Apoptosis

Cell Death

Apoptosis is the process of programmed **cell death** characterized by distinct morphological characteristics and energy-dependent biochemical mechanisms. Apoptosis is a naturally occurring phenomenon that occurs in a cell's life and is vital for normal embryonic development, chemical-induced cell death, and normal functioning of the immune system. Controlled apoptosis functions as a homeostatic mechanism to avoid uncontrolled cell division and the potential development of a tumour.

Molecular Mechanisms of Apoptosis

Alterations within the cytoskeleton and membrane structure is often seen in apoptotic cells, leading to protrusions or bulges on the cell membranes surface. This is known as **blebbing**, and leads to the irregularly shaped structure of an apoptotic cell seen in the early stages of apoptosis. An apoptotic cell will also undergo **karyorrhexis**, which refers to the fragmentation of a cell nucleus. Karyorrhexis leads to the disintegration of the nucleus into smaller fragments which will subsequently be phagocytosed by phagocytic cells.

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Apoptosis Pathway

1

Apoptosis is initiated in response to cell damage or apoptosis-inducing signals.

2

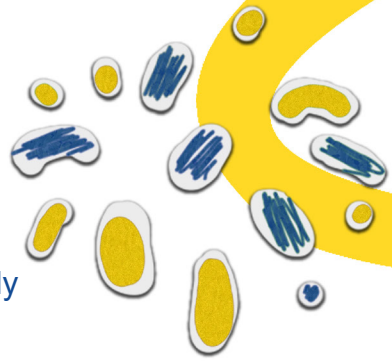
Early apoptotic cells begin to shrink and chromatin is irreversibly condensed.

3

Apoptotic cells become fragmented and release signals to attract macrophages.

4

Cell fragments are separated into apoptotic bodies consisting of cytoplasm and tightly packed organelles.



5

Macrophages detect, engulf and remove apoptotic cell fragments from the body.

There are three main types of biochemical changes observed in apoptosis:

1. Activation of caspases

Caspases are a family of **protease enzymes** that become activated through proteolytic cleavage during the initiation phase of apoptosis. They cleave specific substrates, leading the biochemical and morphological changes associated with apoptosis.

2. Breakdown of DNA and protein

DNA fragmentation is mediated by **caspases** in apoptotic cells. DNA repair and maintenance proteins are cleaved, leading to the partial degradation of nuclear DNA into nucleosomes.

3. Membrane changes and recognition by phagocytic cells

Plasma membrane structural changes are vital for the clearance of dying cells by **phagocytes** in apoptosis. The expired cells secrete **chemotactic signals**, which activate and attract local phagocytes to seek out, engulf and clear the cell fragment. The chemotactic signals determine the fate of the apoptotic cell.