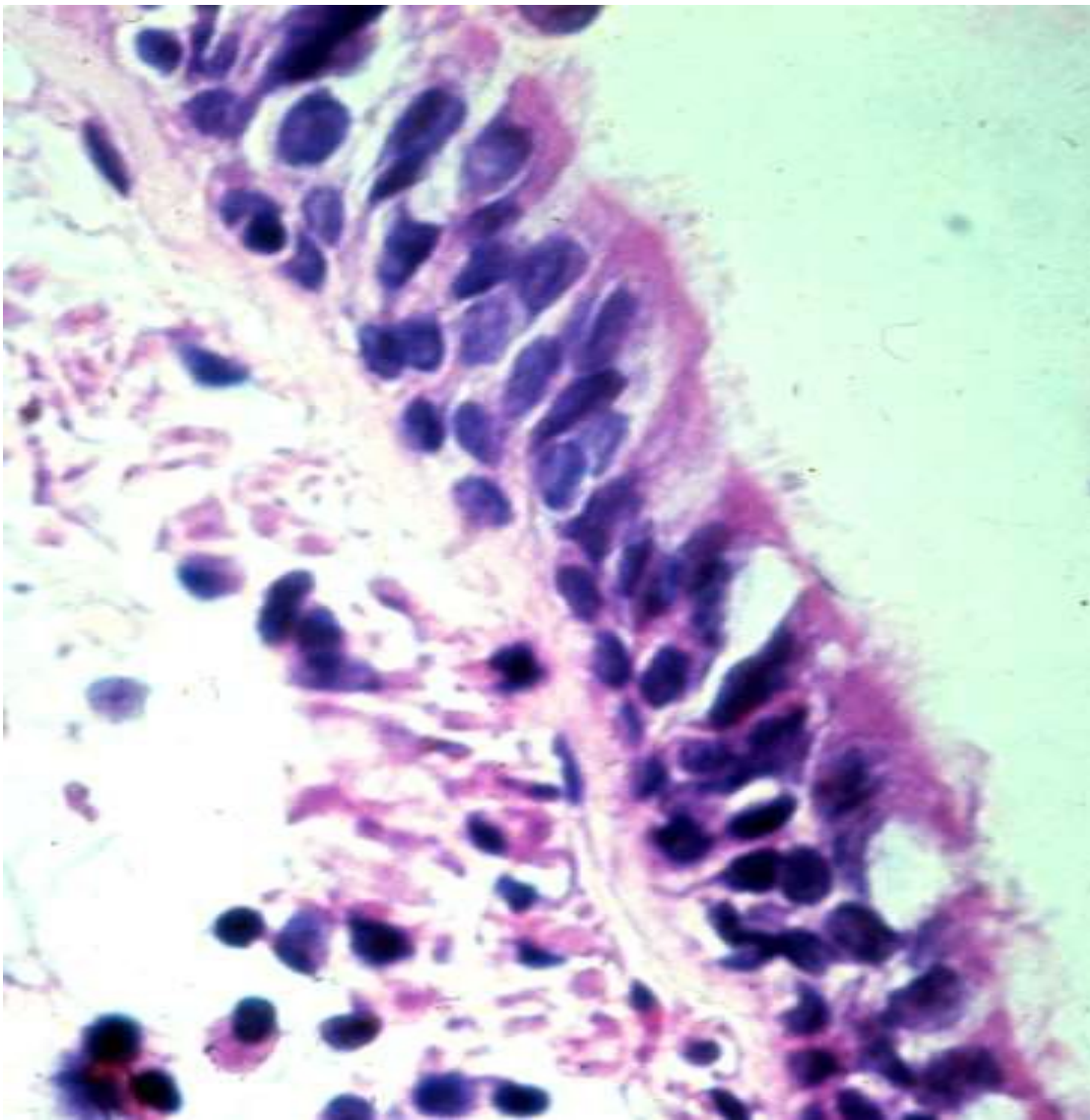
- **Definition** : reversible change in which one differentiated cell type (epithelial or mesenchymal) is replaced by another cell type
- **Causes:**
 1. Changes in environment
 2. Irritation or inflammation
 3. Nutritional
 4. Tissue injury

Types of metaplasia

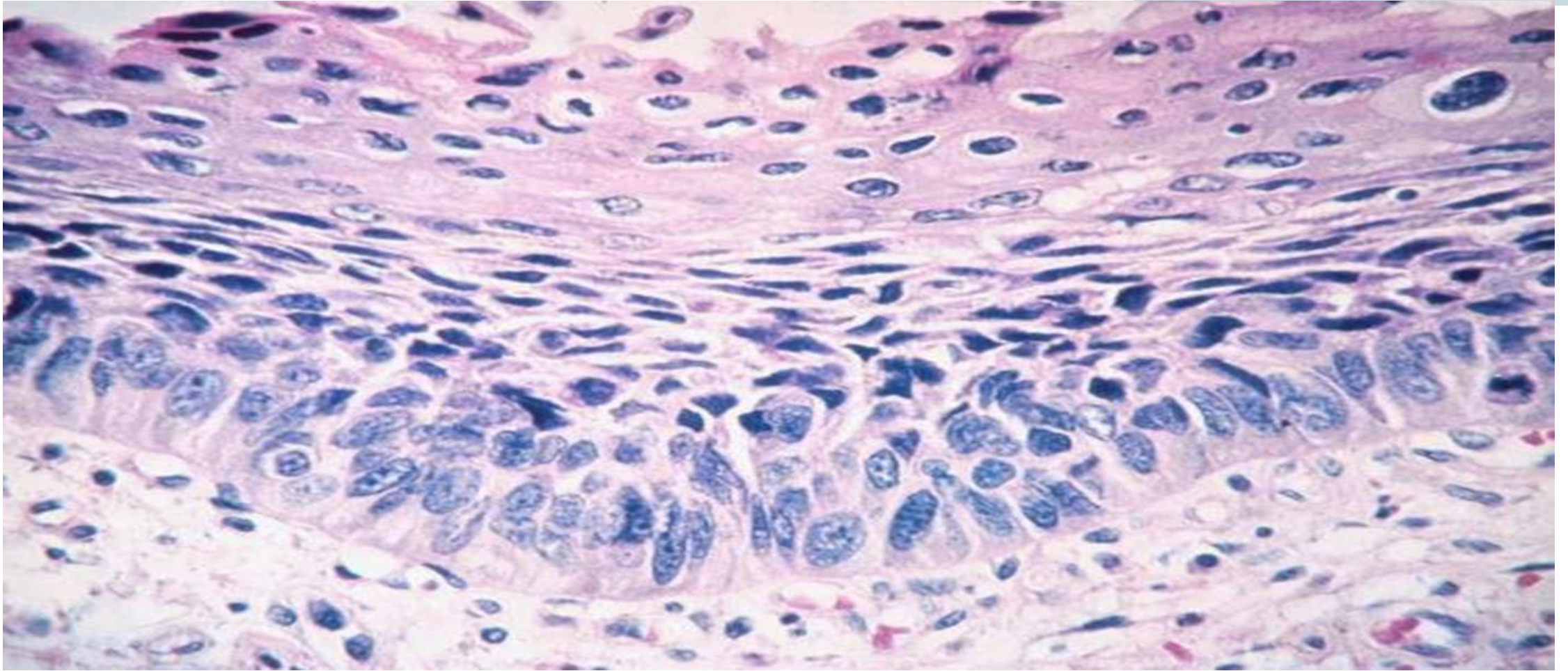
1. Columnar to squamous (Squamous metaplasia)

- In respiratory tract in response to chronic irritation (cigarette smokers) normal ciliated columnar epithelium of trachea replaced by stratified squamous epithelium
- Squamous metaplasia of resp. epithelium by vitamin A deficiency
- Stones in excretory ducts of salivary gland, pancreas, or bile duct lead to change from columnar epithelium to stratified squamous epithelium





Squamous metaplasia in bronchitis



Photomicrograph of the trachea from a smoker. Note that the columnar ciliated epithelium has been replaced by squamous epithelium.

2. Squamous to columnar metaplasia

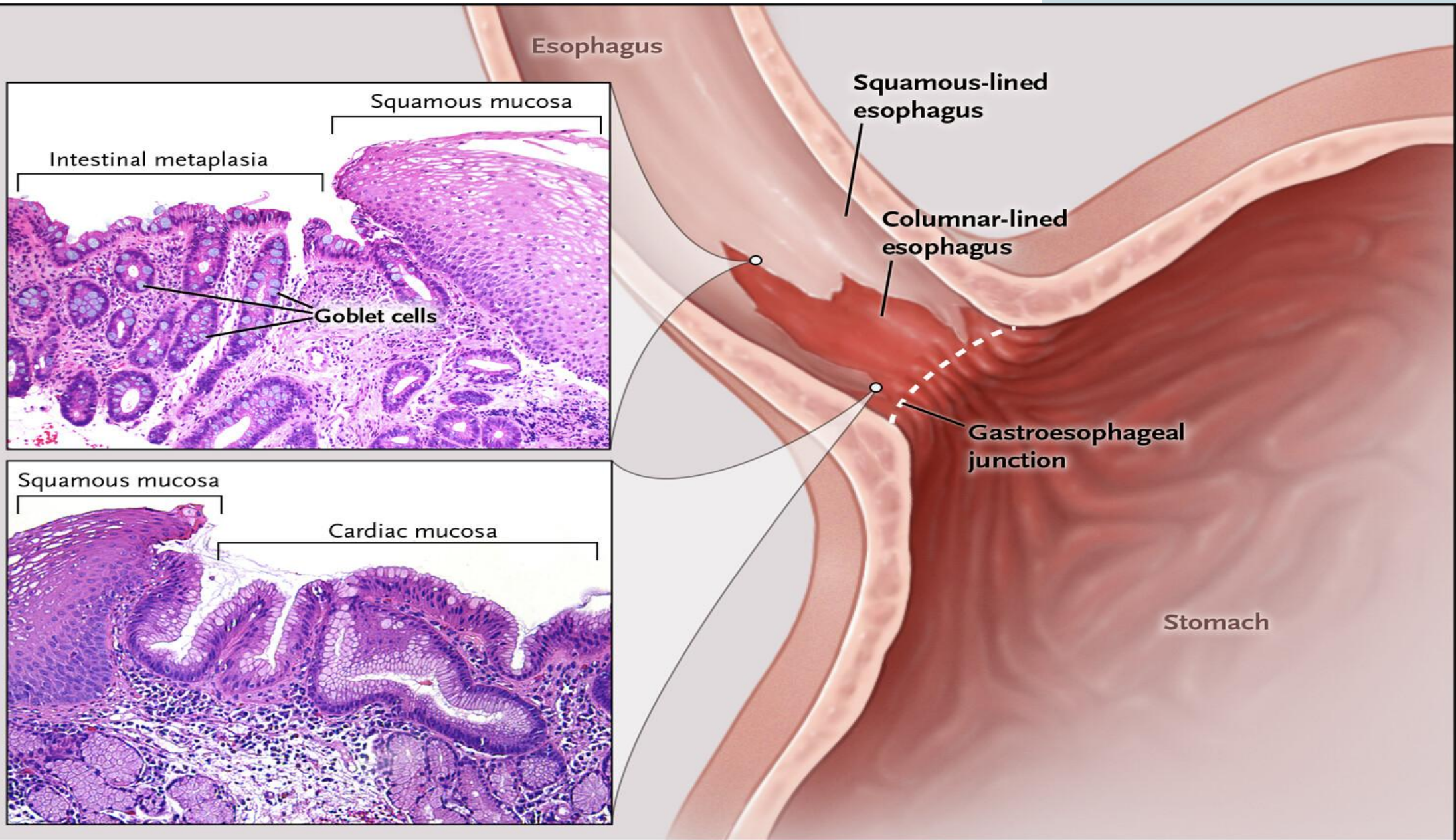
- Barrett's esophagus : esophageal squamous epithelium replaced by intestinal-like columnar cells due to refluxed gastric acid.

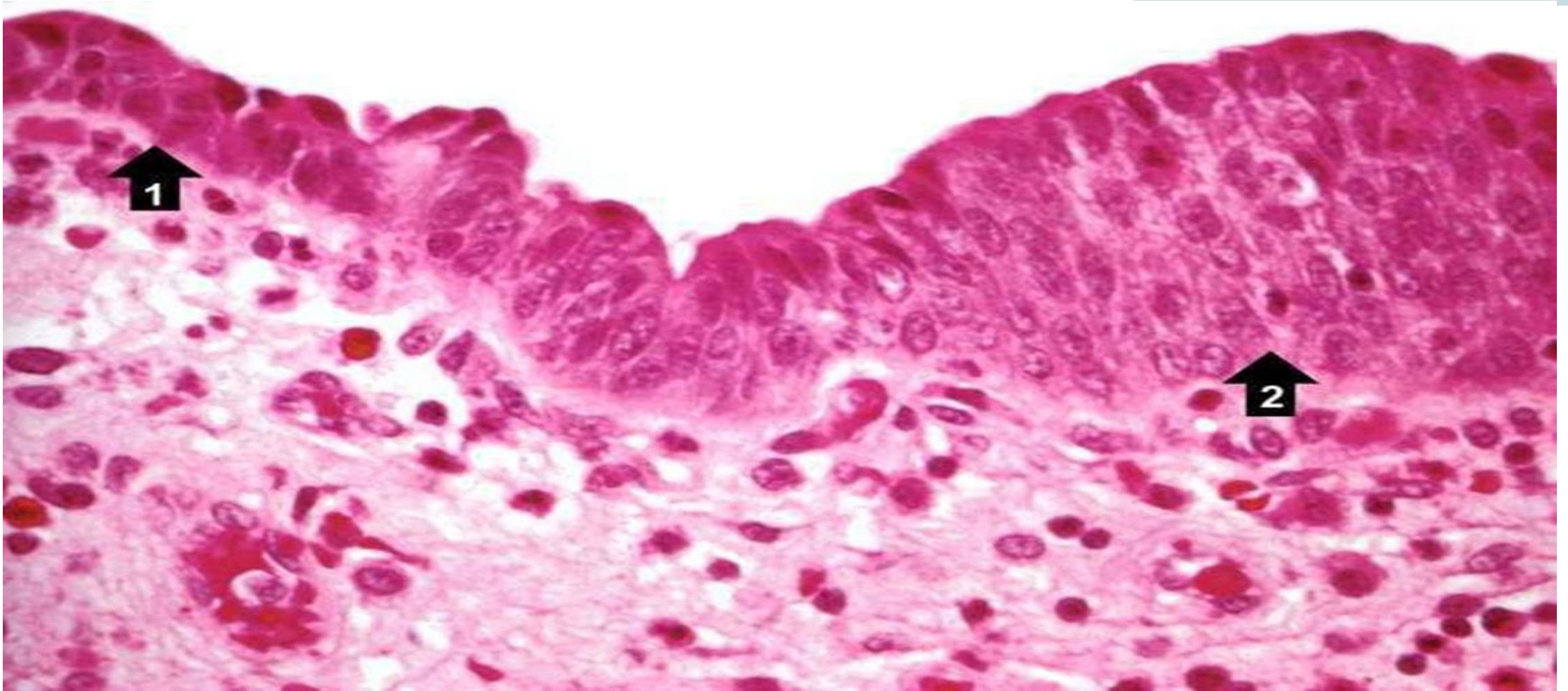
3. Connective tissue metaplasia

- Formation of bone, cartilage or adipose (mesenchymal tissue) in tissues that normally do not contain these elements
- Myositis ossificans : bone formation in muscle occasionally occurring after intramuscular hemorrhage

4. transitional epithelium to squamous

- Urothelium in response to stone





Photomicrograph of the junction of normal epithelium (1) with hyperplastic transitional epithelium (2).

References

1. Kumar, V., Abbas, A. K., & Aster, J. C. (2023). Robbins & Cotran Pathologic Basis of Disease (11th ed.). Elsevier.
2. Mitchell, R. N. (2023). Basic Pathology. Elsevier.

Any questions?

*Thank
You*