CELLULAR ADAPTATION TO STRESS

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Adaptations are reversible changes in the number, size, phenotype, metabolic activity, or functions of the cells in response to changes in their environment.

Physiological adaptations: usually represent responses of cells to normal stimulation by hormones or endogenous chemical mediators e.g. (hormone – induced enlargement of the breast and uterus during pregnancy).
Pathologic adaptations: are responses to stress that allow cells to modulate their structure and functions and thus escape injury. Such adaptation can take several distinct forms:

- Hypertrophy.
- Hyperplasia.
- Atrophy.
- Metaplasia.
Hypertrophy

- Hypertrophy is an increase in the size of cells resulting in increase in the size of the organ. In pure hypertrophy there are no new cells, just bigger cells, enlarged by an increased amount of structural proteins and organelles. It occurs when cells are incapable of dividing.

- Hypertrophy can be physiologic or pathologic and is caused either by increased functional demand or by specific hormonal stimulation e.g. hypertrophy of the uterus during pregnancy.
Hyperplasia is an increase in cell number; it is an adaptive response in cells capable of replications. Hyperplasia can be divided into two main groups:

1. Physiologic hyperplasia: Hormonal hyperplasia such as proliferation of glandular epithelium of the female breast at puberty and during pregnancy. Compensatory hyperplasia; is occurred when a portion of the tissue is removed or diseased such as partially resected liver.
2. Pathologic hyperplasia:

- Are caused by excessive hormonal or growth factor stimulation e.g. after normal menstrual period there is a burst of uterine epithelial proliferation that is normally tightly regulated by stimulation through pituitary hormones and ovarian oestrogen and by inhibition through progesterone.
Atrophy

Atrophy is the shrinkage of cell by the loss of cell substances, when a sufficient number is involved, the whole tissue or organ diminishes in size, becoming atrophic.
Causes of atrophy

- Decrease work load.
- Loss of innervations.
- Diminished blood supply.
- Inadequate nutrition.
- Loss of endocrine stimulation.
- Aging (senile atrophy).
Some of these stimuli are physiologic such as loss of hormonal stimulation in (menopause), while other may be pathologic such as (denervation).

Atrophy result from decreased protein synthesis and increased protein degradation in cell.
Metaplasia is a reversible change in which one adult cell type (epithelial or mesenchymal) is replaced by another adult cell type. In this type of cellular adaptation, cells sensitive to a particular stress are replaced by another cell type better able to withstand the adverse environment.

Metaplasia is thought to arise by genetic reprogramming of stem cells rather than trans-differentiation of already differentiated cells.
Epithelial Metaplasia is exemplified by the squamous change that occurs in the respiratory epithelium in habitual cigarette smokers. The normal ciliated columnar epithelium cells of the trachea and bronchi are focally or widely replaced by stratified squamous epithelium.
Intracellular accumulations

Under some circumstances cells may accumulate abnormal amounts of various substances, which may be harmless or associated with varying degrees of injury. The substance may be located in the cytoplasm, within organelles (typically lysosomes), or in the nucleus, and it may be synthesized by the affected cells or may be produced elsewhere.
There are various pathways of abnormal intracellular accumulations, these are:

- A normal substance is produced at a normal or an increased rate, but the metabolic rate is inadequate to remove it. An example of this type of process is fatty change in the liver.

- A normal or an abnormal endogenous substance accumulates because of genetic or acquired defects in its folding, packaging, transport, or secretion.
Mutations that cause defective folding and transport may lead to accumulation of proteins (e.g., α₁-antitrypsin deficiency). An inherited defect in an enzyme may result in failure to degrade a metabolite. The resulting disorders are called storage diseases.

An abnormal exogenous substance is deposited and accumulates because the cell has neither the enzymatic machinery to degrade the substance nor the ability to transport it to other sites. Accumulations of carbon or silica particles are examples of this type of alteration.
The End

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