Cells that engulf pathogens

Phagocytes are white blood cells that take in and destroy microbes and clear cellular debris. Neutrophils and macrophages are two important examples.

1. AN INNATE, NON-SPECIFIC DEFENCE

Phagocytosis acts against a broad range of microbes without needing a new, antigen-specific response each time. "Non-specific" does not mean no recognition: phagocyte receptors recognise common microbial features and other signals.

2. COMPARE THE TWO PHAGOCYTES

Feature	Neutrophil	Macrophage
Typical location	Circulates in blood; enters infected tissues.	Found in tissues; many are resident sentinels.
Response	Rapidly recruited, often among the first arrivals.	Resident cells respond locally; more can develop from recruited monocytes.
Appearance	A nucleus with several connected lobes; many granules.	Usually larger, with abundant cytoplasm and an irregular or kidney-shaped nucleus.
Role	Engulfs and kills microbes; generally short-lived.	Engulfs microbes and debris; can also signal and present antigens.

3. THE SHARED JOB

Both cell types can recognise, engulf and digest pathogens. They contain enzyme-rich compartments and can change shape to surround particles. A phagocyte is the cell; phagocytosis is the process it carries out.

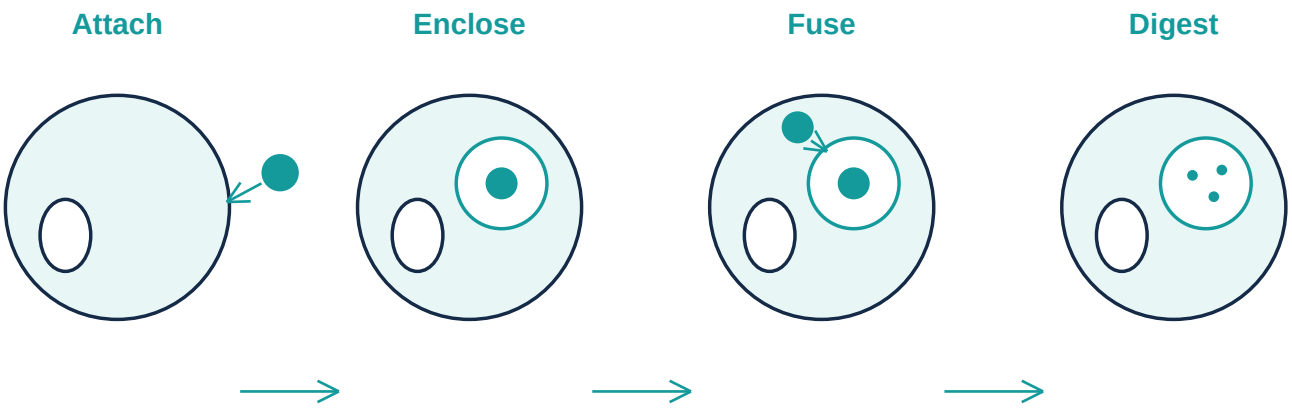
Cell types and morphology: OpenStax, Microbiology 17.3.
Tissue roles and signalling: British Society for Immunology, Macrophages.

Scope: Cambridge Biology 9700 syllabus, section 11.1, outcome 1, p. 31.

Phagocytosis, step by step

The pathogen is enclosed inside a membrane-bound compartment. Digestion then occurs within the cell, not simply on its outer surface.

1. TRACK THE PATHOGEN



Teal dot = pathogen; teal fragments = digested material. Small teal vesicle = lysosome. White oval = nucleus. Schematics show successive stages, not cell sizes.

2. RECOGNISE AND ENGULF

A phagocyte attaches to a microbe. Extensions of cytoplasm and cell surface membrane surround it; the membrane encloses it in a phagosome, also called a phagocytic vacuole.

3. FUSE AND DIGEST

Lysosomes fuse with the phagosome. Their hydrolytic enzymes digest microbial components in the resulting phagolysosome. Killing mechanisms help destroy the engulfed microbe.

4. DEAL WITH THE REMAINS

Useful breakdown products may be retained, while undigested material can leave by exocytosis. Some pathogen-derived fragments can instead be used for antigen presentation by macrophages.

Recognition, engulfment and digestion: OpenStax, Microbiology 17.4.
Phagocytosis and presentation: British Society for Immunology, Macrophages.

Scope: Cambridge Biology 9700 syllabus, section 11.1, outcome 1, p. 31.

Reach, destroy and communicate

Phagocytes do more than wait for microbes to arrive. Their movement, intracellular compartments and signalling help coordinate defence in infected tissues.

1. REACH THE SITE OF INFECTION

Neutrophils can leave small blood vessels by squeezing between endothelial cells, then move through tissues. Chemical signals from microbes and damaged or activated cells attract them; directed movement along a chemical gradient is chemotaxis.

2. MATCH STRUCTURE TO FUNCTION

A flexible cell surface allows movement and engulfment. Lysosomes contain digestive enzymes. Neutrophil granules contain antimicrobial substances, and neutrophils can generate reactive molecules that help kill microbes. These are cellular defences, not antibody production.

3. MACROPHAGES LINK DEFENCE SYSTEMS

Macrophages help remove dead cells as well as microbes. They release signalling molecules and can display pathogen-derived antigen fragments on their surface for recognition by helper T cells. This connects innate defence to adaptive immunity; presentation is not secretion of antibodies.

4. KEEP THESE TERMS DISTINCT

A phagosome contains the engulfed particle. A lysosome supplies digestive enzymes. A phagolysosome forms when these compartments fuse. Engulfment brings the particle inside; digestion breaks it down. Not every engulfed pathogen is successfully destroyed.

Next-lesson link: antigens and the distinction between self and non-self.

Neutrophil movement and antimicrobial activity: BSI, Neutrophils.
Compartments and microbial survival: OpenStax, Microbiology 17.4.

Scope: Cambridge Biology 9700 syllabus, section 11.1, outcome 1, p. 31.