

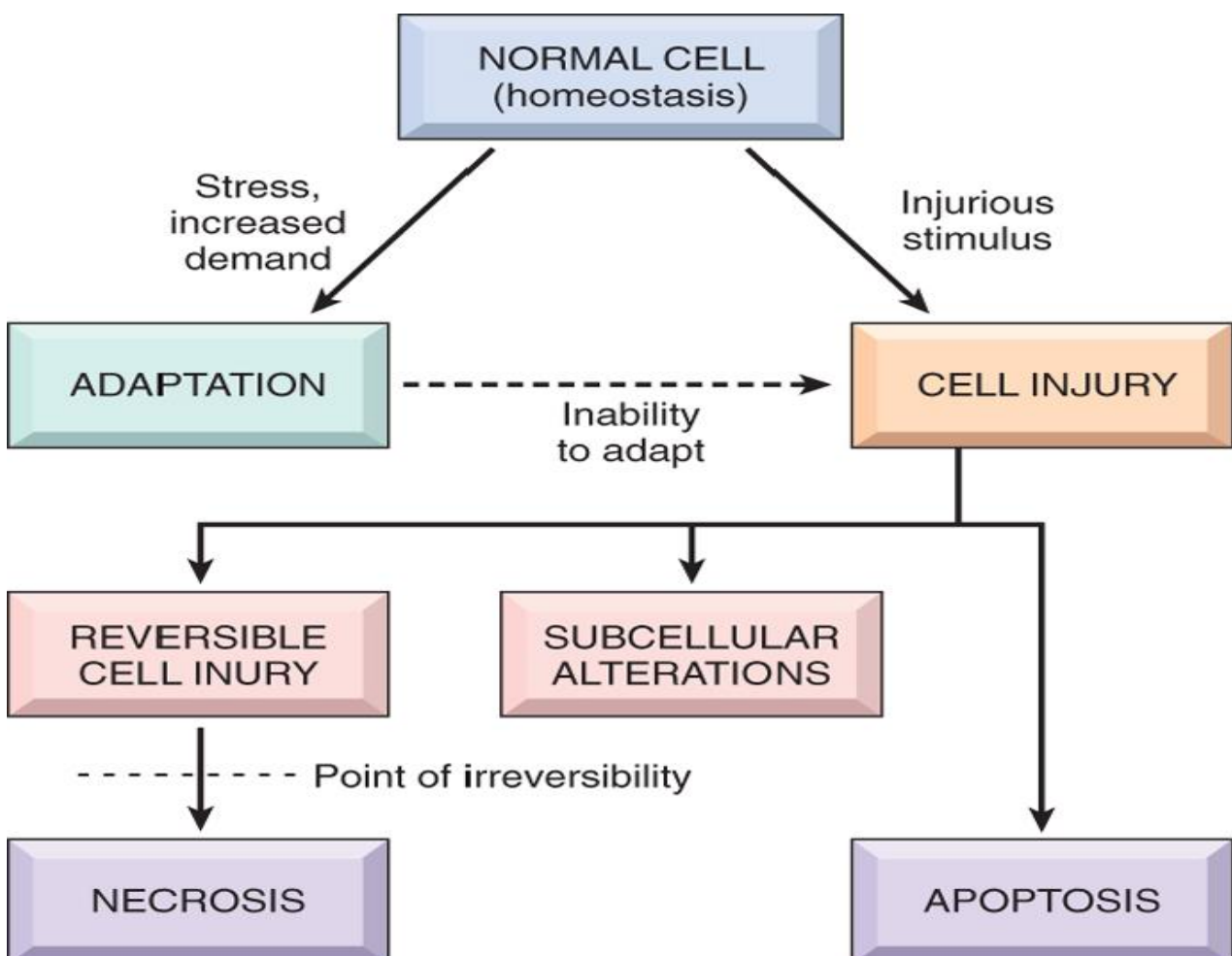
Cell Injury, Cell Death, and Adaptation

Cellular responses to stress and injurious stimuli:

Cells are the active part in their environment, maintaining normal homeostasis (staying stable) and adjusting their structure and function to accommodate any changes or extracellular stresses. Any physiologic stresses or pathologic stimuli on the cells, they can undergo **adaptation**, achieving a new steady state and preserving viability and function.

Types of adaptation are: **Hypertrophy, Hyperplasia, Atrophy and Metaplasia.**

If the adaptive capability is exceeded or if the external stress is harmful, **cell injury** develops.



Cell injury is of two type:

1- Reversible injury: The cells return to a stable state.

2- Irreversible injury: Severe or persistent stress results in **cell death**.

Cellular adaptations to stress:

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

1- Physiologic adaptations: Responses of cells to **normal stimulation** by hormones or endogenous chemical materials, e.g.: the hormone-induced enlargement of the breast and uterus during pregnancy.

2- Pathologic adaptations: Responses to **stress** that allow cells to modulate their structure and function and thus escape injury.

Types of adaptations:

1- Hypertrophy:

An increase in the size of cells resulting in increase in the size of the organ. There are no new cells, just bigger cells, enlarged by an increased amount of structural proteins and organelles. Hypertrophy occurs when cells are incapable of dividing.

a- Physiologic hypertrophy: e.g.: in skeletal muscle cells of weight lifter.

b- Pathologic hypertrophy: e.g.: cardiac enlargement that occurs with hypertension or aortic valve disease.

2- Hyperplasia:

An increase in number of cells that occur if the cell population is capable of dividing.

A- Hormonal hyperplasia: e.g.: The proliferation of the glandular epithelium of the female breast at puberty and during pregnancy.

B- Compensatory hyperplasia: occurs when a portion of the tissue is removed or diseased. e.g.: when a liver is partially resected, mitotic activity in the remaining cells begins to restore the liver to its normal weight.

C- Pathologic hyperplasia: caused by excessive hormonal or growth factor stimulation. e.g, endometrial hyperplasia that occurs due to disturbances in the balance between oestrogen and progesterone hormones causing abnormal menstrual bleeding. Another example is connective tissue hyperplasia in wound healing in which proliferating fibroblasts and blood vessels aid in repair.

3- Atrophy:

Shrinkage in the size of the cell by the loss of cell substance. Atrophic cells may have diminished function but they are not dead. Causes of atrophy include a decreased workload, e.g., immobilization of a limb to permit healing of a fracture, loss of innervation, diminished blood supply, inadequate nutrition, loss of endocrine stimulation, and aging (senile atrophy).

4- Metaplasia:

Change in which one adult cell type (epithelial or mesenchymal) by another adult cell type, e.g. in cigarette smokers, the normal ciliated columnar epithelial cells of the respiratory epithelium are replaced by stratified squamous epithelial cells.

Overview of cell injury and cell death

Cell injury results when cells are stressed so severely that they are no longer able to adapt or when cells are exposed to inherently damaging agents or suffer from intrinsic abnormalities. Injury may progress through a reversible stage and culminate in cell death.

1- Reversible cell injury: In early stages or mild forms of injury the functional and morphologic changes are reversible if the damaging stimulus is removed. At this stage, although there may be significant structural and functional abnormalities, the injury has typically, not progressed to severe membrane damage and nuclear dissolution.

2- Cell death: With continuing damage, the injury becomes irreversible, at which time the cell cannot recover and it dies.

Types of cell death:

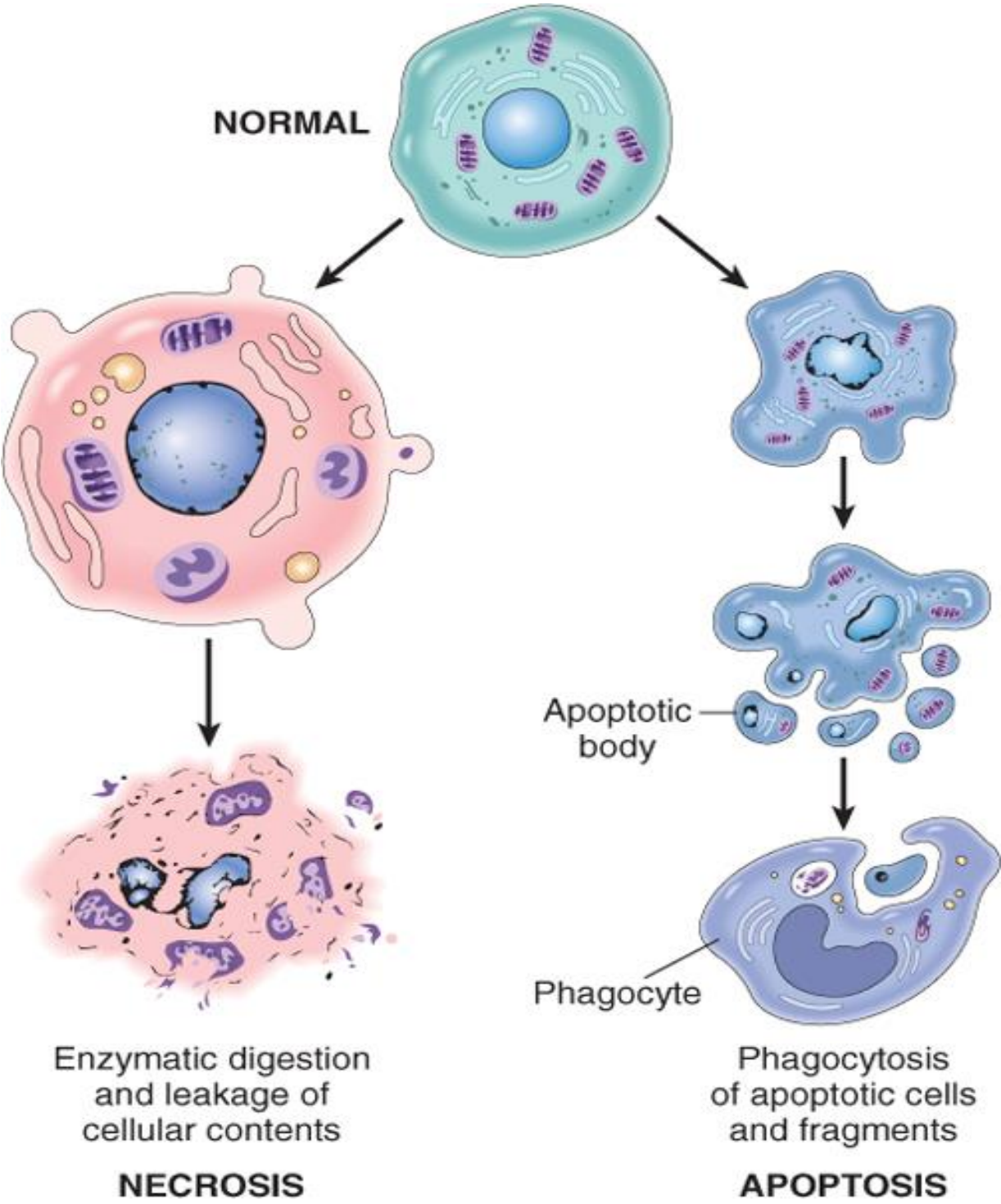
1- Necrosis:

Occur when the damage to membranes is severe, enzymes leak out of lysosomes, enter the cytoplasm, and digest the cell. Cellular contents also leak out through the damaged plasma membrane and result in a host reaction (inflammation). Necrosis results from ischemia, exposure to toxins, various infections, and trauma.

2- Apoptosis:

Occurs when a cell is deprived of growth factors or the cell's DNA or proteins are damaged beyond repair, the cell kills itself by another type of death, called apoptosis, which is characterized by nuclear dissolution without complete loss of membrane integrity. Apoptosis is an active, energy-dependent, tightly regulated type of cell death that is seen in some specific situations. Whereas necrosis is always a pathologic

process, apoptosis serves many normal functions and is not necessarily associated with pathologic cell injury.



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