

The End of the Cell: Mechanisms & Patterns

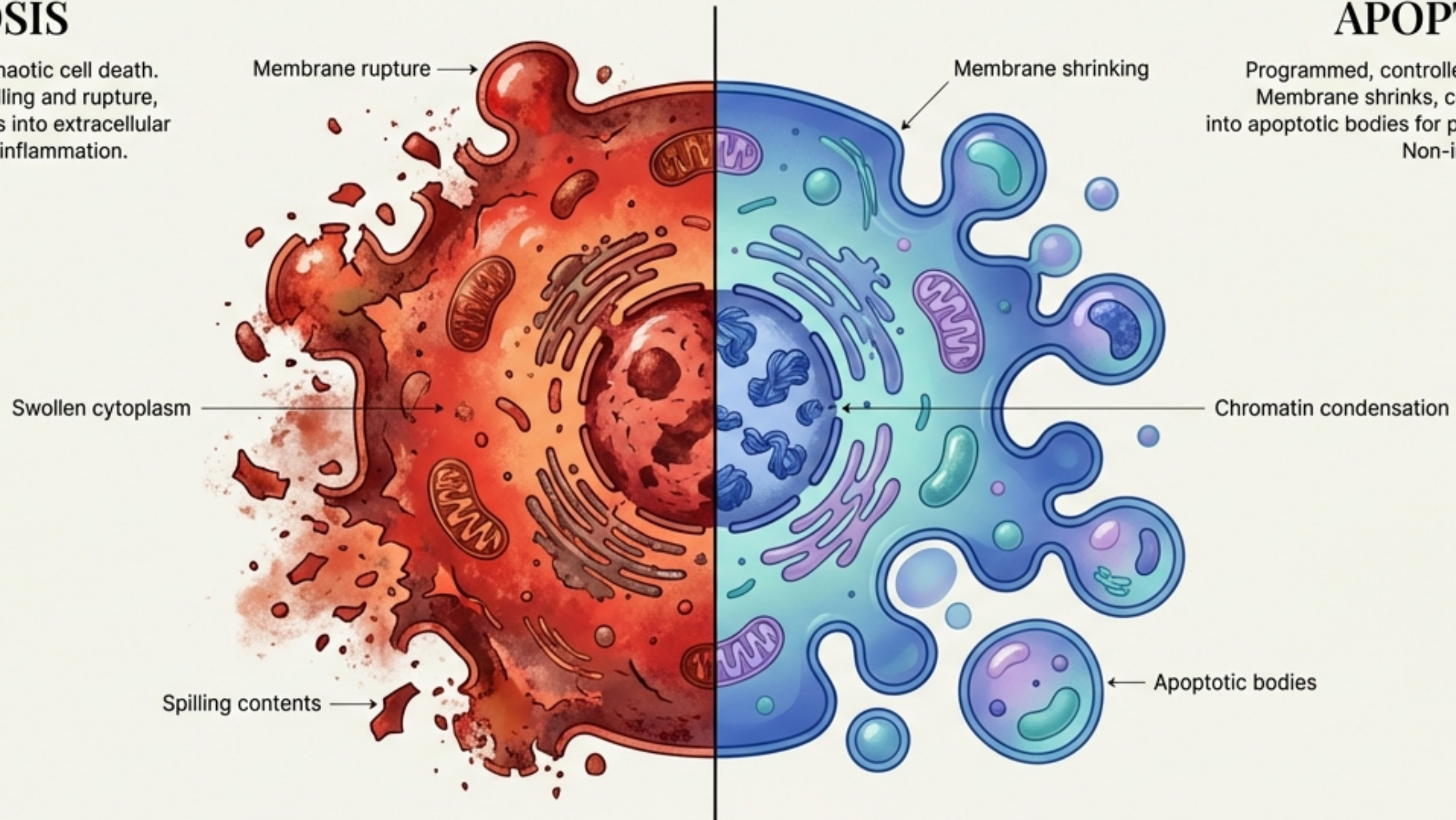
A Visual Guide to Biological Order vs. Chaos

NECROSIS

Uncontrolled, chaotic cell death. Membrane swelling and rupture, spilling contents into extracellular space. Induces inflammation.

APOPTOSIS

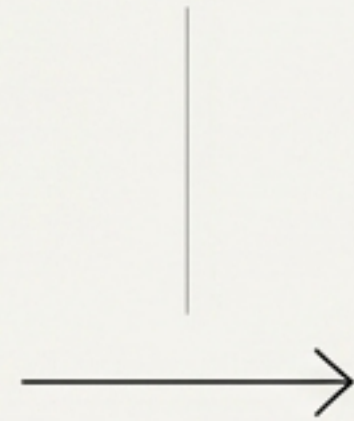
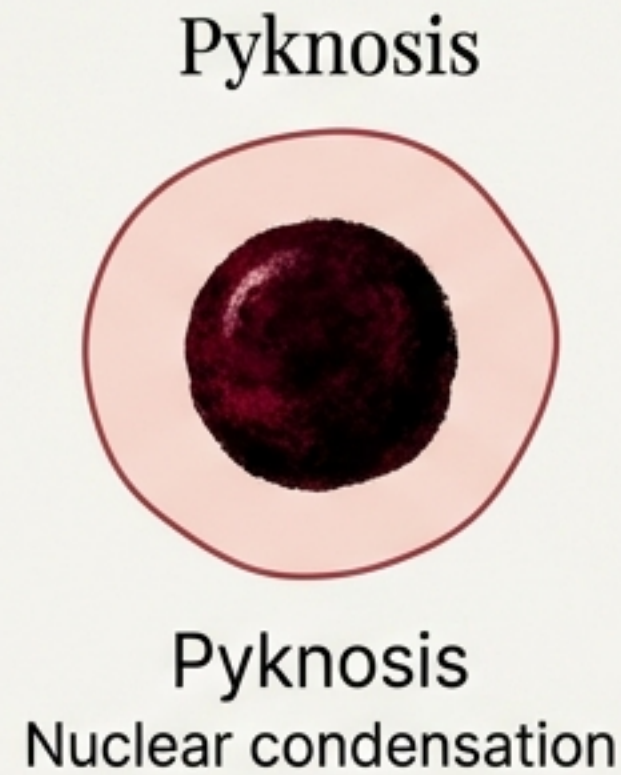
Programmed, controlled cell death. Membrane shrinks, cell fragments into apoptotic bodies for phagocytosis. Non-inflammatory.



The Universal Sign of Cellular Death

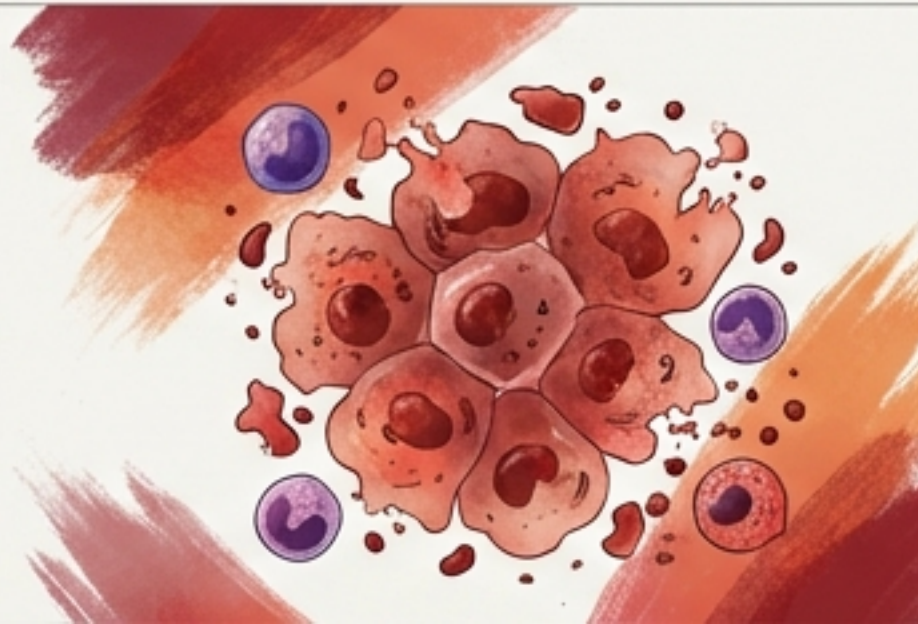
The morphologic hallmark of cell death is the loss of the nucleus.

The Fate of the Nucleus



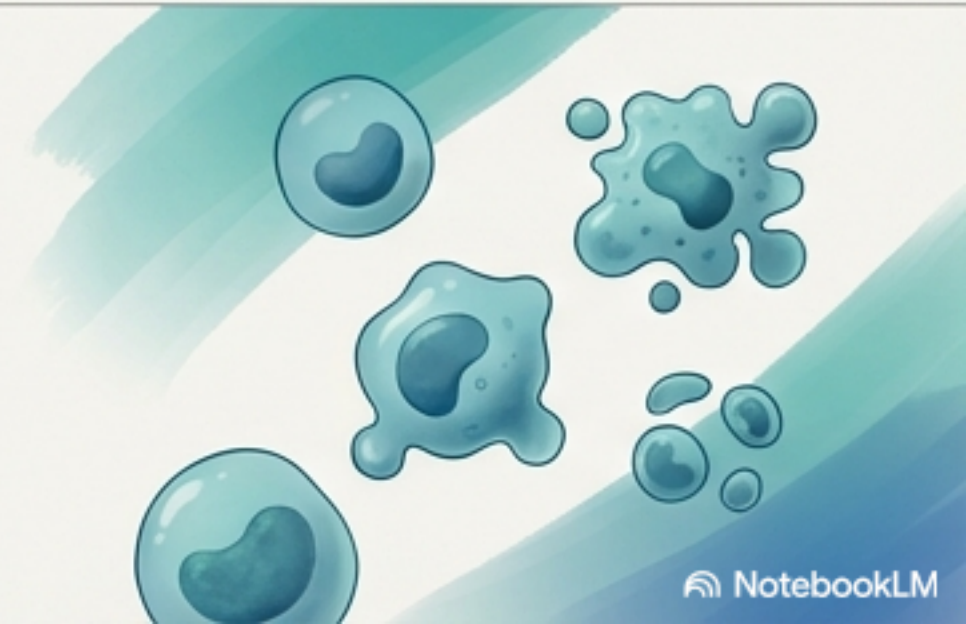
Necrosis

Pathologic death of large groups of cells. Followed by acute inflammation. Never physiologic.



Apoptosis

Genetically programmed removal of single cells. Energy (ATP) dependent. No inflammation.



Necrosis is a Pathologic Collapse



THE MECHANISM

1. Cell Swelling
2. Membrane Rupture
3. Leakage of Contents

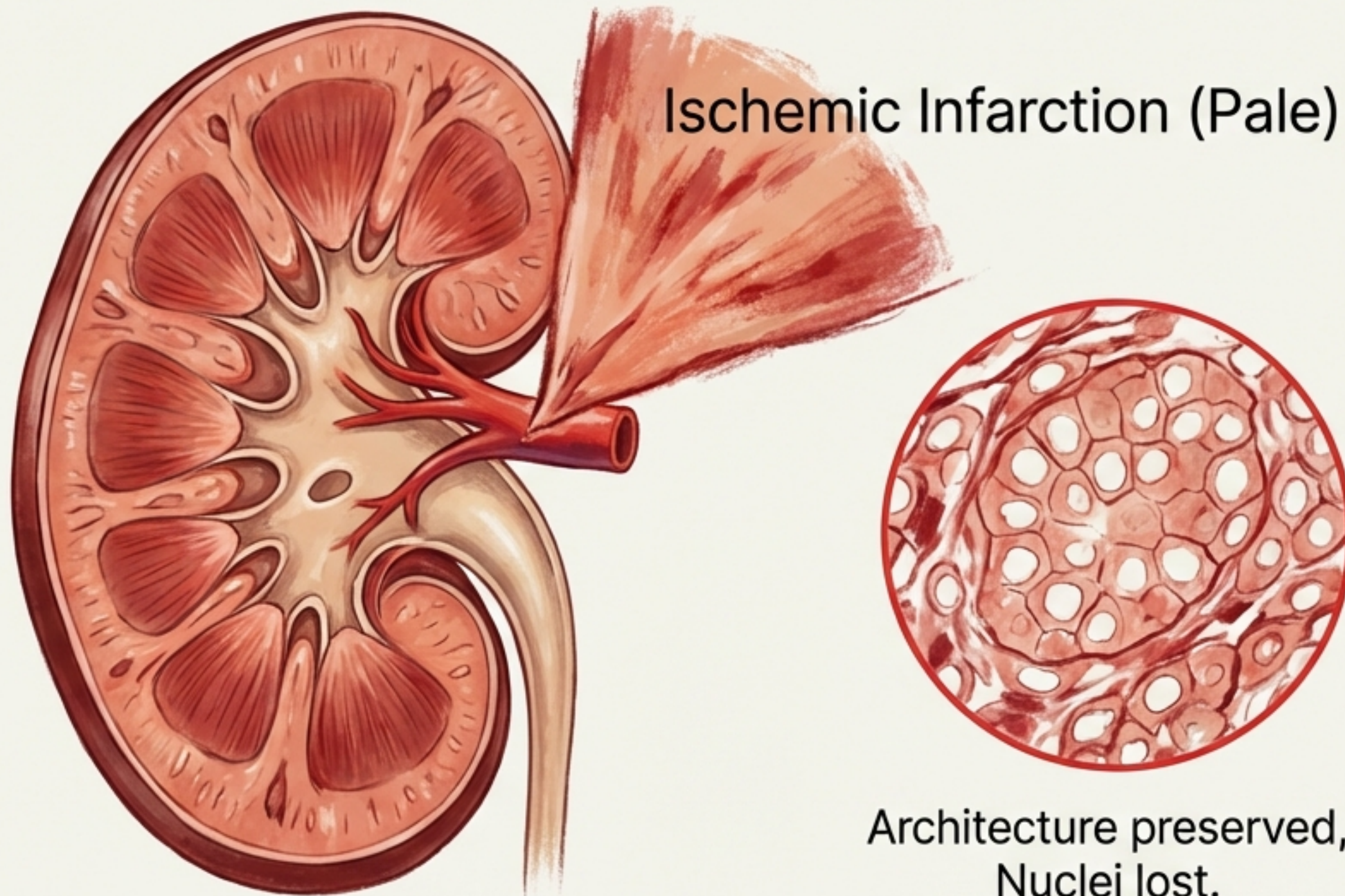
KEY CHARACTERISTICS

Scope: Large groups of cells.

Reaction: Acute inflammation (Neutrophils).

Context: Always pathologic (never physiologic).

Coagulative Necrosis: The Ghost Town



Mechanism

Ischemia (Loss of blood supply).

Location

All organs except the brain.

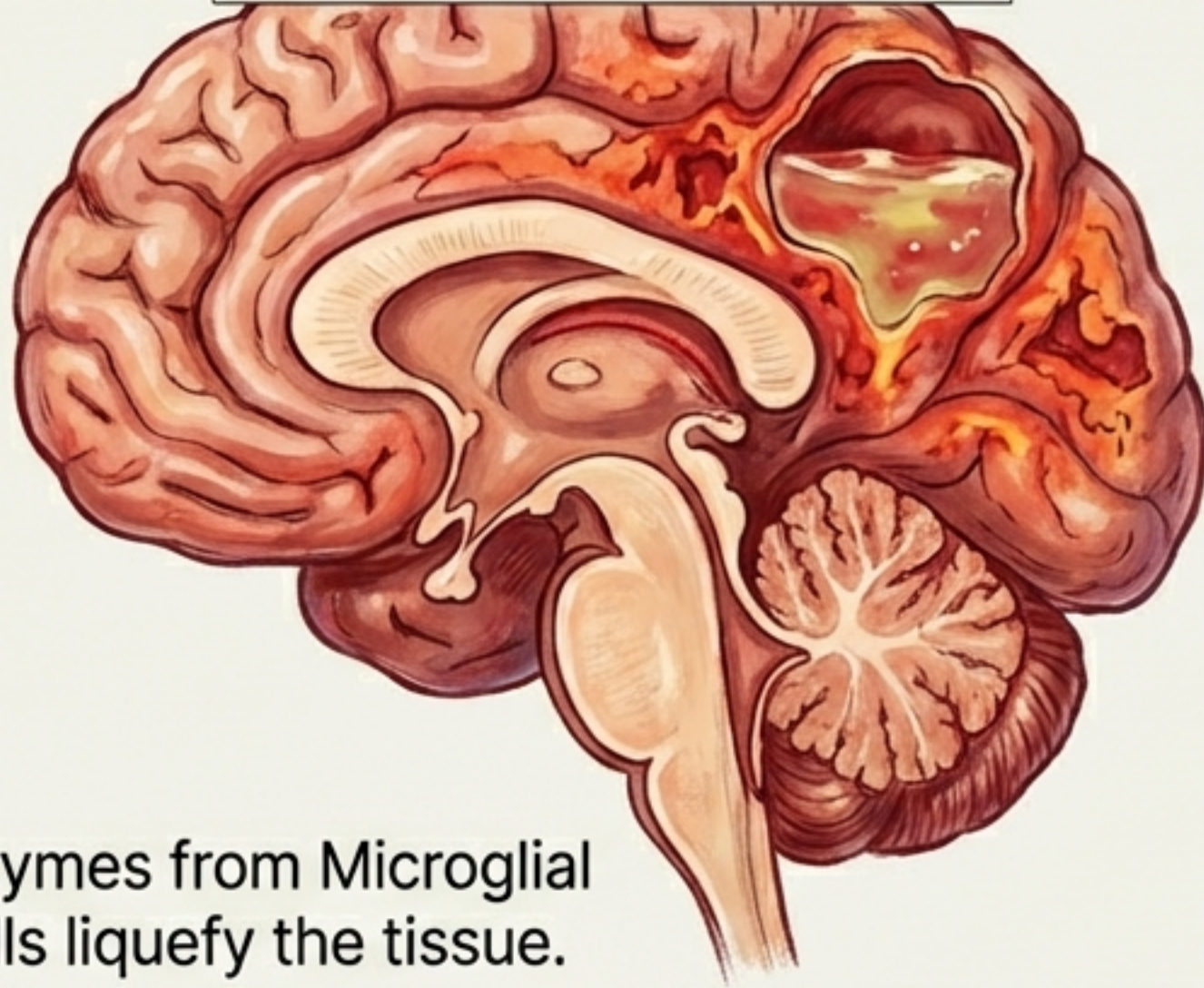
Note: Red Infarction



Occurs when blood re-enters loosely organized tissue (e.g., Testicle, Lung).

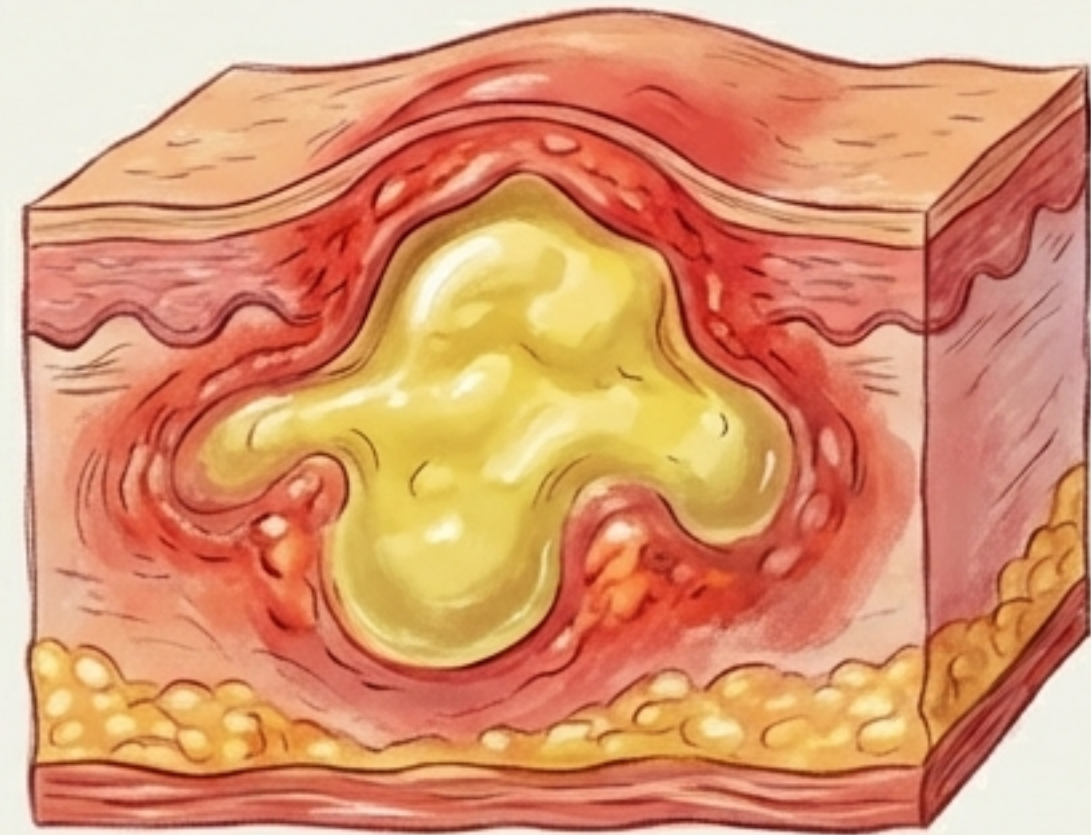
Liquefactive Necrosis: Enzymatic Digestion

Brain Infarction



Enzymes from Microglial cells liquefy the tissue.

Abscess



Enzymes from Neutrophils liquefy the tissue.

Also seen in Pancreatitis (Enzymes from pancreas liquefy parenchyma). Mechanism: Enzymatic lysis of cells and proteins.

Special Variants: Gangrenous & Caseous Patterns

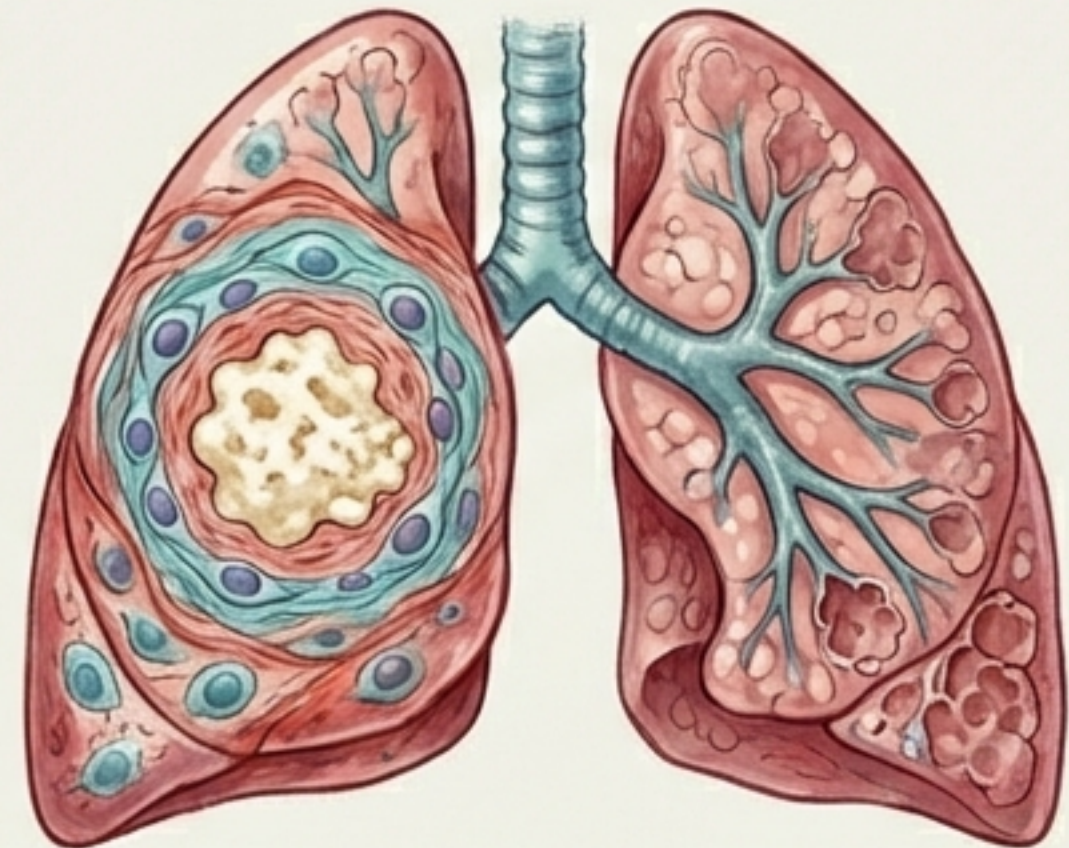
Gangrenous Necrosis



- **Context:** Ischemia of lower limbs or GI tract.

- **Dry Gangrene:** Mummified tissue (Coagulative pattern).
- **Wet Gangrene:** Superimposed infection leading to liquefaction.

Caseous Necrosis



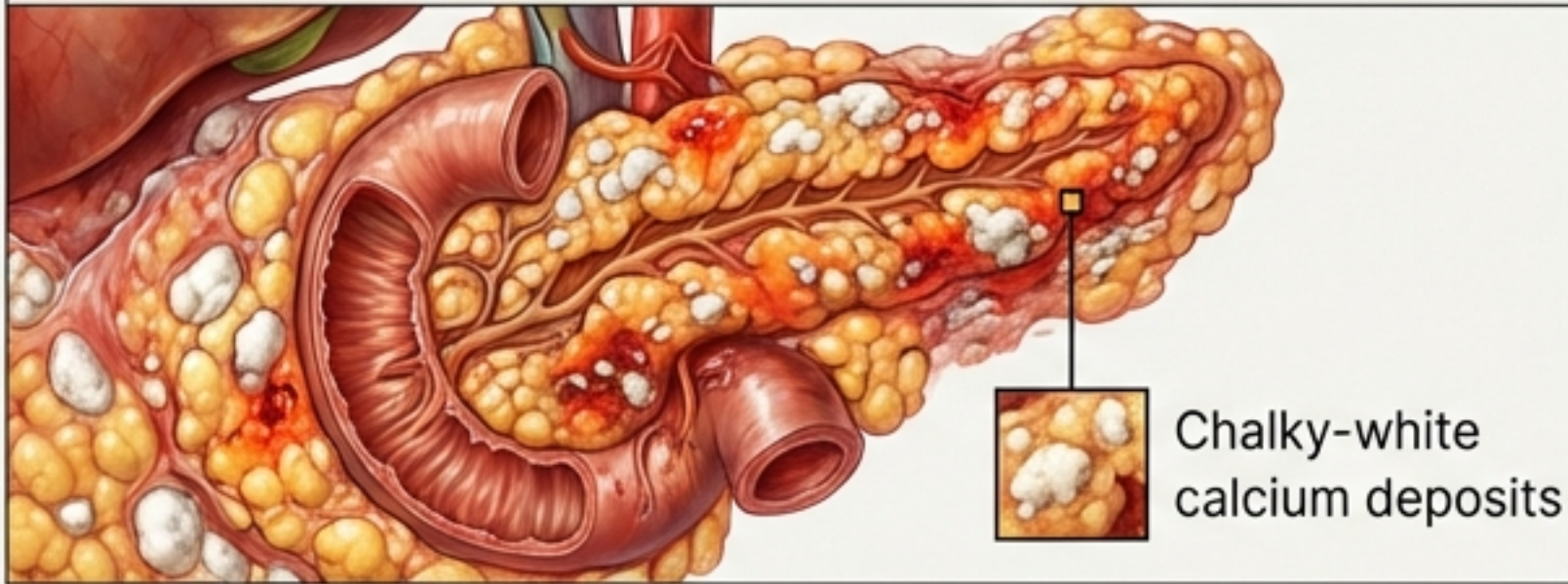
- **Context:** Granulomatous inflammation (TB or Fungal infection).

- **Morphology:** Soft, friable, 'cottage cheese-like'.

- **Mechanism:** A mix of Coagulative + Liquefactive.

Targeted Destruction: Adipose & Vessels

Fat Necrosis



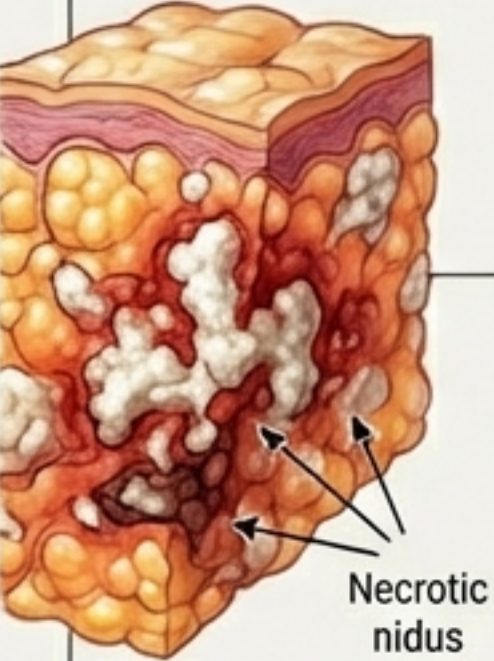
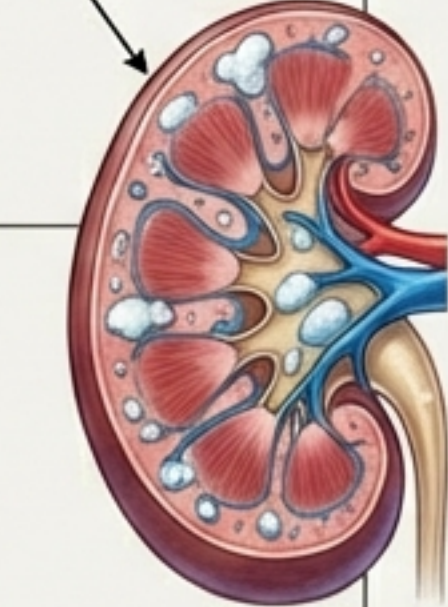
- **Mechanism:** Saponification. Fatty acids released by trauma or lipase bind with calcium.
- **Context:** Breast trauma or Pancreatitis.

Fibrinoid Necrosis

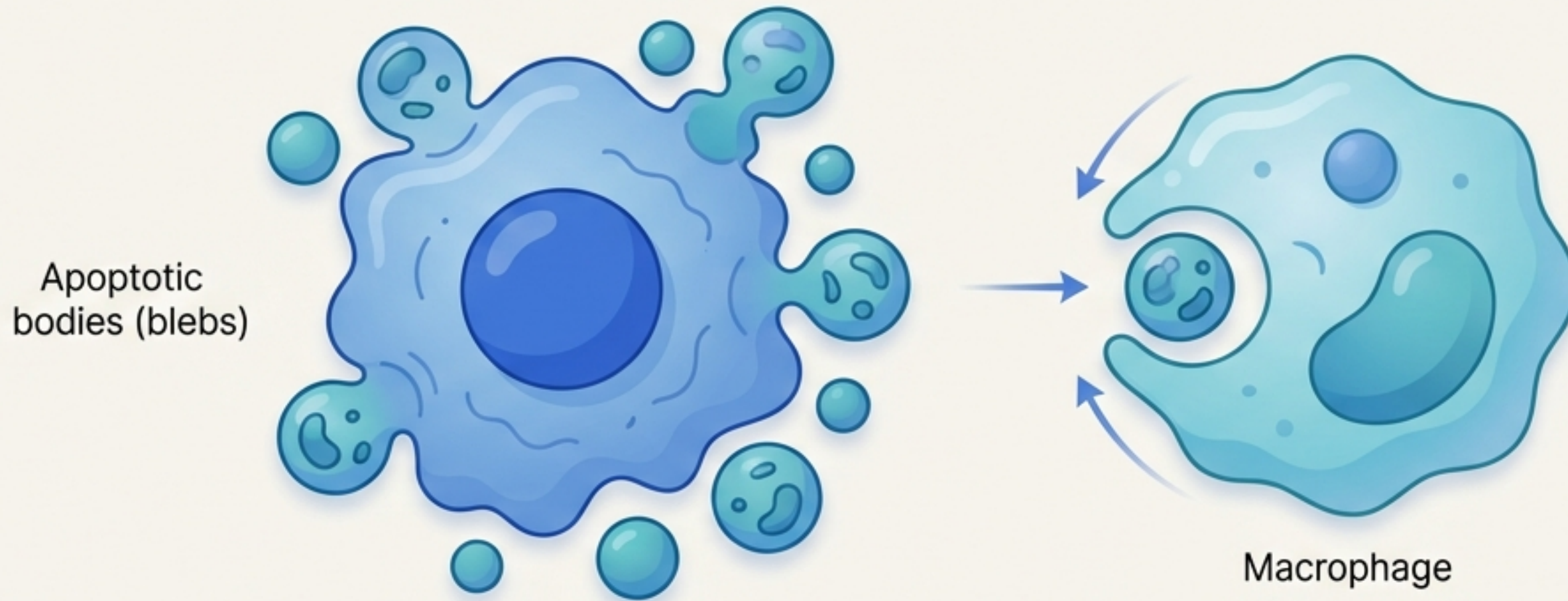


- **Mechanism:** Leakage of proteins (fibrin) into the vessel wall.
- **Context:** Malignant Hypertension or Vasculitis.

When Calcium Meets Tissue

Dystrophic Calcification	Metastatic Calcification
 <ul style="list-style-type: none"> • Where: Deposits on DEAD tissues (e.g., Fat Necrosis). 	 <ul style="list-style-type: none"> • Where: Deposits on NORMAL tissues (e.g., Kidney nephrocalcinosis).
<ul style="list-style-type: none"> • Chemistry: Serum Calcium: NORMAL. Serum Phosphate: NORMAL. 	<ul style="list-style-type: none"> • Chemistry: Serum Calcium: HIGH. Serum Phosphate: HIGH.
<ul style="list-style-type: none"> • Mechanism: Necrotic tissue acts as a nidus for calcification. 	<ul style="list-style-type: none"> • Mechanism: Driven by systemic metabolic imbalance (e.g., Hyperparathyroidism).

Apoptosis is a Programmed Exit



Key Insight:

The 'Clean Suicide'.

Energy:

ATP-dependent process.

Scope:

Single cells or small groups.

Result:

No Inflammation.

Physiologic Examples

- 1. Endometrial shedding (Menstrual cycle)



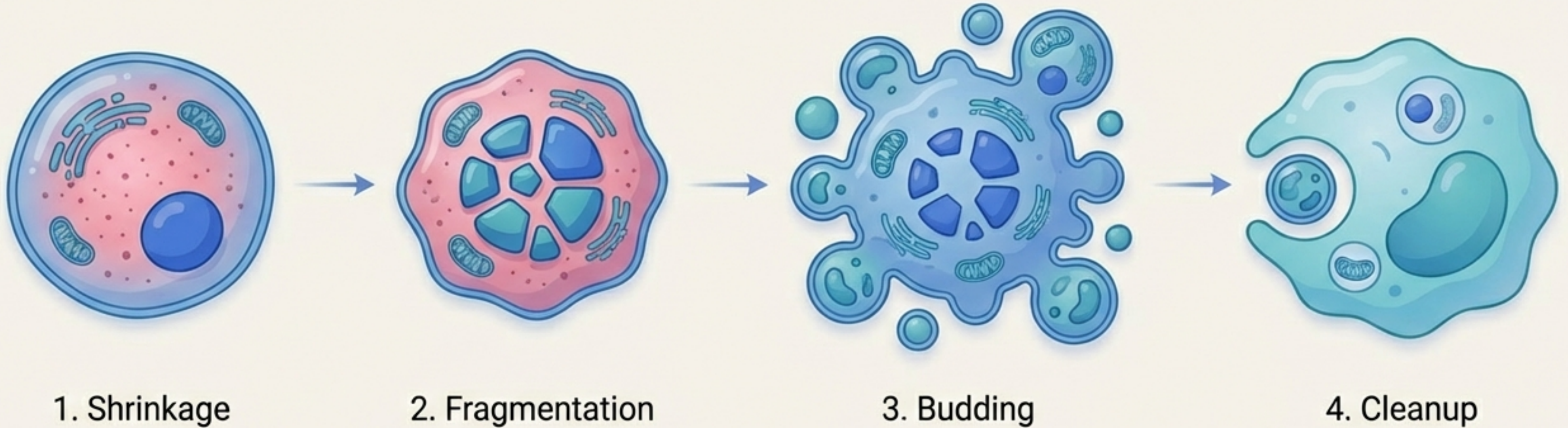
- 2. Embryogenesis (Removing webbed fingers)



- 3. CD8+ T-cell defense (Viral removal)

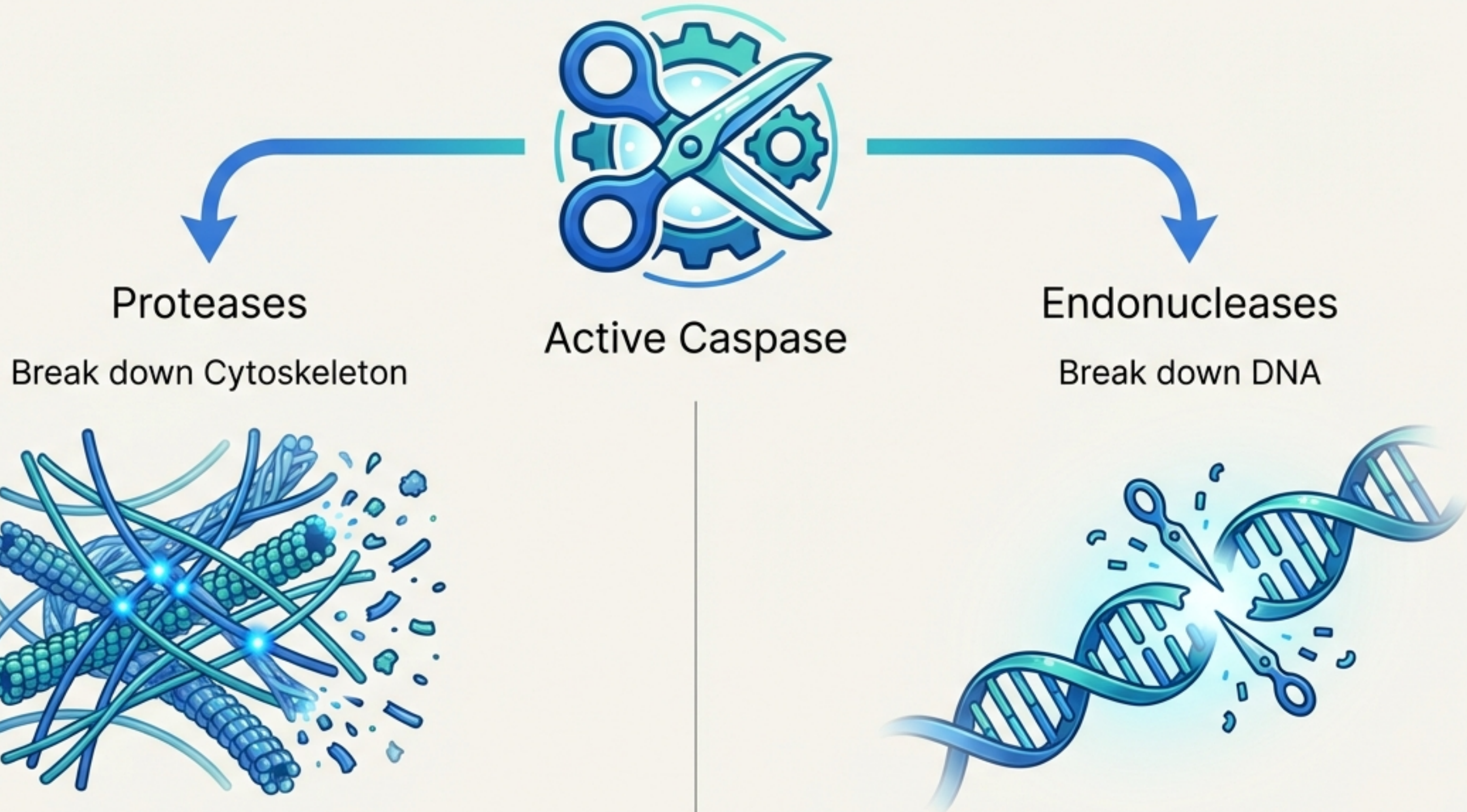


Morphology of the Shrinking Cell

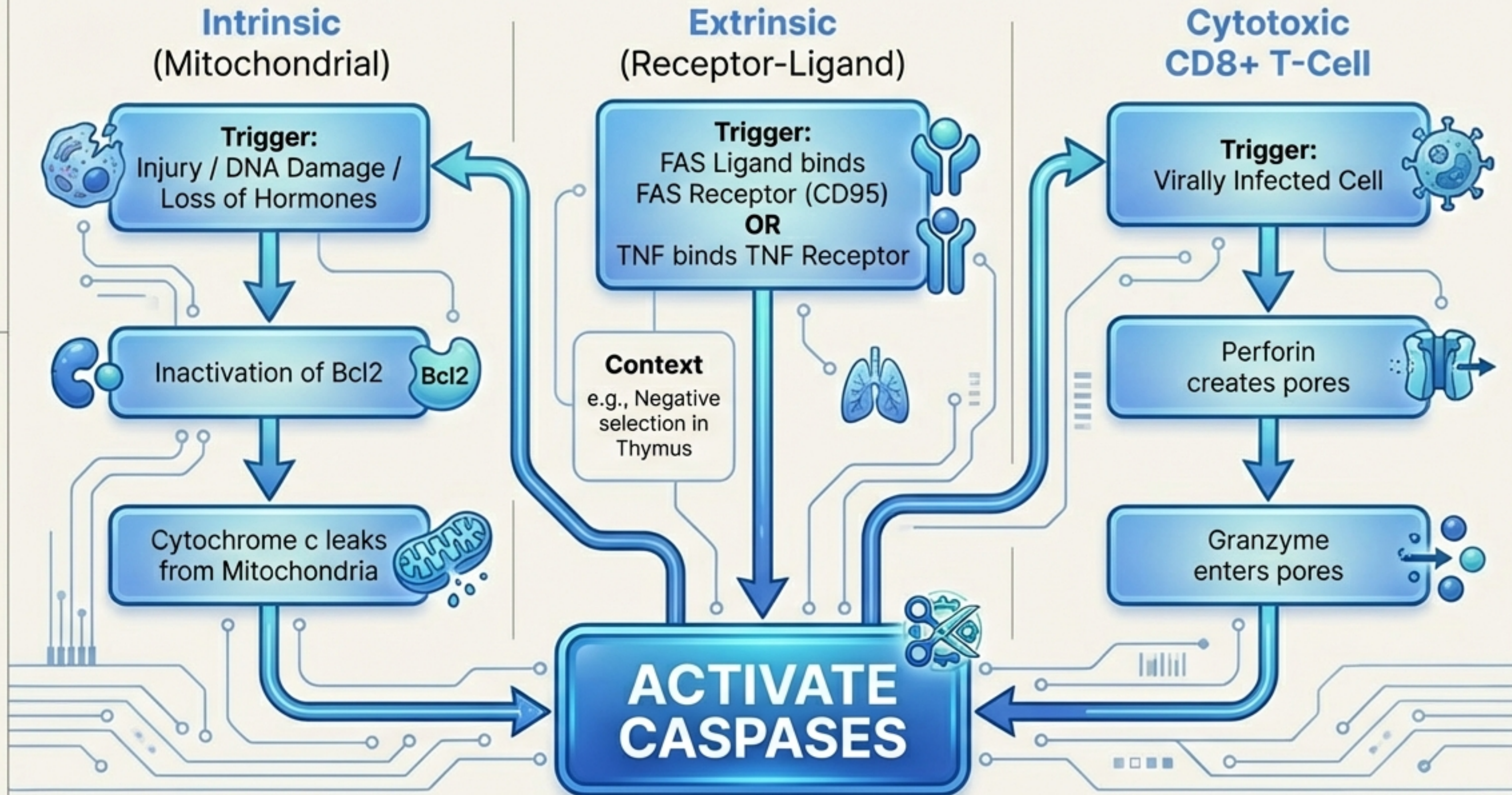


Crucial Distinction: The plasma membrane remains intact until the bodies are eaten, preventing leakage and inflammation.



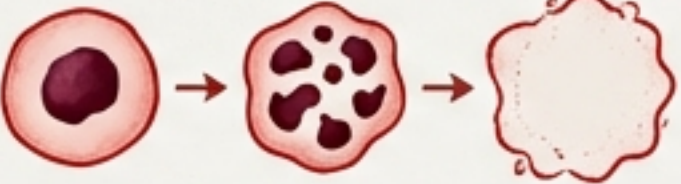






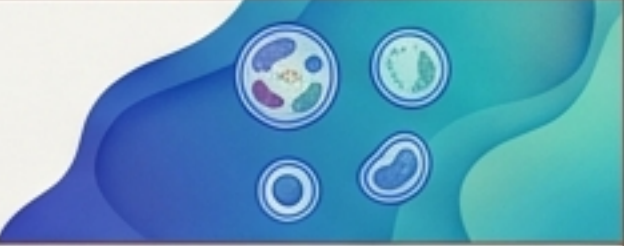

The Executioners: Caspases



Three Pathways to Activation



At a Glance: Necrosis vs. Apoptosis

Feature	Necrosis (The Accident)	Apoptosis (Programmed)
Cell Size	Swelling (Enlarged) 	Shrinking (Reduced) 
Nucleus	Pyknosis -> Karyorrhexis -> Karyolysis 	Organized fragmentation 
Plasma Membrane	Disrupted (Leaking) 	Intact (Altered structure) 
Cellular Contents	Enzymatic digestion; leak out 	Intact; packaged in bodies 
Inflammation	Frequent (Acute) 	Absent 
Role	Always Pathologic 	Often Physiologic 