# Cellular adaptations

HYPERTROPHY

HYPERPLASIA

ATROPHY

METAPLASIA

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Maut Kya Hai !! Inhi Ajza Ka Pareshan Hona


- Process of increase in size resulting from the synthesis of specific tissue components.
- Populations, individuals, organs, cells, or even subcellular organelles such as mitochondria. :

# Types of growth in a tissue

# *Multiplicative*

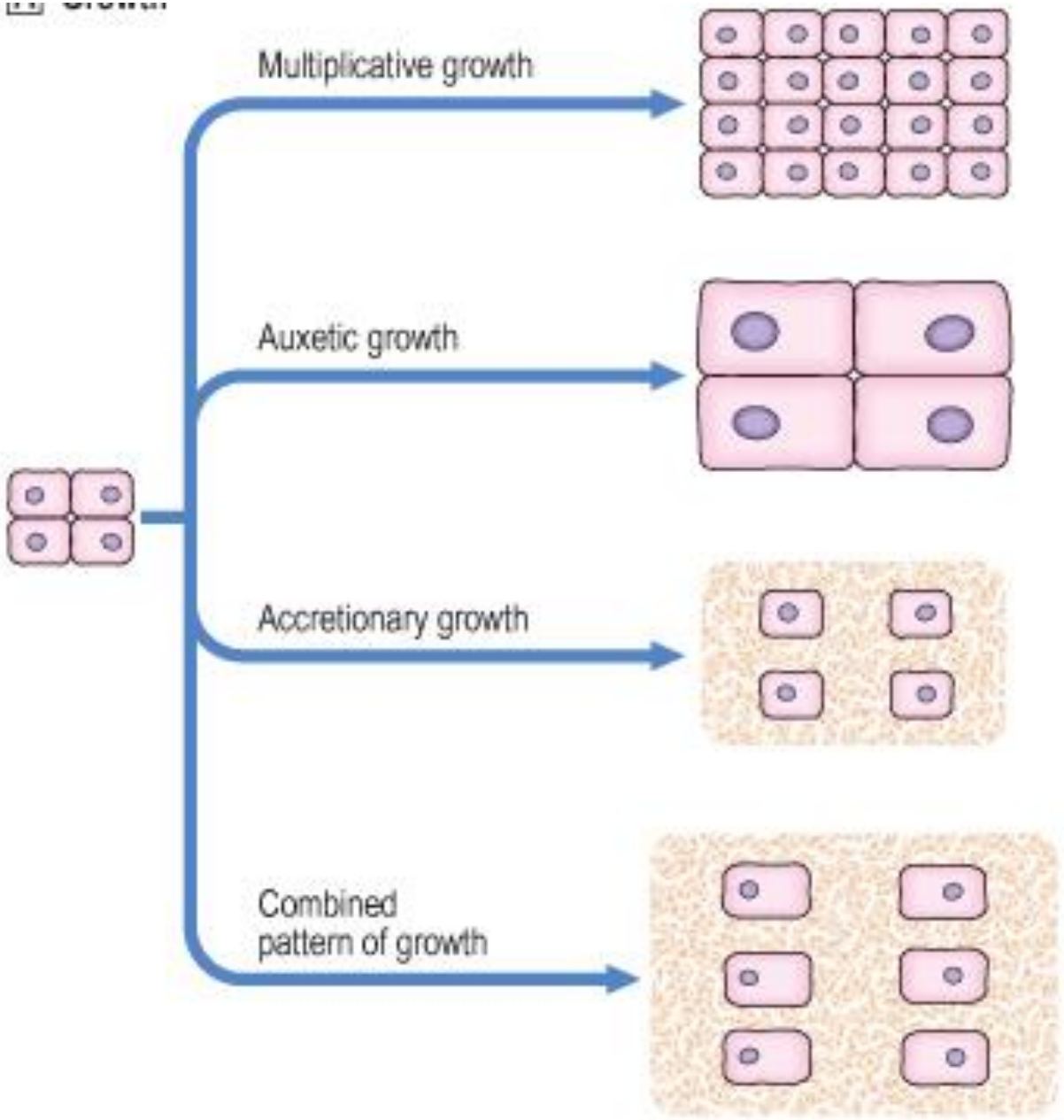
- Involving an increase in numbers of cells (or nuclei and associated cytoplasm in syncytia) by mitotic cell divisions)

- All tissues during embryogenesis

- *Auxetic*, increased size of individual cells (growing skeletal muscle)

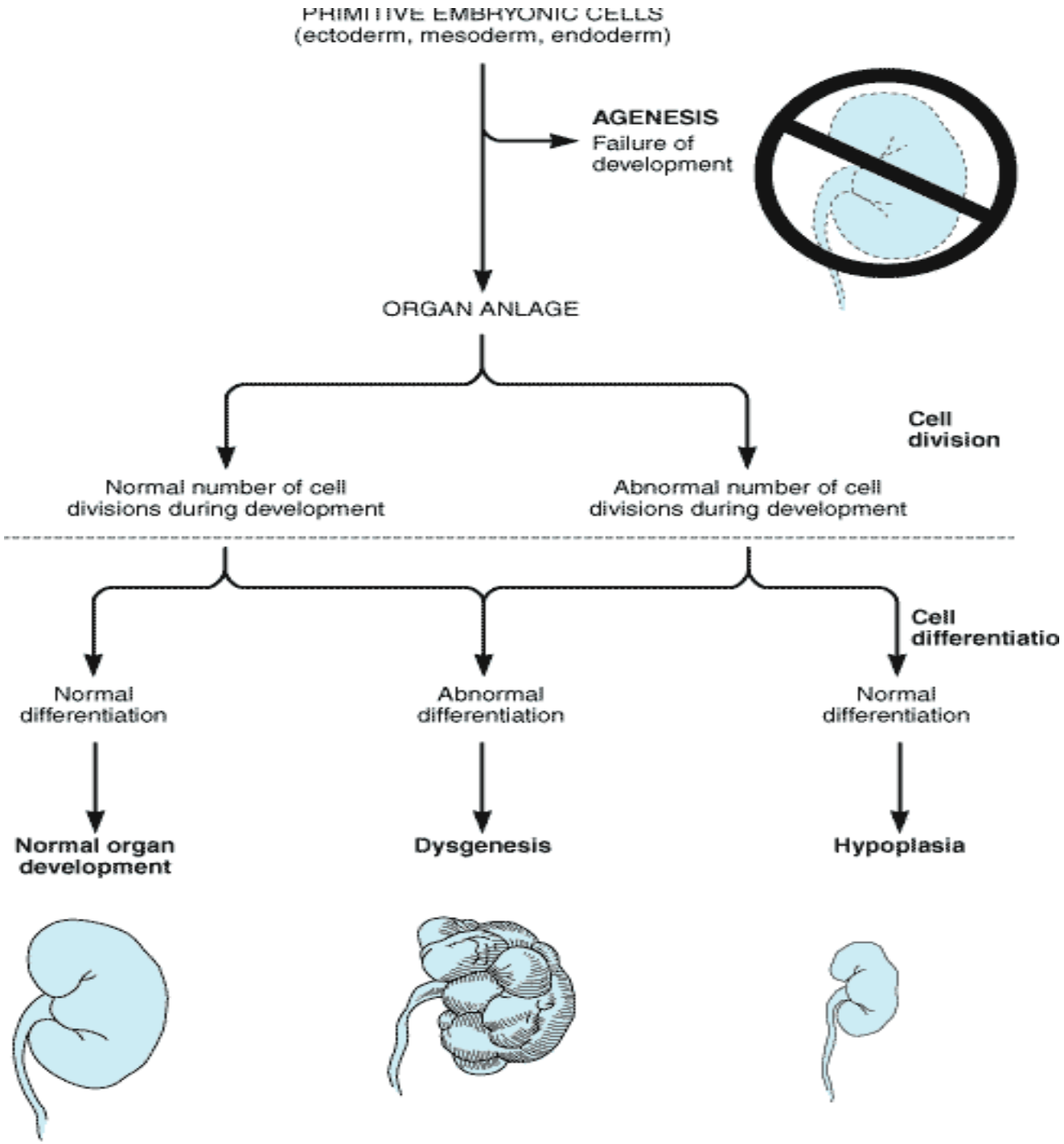
- *Accretionary*, an increase in intercellular tissue components, as in bone and cartilage.

- *Combined patterns* of multiplicative, auxetic and accretionary growth as seen in embryological development



# Normal Growth & Maturation

- Cells continue to grow, divide, and differentiate throughout life
- Labile stem cells
- Skin, as superficial keratinized cells
- Psoriasis,


PRIMITIVE EMBRYONIC CELLS
(ectoderm, mesoderm, endoderm)
AGENESIS
Failure of development
ORGAN ANLAGE
Cell division
Normal number of cell divisions during development
Abnormal number of cell divisions during development
Cell differentiatio
Normal differentiation
Abnormal differentiation
Normal differentiation
Normal organ development
Dysgenesis
Hypoplasia

# Renal dysgenesis

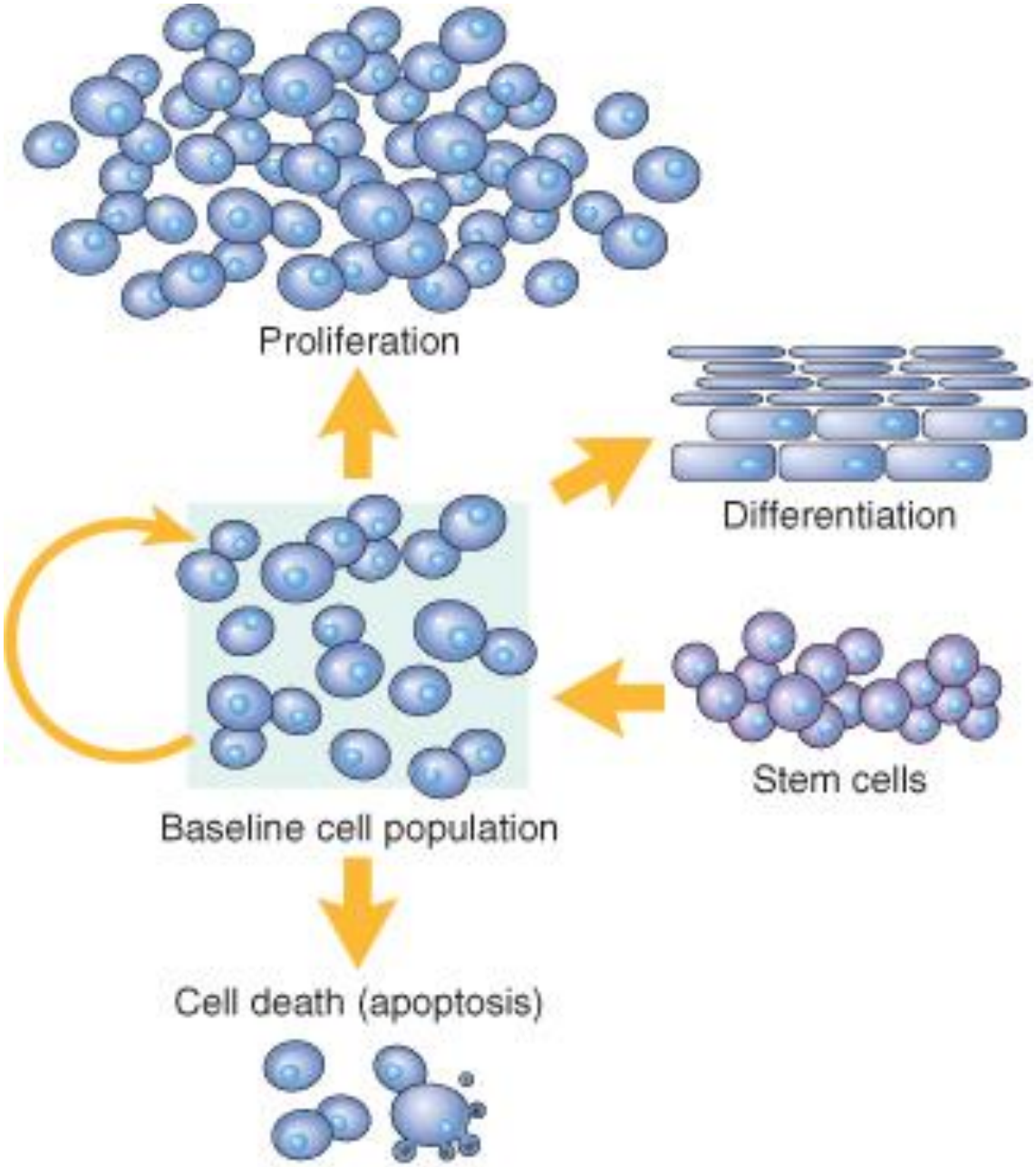
# Control of Growth

- Net balance cell proliferation ⇔ cell differentiation, leading to cell death

- The rate of proliferation

- Many of the **cellular proto-oncogenes**

# Mechanisms regulating cell populations



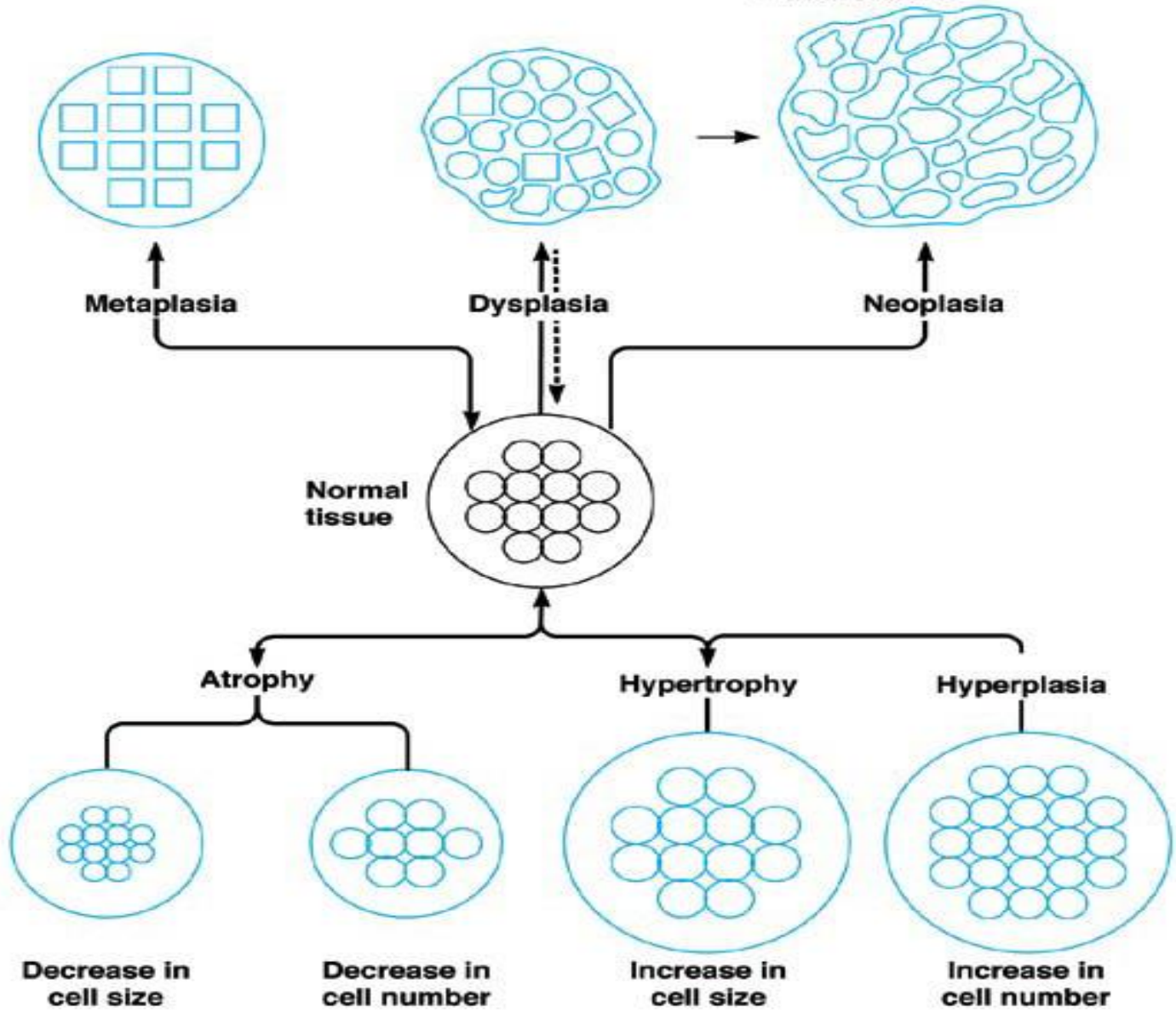
# Growth Factors: Major Categories and Families

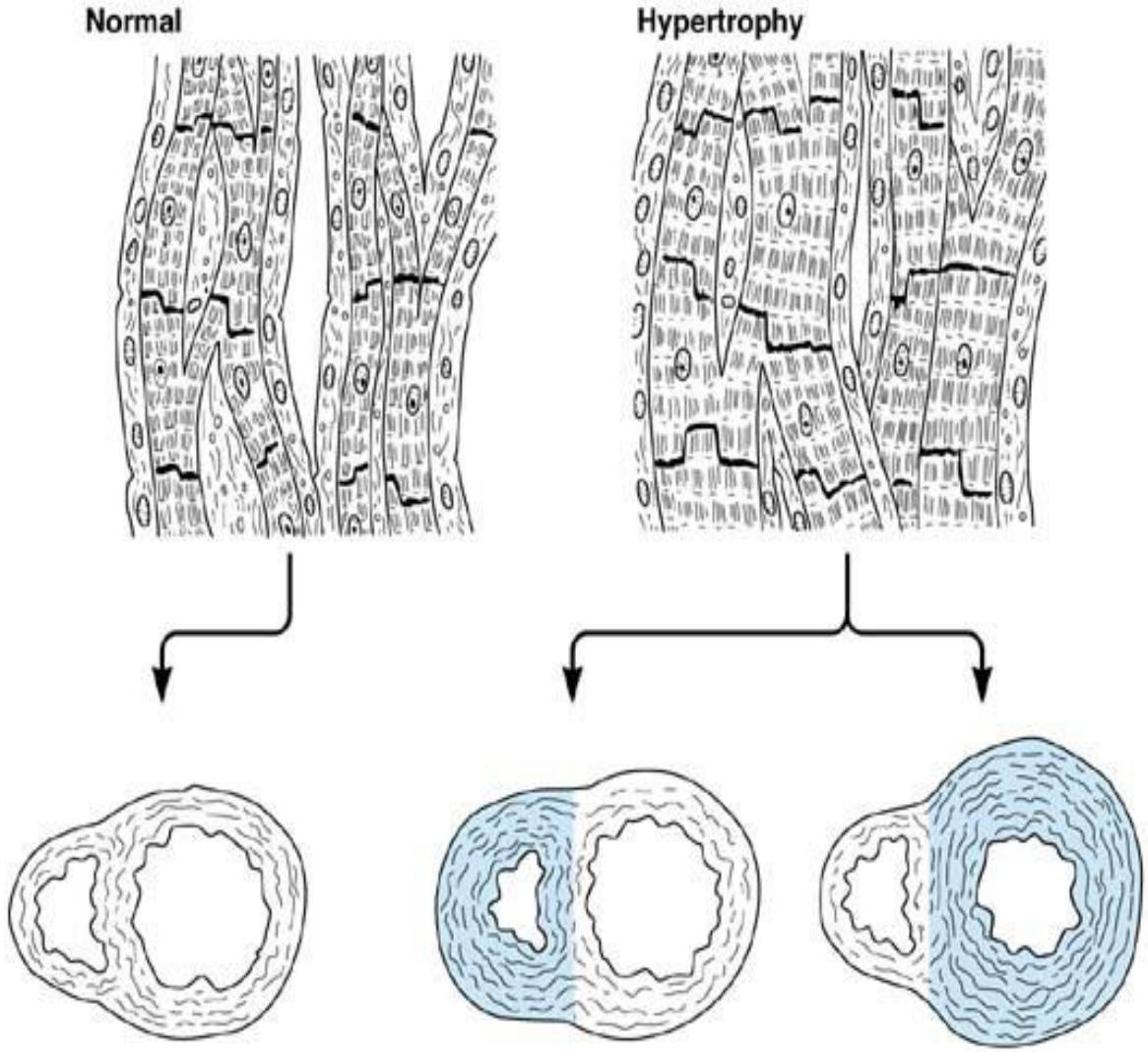
| **Major categories** |
| --- |
| *Endocrine* |
| The systemic hormones, eg, pituitary hormones, steroid hormones, thyroid hormones, insulin |
| *Paracrine* |
| Locally acting hormones, eg, the neuroendocrine system of the gastrointestinal tract |
| *Autocrine* |
| Same cell produces growth factor and corresponding receptor |
| **Families** |
| Epidermal growth factor (EGF) |
| Platelet-derived growth factor (PDGF) |
| Transforming growth factor (TGF) |
| Interleukin |
| Insulin-like growth factors |
| Fibroblast growth factors |
| The interferons |

- Abnormal differentiation
- Replacement of mature cells of one type with cells of another type
- Regular organization of tissue maintained
- Reversible

- Abnormal differentiation and maturation
- Partial loss of control and organization
- Slight increase in cell number
- Cytologic abnormalities
- **Partially reversible**

- Abnormal differentiation and maturation
- Marked increase in cell number
- Complete loss of control
- Variable loss of organization
- Cytologic abnormalities
- **Irreversible**

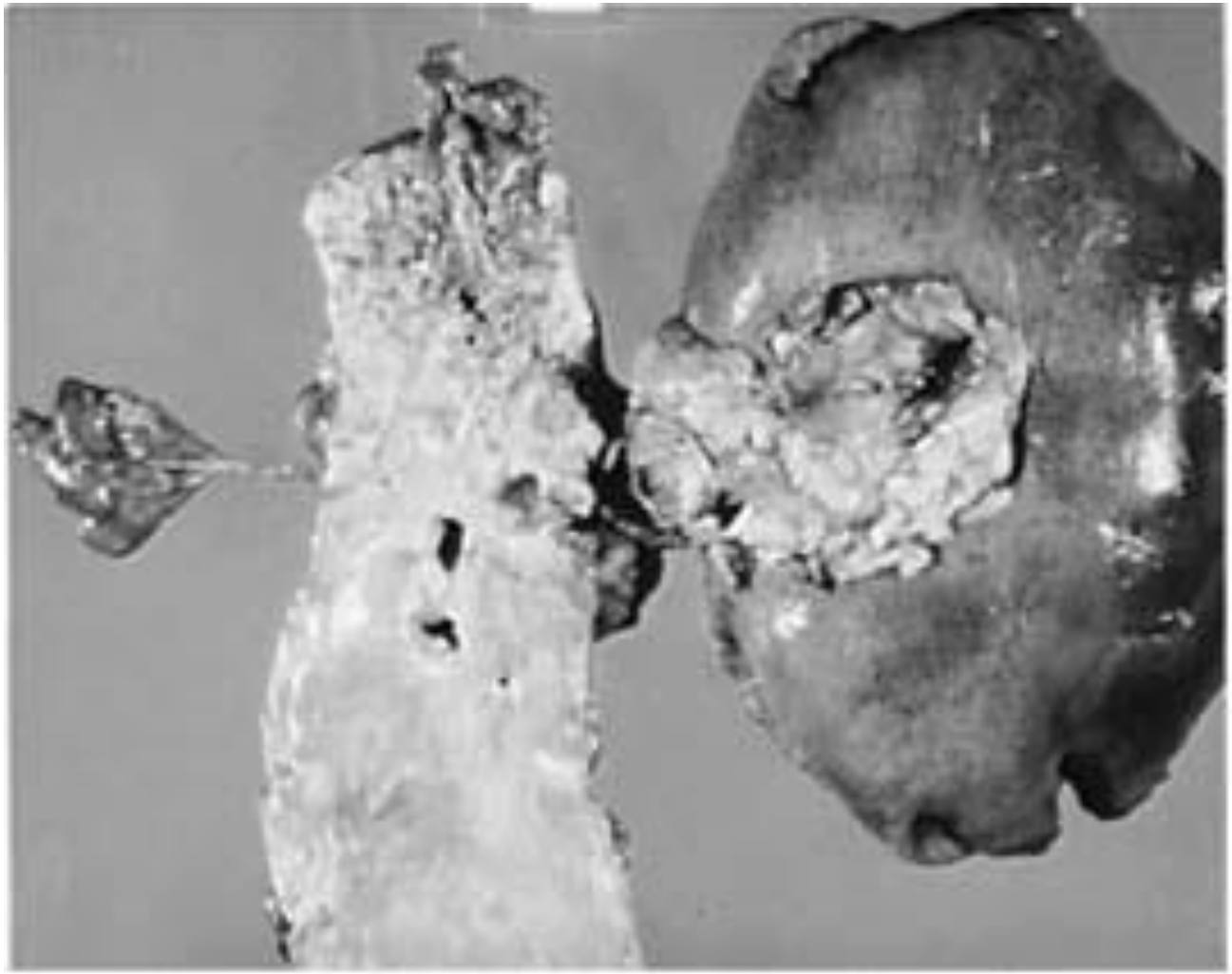



Normal
Hypertrophy

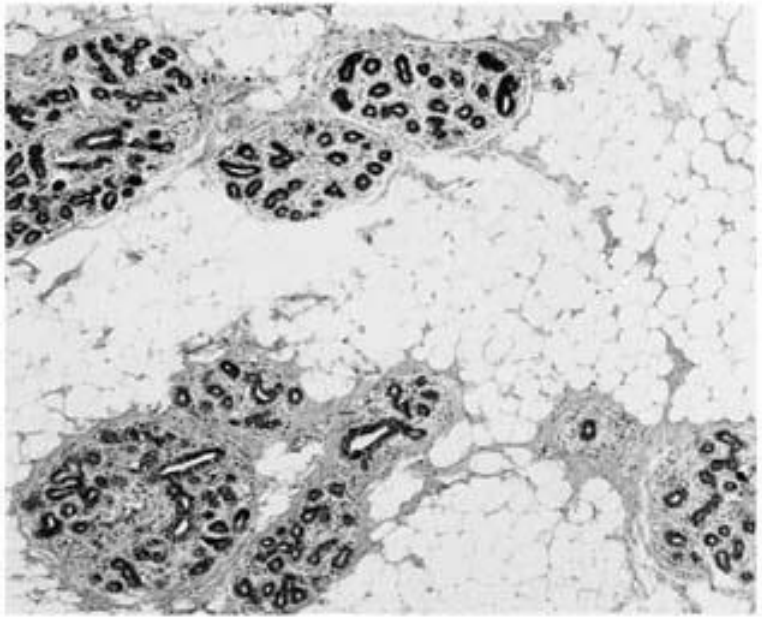
# Hypertrophy and Hyperplasia of Organs.

| Tissue | Cause of Increased Demand |
|---|---|
| Skeletal muscle hypertrophy | Physical activity, weight lifting |
| Cardiac muscle hypertrophy | Increased pressure load (high blood pressure, valve stenosis) or increased volume load (valve incompetence causing regurgitation of blood) |
| Smooth muscle (wall of intestine, urinary bladder) hypertrophy | Obstructive lesions |
| Uterine myometrial hypertrophy | Pregnancy (hormone–induced) |
| Bone marrow hyperplasia | |
| Erythroid hyperplasia | Increased destruction of erythrocytes (hemolytic process); prolonged hypoxia (living at high altitudes). |
| Breast hyperplasia | Pregnancy and lactation (hormone–induced) |

Developmental hypoplasia of one kidney associated with marked compensatory hyperplasia of the other



A



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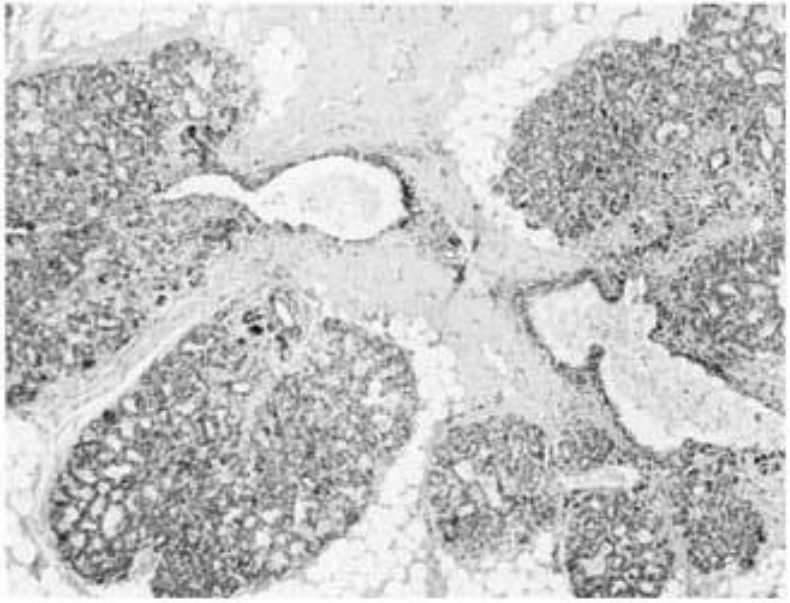


- Cells respond to increased demand and external stimulation by *hyperplasia* or *hypertrophy*,
- Respond to reduced supply of nutrients and growth factors by *atrophy*.
- Cells change from one type to another, a process called *metaplasia*.
- Some adaptations are induced by direct stimulation of cells by factors produced by the responding cells themselves or by other cells in the environment.
- Others are due to activation of various cell surface receptors and downstream signaling pathways.

# Atrophy

- Decrease in the size of a tissue or organ, resulting from a decrease either in the size of individual cells or in the number of cells composing the tissue.

- Note that atrophy, which is a decrease in size of a normally formed organ, is distinct from agenesis, aplasia, and hypoplasia, which are abnormalities of organ development.

# Causes of Atrophy

- Atrophy of Disuse
- Denervation Atrophy
- Atrophy Due to Loss of Trophic Hormones
- Atrophy Due to Lack of Nutrients
- Senile Atrophy
- Pressure Atrophy

# Atrophy Due to Loss of Trophic Hormones

- Estrogen secretion by the ovary decreases at menopause, there is physiologic atrophy of the endometrium, vaginal epithelium, and breast.

- Pituitary disease associated with decreased secretion of pituitary trophic hormones results in atrophy of the thyroid, adrenals, and gonads.

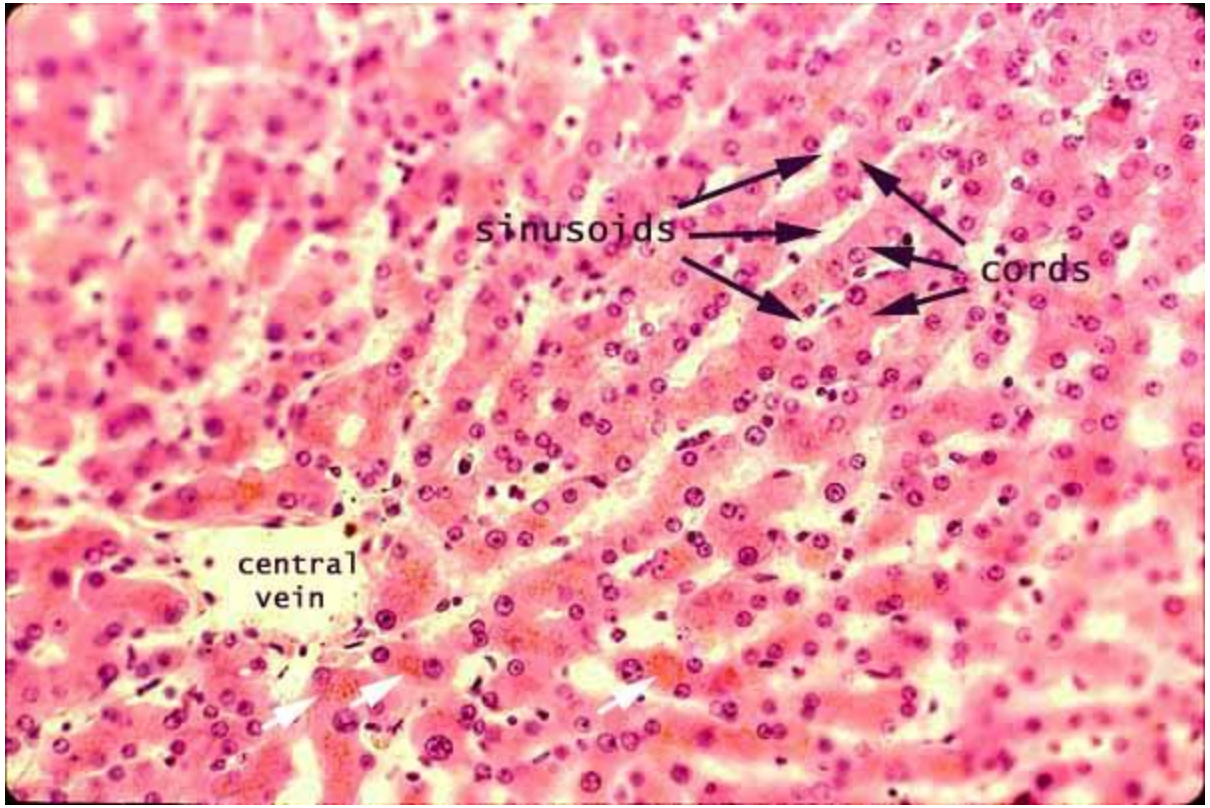
- High-dose adrenal corticosteroid therapy, which is sometimes used for immunosuppression, causes atrophy of the adrenal glands because it suppresses pituitary corticotropin secretion.

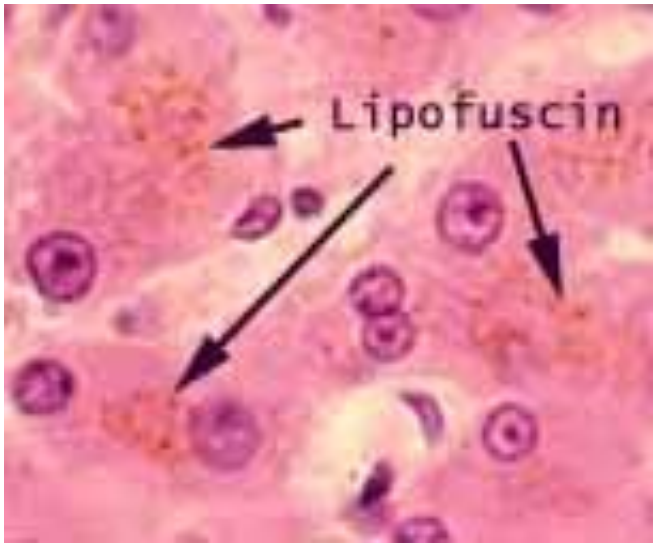
- Such patients soon lose the ability to secrete cortisol and become dependent on exogenous steroids. Withdrawal of steroid therapy in such patients must be gradual enough to permit regeneration of the atrophied adrenal.

# Reduction in the amount of cytoplasm and the number of cytoplasmic organelles

- Diminished metabolism.
- Degenerating organelles are taken up in lysosomal vacuoles for enzymatic degradation (autophagy).
- Residual organelle membranes often accumulate in the cytoplasm as brown lipofuscin pigment.

# Liver, Kidney, Heart, Muscle,Nerve Cells



# Hypertrophy and hyperplasia

- => Adaptation to increased demand.
- Controlled responses
- Demand is removed, the tissues revert toward normal.

# Hypertrophy

- Increase in the size of a tissue due to increased size of individual cells

- Tissues made up of permanent cells, in which a demand for increased metabolic activity cannot be met through cell multiplication.

# Hyperplasia

- Increase in the size of a tissue as a result of increased numbers of component cells
- Labile and stable cells.

- Not uncommonly, increased size of a tissue is due to a combination of hypertrophy and hyperplasia.

# Causes of Hypertrophy & Hyperplasia

- Hypertrophy results from increased amounts of cytoplasm and cytoplasmic organelles
- In secretory cells, the synthetic apparatus
- In contractile cells such as muscle fibers, cytoplasmic myofibrils

- **Hyperplasia** results when cells of a tissue are stimulated to undergo mitotic division, thereby increasing the number of cells.

# Pathologic Hypertrophy and Hyperplasia

- Absence of an appropriate stimulus of increased functional demand. **Myocardial hypertrophy,** if it occurs without recognizable cause

- Such hypertrophy is frequently associated with abnormal cardiac function, producing **cardiomyopathy**

# Endometrial hyperplasia

- Increased estrogen stimulation
- Near menopause.

- Excessive trophic hormones => hyperplasia of the target organs
- Excessive secretion of ACTH => **bilateral adrenal hyperplasia.**
- Increased function. In the case of the adrenal gland,
- (Cushing's syndrome)

- **Thyroid hyperplasia (goiter; Graves' disease)** increased TSH stimulation of the thyroid or from the action of autoantibodies that are able to bind to TSH receptors in thyroid cell membranes

- **Hyperplasia of the prostategland**

# Abnormal Growth Principally Involving Differentiation: Metaplasia

- Varied potential for differentiation
- Germinative stem cells
- Differentiate in a manner that is abnormal for that location
- Following chronic physical or chemical irritation.

# Squamous metaplasia

- —The most common type of epithelial metaplasia—
- Nonsquamous pseudostratified columnar/cuboidal epithelium => normal-appearing stratified squamous epithelium

## Glandular metaplasia

- Esophagus, where the normal squamous epithelium => glandular, mucus-secreting epithelium
- Stomach and intestine,
- Intestinal metaplasia
- Gastric metaplasia

- Rarely occurs in mesenchymal tissue and is best exemplified by osseous metaplasia in scars and other fibroblastic proliferations.

- Potential for diverse differentiation of mesenchymal stem cells.

# Functional deficits

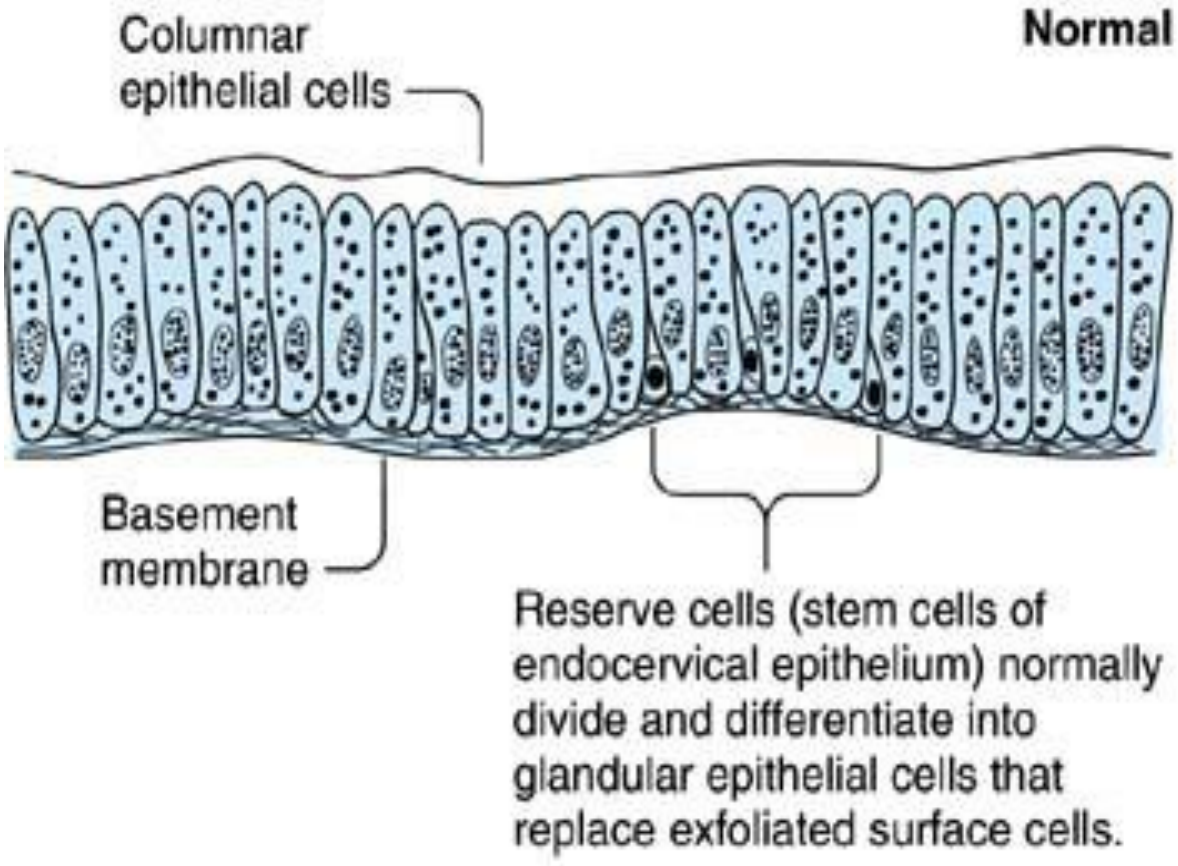
- Loss of cilia and of mucus production in the bronchi may predispose to development of infection.

- Metaplastic tissue is structurally normal and itself carries no increased risk of development of cancer. However, **dysplastic changes** are often present as well , and cancer does occur in metaplastic epithelia under such circumstances.

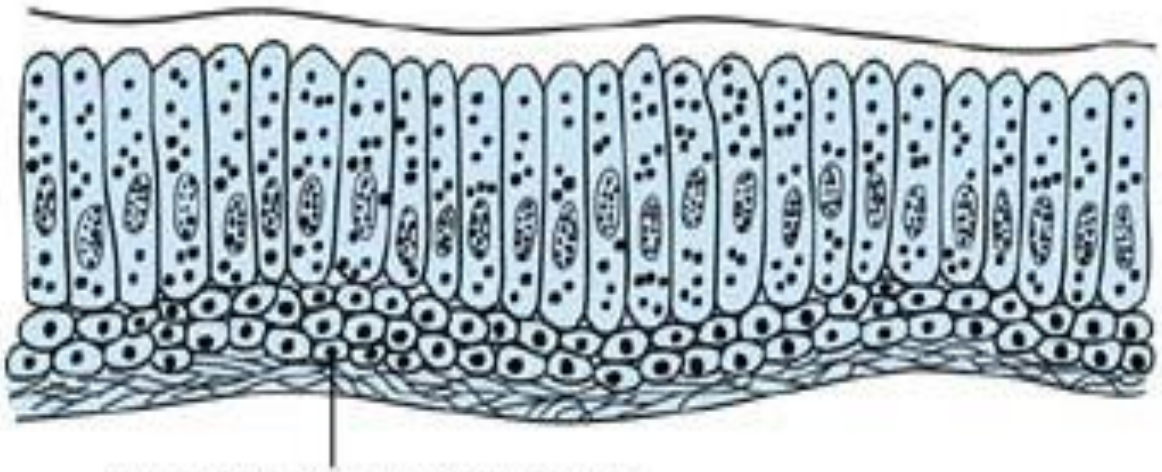
- Squamous carcinoma develops in metaplastic squamous epithelium in the bronchus, and adenocarcinoma may arise in the esophagus from metaplastic glandular epithelium.

# Abnormal Growth Principally Involving Differentiation: Metaplasia

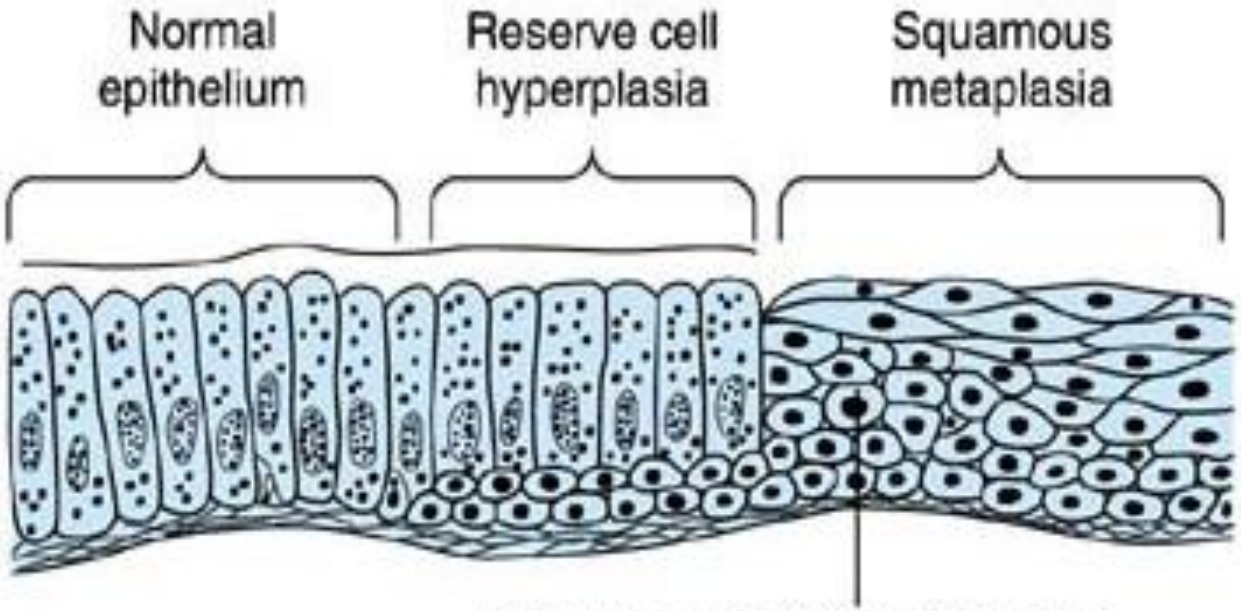
| Type of Metaplasia | Site | Causative Factors |
|---|---|---|
| **Epithelial metaplasia** | | |
| Squamous metaplasia | Multiple sites<br>Bronchus<br><br>Endocervix<br>Urinary bladder | Vitamin A deficiency<br>Cigarette smoking, chronic inflammation<br>Chronic inflammation<br>Chronic inflammation, schistosomiasis |
| Intestinal metaplasia | Esophagus<br>Stomach | Acid reflux<br>Alkaline reflux, chronic inflammation |
| Gastric metaplasia | Esophagus Intestine | Acid reflux Unknown |
| Serous or mucinous metaplasia | Germinal epithelium of ovary | Trauma of multiple ovulation |
| **Mesenchymal metaplasia** | | |
| Osseous metaplasia | Fibrous scars Areas of calcification | Unknown<br>Unknown |
| Myeloid metaplasia | Spleen, liver | Unknown |


Columnar
epithelial cells
Normal
Basement
membrane
Reserve cells (stem cells of
endocervical epithelium) normally
divide and differentiate into
glandular epithelial cells that
replace exfoliated surface cells.

# Hyperplasia

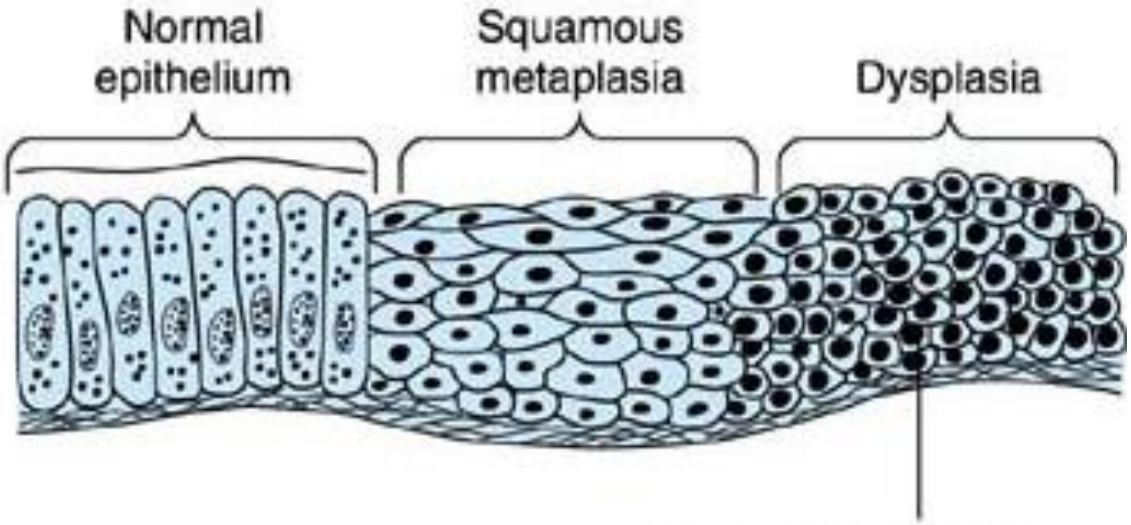


Hyperplastic reserve cells differentiate into normal glandular epithelial cells.



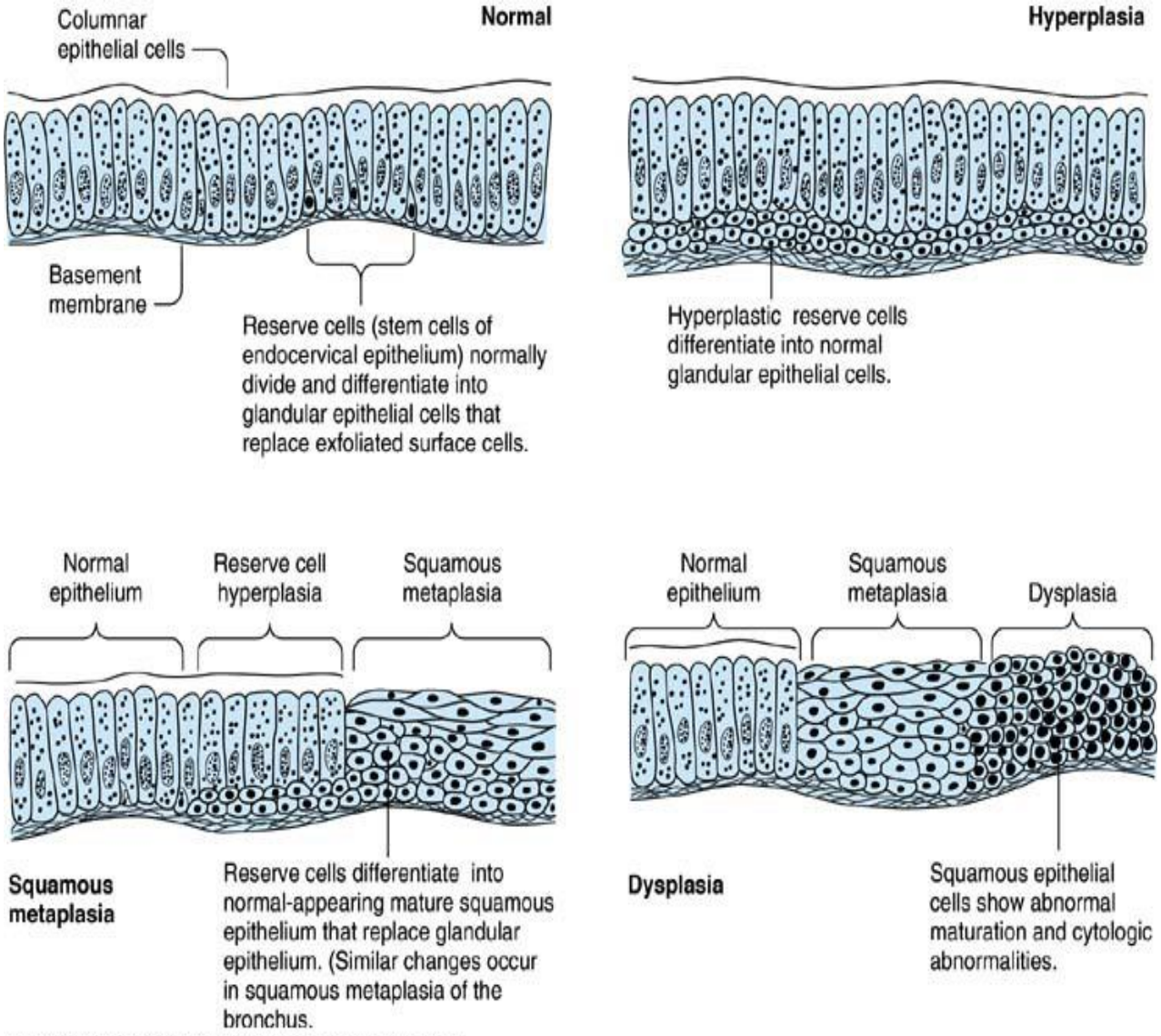

**Squamous metaplasia**

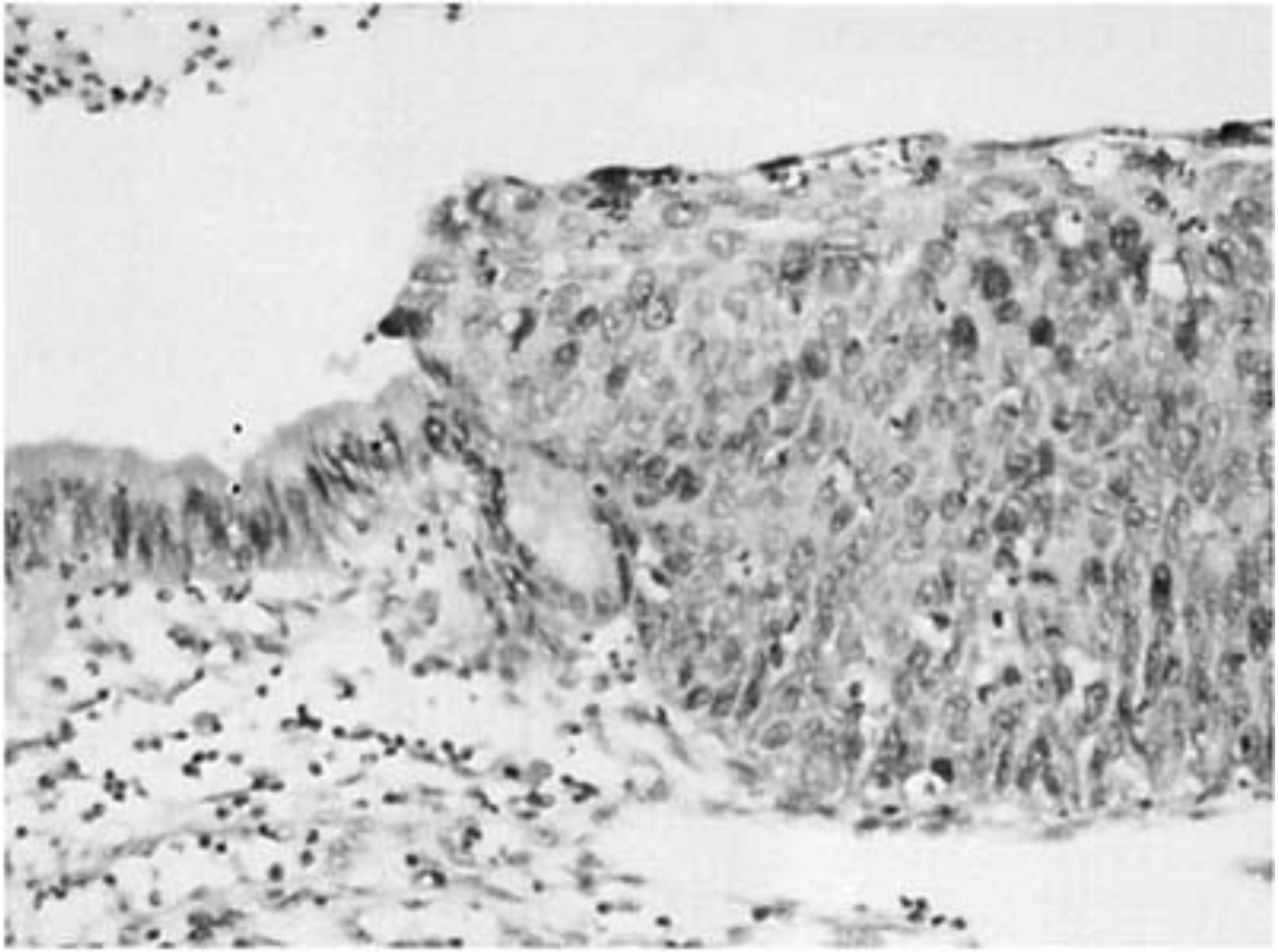
Reserve cells differentiate into normal-appearing mature squamous epithelium that replace glandular epithelium. (Similar changes occur in squamous metaplasia of the bronchus.




**Dysplasia**

Squamous epithelial cells show abnormal maturation and cytologic abnormalities.





The world is a tragedy to those who feel, but a comedy to those who think