

Lecture-2

ADAPTATION

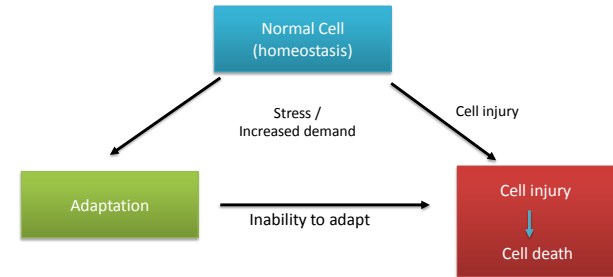
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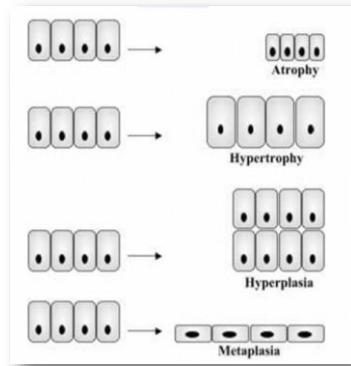
ALTERED CELLULAR AND TISSUE BIOLOGY



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ALTERED CELLULAR AND TISSUE BIOLOGY

- Cellular adaptation
 - Atrophy
 - Hypertrophy
 - Hyperplasia
 - Metaplasia



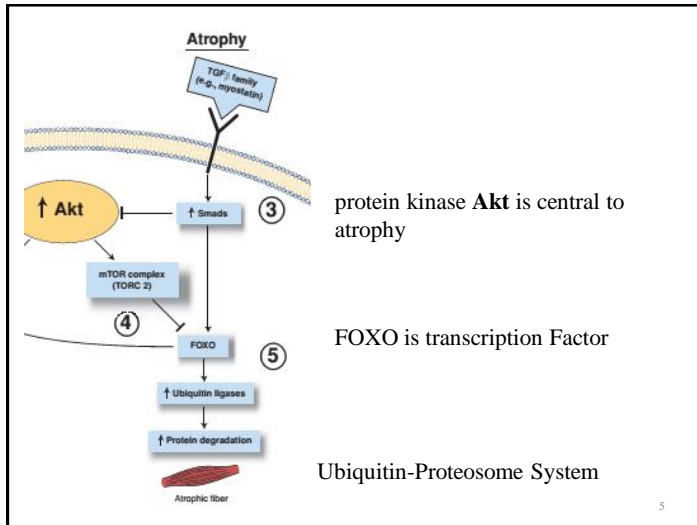
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ATROPHY

- Decrease in size of an organ or tissue
- Cell Atrophy
- Causes of atrophy include
 - Mutations
 - Excess apoptosis
 - reduction in the work load
 - loss of nerve supply,
 - loss of endocrine stimulation,
 - reduced blood supply,
 - inadequate nutrition,
 - pressure
 - certain disease conditions and Aging



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Reduction in structural components

Decreased number of mitochondria, myofilaments, ER via proteolysis (lysosomal proteases; ubiquitin-proteasome system)

Increase in number of autophagic vacuoles

Residual bodies (i.e., lipofuscin → brown atrophy)

- catabolic processes exceed anabolic processes
- Autophagy ("self-eating") is the process in which the starved cell eats its own components in an attempt to find nutrients and survive.

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Atrophy

Physiologic atrophy:

- Occurs due to a normal stressor.
 - For example, decrease in the size of the uterus after pregnancy.

Pathologic atrophy:

- Occurs due to an abnormal stressor.
 - In general, atrophy is due to the loss of stimulus to the organ.
 - Specific types of loss of stimulus include loss of blood supply or innervation, loss of endocrine stimulus etc.

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Atrophy

Microscopically,

- cells in certain tissues may be **fewer** (numerical) or **smaller** than normal (quantitative atrophy).
- In **spleen**, the trabeculae may appear prominent/large or too numerous due to loss of parenchyma (lymphocytes).
- in **kidneys**, the glomeruli may appear too numerous and closely placed due to the loss of renal tubules.
- In **uterine atrophy**, reduction in endometrial glands with abundance of connective tissue.
- In **atrophic muscles**, the sarcoplasm becomes thinner and eventually disappears leaving sarcolemma, the membrane.
- Nuclei become pyknotic and persist in linear arrangement in the destroyed myofibers.

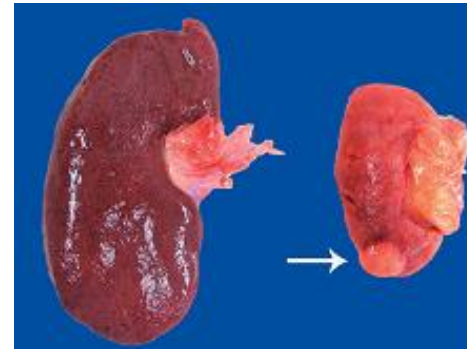
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Atrophy

Grossly,

- the organ or part of the organ appears **smaller** than normal.
- Such a change is well appreciated in **paired** organs where one organ is reduced in both size and weight compared with its counterpart.
- If **both the organs** are atrophied, which is a rarity but can occur, then we need to compare these organs with the size and weight of a normal animal of same age, sex, breed and specie.
- If an organ has a **capsule**, the wrinkled or undulating capsule may be the most obvious indication of the atrophy.

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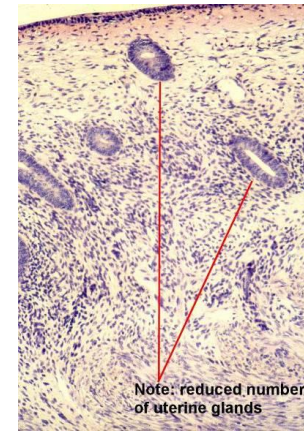
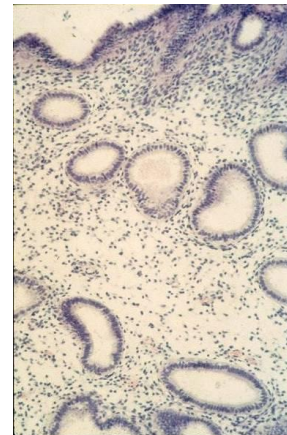
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Atrophy

Microscopically,

- **Lipochrome** pigments develop and persist in some myofibers, especially in the cow.
- In **liver**, the hepatic cords become thinner and sinusoids appear widened.
- In **atrophied organs**, the missing cells may get replaced by adipose tissue (**fatty atrophy**) as in physiologic atrophy of the thymus or may be replaced by proliferating fibrous connective tissue (**fibrous atrophy**).

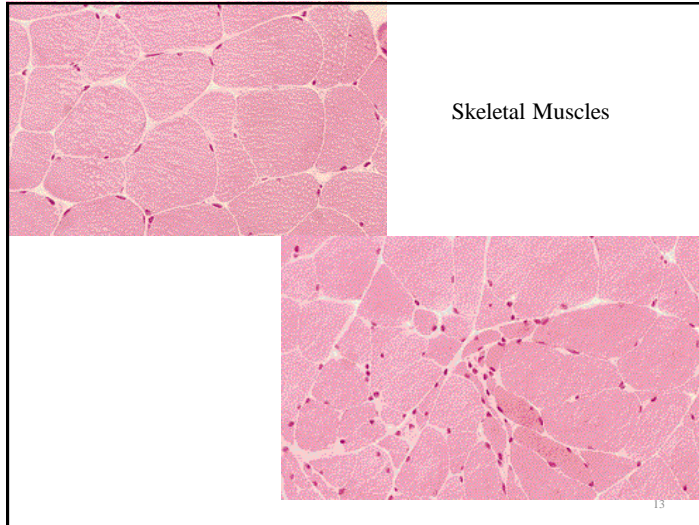
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Note: reduced number of uterine glands

Uterine Endometrium

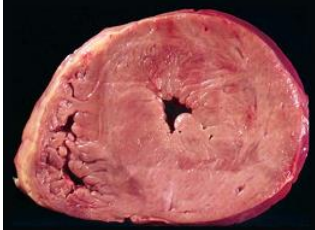
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HYPERTROPHY

(from Greek "excess" + "nourishment")

- Increase in size of tissue or organ
- Examples - enlarged heart or kidney
- Enlargement is due to an increase in organelles not in the increase of intracellular fluid



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Hypertrophy

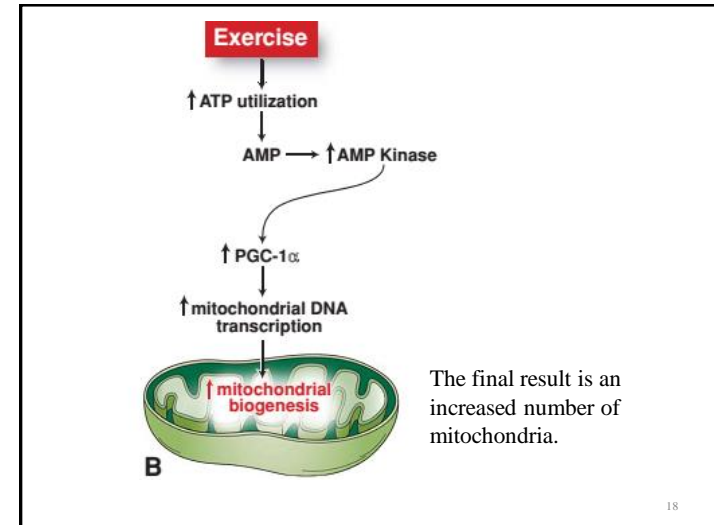
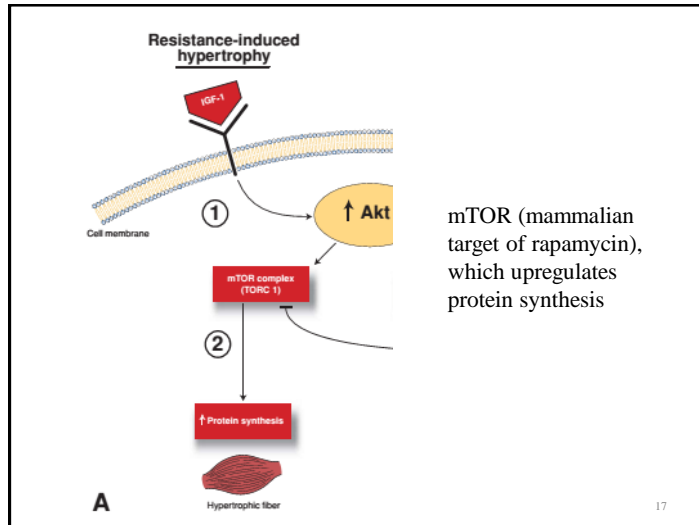
- **Liver** cells have increase amounts of **endoplasmic reticulum**
- Hypertrophy in **skeletal** muscles in weight lifters have increase amounts of myofibrils
- **Uterine** smooth muscles undergo hypertrophy during pregnancy under hormonal stimulation.
 - The cellular enlargement is stimulated by **estrogenic hormones** acting on smooth muscle estrogen receptors, eventually resulting in increased synthesis of smooth muscle proteins and an increase in cell size.

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Hypertrophy

- In female animals, the acinar cells of the **mammary** gland undergo marked hypertrophy in late pregnancy.
- **missing of one organ** in paired organs, e.g., missing or removal of one kidney.
- Hypertrophic growth can be seen within **24-hours** and reach the maximum by **5-days**.
- It appears that the hypertrophying muscle produces **autocrine growth factors**.
- The stretching of skeletal muscle results in the activation of **intracellular signaling molecules**.

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(Mechanisms)

- one of the first responses is accelerated degradation of selected cellular proteins
 - proteins that do not contribute to the need for hypertrophy are removed,
 - production of proteins that promote hypertrophy tends to increase
 - Increased protein translation
 - production of certain proteins increases.
 - Increased gene expression
 - Concentrations of key proteins are also elevated by transcriptional upregulation of their genes.
 - Survival
 - cell death is inhibited.
 - stimulation of specific receptors activates several enzymes (e.g., Akt, PI3K; see below) that promote cell survival largely by inhibiting programmed cell death
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Hypertrophy (Mechanisms)

- Extracellular matrix
 - In some situations hypertrophy involves changes in a cell's environment, such as remodeling extracellular matrix.
 - Recruitment of satellite cells
 - Skeletal muscle hypertrophy includes recruiting perimuscular satellite cells that fuse with myocyte syncytia to provide additional nuclei that support the expanded protein synthetic needs
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Hypertrophy

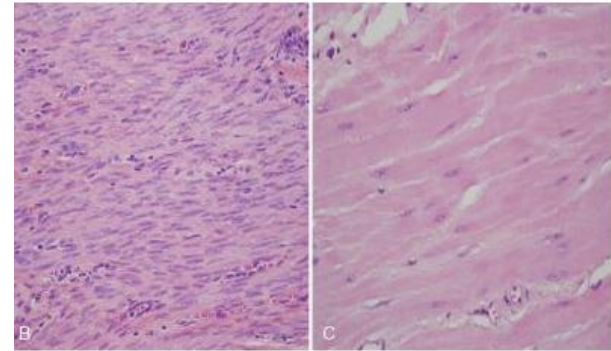
Microscopically,

- the cells appear larger.
- however, the change of enlarged cells may be difficult to appreciate unless compared with cells of the other similar organ or with organ of another animals of same age.

Grossly,

- Organs or tissues appear enlarged.
- The change can be appreciated in paired organs.
- In cardiac hypertrophy, the ventricular wall of the heart becomes thickened.

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Normal

Hypertrophied

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Hypertrophy

Significance of Hypertrophy

- Hypertrophy is a protective mechanism
- A response to an increased functional demand.
- however, the enlarged organ may cause mechanical hindrance in the function of certain closely associated organs.
- If the stimulus is removed which caused the hypertrophy, the organ or tissue regresses, although the previous size is rarely attained.

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*Great Spirits
Have Always Encountered
Violent Opposition From
Mediocre Minds*

ALBERT EINSTEIN

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